



Sustainability Performance Assessment Version 2.0

Towards Consistent Measurement
of Sustainability at Farm Level





Sustainability Performance Assessment Version 2.0

Towards Consistent Measurement of Sustainability at Farm Level

Editors of version 2.0

Gijs Kuneman - CLM

Emeline Fellus - SAI Platform

Contributors to version 2.0:

Peter Erik Ywema - SAI Platform

Emiel Elferink, Erna van der Wal, Jenneke van Vliet, Lien Terryn - CLM

Contributors to animal welfare module:

Brian Lindsay and the Dairy Working Group - SAI Platform

Frits van der Schans - CLM

April 2014

CLM 843-2014

Note for the reader

This report presents guidelines for the Sustainability Performance Assessment of farming practices, as recommended by SAI Platform. It aims to guide developers of farm-reporting tools towards the use of more farmer-friendly, practical and uniform indicators, methodologies and approaches.

This "Version 2.0" is an update of the Version 1.0 published in 2012. New features include:

- A benchmark of thirteen existing tools against SPA
- A new chapter on animal welfare
- A more detailed comparison between FAO's SAFA and SPA

Companies developing software tools for monitoring and reporting sustainable farming are encouraged to make use of these guidelines for further deployment of their tools.

SAI Platform

Peter Erik Ywema and Emeline Fellus

T: +31 651 22 33 50 and +33 6 22 22 84 74

E: peywema@saiplatform.org and efellus@saiplatform.org

I: www.saiplatform.org

Centre for Agriculture and Environment CLM

Gijs Kuneman

T: + 31 345 47 07 26

E: gkuneman@clm.nl

I: www.clm.nl

Contents

Foreword

1. Introduction	1
2. Comparing existing tools with SPA	5
3. Climate and energy	9
4. Pesticides	15
5. Soil quality	25
6. Water quantity	33
7. Nutrients	39
8. Biodiversity	43
9. Land use	49
10. Animal welfare	53
11. Considerations on data	57
Annex 1: Full list of farm data and background data	59
Annex 2: Benchmark of promising tools against SPA	63
Annex 3: Comparison of FAO's SAFA and SPA	65
Annex 4: Steering Committee and external experts	67
Annex 5: About SAI Platform and CLM	69

Foreword

Measuring and demonstrating positive impact is a challenge for all stakeholders working to improve their sustainable agricultural practices. The key to overcome this challenge is to generate relevant management information. Firstly for farmers, so they can pick and choose practices with the largest positive impact. Secondly, for the whole food and drink industry to support their commitments to sustainable sourcing and communicate their progress to interested parties including consumers. And thirdly, to other third parties and NGOs that are genuinely interested in sustainable agriculture.

For over a decade, SAI Platform has been working towards sector alignment on what constitutes sustainable Principles and Practices at farm level and has achieved agreed guidelines for a variety of commodities. This work made us realize how important quantifiable indicators are, and on top of that the need for clear consensus on indicators and the way they are calculated amidst the endless options.

Over the years we have witnessed confusion arising from hundreds of slightly differing sets of qualitative requirements from public, private and in-company standards. Most of them with the same intent but each of them using slightly different wording. SAI Platform has set itself the ambition of avoiding the same thing happening for quantitative assessment, by intervening at an early stage of the discussion. This is what SPA (Sustainable Performance Assessment) is all about.

With SPA we aim to reduce confusion by building consensus on ways to quantify sustainable agriculture in a simple, pragmatic yet scientifically robust way. While we don't claim to be the utmost expert, we use expertise from our members and partners to propose a practical way to bring impact assessment into practice across regions, farming types and commodities.

I have talked to excellent farmers who weren't convinced that quantitative measurement would bring added value to them and their work. After long discussions, I found out that this fact might be true for them: they judge the impact of adding compost to their fields, by watching improvement over 10-15 years. They are like Michelin-chefs in the kitchen who cook with their senses and taste, and their gut feeling. For most of us, however, we need to weigh the flour and sugar to make a decent cake. And so 'measuring carbon content of soil' is an excellent indicator to evaluate daily practices and create productive soils. That's why we believe in SPA, as a helping hand and support tool.

I hope that the guidelines provided in this document will be used in practice and improved over time. I hope they will find their place in the algorithms of good calculators, in a similar way that good recipes make it from a cooking book to the kitchen and there are adapted to the taste of a local cook or audience.

Peter Erik Ywema
General Manager SAI Platform

1 Introduction

In a nutshell

This report outlines choices and calculation rules for one or several computerised system(s) to measure sustainable farming in a scientifically robust, farmer-friendly and sector-consistent manner. These general rules are meant to guide software developers and designers of farm-reporting tools towards more uniform assessment.

Towards more uniform assessment of sustainable farming

The Sustainable Agriculture Initiative Platform (SAI Platform) is a food and drink company initiative supporting the development of sustainable agriculture worldwide. It brings together over 55 food and drink companies and affiliate members. More information can be found at www.saiplatform.org.

The aim of this Sustainability Performance Assessment (SPA) project of SAI Platform is to arrive at more uniform criteria for measuring and reporting on-farm sustainability. In other words: food companies in the future would like receive from their suppliers robust and consistent data about the sustainability of the production of raw agricultural material, allowing for the compilation of data on farmers' sustainability efforts in uniform formats.

The future SPA-proof calculation tool(s) will allow:

- Farmers to compare their performance to other farmers in the same region (country/continent), and to track their own performance over the years.
- Farmers to understand the various impacts of their practices on the three pillars of sustainability, and to adapt these practices over time so as to mitigate those impacts.
- Food and drink companies to assess the performance of their supply base (farmers) over the years, and to some extent benchmark their scores against other food companies sourcing agricultural products in the same region.

From principles and practices to metrics

SAI Platform has already defined Principles & Practices for sustainable farming (P&P, to be found on the SAI Platform website). These P&P have been translated into a smaller and more concrete set of questions posed to farmers: the Farmer Self Assessment (FSA). The P&P and FSA are descriptive and focus on management, administration and plans at farm level. The challenge is to get from these general descriptive P&Ps and FSA to something that can actually be measured and quantified: to express performance into *metrics*. This step is outlined in this report.

First the main *issues* were identified: the big building blocks of sustainable farming. SAI Platform has decided to focus on the following issues:

1. Climate change and energy
2. Pesticides
3. Soil quality
4. Water quantity
5. Nutrients
6. Biodiversity
7. Land use
8. Animal welfare
9. Occupational Health and Safety
10. Financial stability

Criteria for choosing these issues are that the issue:

- is important in all agriculture sectors;
- is relevant at farm level;
- can meaningfully be put into numbers to measure trends, and these numbers can be derived from information easily collected and supplied by the farmer;

- is not covered implicitly by other themes.

A balanced set of indicators: some excluded or on hold

Two examples of themes not explicitly included but implicitly covered are: water quality and waste. Farmers generally do not measure water quality in water courses around the farm, so asking farmers to enter data on local water quality is not feasible. Nutrient load and pesticide pollution are the most important drivers for water quality around the farm. Nutrients and pesticides are covered as separate issues. Therefore, water quality is thought to be sufficiently covered by these two issues.

Waste is not in the list of main issues. Organic waste is covered by the balances calculated in 'Soil quality' and 'Climate & energy'; inorganic waste (plastic, rubber) is not measured by farmers and is not extremely important at farm level.

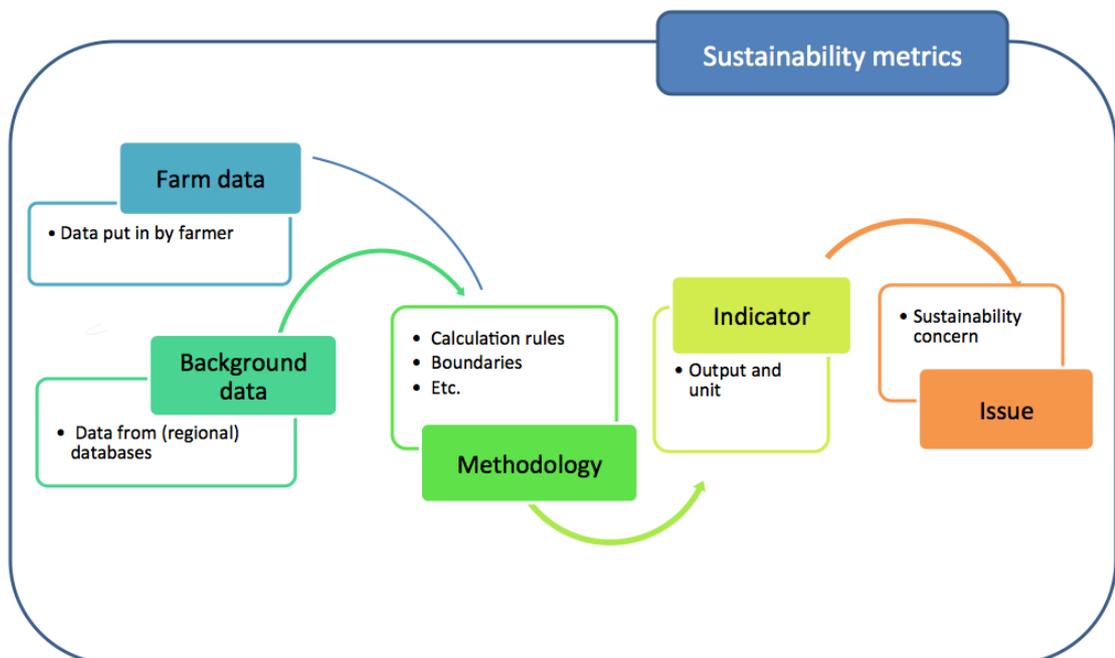
This report covers the first eight issues. Social issues such as occupational health and safety, and financial stability, are naturally as important if not more important. But they have proven to be so complex, that longer-term efforts are needed before a single measurement system can be identified. SAI Platform and its members are working on this in separate programmes.

Core elements of sustainability metrics

We have defined "metrics" as "quantifying sustainable farming". When setting rules for how to do that, we work with four core elements:

- Essential farm data as input (data entered by the farmer).
- Essential background data as input (defaults and reference data for countries and regions).
- Methodology (calculation rules, boundaries etc).
- Output indicators (units in which performance is expressed).

These core elements together form the SPA Guidelines for software developers to build assessment systems or tools. The graph below outlines the coherence between the core-elements.



Basic demands for the system

SAI Platform recommends a system with the following basic requirements:

- Output must be quantitative data.
- The tool must be computer based; preferably internet based, and ideally also suited for smartphone.
- It must be user-friendly. Farmers enter data into the system in a limited time by themselves, unaided by advisors (though supported by a manual).
- Target group: (computer) literate farmers or their co-operatives.
- The system must feed back results real-time to the farmer; it facilitates learning and ideally gives practical suggestions.
- The system must compare farm results to a benchmark.
- It must provide reports at farm level.
- Output indicators must be compiled in a central database, anonymously.
- The system must allow flexible reporting and data comparisons.
- All SAI Platform priority issues (listed above) must be covered.

Following these basic criteria, the SAI Platform system is meant to be practical rather than scientific, simple and accessible rather than exhaustive.

Re-inventing the wheel?

Readers may be tempted into thinking that the SPA system duplicates existing systems. It may do, partly. However, it responds to several needs that existing tools do not entirely satisfy. For instance, SPA overlaps with quantified parts of existing reporting systems like Unilever's Sustainable Agriculture Code - but that is a very extensive system for collecting yes/no data and individual data. Similarly, Nestle's RISE system covers (more than) all, but RISE requires several hours of interview and support by a farm advisor. Systems like Field to Market and Simpatica come close to what SPA envisages, but take somewhat different routes for assessing impacts. The many existing computerised farm management systems that farmers use for day-to-day management do not cover all SPA-issues. Finally, some single-issue tools exist which come very close to the SPA Guidelines - but these cover only one issue, like the Gaia Biodiversity Yardstick and the Cool Farm Tool. More detail the twelve most promising tools in comparison to SPA can be found in the next chapter.

In any case, so far no system exists that fulfils all basic requirements listed above.

A practical way of getting to a practical SPA-compliant system would be to develop plug-in tools for existing farm management systems. For instance, the above-mentioned single-issue tools could be added to existing crop management systems.

What the system is not meant to do

It is important to note that SPA is not meant to enforce compliance with standards. It is meant for data collection and aggregated reporting only. At farm level, SPA aims to raise awareness and track improvement.

Sustainability B2B and B2C certificates are meant to assure general good performance, often more focused on good planning and management than on-the-ground quantified performance. Such certificates usually do not measure annual progress. The SPA system is meant as an additional source for insight, and not meant to replace market certificates.

Process of developing SPA Guidelines up to version 2.0

The guidelines in this report build upon work done in 2011: setting priorities, identifying indicators and scanning existing sustainability tools. The Centre for Agriculture and Environment (CLM) in the Netherlands has carried out the work. Subsequently, in 2012 CLM described the draft SPA Guidelines. In spring 2012, external experts from science and practice were approached to reviews drafts. Some 11 experts provided input; their names are listed in the annex. It should be noted that, although these experts gave input, the final responsibility on the choices made and the contents of the report lie with SAI Platform and CLM.

After publication of the Guidelines 1.0, CLM completed a quick-scan benchmark of twelve promising tools (identified earlier in 2011). Two years later CLM approached the owners and designers of these tools with a questionnaire. It covered a re-assessment of the benchmark, and also questions on the tool owners' plans to develop their tool and possible convergence with SPA. The results of the benchmark and questionnaire are described in chapter 2. A full table containing the benchmark results can be found in Annex 2.

During 2013 SAI Platform provided input into the development of the Sustainability Assessment of Farm and Agricultural systems (SAFA) indicators, guidelines and tool, initiated by the UN's Food and Agriculture Organisation (FAO). SAFA currently is the most comprehensive set of indicators and assessment methodologies for food and agriculture. Therefore CLM also compared the SAFA-tool to SPA. The summarized assessment can be found in chapter 2, and a more detailed assessment in Annex 3.

In the course of 2013 a chapter on animal welfare was completed. The contents of that chapter were drafted and agreed upon in SAI Platform's Dairy working group. Early 2014, the animal welfare criteria were cross-checked with stakeholders and animal welfare NGOs as well as a veterinary group.

Finally, in 2013 CLM also coordinated a debate on socio-economic indicators within SAI-Platform and Sustainable Food Lab. The discussion made clear that the connection economic-social is logical but hampers finding effective metrics, and made clear that though quantifying farm *economics* is not the most difficult part, expressing farm-level *social* performance into meaningful indicators is quite a challenge. The discussion is not closed.

Outlook

The SPA Guidelines (version 2.0) are published in April 2014. SAI Platform naturally has intellectual ownership of the SPA Guidelines but not of the tool(s) which will be developed or adapted to follow these. Everyone is free to use the SPA Guidelines as they like. Companies developing software tools for monitoring and reporting sustainable farming are encouraged to make use of the SPA Guidelines for further deployment of their tools – in a way that is endorsed by SAI Platform Members.

2 Comparing existing tools with SPA

1. Introduction

In 2011, over a year before the SPA Guidelines were developed, SAI Platform carried out a review of existing farm-level sustainability measurement tools. The aim was to understand their similarities and differences, as well as how good they were with regards to a number of key criteria. These criteria included: focus on farm-level, online availability and user-friendly, feedback provided to user etc. As a result, a dozen tools were identified as “promising” and further described.

Based on this first comparison, we realised that existing assessment tools were very diverse, and did not allow for any scientifically-sound aggregation or comparison. This triggered development of the SPA Guidelines as a common reference for owners and builders of sustainability assessment tools, towards better consistency and alignment across tools.

After the SPA Guidelines were completed in 2012, SAI Platform benchmarked the most promising tools against them, which resulted in an overview, presented in two tables in this chapter (full table in Annex 2). In 2013, the owners of these tools were approached for a short interview, to verify the comparison and aiming to find out if further development and possibly alignment with SPA was possible. The summarized results of those interviews are presented below.

2. Review of promising tools

Many calculator tools and systems were scanned and reviewed over the years. Many of these have a narrow scope (for instance nutrients on grassland only), are not sufficiently user-friendly for use at farm level, or are not accessible via internet. In addition to sustainability calculator tools, we considered some farm management systems that usually help a farmer manage inputs on a day-to-day basis.

The final list of promising tools¹ contains three different categories:

- *Single issue tools*: the Cool Farm Tool, Climate Yardstick, Environment Yardstick for Pesticides, PRIME, Water Footprint Calculator and Gaia Biodiversity Yardstick.
- *Farm management systems* (meant for management support but also covering environmental performance): Agri-Yield Management System, Quickfire and Land db/Ag connections.
- *Multiple issues tools*, taking on board many environmental and other issues: Simpatica, RISE and the Fieldprint Calculator (Keystone Field to Market). Recently, we also added a review of the FAO’s SAFA tool to the original list. SAFA was published early 2014, and is probably the most comprehensive approach so far.

The tools were all promising in their own way, but none was entirely in line with SPA. The *single issue tools* reviewed all are more or less in line with SPA, except that they are not broad and integral, but focused on a single issue. The *farm management systems* have a SPA-proof methodology for some themes, but farm management systems function at a more detailed level than SPA had foreseen. Finally, the *multiple issues tools* have the desired breadth in priority issues in common with SPA. But they often take a different calculation approach, and

¹ The 13 tools selected are not *per se* the top best in class, but rather labeled promising, or exemplary. Several other tools have been encountered, were improved or launched since the benchmark was done. These might also have featured in the list. We explicitly note Farm Smart (dairy), developed by Innovation Centre for US Dairy, Rural Horizons, developed by Solidaridad and the tool from COSA, the Committee on Sustainability Assessment.

in some cases are not user friendly enough to be used by a farmer without support. The table below describes the main strengths and weaknesses of the tools reviewed.

Table 2.1: Concise review of strengths and weaknesses of promising tools.

		Strengths	Weaknesses
Single issue tool	Cool Farm Tool	Covers all sectors and applicable on global scale. Most input data available to farmer.	Single issue tool. Some parts are complex to fill in for an average (computer literate) farmer, especially the livestock part is difficult for farmers. Apart from clear results (graphs and tables) no additional feedback to farmer.
	Climate Yardstick	Free online tool, available for dairy, arable, vegetable and pigs. Very user friendly, easy to understand for farmers. Central data storage.	Single issue tool. Applicable to "western" farmers only; current background data cover NL and DK. Online version gives graphic results but no additional feedback to farmer.
	Environmental Yardstick for Pesticides	Simple tool to compare pesticide risks and to be used as benchmark and evaluation tool on crop or farmlevel. Scores on several environmental compartments (aquatic, soil life etc). Easy to use and available on the internet. All crops.	Single issue tool. Mainly based on EU and NL data, though already internationally used.
	PRIME	Simple tool to compare pesticide risks. Scores on several environmental compartments. Also gives info on the effectiveness of various methods for reducing pesticide risk. Contains a mapping tool. Scores are calibrated against documented field impacts (in USA). All crops.	Single issue tool. Shows relative impact, not the real impact. Partly based on US specific data, but already internationally used.
	Water Footprint Calculator 2006	Broad support, well founded approach to water impacts, online.	Not available for use at farm level.
	Gaia Biodiversity Yardstick	Only known tool of its kind. Online. Easy to understand for farmers. Arable and dairy.	Single issue tool. Based on agriculture practices and biodiversity in N-W Europe. Additional feedback to farmer not yet in current version.
Multiple issue (integral) tools	SAFA	Holistic approach to sustainability (includes wide arrange of themes). Easy to (down)load, customize, fill out etc. Clear output.	Overall not user-friendly. For some environmental indicators, complex data (measurements, sampling, calculations) are required instead of readily available farm data.
	Fieldprint Calculator (Keystone)	User-friendly tool, easy to access, clear display of result, feedback by benchmarking (county, state, national) on scale, background documentation with advice.	USA-based, only a limited amount of (commodity) crops.
	Simpatica	Universal use; very flexible. Inclusion of additional themes, languages, units, currencies and objects (crops, products, activities...).	Detailed information required; every operation is documented. Close to farm management system rather than sustainability tool.
	RI SE 2.9	Very complete. Expresses all sustainability issues in numerical scores.	Not online. Relies on one-on-one interviews for data collection; system can only be filled in by external advisor.
Farm management systems	Agri Yield Management System	Complex , but user friendly interface. Good explanations. Combines a lot of data for several purposes.	Does not include climate change, water footprint and biodiversity (yet).
	Quickfire (related to Greenlight, CropWalker)	Operates globally, multilingual, already used in supply chain of different companies.	Mainly used as an audit management system; not very user friendly yet.
	Land db/ Ag connections	Combines advice (very interesting for farmer), record keeping (less interesting for farmer) and calculation on a few sustainability indicators.	Pesticides and manure/fertilizers: only use, not environmental impact.

Apart from the general features of the tools, i.e. user-friendliness, geographical scope, breadth of issues covered etc, a specific issue is the calculation methodology. The methodology for calculating the carbon footprint, pesticides' impact etc, is the core of the SPA Guidelines – as it

is the reason why SPA was started in the first place. So the main question is: are there tools that calculate environmental and animal welfare impacts in the same way as SPA? An indicative answer to that question can be found in the table below.

Table 2.2: Summary benchmark of methodologies of promising tools against SPA.

SPA alignment overview	Cool Farm Tool	Climate Yardstick	Environmental Yardstick for Pesticides	PRIME	Water Footprint Calculator 2010	Gaia Biodiversity Yardstick	SAFA	Fieldprint Calculator	Simpatica	RISE 2.0	Agri Yield Management System	Quickfire (related to Greenlight, CropWalker)	Land db/ Ag connections
Climate & Energy	Entirely aligned	Entirely aligned				Almost aligned	Entirely aligned	Not aligned	Not aligned	Not aligned	Entirely aligned		
Pesticides			Entirely aligned	Entirely aligned			Not aligned	Not aligned	Not aligned	Not aligned	Entirely aligned	Not aligned	Not aligned
Soil quality							Almost aligned	Not aligned	Not aligned	Not aligned	Not aligned	Not aligned	
Water quantity					Not aligned		Almost aligned	Not aligned	Entirely aligned	Not aligned	Almost aligned	Almost aligned	Not aligned
Nutrients							Almost aligned	Not aligned	Entirely aligned	Entirely aligned	Not aligned	Not aligned	Almost aligned
Biodiversity						Entirely aligned	Entirely aligned		Not aligned	Not aligned		Not aligned	
Land use							Not aligned	Almost aligned	Entirely aligned				
Animal welfare							Not aligned		Entirely aligned	Not aligned			
	Single issue tools					Multiple issue (integral) tools					Farm management systems		
Explanation	Entirely aligned				Contains elements SPA approach					Issue not included			
	Almost aligned				Not aligned								

In summary, it can be stated that:

- The single issue tools (except the water footprint calculator) qualify as SPA-compliant on methodology, except of course that they only cover one issue.
- The farm management systems incorporate several priority issues, which are only partly in line with SPA methodology. In addition, they comprise system for day-to-day farm management, not a "light" tool for sustainable performance assessment.
- RISE is a very thorough tool, much wider in themes covered than SPA. It takes its own route for calculation different from SPA, and also relies on input from interviews.
- The Fieldprint Calculator and Simpatica include a few SPA-aligned methodologies, but take a different approach on other themes.
- SAFA covers many more indicators and themes than SPA. The scoring system in 5 classes is totally different from SPA. However, "behind the scenes" inside the SAFA tool some methodologies are used that are, or can be, in line with SPA.

3. Towards further alignment of tools

On behalf of SAI Platform, CLM conducted nine technical interviews with the owners of the promising tools identified in 2011. In addition, CLM reflected as owner of a few of the instrument listed among the promising tools. The summarized results of the interviews are as follows.

Agreement with assessment

When asked if the tool-owners agreed with the review against the SPA Guidelines, they generally did. No large discrepancies were found. However, some tools have made changes since the last assessment.

Some tools have come online since the assessment:

- RISE 2.0 can be downloaded to desktop.
- Cool Farm Tool is now available online.
- Simpatica source code can be downloaded.
- Water Footprint Network launched an online assessment tool in September 2013. However, this tool is not suitable for farmers who want to assess the specific water footprint of their crops/ fields.

The Cool Farm Tool has some minor discrepancies compared to the SPA Guidelines. Embedded emissions of seeds, energy carriers etc. are not yet programmed in the CFT.

Getting (more) in line with the SPA guidelines

Most tool owners found the SPA guidelines to be very interesting and helpful, especially for aligning tools. They all appreciated the idea of adapting their tools to the SPA guidelines – though in differing ways. For example, some see difficulties in implementing the complete analysis and are open to expand their tool with some indicators e.g. CFT, others are willing to combine their tool with other e.g. WFN, some are interested to build a SPA tool for a specific region e.g. Simpatica for developing countries, some see difficulties due to their review process/ completeness of their tool e.g. rise 2.0, Prime and the fieldpoint calculator.

Resources and funding required

Most interviewees found it difficult to make an assessment of the exact resources and time needed to adapt or broaden their tool. Those who did, made a rough estimate based on previous experience with building the current tool. In general, cost/funding is an important aspect. If tool owners have their own funding, further investments will depend on how the market for sustainability tools will develop.

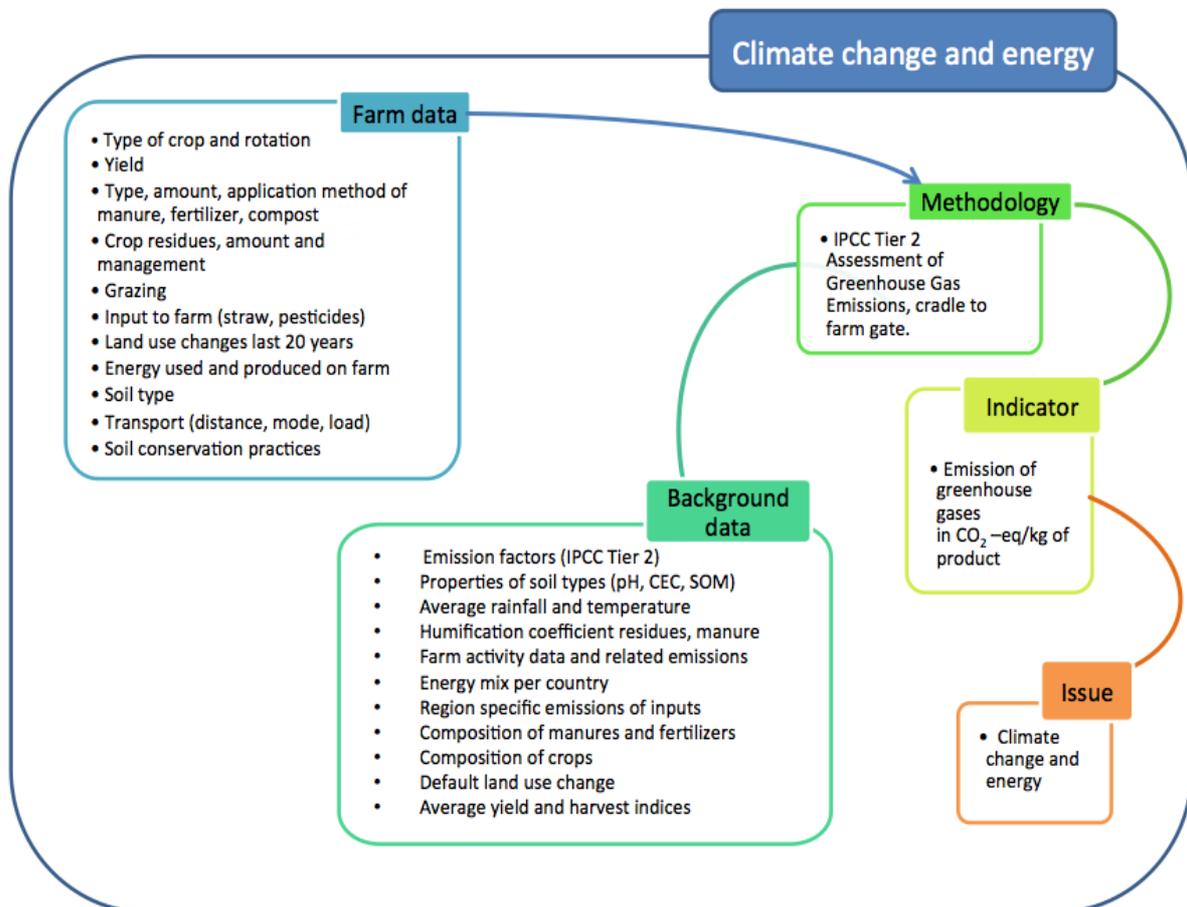
Suggestions for improving the guidelines

Most tool owners had few or no suggestions to improve the methodologies stated in the guidelines. Suggestions for improvement were mainly on expanding the guidelines such that tool builders get more guidance. We received one methodology suggestion from WFN to add the Grey water footprint to the guidelines.

Analysis and conclusions

- There are many tools out there, differing in methodology, but also per crop and per region. It is unlikely that eventually only one or two tools remain, serving all SAI Platform member companies worldwide. There will be a range of suitable tools. On the other hand, there is a chance that some tools will become dominant in particular sectors and regions. The SPA Guidelines provide a robust guiding principle for these.
- Several tool owners would like to receive more detailed guidance from SAI Platform, which may stimulate SPA-alignment. Conversely, such more detailed prescriptions will narrow the tool builders' room for manoeuvre, which may reduce their willingness to follow SPA Guidelines. It is clear that the more prescriptive the guidelines and the stricter they are "applied" by SAI Platform, the smaller the group of tools that fit.
- There is openness to cooperate and willingness to converge. Owners of single issue tools (e.g. Prime, CFI, CLM) see the interest of broadening the scope towards other issues, and are indeed already underway in doing so, often in cooperation with other tool-builders. Interviewees report that they do want follow SPA guidelines, but it is as yet unclear if they will succeed. In the case of CFT and CLM, the SPA Guidelines do already play a guiding role.
- Several tool owners have indicated that a serious investment is needed. They hesitate to make such an investment because it is unclear how actively SAI Platform members intend to use SPA indicators to evaluate their performance. Put in another way: once SAI Platform members explicitly push SPA as the guiding methodology, tool builders will be more likely to invest.
- A different way of supporting and stimulating tool alignment is to set up a platform for exchange and support. Tool builders can exchange knowledge and ask questions, and thus co-create further features.
- Social and economic themes are the remaining priorities yet to be further defined in SPA. Quantified *economic* indicators are not hard to imagine, but lead to questions about reliability and confidentiality. Quantifying indicators on *social* performance proves to be more difficult. And, given that in some circumstances (notably in developing countries) social and economic issues are closely linked, the debate on these indicators and methodologies is not closed as yet.
- Since SPA guidelines are built on SAI Platform's P&Ps, the SPA indicators are the best possible way to measure progress on farm level. It is the indispensable QUANTITATIVE pillar to implement the P&Ps. Any stakeholders who are interested to test or develop calculators are encouraged to use the guidelines and bring implementation of quantitative performance assessment to a next level.

3 Climate and energy



1. The issue

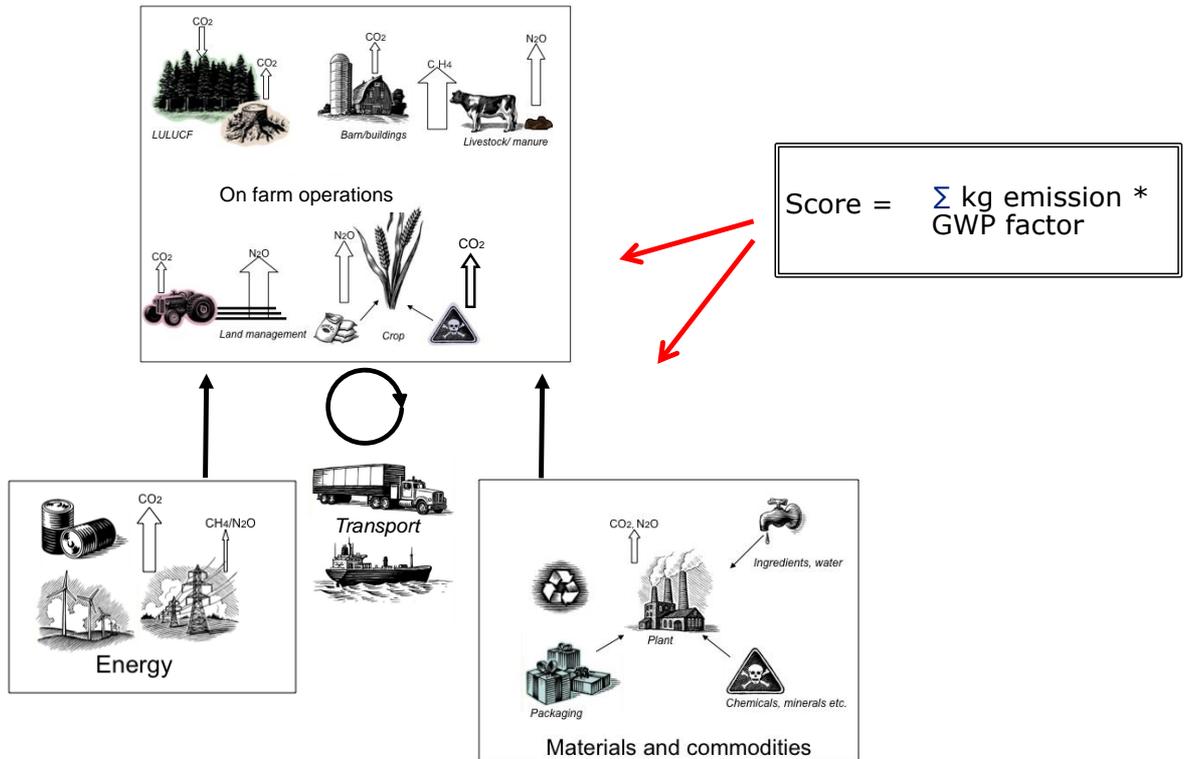
Climate change is a problem that affects people and the environment. Concern over climate change means that greenhouse gas (GHG) emissions are now a priority for many sectors of the economy. Agriculture is, on the one hand, an important emitter of greenhouse gases (CO₂, N₂O and CH₄) but could also play a prominent role in efforts to address climate change. Farmers can undertake activities that reduce GHG emissions or take GHGs out of the atmosphere. To evaluate current emissions and the effects of activities on farming, a methodology is required that can handle the diversity of farms and farm management, and which can be converted to a tool which gives sound and clear outcome with a minimum of farmer effort.

Important challenges are in identifying the system boundary, the sources of GHG emissions associated with farming/ agricultural products that fall inside the system boundary, the data requirements for carrying out the analysis, and the calculation of the results.

The methodology builds on existing methods for estimating and calculating greenhouse gas emission such as IPCC, PAS 2050, ISO 14040/ 14044 and IDF for the assessment of GHG emissions of agriculture and agricultural products.

2. Output indicators

The output indicator is: emission of greenhouse gases expressed in CO₂-eq/kg² of product.



3. Methodology

System boundary

The boundary is set at cradle to farm gate, from input production (e.g. fertiliser) up to products leaving the farm. This can include products that had an extra on-farm processing step, e.g. drying or storing. To distinguish between products that had and did not have an extra processing step, the product description should mention additional processing steps after harvesting and indicate what the extra GHG emissions are due to additional processing.

GHG emissions to be included: at least 95% of the overall GHG associated should be incorporated in the tool. Therefore, all inputs and activities that potentially contribute more than 1% to the overall GHG emissions up to the farm gate are taken into account. Therefore, unless shown that inputs and activities contribute less than 1%, the GHG emissions of the following inputs and activities are taken into account:

- **Energy:** The GHG emissions associated with the production and use of energy inputs (scope 1, 2 and 3). This includes emissions at the point of consumption of the energy (e.g. emissions from the burning of diesel and gas). But also emissions arising from the production of the energy, including the generation of electricity and heat, and the growing and processing of biomass for use as a fuel.
- **On-farm operations:** The GHG emissions arising from the agricultural operations, including those from field activities, heating farm buildings, use of machinery, etc, shall be included in the calculations. More specifically, if relevant these should include emissions from:

² Units can vary according to region. The system should be able to automatically convert from, for instance, hectare to acre and v.v.

- Rice cultivation;
- Manure management;
- Agricultural soils, N₂O emissions, direct (manuring) and indirect (atmospheric deposition and leakage);
- Use of energy carriers, from e.g field activities, transport, heating, lighting;
- Emissions from waste-water;
- Land use, land-use change and forestry (LULUCF) incl. sequestration.
- **Production of materials and commodities:** The GHG emissions from all processes used in the formation, extraction or transformation of materials used in agricultural production, e.g. fertilizer, feed, pesticides, propagation material, shall be included in the assessment, including all sources of energy consumption or direct GHG emissions associated with that formation, extraction or transformation.
- Example:
 - Fertilizer production: emissions arising from the production of the fertilizer including mining or extracting of minerals.
- **Pre-farm transport:** The GHG emissions arising from road, air, water, rail or other transport methods shall be included in the GHG emissions. Note: transport emissions are often already included in the GHG emissions of materials or commodities used on farm. It is not a tool requirement that the results indicate separately the GHG emissions of transport.

Not to be taken into account are:

- Capital goods: the relative share in total emissions is low, whilst obtaining all necessary data is very time consuming. Therefore, the GHG emissions arising from the production of capital goods (buildings, machinery, etc.) shall be excluded.
- Waste and waste recycling: post-farm GHG emissions arising from final disposal (e.g. waste disposed of through landfill, incineration, burial and wastewater) of the final agricultural product shall be excluded. Note: on farm composting, manure digesting, etc, is not regarded as waste recycling and shall be included.
- Biogenic carbon: carbon incorporated into food and feed products, plants or animals shall be excluded.
- Breathing: exhalation of CO₂ from human or animals shall be excluded. Note: if applicable, CH₄ resulting from enteric fermentation of livestock shall be included.
- Nutritional requirements: human and/ or livestock energy inputs to on farm processes and/or preprocessing.

Example:

- if fruit is picked by hand rather than by machinery;
- transport or draught power provided by animals;
- transport of humans: transport of employees to and from their normal place of work or and of advisors and representatives of farm-input providers shall be excluded.

Allocation

To distribute impacts among products that emerge from the same origin, allocation is required. For instance, in wheat production climate impacts must be divided over straw and grain. There are various ways to allocate the impact of co-products. The choice for a type of allocation can have a significant effect on the results. However, there is no common established method. ISO 14044 and PAS2050 give the best guidance in this respect.

The preferred approach is:

- 1) If allocation can be avoided it should be. This can be achieved by systems expansion or by dividing the unit processes to be allocated into two or more sub processes.
- 2) If allocation cannot be divided or isn't practicable the preferred allocation is physical allocation or mass allocation.
- 3) If applicable supplementary requirements are not available or a physical relationship cannot be established, economic allocation should be used. To counteract price fluctuations, a five-year average on market prices should be used. When used, the method and proportion based on economic value used between co-products should locally/ regionally be uniformly applied. Especially for major commodities, it is preferable that per economical region one

institution determines the economic allocation.

Arable crops

Many arable crops generate more than one product. In such cases economic allocation is the recommended allocation, because:

- Subdivision of the system is not feasible.
- It's difficult to find a physical relationship between the co-products that reflects the relation between inputs and outputs. E.g. straw is used for a different purpose than the grain.

Animal manure - production

If animal manure or manure derivative has a positive economic value the environmental burden of the production chain of the manure or derivate should be economically allocated. If the animal manure has a negative value, e.g. the arable farmer gets paid to apply the manure, the animal manure or derivative should be regarded as a waste and no environmental burden during the production should be attributed.

Animal manure - transport and application

The environmental burden of transport and application of the manure is not specifically allocated and shall be attributed to the crop.

Global warming potential (GWP)

GHG shall be measured by mass and shall be converted into CO₂-equivalents using the latest IPCC 100-year global warming potential (GWP) coefficients.

IPCC 2007 (the latest available at the publication of this document) gives:

Carbon dioxide, CO ₂ :	1 CO ₂ .eq
Methane, CH ₄ :	25 CO ₂ .eq
Nitrous oxide, N ₂ O:	298 CO ₂ .eq

Functional unit

The preferred functional unit is: kg/ product sold. If there is an explicit quality distinction, e.g. in nutritive value, between products a correction factor is allowed but should be mentioned explicitly.

Calculations

For calculating the on-farm emissions the suggested method is IPCC Tier 2 as published in Good Practice Guidance and Uncertainty management in National Greenhouse Gas Inventories (IPCC 2001). For some emission sources IPCC doesn't suffice e.g. production of inputs and transport. For inputs the preferred method for calculation is using regional specific emission figures based on attributional Life Cycle Assessments (LCA) and for transport the preferred method is using regional specific emission factors per tonne-km³ for the modality used.

Example of calculation [please note: we will not reproduce all calculation rules here, but refer to IPCC]: Direct soil emissions (N₂O)

IPCC calculation: N₂O emission = $\sum E_{ij} * EF_{ij} * 44/28$

Where:

E_{ij} = amount N in source (i) and soil type (j) (kg N)

EF_{ij} = emission factor for source (i) and soil type (j), in kg N₂O-N/kg N

44/28 = conversion factor from N₂O-N to N₂O

Important N-sources are:

- Fertilizer
- Animal manure application
- Animal manure droppings
- N-fixing crops
- Crop residues

³ The transport of one tonne over one kilometre

- Remaining N (mud, ashes, etc.)
- If significant, N in irrigation water.

4. Farm data

A distinction is made in crucial and useful data:

- Crucial: farmer enters only relatively simple “crucial” data. For any data not entered, defaults from the background database are used.
- Useful: farmer also enters the extra “useful” information. In this case fewer background data are needed.

The ideal system is flexible, allowing for both routes (more or less farm data entered) to calculate the output scores.

	Crucial	Useful
Type of crop and rotation (split in 1st, 2nd or combined, incl grass and legumes))	x	
Yield (e.g. tonnes/ha)	x	
Soil conservation practices		x
Type and amount of fertilizer, compost, manure	x	
Application rate (e.g. kg/ha)	x	
Application method	x	
Emission inhibitor		x
Split application		x
Crop residues (e.g. kg/ha)		x
Crop residue management (burning/plowing)	x	
Distance, load weight and modality of transport (miles, km)		x
Grazing (nr days/yr, hrs/day)	x	
Type of product used on farm (straw, saw-dust, propagation material, pesticides, ..)		
Amount (kg/year)	x	
Land use changes last 20 years (forest to arable or grassland and vv)		x
Use and type of energy and fuels	x	
Energy produced on farm and type	x	
Soil type	x	

5. Background data

- Emission factors: IPCC rules, Tier 2.
- Biotic and abiotic factors of soil types e.g. pH, CEC, organic matter.
- Weather data (preferably 5 year average): precipitation, temperature.
- Humification coefficient of crop residues and manure.
- Farm activity data and related emission, e.g. manure application, etc.
- Energy mix per country or country specific emission factors per energy carrier.
- Country or region specific emissions of inputs (fertilizers etc).
- Composition of organic manures and fertilizers.
- Composition of crops (N-fixation, crop residues).

And additionally, when farmers only enter the crucial data.

- Default land use change.
- Average yield; region and crop specific, primary production and harvest indices.

6. Preferences and rationale

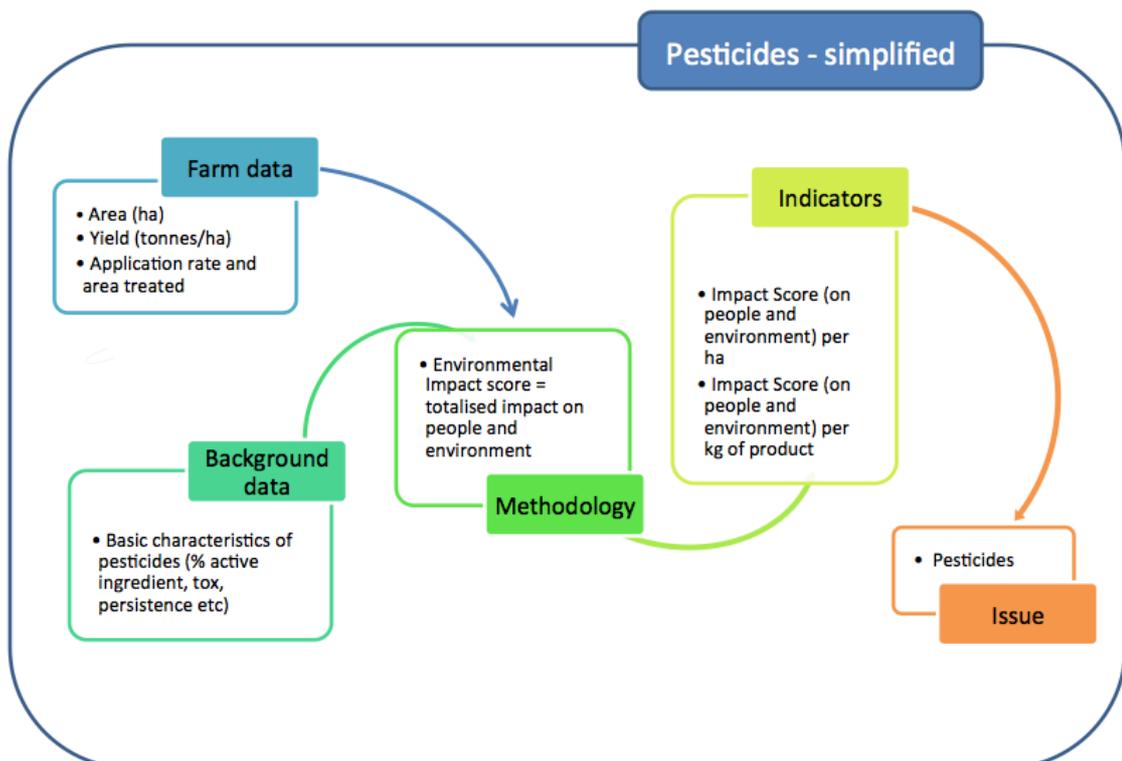
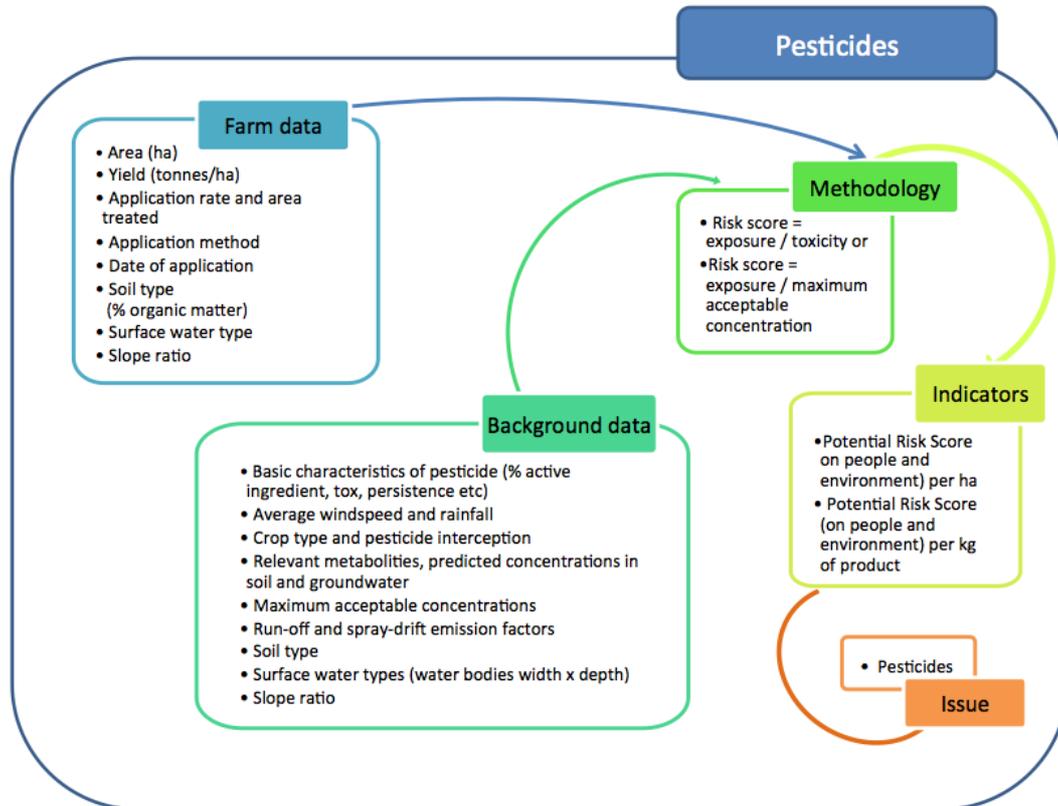
In this chapter we have made a number of choices. Below we outline the main choices and the arguments for our recommendation.

- System boundary: from input production (e.g. fertiliser) up to product leaving the farm. This gives farmers the most perspective, since all measures in the farmers' grasp (e.g. reduce fertiliser input, choose alternative fertilizers, application methods or type of dryer) are included.
- Type of GHG: The methodology includes the three most important gases from both fossil and biogenic sources; CH₄, N₂O and CO₂. Although, other gases can have a significant large global warming potential (GWP-100) the overall contribution is small in the on-farm setting. Calculation rules: The complexity of the Tier 2 method achieves reasonable certainty, using regional and technology specific emission factors. It also requires intermediate spatial/temporal activity data. Process-based models (Tier 3) give a higher certainty and are therefore scientifically preferred above Tier 2. Process-based models, however, require explicit fine scale data e.g. fine scale soil maps, daily/weekly climate data, detailed information on feed, land use and management. Generally farmers do not generally have access to such data, making a tool based on a process-based model too complex to use. For certain regions where local variability can be managed and data on land use and verified activities can be easily obtained or is available, a process-based model can be the preferred choice. However, in practice this means that the tool will be a Tier 2 model with very specific region and technology emission factors. Therefore a Tier 2 tool should currently be used. However, in the future it may be that farmers become more familiar with the systems and metrics required that they can provide Tier 3 data.
- Allocation is very important to the final results. We have described the general approach to handle allocation. However, this approach can become problematic if different regions use different approaches. Furthermore, some cases/ sectors/ products are so specific that a more tailored approach should be developed.

7. References

- BSI 2011, PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services.
- FAO, 2009: Greenhouse gas emissions from the Dairy sector, a life cycle analysis.
- IPCC, 1996: IPCC Second Assessment. Climate Change 1995. IPCC, Geneva.
- IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Emission Inventories.
- IPCC, 2001: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.
- IPCC, 2003: LUCF Sector Good Practice Guidance. Penman et al. (Eds.), IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry. IPCC NGGIP Programme.
- IPCC, 2006: IPCC guidelines for National Greenhouse Gas Inventories.
- IPCC, 2007-1: Climate Change 2007, the physical science basis. Contribution of Working Group I.
- ISO 14040, 2006: Environmental management – Life cycle assessment – Principles and Framework, International Organization for Standardization (ISO), Geneva.
- ISO 14044, 2006: Environmental management – Life cycle assessment – Requirements and guidelines, International Organization for Standardization (ISO), Geneva.
- ISO 14067-1, 2010: Carbon footprint of products- part 1: Quantification International Organization for Standardization (ISO), Geneva.

4 Pesticides



1. The issue

Pesticides are used to protect plants, to ensure adequate harvest output and economical food production. In some cases pesticides can also be harmful to the environment and humans. This risk depends on the characteristics of the active ingredient (e.g. toxicity, persistence, adsorption), the amount that is used, and the application method and circumstances. Often, farmers have opportunities to choose between pesticides and application methodologies that minimize the environmental risk.

Several tools to measure the environmental impact are available, often taking a different approach. The challenge is to identify a methodology that is globally useful, taking decisions about the system boundaries and the detail level.

2. Output indicators

The output indicator is: environmental impact of pesticide use expressed in a Potential Environmental Risk Score/ha and Score/kg product per year, on crop level and farm level. The score is based on pesticide characteristics, referred to a calculated predicted environmental concentration (PEC) after exposure.

If this is not feasible, a *fall-back approach* (see methodology) results in a less accurate output indicator: environmental impact of pesticide use expressed in an Environmental Impact Score/ha and Score/kg product per year, on crop level and farm level. This score gives the relative impact of pesticides, which can be used to rank them. Because exposure is not included in this calculation method, it does not give an indication of the real potential risk to people and the environment.

3. Methodology

System boundary

The system takes the following factors into account.

- Amount (kg/ha) per pesticide per field per crop per year.
- Potential impact of active ingredients (including relevant metabolites) on:
 - Surface water organisms (indicator species: algae, daphnia, fish)
 - Soil organisms (indicator species: earthworms)
 - Beneficial insects (pollinators, natural enemies)
 - Birds (indicator species: region specific)
 - Humans (people applying pesticides, pickers and consumers)
- Fraction intercepted by the crop (fraction on soil).
- Emission routes to surface water: spray drift and runoff.
- Persistence (DT₅₀ on plant and in soil).
- Leaching to groundwater, predicted for 1-2 meters below ground level, based on persistence in soil, adsorption (K_{om}) and amount of rainfall.
- Impact on soil organisms is predicted for organisms in 0-1 meter below ground level.
- *Optional: Maximum acceptable concentrations (MAC's) are the reference values for the predicted exposure. MAC's concerning toxicity are based on the most sensitive organisms within the compartment multiplied by a certain safety factor (usually 10 or 100) and also the worst case value is chosen between the acute and chronic toxicity. The MAC's concerning leaching to groundwater in most (European) countries are 0,1 microgram/litre.*

Not to be taken into account are:

- Seed treatment with pesticides.
- Emission routes to surface water through soil (and drainage) and atmospheric deposition.
- Combination toxicity of different active ingredients together, nor the impact of repeated treatments.

Allocation

Some pesticides are used to combat pests (e.g. weeds or nematodes) once in 2-3 years. The methodology allocates this use to the crop that is (to be) grown on the field in the season in which the pesticide is used. This is not the best way, but makes the input and calculation simpler.

Functional unit

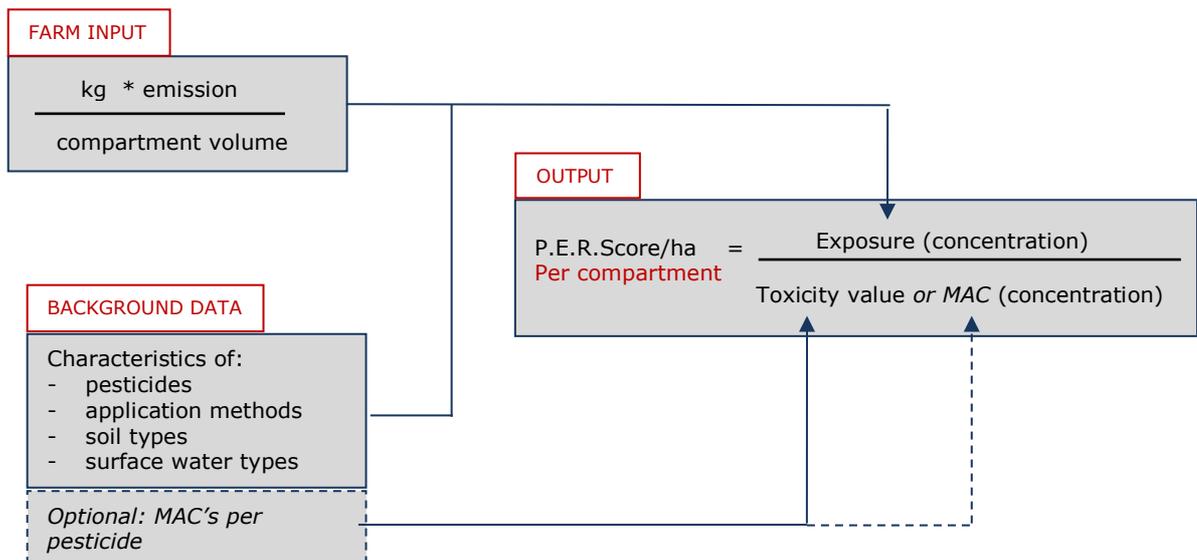
The preferred functional unit for environmental impact is land and water surface: hectares/acres. The output of most other issues in other chapters of this report is kg/pounds of product. Therefore it is valuable to include an additional calculation to display the output in per kg product.

Calculations

For calculating the exposure of different organisms and elements of the environment there is no globally accepted and scientifically established guidance (like the IPPC for the climate methodology). The methodology described in this chapter is largely based on the European Guidance for the evaluation of pesticides necessary for registration (determined by the European Commission) and an analysis of existing pesticide risk indicators (see references). The methodology is in use in different existing systems such as EPRIP (Italy), EYP (CLM, Netherlands) and SYNOPS_2 (Germany).

In the calculation there is an option to compare pesticide impact with a reference level, like Maximum Accepted Concentrations (MAC), which are often part of (national specific) legislation.

The methodology schematically is as follows.

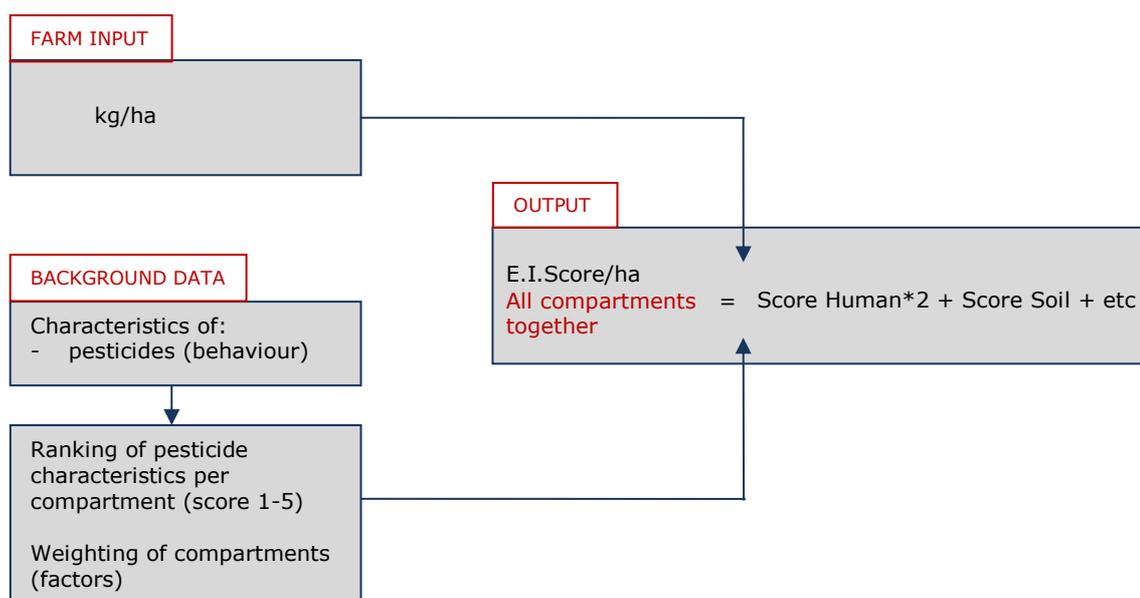


Annex 3.A. gives a more detailed example of the calculation rules.

Calculation - simplified fall-back option

The preferred methodology is to be based on substantive available background data and farm data. If such data are not available, a simplified version of the calculation can be used. This calculation excludes emission-routes and exposure. The simplified version is being used among others in the system called EIQ (USA).

The simplified methodology is as follows.



See Annex 3.B. for an example of the simplified calculation rules.

4. Farm data

A distinction is made in crucial and useful farm data:

- Crucial: farmer enters only relatively simple “crucial” data. For any data not entered, defaults from the background database are used.
- Useful: farmer also enters the extra “useful” information. In this case fewer background data are needed.

Farm data input	Crucial	Useful
Data below per crop	x	
Data below per field		x
Area (ha)	x	
Yield (tonnes/ha)	x	
Soil type (% organic matter)		x
Application rate: amount used per product name, area treated	x	
Surface water type (width x depth of receiving water bodies) in four classes		x
Slope ratio in four classes		x
Application method	x	
Date of application	x	

5. Background data

The following background data are needed for the preferred calculation:

- Average wind speed
- Average rainfall
- Crop type and pesticide interception dependent on height
- Basic characteristics of pesticides: % active ingredient per product name, relevant metabolites, toxicity, persistence, adsorption, etc.
- MAC's per active ingredient, if available
- Further characteristics of pesticides combined with application circumstances (soil and surface water types, application methods, weather) to predict exposure

- Run-off emission factors per slope ratio (may be simplified to for instance 4 classes)
- Spray drift emission factors per application method (and simplification to, for instance, 10 types)

And additionally, when farmers only put in the crucial data:

- Soil types (from maps)
- Surface water types (width x depth of receiving water bodies, may be simplified into 4 classes)
- Slope ratio (may be simplified to for instance 4 classes)

For the simplified calculation, the following background data are needed:

- Basic characteristics of pesticides: % active ingredient per product name, toxicity, persistence, adsorption, etc.

6. Preferences and rationale

In the methodology for assessing the use and impact of pesticides we have made a number of choices.

Output indicator: There are two approaches, one to minimize pesticide risk, and one to optimize pesticide use. Related to that, one can express the outcome in a Score/ha or a Score/kg of product. Both can be calculated, depending on the preferences of the user.

System boundary: We selected this boundary so that the most important environmental compartments and indicator organisms are included in the methodology. And all measures in the farmers' grasp (e.g. choice of pesticides and application methods) are included.

Calculation rules: The methodology simplifies the real world. This is necessary, because otherwise the tool becomes too complex. At this time no tool with the complete preferred methodology exists. But with all the information available it is relatively easy to develop a globally applicable tool based on the simplified calculation. It essentially means completing existing pesticide tools with all the pesticides used world-wide. Most complete databases at this moment are The Pesticide Manual from BCPC Publications: <http://www.pesticidemanual.com/>, the Pesticide Properties Database from the University of Hertfordshire: <http://sitem.herts.ac.uk/aeru/footprint/en/> and, still for EU-MRL's only, the EU Pesticides Database: http://ec.europa.eu/sanco_pesticides/public/index.cfm). An extensive but less reliable source is the website of the Pesticide Action Network: <http://www.pesticideinfo.org/>. Also pesticide authorisation boards of individual countries sometimes give access to pesticide information (for example, the CTGB in the Netherlands: <http://www.ctgb.nl>). For the full and preferred calculation this is also possible, but requires more data.

Background data: it is possible to use detailed background data such as monthly (or even weekly) rainfall, detailed data on water bodies etc. This does entail complex models to calculate impacts.

In practice, it is recommended to work with classes. For instance, for determining the slope ratio, the following classes might be used:

- Nearly level (0-2%)
- Gently Sloping (3%-6%)
- Moderately Sloping (6%-12%)
- Strongly Sloping (12%-18%) and steep slopes (18% or more)

For water bodies the same simplified classification can be developed, from no water bodies to extensive surface water present on farm. It is up to the tool developer to choose the level of detail.

7. References

Guidances for the evaluation of pesticides:

- EU: http://ec.europa.eu/food/plant/protection/resources/publications_en.htm#council)
- USA: <http://www.epa.gov/pesticides/bluebook/>

Existing pesticide risk indicators:

- AFT website: www.aftresearch.org/ipm/risk/index.php (results of a research in 2004).
- CLM report 'Comparing environmental risk indicators for pesticides' (1999).

Pesticide models (toxicity and environmental fate):

- http://www.epa.gov/pesticides/science/models_db.htm

Annex 4.A. Example of calculation for preferred methodology

Example based on the EYP (Netherlands), EPRIP (Italy) and SYNOPSIS_2 (Germany)

Surface water organisms

$$PERSw = \frac{PEC}{\text{most critical LC50 (acute tox) or NOEC (chronictox) fish, daphnia or algae}}$$

$$PECw \text{ (mg/l)} = \frac{\text{dosage (kg/ha)} * \text{emission percentage to surface water (\%)} * 0.1}{\text{ditch depth (m)}}$$

$$\text{Emission percentage to surfacewater (\%)} = \text{drift \%} + \text{run off \%}$$

This is a rather simple way to calculate the PEC. In literature you can find more detailed and complex calculation rules, encountering also for example degradation. Available computer simulation models are:

- USA: PRZM, EXAMS, GENECC2 and MUSCRAT (both based PRZM/EXAMS), WARP (in testing phase)
- EU: FOCUS, TOXWA, SWASH.

There are different rules, models and tables available to calculate or derive drift and run off percentages, sometimes as part of the models mentioned above.

Soil organisms

$$PERSs = \text{most critical } \frac{\text{PECs acute (2,5cm)}}{\text{LC50 (acute tox) earthworms}} \text{ or } \frac{\text{PECs chronic (2 years, 20cm)}}{\text{NOEC (chronic tox)}}$$

$$PECs \text{ acute (mg/kg)} = \frac{\text{dosage (kg/ha)} * (1 - \text{fraction crop interception})}{\text{depth of ground layer (0,025 m)} * \text{surface (1ha)} * \text{soil bulk density (kg/m}^3\text{)}}$$

$$PECs \text{ chronic (mg/kg)} = (\% \text{ of pesticide in soil after 2 years}) * PECs \text{ acute (20 cm)}$$

There are different rules and models available to calculate the % of pesticide in soil after 2 years in different soil types.

Contamination of ground water by leaching

$$PERSg = \text{dosage (kg/ha)} * (1 - \text{fraction crop interception}) * PEC \text{ upper (1-2 meter) groundwater (microgram/l)}$$

There are several computer simulation models available to calculate the predicted environmental concentrations (PEC):

- USA: SCI-GROW, PRZM and WARP (in testing phase)
- EU: PEARL, PELMO, PRZM and MACRO.

Most important parameters in these models are the pesticide characteristics half life time

(DT50) and adsorption coefficient (K_{oc} or K_{om}), soil types and weather conditions (rainfall).

Other compartments

Models exist for calculating the exposure of beneficial insects, birds and humans. These are not described in this example.

Annex 4.B. Example of calculation for simplified methodology

Example based on the EIQ (USA).

EIStotal =

$$\text{dosage} * (C(DT*5)+(DT*P))+((C*(S+P)2*SY)+(L))+((F*R)+(D*(S+P)/2*3)+(Z*P*3)+(B*P*5))/3$$

Symbol	Description & Units	(one of the) Indicator(s) for:
B	ranked beneficial arthropod toxicity	tox terrestrial system
C	chronic toxicity small mammals classification	tox human
D	ranked LC50 bird value	tox terrestrial system
DT	ranked dermal LD50 small mammals value	tox human
F	ranked LC50 fish value	tox surface water system
L	ranked leaching potential of the pesticide a.i.	exposure human via drinking water
P	ranked plant surface half-life value	exposure human (applicator, picker, consumer) and terrestrial system via plant(product)
R	ranked runoff potential of the pesticide a.i.	exposure surface water system
S	ranked soil half-life value	exposure human (consumer) and birds
SY	systemic pesticide classification (absorption by plants)	exposure human (consumer)
Z	ranked LD50 bee value	terrestrial system

The ranking scheme consists of different sections for which the pesticide characteristics are ranked

An example of the ranking is given below:

Mode of Action (S):

Rank	
1	non-systemic
1	all herbicides
3	systemic

Acute Dermal LD50 Rats/Rabbits (DT):

Rank	
1	>2000 mg/kg
3	200-2000 mg/kg
5	0-200 mg/kg

Long Term Health Effects (C):

Rank	
1	little / none
3	possible
5	definite

Plant Surface Residue Half Life:

Rank	
1	1-2 weeks
3	2-4 weeks
5	> 4 weeks
1	pre-emergent herbicides

Soil Residue Half Life (P):

Rank	
1	< 30 days
3	30-100 days
5	> 100 days

Fish LC50 (S):

Rank	
1	> 10 ppm
2	1-10 ppm
3	<1 ppm

Bird LC50 (D):

Rank	
1	> 1000 ppm
3	100-1000 ppm
5	1-100 ppm

Bee Toxicity (Z):

Rank	
1	relatively non toxic
3	moderately toxic
5	highly toxic

Beneficial Toxicity (B):

Rank	
1	low impact
3	moderate impact
5	severe impact
3	post-emergent herbicide

Groundwater Potential (L):

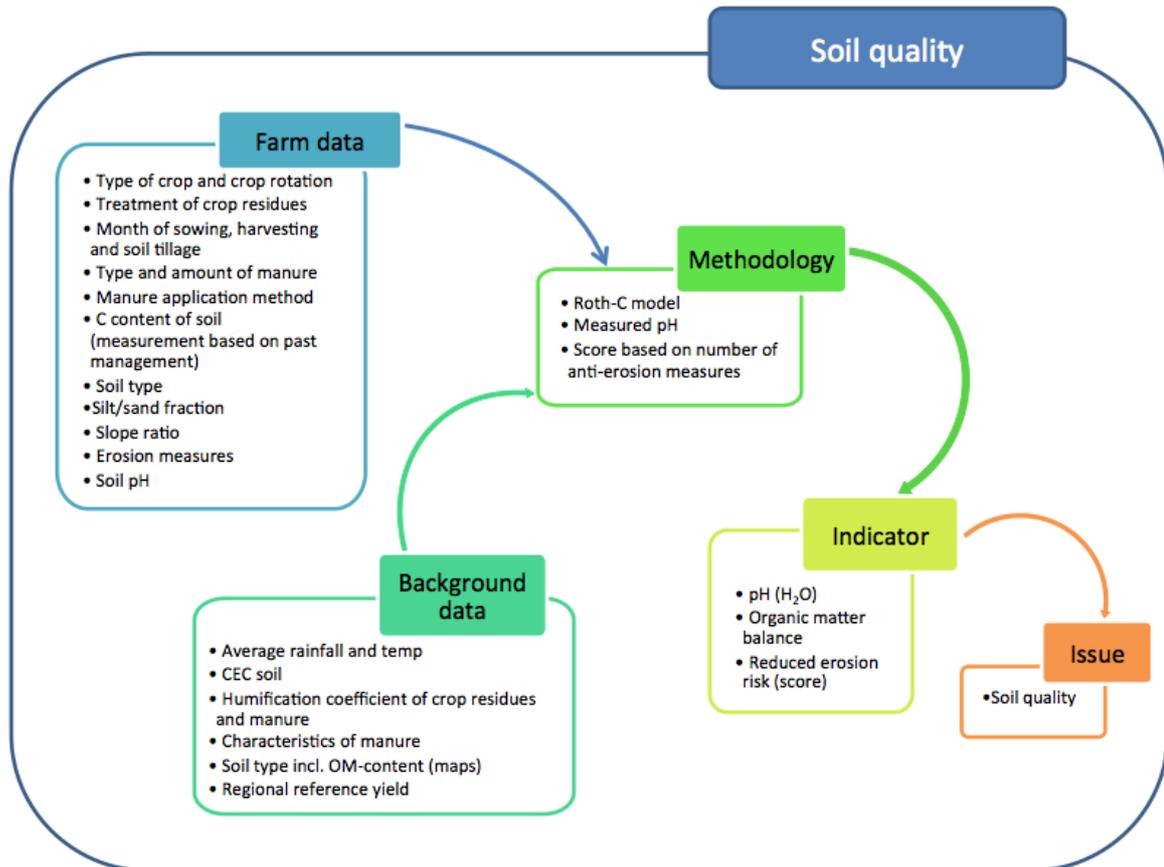
Rank	
1	small
3	medium
5	large

Runoff Potential (R):

Rank	
1	small
3	medium
5	large

There are different databases available on the internet which contain most of these pesticide characteristics. Preferred databases are those which have scientifically reviewed and reliable data, like the data used in the risk assessment for the authorisation of pesticides (e.g. EPA in the US, EC-Sanco in the EU), the Pesticide Manual (BVPC Publications, UK) and the database of the International Union of Pure and Applied Chemistry (IUPAC).

5 Soil quality



1. The issue

Soil provides many natural services for plants to grow, such as nutrient availability, clean water and resistance to pests and diseases. The soil cycle system of growth, death and decay is a natural system. Farmers use this but push it to the limit by removing/harvesting plant material, adding fertilizer and pesticides. In some situations the soil system is undermined, for example when erosion takes place or an excess of nutrients runs off the system to ground or surface water. Starting point of good agricultural practice is to maintain the organic matter content of the soil. Organic material strengthens the soil structure, feeds soil organisms, provides nutrients and contributes to the water holding capacity of the soil. Organic matter is an important indicator for soil quality. Another indicator that is more easily measured is pH (soil acidity). One of the greatest impacts on soil quality on a worldwide scale is water erosion. Therefore erosion potential is the third indicator for a soil quality model.

2. Output indicators

For *Organic matter* the indicator is the calculated organic matter content for the current farm situation (and future 30 years) expressed in % Soil Organic Matter in the top 30 cm of the soil.

Reduced erosion risk (caused by wind and/or water) is expressed in a score between 0 and 14, determined by the natural situation of the field and erosion prevention measures by the farmer.

For *Acidity* the indicator is acidity in water expressed in pH (H₂O)

3. Methodology

3.1 Determining the organic matter balance

Calculation: organic matter inputs and outputs are quantified and soil and farm characteristics are described. The result is a build-up of organic matter or a net loss.

The recommended model is Roth-C. This is a broadly-accepted model for the turnover of organic carbon in non-waterlogged topsoils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process.

Before running the model, a reference value for SOM needs to be determined, as an approximation of the current SOM-level. This can be done in three ways (in order of preference):

- Actual measurement of SOM from soil sample analysis, on the farm. In many cases farmers have such soil samples analysed
- Reference data from regional soil maps
- Calculated SOM based on a model run with past soil management as main driver.

3.2 Determining reduced erosion risk

3.2.1 Methodology in brief

The methodology determining erosion risk is a simple score based on the number of counter-erosion measures taken, related to the erosion risk.

Erosion risk is considered negligible on farms with permanent grassland only, and on arable farms with coarse sandy or peat soils.

3.2.2 Determining erosion risk

Soil type: in case of wind erosion

Water erosion can occur in nearly every soil type that is used for agriculture. In the SPA system it is assumed that wind erosion in agricultural areas occurs when the soil contains silt (diameter 2-50 µm, silt fraction 70-90%) and/or sand (diameter 50-2000 µm, sand fraction 0-100%) and clay particles are absent.

Slopes: in case of water erosion

Steepness and length of slope determine risk of run-off. Steepness and length can be measured and classified into groups. However, in SPA we assume that farmers do not have detailed data on slopes on their land. Therefore we use a simplified classification into 4 classes:

- Nearly level (0-2%)
- Gently Sloping (3%-6%)
- Moderately Sloping (6%-12%)
- Strongly Sloping (12%-18%) and steep slopes (18% or more).

3.2.3 Erosion prevention: determination of measures

Nine erosion prevention measures are chosen that can be checked by the farmers in case of water or wind erosion. There are three groups of measures, based on: crops, management and "landscape".

Landscape measures:

- Buffer strip
A buffer strip is an area of land maintained in permanent vegetation that helps to control air, soil, and water quality. Buffer strips trap sediment, and enhance filtration of nutrients and pesticides by slowing down runoff that could enter the local surface waters.
- Terracing (only for water erosion)
Terraces are used in farming to cultivate sloped land. Graduated terrace steps are commonly used to farm on hilly or mountainous terrain.
- Windbreak (only in case of wind erosion)
A windbreak or shelterbelt is a plantation usually made up of one or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion. They are commonly planted around the edges of fields on farms.

Crop measures:

- Minimal crop rotation
Can improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants. It is assumed that a minimal rotation is necessary of 1 in 3 rotation for deep rooting crops (grain) vs shallow-rooting crops (= a 1 in 3 year grain crop).
- Cover crops
They are often grown for the sole purpose of preventing soil erosion. Dense cover crop physically slows down the velocity of rainfall before it contacts the soil surface, preventing soil splashing and erosive surface runoff. Additionally, vast cover crop root networks help anchor the soil in place and increase soil porosity.
- Perennial crops
Perennial plants often have deep, extensive root systems, which can hold soil to prevent erosion.

Management practices:

- Contour plowing/ contour bunding (only for water erosion)
Contour plowing or contour farming is the farming practice of plowing across a slope following its elevation contour lines. The rows formed slow water run-off during rainstorms to prevent soil erosion and allow the water time to settle into the soil. A similar practice is contour bunding where stones are placed around the contours of slopes.
- Conservation tillage
Keeps the soil (partly) covered or prevents the soil structure being damaged by intensive agricultural tillage like plowing. Conservation tillage can be: no-till, strip-till, mulch-till, rotational tillage and ridge-till.
- Strip cropping
Strip cropping is a method of farming used when a slope is too steep or too long, or when other types of farming may not prevent soil erosion. Strip cropping helps to stop soil erosion by creating natural dams for water, helping to preserve the strength of the soil. Certain layers of plants will absorb minerals and water from the soil more effectively than others.

3.2.4 Scoring erosion prevention

Translating the erosion potential and erosion prevention into a numerical score is done as follows.

- Farmers tick the box if their farm is in a hilly area, and indicate the soil type. This determines if there is an erosion risk.

- Farmers tick the measures taken on-farm. They receive one point for each measure to a maximum of 3 for wind-erosion susceptible farms and 4 for water-erosion susceptible farms.

Table 5.1: Summary erosion measures.

	Risk of water erosion	Risk of wind erosion
<i>Risk determination:</i>		
Farm in hilly area	x	
Farm soil mainly sand or sandy loam		x
<i>Landscape:</i>		
Buffer strips	x	x
Terraces	x	
Wind breaks		x
<i>Crops:</i>		
Minimal crop rotation	x	x
Cover crops	x	x
Perennial crops	x	x
<i>Management:</i>		
Conservation tillage	x	x
Contour plowing	x	
Strip cropping	x	
Score	1 point for each measure to maximum of 8	1 point for each measure to maximum of 6

3.3 Determining the acidity

The pH of soil in water (pH-H₂O) is available from most crop management systems. Otherwise the pH can be determined by a farmer or an expert by taking a soil sample that will be analyzed in the field with pH paper or an electronic meter.

Soil pH conditions for agriculture (scale may vary according to regional circumstances).

Good pH: 5,5-7,5
 Moderately pH: 4,5-5,5
 Bad pH: 1-4,5 and 7,5-14



4. Farm data

A distinction is made in crucial and useful data:

- Crucial: farmer enters only relatively simple "crucial" data. For any data not entered, defaults from the background database are used.
- Useful: farmer also enters the extra "useful" information. In this case fewer background data are needed.

The ideal system is flexible, allowing for both routes (more or fewer farm data entered) to calculate the output scores.

Table 5.2: Farm input data.

	Crucial	Useful
<i>For organic matter</i>		
Type of crop	x	
Crop rotation	x	
Treatment of crop residues (incorporation in soil or remove from field)	x	
Month of sowing, harvesting and soil tillage	x	
Type of organic manure	x	
Amount of organic manure	x	
Manure application method (broadcast, incorporated into soil etc)	x	
Initial C content of soil from soil sample measurement		x
Past farm management: crop-manure combinations (for calculating initial C-content of soil)		x
<i>For reduced erosion risk</i>		
Soil type (basic type)	x	
Soil silt/sand fraction		x
Slope ratio (simplified into 4 classes)	x	
Erosion measures	x	
<i>For acidity</i>		
Soil pH	x	

5. Background data

Background data needed:

- Monthly rainfall
- Average monthly mean air temperature
- CEC of the soil
- Humification coefficient of crop residues and manure
- Characteristics of manure

And additionally, in case farmer enters only crucial data:

- Average yield; region and crop specific, primary production and harvest indices
- Soil type including Organic Matter-content (from soil maps)

6. Preferences and rationale

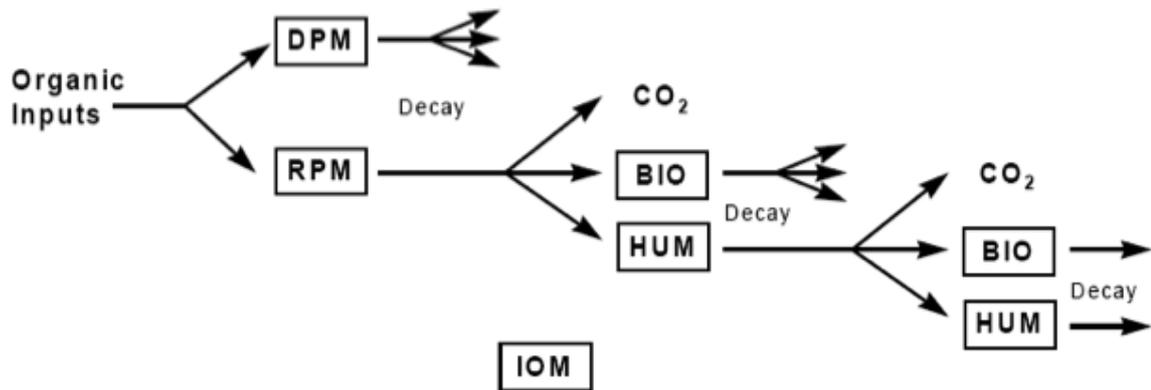
Organic matter

In earlier work on SPA, two options were proposed for determining the soil organic matter on farm level. The first one was 'measured average soil organic matter content on farm (%)', but this output indicator has many disadvantages. It is too difficult to (require farmers to) measure in large parts of the world. Especially in regions where farmers are not used to or able to do soil sampling analyses every year. Default data is difficult to determine because organic matter contents are highly dependent on local climatic and human influences. The second option, a 'calculated organic matter balance' is more feasible. The necessary information can be more easily provided by farmers without help of (laboratory) experts. If farmers can't provide information about their crops and manure, input default data could be used.

The recommended model is Roth-C. This is a worldwide-accepted model for the turnover of organic carbon in non-waterlogged topsoils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. There are many

systems that can model organic carbon, but the Roth-C model is chosen for the simplicity of the input data and realistic output. The reliability of the model is enhanced by the use of different pools of carbon.

Soil organic carbon is split into four active compartments and a small amount of inert organic matter (IOM). The four active compartments are Decomposable Plant Material (DPM), Resistant Plant Material (RPM), Microbial Biomass (BIO) and Humified Organic Matter (HUM). Each compartment decomposes by a first-order process with its own characteristic rate. The IOM compartment is resistant to decomposition. The structure of the model is shown in next diagram.



RPM : Resistant Plant Material
DPM : Decomposable Plant Material
BIO : Microbial Biomass

HUM : Humified OM
IOM : Inert Organic Matter

Erosion risk

A world-wide applicable erosion model is difficult to find. The new RUSLE model has been considered, but judged not sufficiently applicable in general. Therefore, soil type and erosion measures are taken as the basis for calculating an erosion prevention score.

Soil texture and structure affect wind erosion risk. Loams, clay loams and silt loams are generally more resistant to aggregate breakdown, and thus are more resistant to wind erosion. Soil structure is the combination of individual soil particles into aggregates. Aggregates are heavier than individual particles and so are harder for wind to move. Organic matter helps to hold aggregates together and so soils with more organic matter are more resistant to wind erosion. Sandy soils are very susceptible to erosion. Clay soils which have been pulverized by frequent freezing and thawing are also very erodible.

The question also arises if steepness (and or length) of a slope can be included in the methodology. Expressed in simple classes for erosion risk, the steepness of a slope could be evaluated as follows:

- Nearly level (0-2%). Has no limitation on its uses. Any limitations are the result of other factors, such as drainage.
- Gently Sloping (3%-6%). May have erosion problems.
- Moderately Sloping (6%-12%). May have severe erosion problems.
- Strongly Sloping (12%-18%) and steep slopes (18% or more). Severe erosion risk.

In the methodology we assume a farmer can estimate the steepness of the slopes in these categories. If not, background data from detailed maps can be a fall-back. These can help

determine slopes at regional level. The estimates by the farmer may be more precise since the farmer knows the specific fields.

Acidity

The pH is a rough indicator of soil quality. It also depends on natural soil characteristics and preferences of the crop (and therefore the farmer) in a particular year.

The pH of the soil can be most easily measured by dissolving soil in a water solution and using some pH indicator paper to determine the acidity of the soil. A more accurate method is the pH in a KCl solution, but this needs to be done by a laboratory expert. The range of good agricultural soil acidity is broad; therefore a very accurate method is not necessary. When no pH indicator is available default data is provided.

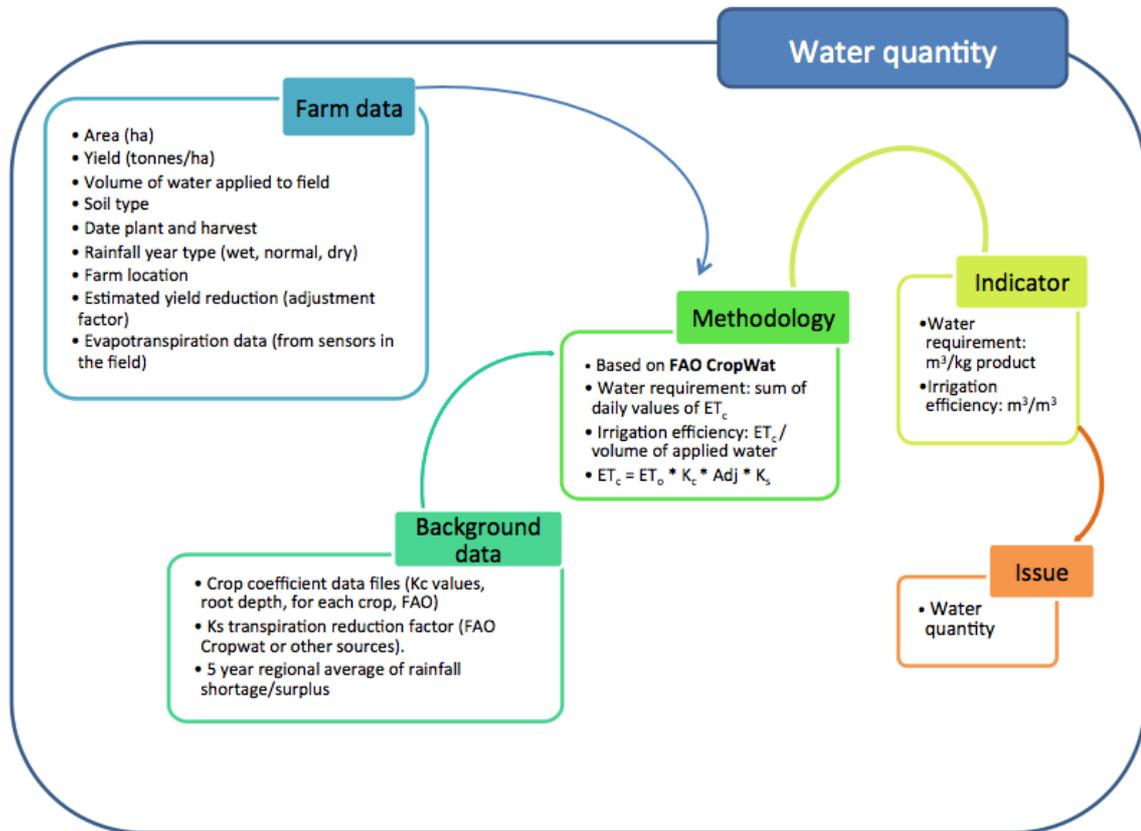
Both macro and trace nutrient availability is controlled by soil pH. In slightly to moderately alkaline soils, molybdenum and macronutrient (except P) availability is increased, but P, Fe, Mn, Zn Cu, and Co levels are reduced to such a low level they may affect plant growth. In acid soils, micronutrient availability (except Mo and Bo) is increased. Nitrogen is supplied as ammonium (NH_4) or nitrate (NO_3) in fertilizer amendments, and dissolved N will have the highest concentrations in soil with pH 6-8. Concentrations of available N are less sensitive to pH than concentration of available P. In order for P to be available for plants, soil pH needs to be in the range 6.0 to 7.5. If pH is lower than 6, P starts forming insoluble compounds with iron (Fe) and aluminum (Al) and if pH is higher than 7.5 P starts forming insoluble compounds with calcium (Ca).

Most nutrient deficiencies can be avoided between a pH range of 5.5 to 6.5, provided that soil minerals and organic matter contain the essential nutrients to begin with.

7. References

- Cate, ten J.A.M., Holst, van A.F., Kleijer, H., Stolp, J., 1995: Handleiding bodemgeografisch onderzoek, richtlijnen en voorschriften. Dienst Landbouwkundig Onderzoek. Staring Centrum, Wageningen, The Netherlands.
- Coleman, K. and Jenkinson, D.S., 1999: ROTHC-26.3. A model for the turnover of carbon in soil. Model description and windows users guide. Modified version 2008. Rothamsted Research, Harpenden, United Kingdom.

6 Water quantity



1. The issue

Crops require sufficient amounts of water to grow. In some areas there is sufficient surface water and/or ground water available for agriculture. In other areas water can be limited. In those areas irrigation is needed to prevent crop losses.

The impact of water usage by agriculture depends on:

- the type of crop (water demands differ);
- the origin of the water (e.g. irrigation, groundwater or surface water);
- the availability of water;
- competition between usage;
- percolation of pollutants due to application of manure and/or agrochemicals e.g. fertilizers and pesticides;
- efficiency of water application practices.

Water requirement by crops is determined by evapotranspiration. Evapotranspiration is the combination of two separate processes whereby water is lost from the soil surface by evaporation and from the crop by transpiration. Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. The evapotranspiration rate is normally expressed in millimetres (mm) per unit time. The rate expresses the amount of water lost from a cropped surface in units of water depth. The time unit can be an hour, day, decade, month or even an entire growing period or year.

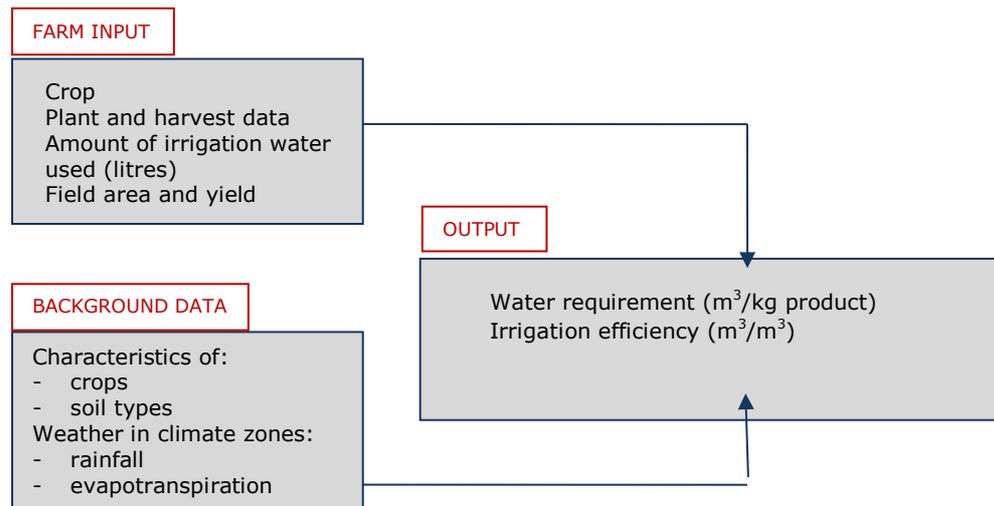
The actual crop evapotranspiration depends on climate parameters (which determine potential

evapotranspiration), crop characteristics and soil water availability. When water availability is locally limited, irrigation is often applied. The amount of water used for irrigation compared to the total water requirement is an indicator of how efficient irrigation water is used.

2. Output indicators

The output indicators and functional units are:

- water requirement in m^3/ha and/or m^3/kg product harvested
- irrigation efficiency in m^3/m^3



3. Methodology

System boundary and allocation

- Water requirement:
 - Total volume of water required by the crop for evapotranspiration. This includes rainwater and irrigation water used from ground or surface sources.
- Not to be taken into account is indirect water requirement:
 - The amount of water required for the production of seeds.
 - The amount of water required for the production of agrochemicals or other inputs e.g. pesticides or fertilizer.
 - The influence of the water quality used on crop health (pH, CE, etc). It is assumed the water quality has no negative effect on the growth of the crop.

Functional unit

For water requirement two indicators are used:

- Water requirement: m^3/kg product.
- Irrigation efficiency: m^3 (crop evapotranspiration) / m^3 (applied irrigation water).

Calculations

Calculations are based on FAO 1998 *Crop evapotranspiration - Guidelines for computing crop water requirements* and Mekonnen en Hoekstra 2010 *The green, blue and grey water footprint of crops and derived crop products*.

a. Water requirement

Water requirement is calculated by summing up the daily values of ET_c (mm/day) over the length of the growing period (ET_c see below).

b. Irrigation efficiency

Irrigation efficiency is determined as $ET_c / \text{volume of applied water (m}^3/\text{m}^3)$

c. Evapotranspiration

Crop Evapotranspiration ET_c is the central unit needed for the two output indicators. It is recommended to calculate ET_c (rather than measure it, or take it from background databases).

ET_c is calculated according to the formula:

$$ET_c = ET_o * K_c * Adj * K_s$$

with the following elements:

- ET_c crop evapotranspiration [mm d^{-1}], the determining factor to be calculated
- K_c crop coefficient [dimensionless], which varies predominately with the specific crop characteristics and only to a limited extent with climate. The crop coefficient varies in time, as a function of the plant growth stage. K_c values can be obtained from different sources e.g. FAO (1998) Hoekstra (2004).
- ET_o reference crop evapotranspiration [mm d^{-1}], a reference value related to the regional climate (temperature, humidity, sunshine, wind speed). ET_o can be calculated using the Penman-Monteith equation in the tool (most accurate), be calculated using the CROPWAT tool of FAO (somewhat less accurate) or be obtained from reference sources like Chapagain and Hoekstra (2004) (more general data).
- Adj is an adjustment factor, correcting theoretical ideal circumstances to the real farm situation. It is based on an estimate of reduced crop cover or yield by the farmer.
- K_s is a dimensionless transpiration reduction factor with a value between zero and one. It corrects for reduced soil water availability. K_s needs to be calculated and should be embedded in the tool. Data required and the equations can be obtained from FAO 1998.

4. Farm data

A distinction is made in crucial and useful data, needed to calculate the output scores:

- Crucial: farmer puts in relatively simple and few data ("crucial"); need for an extensive background database.
- Useful: farmer puts in more data ("useful"); in this case fewer background data are needed.

Farm data input	Crucial	Useful
Data below per crop	x	
Area (ha)	x	
Yield (tonnes/ha)	x	
Volume of water applied to field	x	
Soil type	x	
Date of plant crop	x	
Date of harvest crop	x	
Rainfall year type (wet, normal, dry)	x	
Farm location (for determining the climate zone)	x	
Estimated yield reduction (for calculating adjustment factor)		x
Evapotranspiration data (from sensors in the field)		x

5. Background data

The following background data and defaults are needed:

- Crop coefficient data files: including K_c values, root depth, for each crop (FAO or Allen et al., 1989).
- Transpiration reduction factor dependent on available soil water (K_s), calculated by use of FAO calculations (1998) or from qualified sources.

And additionally, when farmers only put in the crucial data:

- Climate data: 5 year average of rainfall shortage or surplus in a region to classify the availability of water; and evaporation

6. Preferences and rationale

The simplest approach is to calculate water requirement based on average literature values for ETC. This means using average values of evapotranspiration per crop per region. This would entail each farmer in a region getting the same water requirement score. Subsequently, farmers can calculate irrigation efficiency based on this average ETC. This gives them insight into the irrigation efficiency on their farm, and could help them to reduce it over the years, and also allows for comparison with neighbouring farms.

There are, however, other factors which influence the water needs, factors that are under the farmers influence: crop type planted, planting time and harvest time. If we want farmers to “play” with these variables, they should be given a place in the assessment. This is what we have chosen to do. The result is a water footprint calculation that is complex for the tool builder, but should be simple for the farmer to use: the farm data required as input are all within the farmers’ grasp.

There currently is much discussion on water use metrics, in both plant and animal production sectors. We have chosen the above methodology as an intermediate step, covering the larger share (up to 80%) of all water used in the product's life cycle. The International Dairy Federation plans to publish its approach to water metrics in 2013. SAI would like to as much as possible align the ideas in this report to the IDF-approach.

7. Outlook

For deciding if agriculture is sustainable, it is important to know not only the water needs of agricultural practices, but also what the impact of that requirement is on the availability in the area surrounding the farm (for example more downstream).

Two indicators that are related to this impact are the attendance of renewable water sources ($m^3/year$) and water scarcity (differentiated in physical and economic scarcity). The FAO has databases with this information for every country in the world. But this is often not detailed enough for individual farmers since impacts are always fully local-context dependent. And the farmer himself does not know these parameters for his own local situation. It might be interesting to develop a score from (for example) 1-5, depending on the relation between farm water use and regional water scarcity, which is easy to fill in by farmers. However, at this moment there is no suitable methodology available for this.

8. References

- Chapagain, A.K. and Hoekstra, A.Y., 2004: ‘Water footprints of nations’. Value of Water Research Report Series No.16, UNESCO-IHE, Delft, The Netherlands.
- FAO, Cropwat, april 2012. http://www.fao.org/nr/water/infores_databases_cropwat.html.
- FAO, 1998: Crop evapotranspiration - Guidelines for computing crop water requirements.
- Mekonnen, M.M. and Hoekstra, A.Y., 2010: The green, blue and grey water footprint of farm animals and animal products. Value of Water Research Report Series No.48. UNESCO-IHE, Delft, The Netherlands.

Annex 6.A. Water requirement calculation methodology in more detail

There are three ways to determine crop Evapotranspiration

- measure actual ET_c
- calculate seasonal ET_c
- obtain seasonal ET_c from a source

Measuring ET_c is the preferred methodology however is not feasible for most farmers.

Obtaining ET_c from a source doesn't distinguish enough between farmers and preferably is not used. Therefore we recommend that the ET_c is calculated. This is done in 2 stages: the basic (standard) conditions of an ideal farm (with year round sufficient water everywhere) and a stage which corrects for real life.

1. Calculated ET_c standard conditions

Under standard conditions crops are grown in large fields under excellent agronomic and soil water conditions. ET_c is calculated by multiplying the reference crop evapotranspiration, ET_o, by a crop coefficient, K_c:

$$ET_c = K_c * ET_o$$

Where:

ET_c crop evapotranspiration [mm d⁻¹],

K_c crop coefficient [dimensionless],

ET_o reference crop evapotranspiration [mm d⁻¹].

Most of the effects of the various weather conditions are incorporated into the ET_o estimate. Therefore, ET_o represents an index of climatic impact on the plant and soil evaporation. ET_o can be based on daily, weekly or monthly climatic data: minimum and maximum air temperature, relative humidity, sunshine duration and wind speed. Whereas daily or weekly data give more accuracy; using monthly averages is accurate enough.

ET_o can be obtained as follows.

- It can be calculated using the Penman-Monteith equation in the tool, which is the most accurate approach. For such a calculation data with regard to radiation, air temperature, air humidity and wind speed data is required.
- A more generalised approach is to calculate ET_o using existing tools like CROPWAT from FAO to build one's own regional set of default data.
- Thirdly, least accurate but also sufficient for SAI purposes, average ET_o can be obtained from reference sources like Hoekstra (2004).

To determine ET_o from a reference source the climatic zone is required and the weather year type e.g. wet, normal or dry.

K_c varies predominately with the specific crop characteristics and only to a limited extent with climate. The crop coefficient varies in time, as a function of the plant growth stage. During the initial and mid-season stages, K_c is a constant and equals K_{c,ini} and K_{c,mid} respectively. During the crop development stage, K_c is assumed to linearly increase from K_{c,ini} to K_{c,mid}. In the late season stage, K_c is assumed to decrease linearly from K_{c,mid} to K_{c,end}.

The crop coefficient, K_c, is basically the ratio of the crop ET_c to the reference ET_o, and it represents an integration of the effects of four primary characteristics that distinguish crops:

- Crop height
- Albedo (reflectance) of the crop-soil surface
- Canopy resistance
- Evaporation from soil, especially exposed

K_c values can be obtained from different sources e.g. FAO (1998) Hoekstra (2004).

2. Non-standard conditions

In well-managed fields, the standard conditions are generally the actual field conditions.

Where the conditions encountered in the field differ from the standard conditions, a correction on ET_c is required. Low soil fertility, salt toxicity, soil waterlogging, pests, diseases and the presence of hard or impenetrable soil horizons in the root zone may result in scanty plant growth and lower evapotranspiration. Soil water shortage and soil salinity may reduce soil water uptake and limit crop evapotranspiration.

Under non-standard conditions ET_c is calculated as follows:

$$ET_c = ET_o * K_c * Adj$$

Under non-standard conditions with reduced soil water availability $ET_{c,r}$ is calculated by:

$$ET_{c,r} = ET_o * K_c * Adj * K_s$$

In line with the Stewardship Index for Specialty Crops (based on work of the University of California), adjustments need to be listed and may be estimated by field observations. For instance if the crop covers due to bare spots only 80% of the area the K_c factor needs to be multiplied by an adjustment factor of 0.8. The same when crop vigor is below optimal due to a pest or disease pressure.

Reduced soil water availability needs to be corrected by a transpiration reduction factor K_s . K_s [t] is a dimensionless transpiration reduction factor dependent on the available soil water, with a value between zero and one. K_s can be determined by the equation:

$$K_s = \frac{TAW - D_r}{TAW - RAW} = \frac{TAW - D_r}{(1-p)TAW}$$

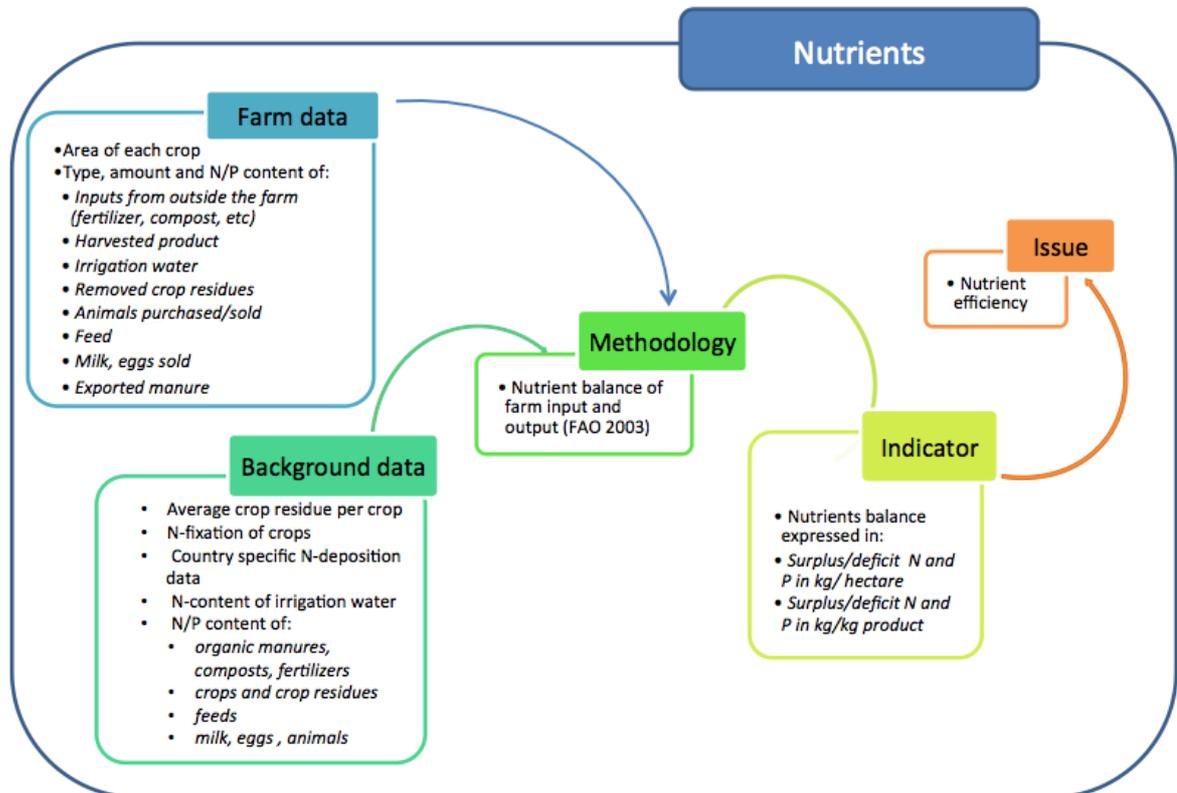
Where

- K_s is a dimensionless transpiration reduction factor dependent on available soil water [0 - 1]
- D_r root zone depletion [mm]
- TAW total available soil water in the root zone [mm]
- RAW the readily available soil water in the root zone [mm]
- p fraction of TAW that a crop can extract from the root zone without suffering water stress [-].

For more in depth information and the required data see FAO (1998).

When farmers irrigate their fields by use of an irrigation planner it can be assumed that reduced soil water availability doesn't occur and therefore K_s is 1.

7 Nutrients



1. The issue

Fertilizers, organic as well as synthetic, are used to enhance the growth and quality of crops. Application of fertilizers leads to risk of nutrient losses (from soil) to the environment, causing eutrophication of surface water and soil, pollution of the groundwater and of air. On the other hand, nutrient depletion of the soil due to ? is a major form of soil degradation in parts of the world.

A farmer has several ways of managing the right nutrient balance. One way is appropriate fertilizer application (amount, time, method, etc.). Improving the soil quality via management measures (optimal crop rotations, crop residues, use of green manure or catch crops in winter) also has a great impact on both nutrient deficiencies and losses.

The nutrient balance described below considers the two most important nutrients, N and P.

2. Output indicators

Output indicator is the the nutrient balance expressed as:

- surplus/deficit of nutrients (N and P) in kilograms per hectare (kg/ha)
- and surplus/deficit deficit of nutrients (N and P) in kilograms per kg of product (kg/kg).

3. Methodology

System boundary and allocation

- The system boundary is the farm gate. For a field nutrient balance, the same data are needed as for the farm nutrient balance, only on field scale.

Input and output considered

- Inputs to the system considered are:
 - synthetic and organic fertilisers (manure, compost, ...)
 - atmospheric deposition of N
 - N in irrigation water (surface and ground water)
 - nitrogen fixation by leguminous crops
 - purchased feeds and animals
 - other material that can contain a substantial amount of nutrients.

At least 95% of all nutrient input must be incorporated in the methodology (the type of input that has to be incorporated depends on regions and crop systems).

- Outputs of the system are all nutrients leaving the arable farm in crop/meat/animals/milk, (un)processed crop residues and manure.
- Only nutrients that are transferred from outside the farm and actually used are counted as input to the system. Not considered are:
 - fertilisers in stock (not yet used)
 - manure used on the farm and "homemade" green manure applied on own fields
 - home-grown feed
 - crop residues left on the field
- Not taken into account are: losses caused by leaching, volatilisation, denitrification and erosion and losses during storage or processing of crop residues.

Functional unit

The preferred functional unit for soil balances is kg N per hectare and kg P per hectare. If desired, an additional unit could be kg N or P surplus per kg product.

Calculations

The calculation of the nutrient balance are to be based on the FAO Assessment on soil nutrient balances (2003) - see Roy, R.N., Misra, R.V., Lesschen, J.P., Smalling, E.M. (2003). Assessment of soil nutrient balance, FAO.

4. Farm data

A distinction is made in crucial and useful data, needed to calculate the output scores:

- Crucial: farmer puts in relatively simple and few data ("crucial"); need for an extensive background database.
- Useful: farmer puts in more data ("useful"); in this case fewer background data are needed.

Farm data input	Crucial	Useful
Area of each crop (ha)	x	
Irrigation water used		x
Nutrients from outside the farm		
Type (synthetic fertilizer, compost, manure, ..)	x	
Amount (kg/ha)	x	
Content (kg N/kg, kg P/kg)	X	x
Harvested product		
Yield (kg)	x	
Nutrient content (N/kg, P/kg)		x
Removed crop residues, including processed products e.g. compost		
Amount (kg)		x
Nutrient content (N/kg, P/kg)		x

In farming systems with livestock following data are extra needed

Farm data input	Crucial	Useful
Animals purchased/sold		
Number and weight	x	
Purchased/sold feed		
Type and amount (kg)	x	
Nutrient content (N/kg, P/kg)		x
Sold milk, eggs		
Amount (kg)	x	
Nutrient content (N/kg, P/kg)		x
Exported manure		
Type and amount (kg)	x	
Nutrient content (N/kg, P/kg)		x

5. Background data

Type of data required:

- N-fixation of crops
- Country-specific N-deposition data
- Region-specific N-content of surface water

And additionally, when farmers only put in the crucial data:

- average amount of crop residue per crop
- and the N and P content of:
 - organic manures, composts, fertilizers and other relevant materials
 - crops
 - crop residues
 - feeds
 - milk, eggs
 - animals.

6. Preferences and rationale

In the methodology for assessing the nutrient balance we have made a number of choices. Below we outline the main choices and the arguments for the preference.

The simplest method for assessing nutrients-use on farms is application rate per hectare. Such information is easily available to farmers. A somewhat more sophisticated indicator is input of N and P per kg of product (yield). A third level is calculation of the nutrient balance. This takes into account accumulation in organic matter and actual (modelled) losses to the environment, and therefore is a more accurate method – which is why we choose this indicator.

In addition, in the chapter on Soil quality, SAI requires farmers to also calculate the C-balance to estimate soil organic matter. Farm data used for the C-balance overlap with data the farmer needs to put in for the N- and P-balances.

Farmers generally have access to the crucial input data: inputs used, material leaving the farm. We assume that in some cases farmers also know the N and P content of fertilisers, manure, compost etc. – the “useful” data in the table. In such cases they can enter such data, making the calculation more accurate. This is why we propose to include two levels, one based on actual data and one based on defaults.

System boundary: the nutrient balance can be made on field or farm level. As crop residues of one field can be composted and used on another field, the farm gate is best taken as system boundary. All nutrients entering the farm, including fertilisers, filling soil, irrigation water, atmospheric deposition of N and nitrogen fixation by leguminous crops, are inputs and all

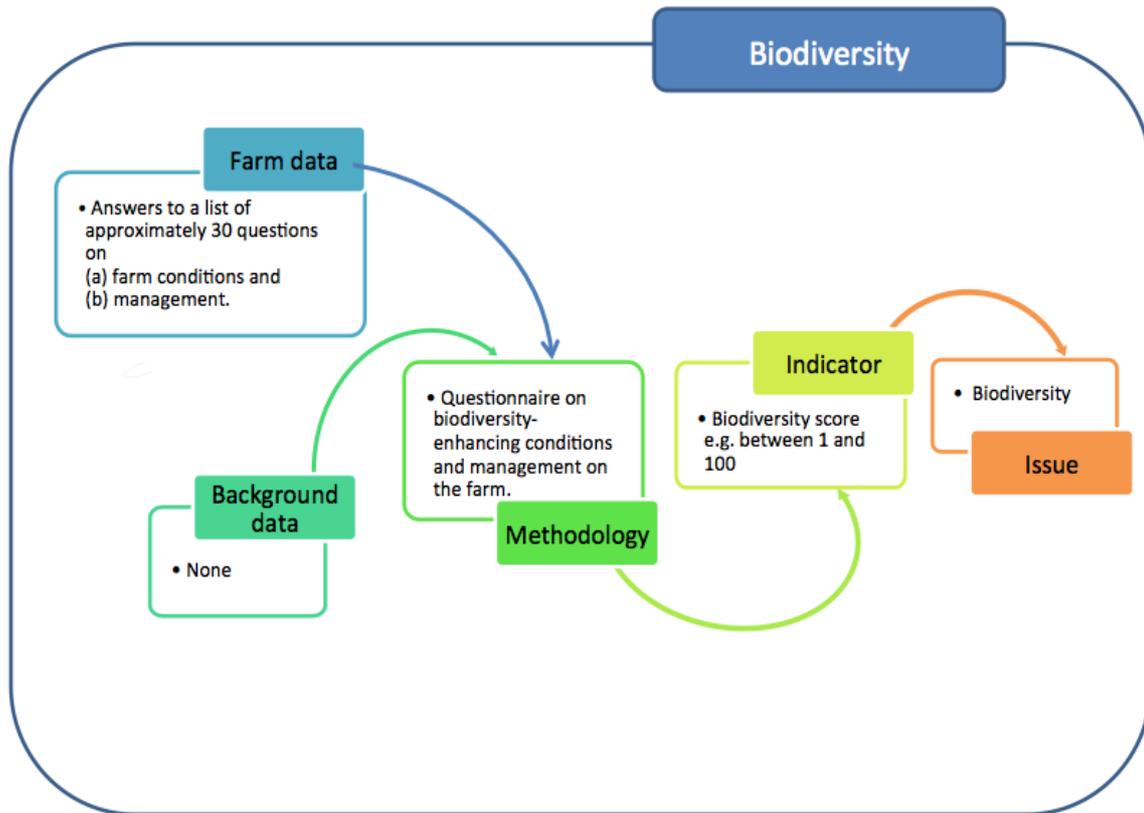
nutrients leaving the farm (farm products, removed crop residues and manure) are outputs of the model. Most important farm products are harvested crops, milk and animals/meat.

Calculation rules: with the described methodology, the nutrient balance expresses the risk for the environment. Gaseous, leaching and erosion losses are not seen as output to the system but as nutrient losses to the environment. N/P that is not exported off the farm, volatilises or stays behind in the soil and can leach to groundwater sources or run-off to surface water. This risk is dependant on the soil and management conditions taken into account by other sustainability issues.

7. References

- IFA Task Force on Fertilizer Best Management Practices, 2009: The Global "4R" Nutrient Stewardship Framework. Developing Fertilizer Best Management Practices for Delivering Economic, Social and Environmental Benefits. IFA, Paris, France.
- International Plant Nutrition Institute, 4R Nutrient Stewardship Portal, april 2012. <http://www.ipni.net/4r>
- Roy, R.N., Misra, R.V., Lesschen, J.P. and Smaling, E.M., 2003: Assessment of soil nutrient balance. Approaches and Methodologies. FAO fertilizer and plant nutrition bulletin 14. FAO, Rome, Italy.

8 Biodiversity



1. The issue

Agro-biodiversity covers life on the farm, from crop and cattle species to minute organisms in the soil to wild flora and fauna in field borders or natural habitats which are part of the farm area. Such non productive areas are essential for resilient agro-ecosystems and are valuable to society. However, biodiversity is complex and difficult to measure and monitor, especially for a farmer with limited time and/or limited knowledge of flora and fauna.

Beyond the farm, the food chain must also take into account its impact on biodiversity, most notably in susceptible regions where agricultural inputs are commonly sourced. The best-known example is the production of fodder in tropical regions, which contributes significantly to the environmental footprint of the meat and dairy products that rely on this feed.

In the framework of SPA, we include only on-farm biodiversity in the assessment for this theme. Additional impacts on biodiversity via water pollution are covered under Nutrient balance and Pesticides. The impacts on off-farm ecosystems, like tropical rainforests, are not included here but are implicitly covered by the indicator for land use.

2. Output indicator

The proxy to be used for biodiversity impact is a score based on efforts to maintain and enhance biodiversity. The biodiversity score is a number on a relative scale, for instance from 1 to 100 (the scale can vary based on the number of questions included in the questionnaire - see below under Methodology).

3. Methodology

The basis of the biodiversity score is an assessment containing approximately 30 questions⁴. Positive characteristics and management efforts on the farm earn biodiversity points in accordance with the questions, which are structured according to six components:

- A. Productive area
 1. Crop and animal varieties used
 2. Farm management resulting in biodiversity benefits for crop production (pest predators, soil life, resilient soil, crops and cattle)
 3. Productive areas under targeted nature management (e.g. extensive cropping to tolerate wild herbs or weeds)

- B. Non-productive area
 4. Area and management of non-productive elements around the fields (e.g. water courses, hedgerows, copses)
 5. Management of natural/semi-natural areas, with or without formal legal protection, either owned or maintained by the farmer (e.g. extensive grazing of natural reserves)
 6. Natural elements and shelters for fauna in the farmyard

An example of such a list of questions is in Table 2 below – in this case 27 questions. National applications of this approach may lead to a smaller or larger number of questions and different features than the ones listed.

Getting from customized questionnaire to score:

- There are a limited number of questions for each of the six components outlined above.
- There are two approaches to choose from:
 - Approach 1: Yes/No questions, with a 1 point score for each “Yes”. *For our 27-question example, there is a theoretical maximum score of 27 points.*
 - Approach 2: Multiple-choice options with 1 point for each option ticked. *In our example, this leads to a theoretical maximum score of 110 over all 27 questions.*
- Scores are added up for each of the six components. The final biodiversity score is composed of these six scores weighted equally and calculated thus:
 - *End score = Score per component * Contribution factor.* An example is shown in Table 1 below.

Table 8.1: Example calculation of contribution factors for maximum score of 110 biodiversity points over 6 components.

max. Score	100
# components	6
weight per component	16,7

component nr.	max score	contribution factor	rel.max.score
1	20	0,8	16,7
2	20	0,8	16,7
3	20	0,8	16,7
4	30	0,6	16,7
5	10	1,7	16,7
6	10	1,7	16,7

⁴ This methodology was developed in 2011 by CLM, in cooperation with farmers, nature organisations and several large food companies.

4. Farm data

The farm data in this case consist of the farmer's answers to a list of approximately 30 questions on biodiversity-enhancing farm conditions and management measures. As outlined in Section 3, these can be simple yes/no questions or, alternatively, multiple-choice options. It is likely that some multiple-choice options will need to be adapted to regional circumstances, as will some of the basic yes/no questions.

Example for the multiple choice options

Are there small wooden elements present on the farm between the fields (minimum areas can be demanded, management practices are assessed in next questions)? Please tick:

- *Hedgerows (minimum 1 m wide, 50 meters long, (e.g. hawthorn, beech))*
- *Outgrowing shrubs (thickets) of for example brambles or hawthorns (minimum 2 m wide, 50 meters long)*
- *Treelines (minimum of 10 trees in line along the field)*
- *Free standing trees (minimum of 5 trees)*
- *Coppices/brushwood (minimum of 0.1 ha)*
- *Woodbanks (minimum 2 m wide, 50 meters long)*
- *Standard orchard (minimum of 20 trees)*

The table below lists an exemplary set of basic questions from which the score is calculated. All questions concern the current situation on the farm.

Table 8.2 Biodiversity conditions and management questionnaire.

Themes	Questions on 6 themes	Score examples		SUM	
		Approach 1: yes/no questions; 1 point per yes	Approach 2: multiple options; 1 point per option ticked	approach 1	approach 2
1. Cattle, cultivars and crops		5	14		14
1.1	Variety of cattle species Which number of cattle species are present in the farm (minimum or multiple choice of three classes)	1	3	1	
1.2	Variety of cattle breeds Number of varieties (likewise)	1	3	1	
1.3	Variety of crop species Number of species (likewise)	1	3	1	
1.4	Variety of crop varieties Number of varieties (likewise)	1	3	1	
1.5	Variety of green manure crops Number of species (likewise)	1	3	1	
1.6	Variety in grassland composition Presence of mix of grass species or clover and herbs (four classes: monoculture, mix of grasses, mix with herbal species, mix with clover)	1	4	1	
1.7	Presence of honeybees Do you have 1 or more beehives on your farm?	1	1	1	
2. Cultivation practices: benefits for soil life, natural enemies and pollinators		5	20		20
2.1	Crop protection Do you take measures to spare natural enemies during crop protection implementation on your	1	4	1	
2.2	Manure application Do you apply organic materials, fertilisers or additives to stimulate the soil life?	1	4	1	
2.3	Provision of nectar/pollen in crops (non-grass) Do you take measures to provide flowers (pollen/nectar) within the actual plots?	1	4	1	
2.4	Soil cultivation in arable fields Do you take other measures to stimulate soil life or natural enemies in the fields/plots?	1	4	1	
2.5	Soil care in grassland Do you take other measures to encourage soil life or natural enemies in grassland fields/plots?	1	4	1	
3. Cultivation practices: benefits for wildlife		5	20		20
3.1	Measures in arable fields for field flora Do you take specific measures in favour of the field fauna or flora?	1	4	1	
3.2	Measures in grassland for field flora Do you take specific measures in favour of field flowers in your grassland (on at least 0.5 ha)?	1	4	1	
3.3	Measures in arable fields for farmland birds Do you take measures in the arable fields to protect farmland birds?	1	4	1	
3.4	Measures in grassland for farmland birds Do you take measures in the grasslands to protect meadow birds?	1	4	1	
3.5	Measures to prevent invasive exotic species Do you take measures to prevent introduction and expansion of invasive exotic species?	1	4	1	
4. Small and linear nature and landscape elements (linear or < 0,5 hectare)		6	30		30
4.1	Small wet elements Are small wet elements present on the farm between the fields, like ditches, ponds, marshlands (minimum size, which elements?)	1	5	1	
4.2	Do you carry out wildlife-friendly measures in these wet elements?	1	5	1	
4.3	Small herbaceous elements Are small herbaceous elements present on the farm between the fields, like ditches, ponds, marshlands (minimum size, which elements?)	1	5	1	
4.4	Do you carry out wildlife-friendly measures in these herbaceous elements?	1	5	1	
4.5	Small wooden elements Are small wooden elements present on the farm between the fields, like ditches, ponds, marshlands (minimum size, which elements?)	1	5	1	
4.6	Do you carry out wildlife-friendly measures in these wooden elements?	1	5	1	
5. Large natural elements		2	10		10
5.1	Grounds designated for nature conservation and/or other large plots for nature conservation (>0.5 ha) Are large natural elements present on the farm (which types like grassland, marsh, open water, shrubland)?	1	5	1	
5.2	Do you carry out management measures (which, like mowing, grazing, cutting?)	1	5	1	
6. Wildlife-friendly elements in the farmyard		2	10		10
6.1	Green elements in the farmyard Are green elements present in the farmyard (which, like orchard, tree lines, pond, ornamental garden)?	1	5	1	
6.2	Shelter places for animals in the farmyard Are shelter places for animals present in the farmyard (which, like woodstock, pile of stones, compost heap)?	1	5	1	
Total		27	104	27	104

5. Background data

In this case there is no need for background data.

6. Preferences and rationale

Proxy for biodiversity

As outlined above, biodiversity is complex and monitoring it is difficult. Farmers usually lack the knowledge of plant and bird species necessary to reliably monitor occurrence. Other biotic life, like insects and soil organisms, require extensive effort to monitor, even for trained biologists. Although reported actual flora and fauna found on and around the farm may be the most accurate indicators, it is impossible to impose monitoring obligations on farmers.

Seeking a proxy, one arrives at conditions that potentially enhance biodiversity. Many assessment systems rely on biodiversity conservation practices that address protected species, protected areas and general farm management. The SPA methodology takes these general notions further, transposing them into activities that are usually within the grasp of the farmer: targeted management, non-cropped areas, soil quality, etc. The SPA methodology then translates the conditions (e.g. presence of hedges) and activities (e.g. maintenance of hedges) into a meaningful relative score (e.g. likely occurrence of woodland bird species).

The questions are phrased such that they are generally applicable worldwide and can be used in the yes/no mode. The questions may need to be phrased more specifically for different regions. If desired, tool developers can take a more sophisticated approach by including regionally applicable, multiple-choice options linked to the questions.

Correlation with other priority issues

There are correlations with biodiversity in several other themes covered by SPA. The impact on biodiversity off the farm, for example via sourcing of inputs, can be important. This impact is addressed in the SAI land use indicator rather than the biodiversity indicator. Implicitly, good scores on pesticide use, nutrient efficiency and soil quality (organic matter) all have a positive correlation with biodiversity.

Core elements of the methodology

The starting point for the methodology is that every element present may increase biodiversity value, because it adds a new habitat for different flora or fauna species. In the same way, different management practices on the same farm and neighbouring fields may provide more different habitats and thus increase biodiversity. Thirdly, presence of different crop species and cattle species (including goats, horses and other farm animals) provide food (e.g. through their manure) for additional wildlife species, starting with micro-organisms and soil life. So the biodiversity scoring system rewards the variety of biotopes on the farm, as well as active management in support of biodiversity. More biotopes and more active management result in a better score.

Basic premise is that all biodiversity in all 6 compartments (from cattle and soil-life to surrounding nature areas) is valuable – to society and to the farmer. This is why scores in the 6 compartments are weighted equally. In theory, giving extra weight to certain categories is thinkable, and can be done on a regional scale.

The scoring system does not distinguish between larger or smaller sizes of biodiversity-rich area. This is in line with the principle above: diversity is rewarded in general. However, a minimum size (area) should be defined for every element and applied measure to ensure an impact.

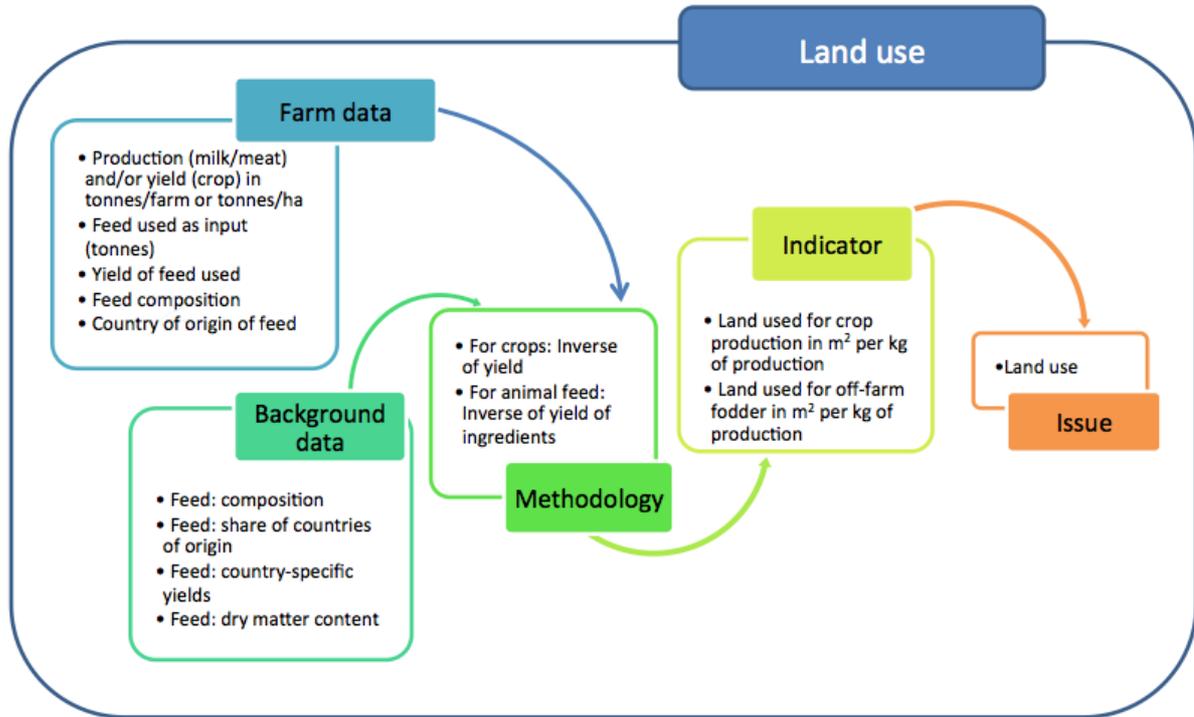
In a more advanced system, additional scores could be given for larger areas where a measure is applied – especially for non-productive areas, so for components 4 and 5. It should be investigated whether this could be applied globally, or more specifically for regions or countries.

Hunting is not included in the biodiversity assessment. It is assumed that farmers (and hunters) adhere to the law, in which case hunting cannot be assessed as having a definitive impact on local biodiversity.

7. Outlook

Biodiversity is a crucial but complex issue; there is great need for simplification. There is debate in different fora such as the International Dairy Federation on biodiversity metrics. This will hopefully lead to further alignment, including with SPA, in 2013 and 2014.

9 Land use



1. The issue

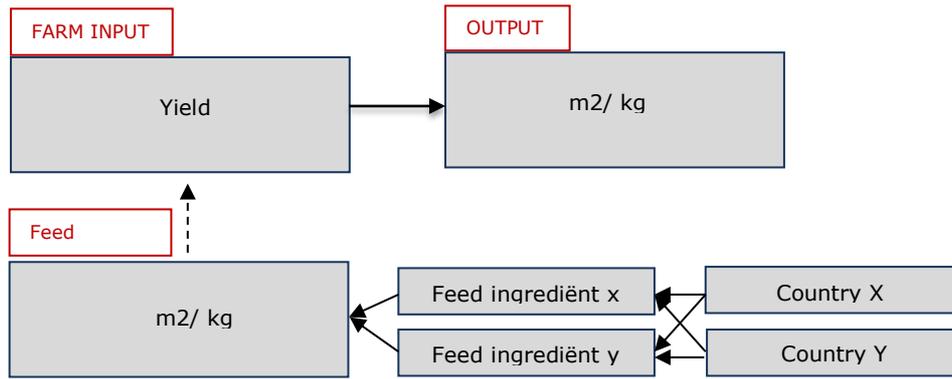
Currently approximately 40% of the land on earth is used for food production. This has led and still leads to transformation of forests, wetlands, savannahs, waterways and other landscapes, creating in turn loss of biodiversity, desiccation and other impacts. Due to population growth and increase in consumption (high quality) land becomes scarce. Furthermore, land for agriculture is competing with land for water and shelter.

Land use is an indication of the area required to produce a product. The indicator puts agricultural production into perspective at the regional or product level. Land use data are a prerequisite to measuring some of the other SAI indicators such as water use and nutrient balance.

Determining land use is rather straightforward. Important challenges are mainly related to livestock on how to include indirect land use effects e.g. identifying the system boundary and data requirements for carrying out the analysis.

2. Output indicators

The output indicator is: land used for production expressed in square meters per kg of product, or square meter per farm.



3. Methodology

System boundary

Land use in agriculture is mainly related to cultivation of the crop with yield as an important driver.

Livestock farms that use rented grazing lands and purchase feed also have to incorporate the land required to cultivate the feed – the *indirect land use*. The contribution of indirect land use due to other inputs used on-farm, e.g. seeds, packaging materials etc. is usually minor and is therefore not taken into account.

Allocation

Arable crops

Many arable crops generate more than one product. In such cases economic allocation is the recommended allocation.

Dairy

For dairy, allocation follows the guidelines set by the International Dairy Federation (IDF), see *A common carbon footprint approach to dairy The IDF guide to standard lifecycle assessment methodology for the dairy sector* (IDF, 2010)

Functional unit

The preferred functional unit is: kg product.

If there is an explicit quality distinction between products, e.g. in nutritive value, a correction factor is allowed but should be mentioned explicitly (following the guidelines of the IDF).

Calculations

The inverse of the yield is taken for obtaining the land requirement per crop.

Single feed sources

- When a single feed source is purchased (whole crop or by-product) and the selling farmer is known, preferably the actual yield is used.
- If the selling farmer or his yield are unknown but the country of origin is, the country or regional average yield will suffice.
- If the country of origin is not known, preferably a weighted average is used. A weighted average is based on the share of every country in the total amount of the feed imported [to the country where the farm is located] and the average yield of that country. A weighted average can be determined or be purchased from literature, or LCA database.
- If a weighted average cannot be determined due to lack of data, the world average yield should be used.
- The land requirement needs to be corrected for feed losses during the product's life cycle and takes into account dry matter differences between crops and feed ingredients.

Concentrates

Feed concentrates are produced out of different feed ingredients e.g. whole crops or by-products from processed food crops. Concentrates have affixed and balanced nutrition, however the feed ingredients used differ throughout the year and per supplier due to market prices of feed ingredients. It is not feasible to determine per farmer the land requirement per batch of concentrate used. Therefore, an average feed composition needs to be determined before the land requirement of the concentrate can be determined. If the average feed composition is determined a weighted average, based on average country of origin of each ingredient, is used for each feed ingredient to determine the weighted land requirement of a concentrate.

The land requirements needs to be corrected for feed losses during the feed product's life cycle and takes into account dry matter differences between crops and feed ingredients.

4. Farm data

A distinction is made in crucial and useful data:

- Crucial: farmer enters only relatively simple "crucial" data. For any data not entered, defaults from the background database are used.
- Useful: farmer also enters the extra "useful" information. In this case fewer background data are needed.

The ideal system is flexible, allowing for both routes (more or fewer farm data entered) to calculate the output scores.

	Crucial	Useful
Yield (tonnes/ ha)	x	
Yield of feed source(s) (tonnes/ha)		x
Feed use	x	
Feed composition		x
Country of origin of feed		x
Product produced (e.g. kg, liters,..)	x	

5. Background data

To calculate land requirement of feed/concentrates the following data are needed:

- Composition of feed concentrates
- Dry matter content of crops and feed ingredients
- Average share of country of origin in ingredients in specific feeds (import and export statistics of feed crops/ ingredients)
- Average country specific yields of crops used as feed ingredients

6. Preferences and rationale

In methodology for assessing land use we have made a number of choices. Below we outline the main choices and the arguments for the preference.

Data input

The amount of feed and type of feed required differs per livestock type and depends on the feed quality (e.g. nutritive value) and on other aspects like farm management. Therefore, the amount of feed used per farm is a crucial variable. For this reason the total feed fed (incl on farm feed losses) must be used as input in the system and be attributed to the product.

Ingredients used for feed differ in land requirements due to different yields per ha. First of all feed ingredients originate from different crops (e.g. wheat, tubers, oil crops etc) which have

different yields and/or nutritive values. Secondly, yields of the same crop differ per parcel, per farm and per country, due to differences in growth circumstances. These different qualities are incorporated in background data.

Determining land requirements of concentrates is complex and requires large amounts of data. Furthermore, differences in composition of feed have a significant effect on calculated land use. However, farmers have often little or no influence on the composition. Therefore, it is advised to use a generic average composition per region or country per type of livestock and per type of concentrate. Defaults are preferably updated yearly and can be determined by specialized consultancies, from (scientific) literature or LCA databases.

System boundary

From input production (e.g. feed) up to product leaving the farm. This gives farmers the most perspective, since all measures in the farmers' grasp are included.

Calculation rules

More advanced and complex calculations are possible. These include indirect land use due to other farm inputs and/or environmental degradation and/or soil quality but are regarded as too complex and require much more data compared to the additional information gained for agricultural products.

Allocation

To distribute impacts among products that emerge from the same origin allocation is required. For instance, in wheat production land use must be divided over straw and grain. There are various ways to allocate the impact of co-products. The choice for a type of allocation can have a significant effect on the results. However, there is no common established method. ISO 14044 and PAS2050 give the best guidance in that respect.

The preferred approach is:

- If allocation can be avoided it should be. This can be achieved by systems expansion or by dividing the unit processes to be allocated into two or more sub processes.
- If allocation cannot be divided or isn't practicable the preferred allocation is physical allocation or mass allocation.
- If applicable supplementary requirements are not available or a physical relationship cannot be established, economical allocation should be used. Due to price fluctuations a five-year average on market prices should be used.

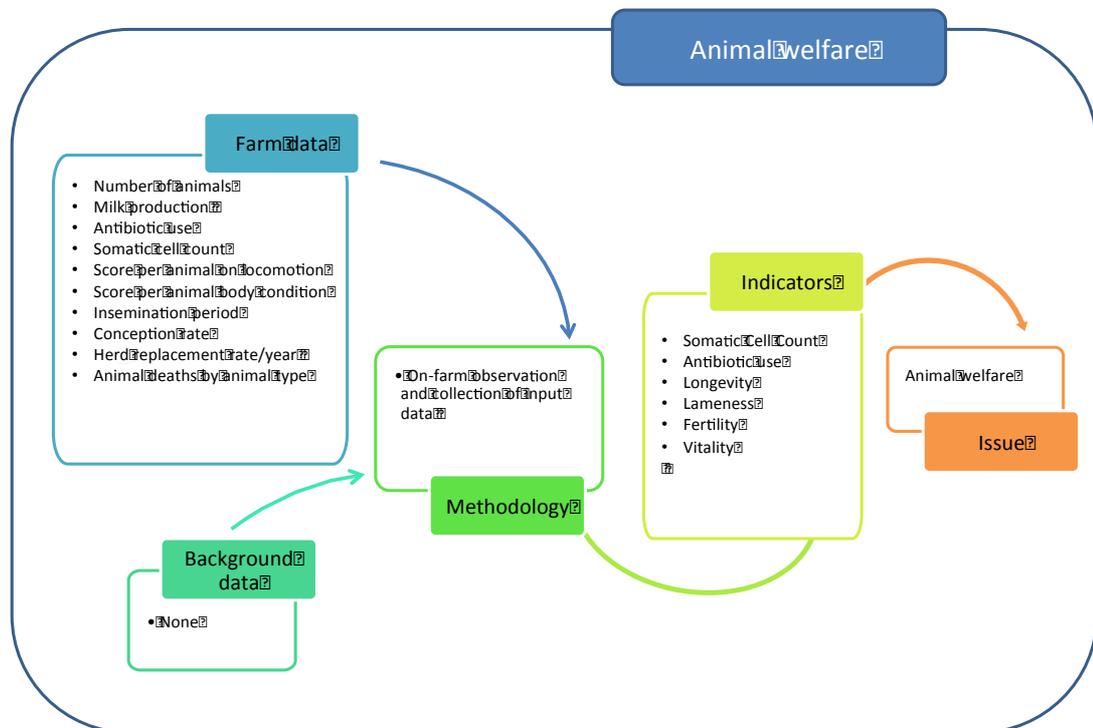
When used, the method and proportion based on economic value used between co-products should locally/regionally be uniformly applied. For major commodities it is especially preferable that one institution determines the economic allocation per economical region.

Economic allocation has become the practical norm in the food chain, which is why we have chosen that approach. In dairy, however, the industry is close to agreeing upon allocation based on physical properties and is broadly agreed upon in the IDF, which is why we advise this type of allocation for dairy products.

7. References

- FAOSTAT, april 2012. <http://faostat.fao.org/>.
- International Dairy Federation, 2010: A common carbon footprint approach for dairy. The IDF guide to standard lifecycle assessment methodology for the dairy sector. Bulletin of the International Dairy Federation 445. IDF, Brussels, Belgium.

10 Animal welfare (dairy)



1. The issue

Animal welfare in dairy production is a sustainability item with considerable public interest, not only in western societies but also worldwide. Animal welfare is also strongly linked to animal health. Therefore animal welfare and health are of high interest for both farmers and other levels of the dairy supply chain. After all, happy cows are healthy cows, and healthy cows require less medicine and are more productive.

The welfare of an animal includes its physical and mental state and as such, good animal welfare implies both fitness and a sense of well-being. Any animal kept by man, must at least, be protected from unnecessary suffering. The welfare of animals whether on farm, in transit, at market or at a place of slaughter should be considered in terms of **Five Freedoms**. These freedoms define ideal states rather than standards for acceptable welfare. They form a logical and comprehensive framework for analysis of welfare within any system together with the steps and compromises necessary to safeguard and improve welfare within the proper constraints of an effective livestock industry.

1. **Freedom from Hunger and Thirst** – by ready access to fresh water and a diet to maintain full health and vigour.
2. **Freedom from Discomfort** – by providing an appropriate environment including shelter and a comfortable resting area.
3. **Freedom from Pain, Injury or Disease** – by prevention or rapid diagnosis and treatment.
4. **Freedom to Express Normal Behaviour** – by providing sufficient space, proper facilities and company of the animal's own kind.
5. **Freedom from Fear and Distress** – by ensuring conditions and treatment, which avoid mental suffering.

The Five Freedoms have been the cornerstone of much legislation and policy, have been used widely in marketing and form the basis of welfare assessment. Recently the aspect whether an animal has a life worth living, from its point of view supplements the Five Freedoms.

The way in which the Five Freedoms are managed varies widely in different countries. For instance, some regions include in the Five Freedoms issues such as grazing, or a ban on dehorning.

2. Output indicators

Animal welfare is expressed in 11 numerical scores covering 6 indicators. These are listed below.

Indicator	Metric (s)
Somatic Cell Count (SCC)	<ul style="list-style-type: none"> Somatic cells in milk (#/ml)
Antibiotic use	<ul style="list-style-type: none"> Antibiotic treatment (days/year/animal) Cows treated with dry cow antibiotic therapy (% of herd)
Longevity	<ul style="list-style-type: none"> Annual herd replacement (%/year) Survival rate or deaths by age class (%) Rate of on farm deaths (%)
Lameness	<ul style="list-style-type: none"> Locomotion score (1-5)
Fertility	<ul style="list-style-type: none"> Finally pregnant by insemination (%) Insemination period (days) Conception rate cows (%)
Vitality	<ul style="list-style-type: none"> Body Condition Score (1-5)

3. Methodology

The methodology is straightforward. In most cases the farmer's input data directly produce the indicator. This is the case with SCC, antibiotic use, longevity and fertility.

The Locomotion Score and Body Condition Score are standardized visual observations of the way dairy cows walk and of the condition of dairy cows. In several countries dairy farmers have this information by regular inspection of the cows and use these scores for their management.

4. Farm data

The following farm data are required:

Number of animals (calves, young-stock, cows)

Yield (kg milk)

Antibiotic use (days of treatment)

Somatic cell count (herd average)

Score per animal on lameness/locomotion, resulting in average herd mobility score

Score per animal on body condition, resulting in average herd body condition score
Herd replacement rate/year (%)
Animal deaths by animal type (number)

5. Background data

There are no background data necessary for determining or calculating the animal welfare indicators.

6. Preferences and rationale

In SPA, the ambition is to work with outcome indicators as much as possible. After all it is the outcome on sustainability issues we are interested in. However, in some cases outcome indicators are not in the farmer's grasp (e.g. surface water quality) or data are hard for a farmer to collect (e.g. occurrence of specific insect species). In such cases, good proxies are input or process indicators, for instance management measures.

In the case of animal welfare, good management practices or farm conditions (e.g. herd management, ventilation, cubicle-size, floor area per animal, roughness of the stable floor, a feed and laying spot for every animal, etc.) do give an indication of animal welfare. But since we seek numerical indicators in SPA that can be used to track performance over the years, to perform benchmarks and to steer improved management, and given these outcome indicators are available, we have chosen the current set.

There are no single measures that indicate the status of animal welfare. That is why the combination of seven indicators has been chosen. Some of these metrics are proxies for specific conditions e.g. SCC for mastitis prevalence. Other measures such as herd replacement rate are more general and reflect performance in a number of areas including fertility, genotype, animal management, nutrition and the impact of diseases.

Several additional indicators have been considered, among others: days in pasture, space for animals, time laying and sudden change in production. These indicators were eliminated in the end, because they were too complex to reliably measure, or because scores would differ widely due to variations in management systems across the globe.

7. References and resources

World Organisation on Animal Health (OIE). Ad Hoc Group on animal welfare and dairy cattle production systems, ongoing work.

<http://www.animalwelfareplatform.eu>

International Organisation for Standardization (ISO) is working on animal welfare standards, aimed to be completed October 2013.

11 Considerations on data

Data quality

Reliability of the results from the tools strongly depends on the extent to which data quality requirements are met. Ideally the tool is backed up with a document that reports the data used such that it can be checked by an independent controller. In accordance with standards like ISO and PAS, the following parameters should be taken into account:

- Time-related coverage: data that are time-specific shall be preferred.
- Geographical coverage: data that are geographically-specific shall be preferred.
- Technology coverage: data that are technology-specific shall be preferred.
- Precision, completeness and accurateness of the data: data that are most precise, complete and accurate shall be preferred.
- Consistency and reproducibility of the methods used throughout the data collection.
- Uncertainty of the information and data gaps.

Data collection

Primary activity data collection

Primary activity data shall be as specific as possible for the farm or farm product assessed. Preferably the data is collected on-farm by use of the farm's documentation. Preferably all data refer to the same time period (in most cases one year). Preferably average weighed data is used in contrast to data that represents a single moment, for instance 5-year average market prices.

Data inputs should be collected in the units most familiar to the intended user, farmers and co-operators. The tools need to convert the data to allow consistent output.

Secondary or background data

Secondary or background data shall be used where primary activity data have not been obtained, are not farm specific or are too specific for a farmer to know. An example of the latter are emission factors of manure.

Determination of the source of the secondary data shall recognize that secondary data arising from competent sources (e.g. peer-reviewed publications, well-established and recognized databases, national governments, statistical offices, official United Nations publications and publications by United Nations-supported organizations) are preferred over secondary data from other sources.

Annex 1: Full list of farm data and background data

Farm data

	Importance of data		Notes and units
	Crucial	Useful	
	Farm location	x	
<u>Crops</u>	Types of crop	x	
	Type of crops in rotation	x	split in 1st, 2nd or combined, incl grass and leguminous
	Area per crop	x	ha
	Yield	x	tonnes/ha, N: kg
	Estimated yield reduction compared to average year		x %
	Dates of sowing/planting and harvest (per crop)	x	month
	Crop residues		x kg/ha
	Crop residue management	x	burning, ploughing, removed from field
	Removed crop residues		x kg, including processed products, e.g compost
	N and P content of crop		x kg/kg
	N and P content of removed crop residues		x kg/kg
<u>Soil characteristics</u>	Soil type	x	
	Organic matter content		x % from measurement
	Sand and silt fraction		x
	Acidity	x	pH
<u>Soil conservation practices</u>	Type of tillage		x
	Tillage date		x
	Measures taken to prevent erosion	x	From list, for instance: contour plowing
<u>Irrigation</u>	Water volume	x	m ³ per farm or per field
<u>Livestock</u>	Types of animal on farm	x	
	Number of animals	x	number
	Animals purchased	x	number and weight
	Animals sold	x	number and weight
	Animal deaths	x	number by age class
	Grazing	x	days/year or hours/day
	N and P content of animals		x N/kg and P/kg
<u>Livestock feed</u>	Type	x	
	Amount	x	kg
	N and P content		x N/kg and P/kg
	Country of origin of feed		x
<u>Livestock products leaving the farm</u>	Type	x	milk, eggs
	Amount	x	kg
	N and P content		x N/kg and P/kg

	Importance of data		Notes and units
	Crucial	Useful	
<u>Animal health and welfare</u>			
Somatic cell count	x		#/ml
Antibiotic use	x		days/yr/animal
Lcomotion score	x		score 1-5
Number of animals finally pregnant by insemination	x		%
Inseminaton period	x		days
Conception rate cows	x		%
Body condition score	x		score 1-5
<u>Input brought to farm</u>			
Type	x		Manure, straw, pesticides, saw-dust, etc.
Amount	x		kg
N and P content		x	N/kg and P/kg
<u>Use of fertilizer, compost, manure</u>			
Type	x		
Application rate	x		
Application method	x		spreading and/or incorporation in soil
Emission inhibitor		x	
Split application		x	
N and P content		x	
<u>Manure leaving farm</u>			
Type	x		
Amount	x		kg
N and P content		x	N/kg and P/kg
<u>Pesticides</u>			
Amount of pesticides	x		kg or liter of product name
Applied area	x		ha/field
Application method	x		
Date of application	x		dd-mm-yy
<u>Transport</u>			
Transport distance		x	miles or km
Transport load weight		x	
Transport modality		x	
<u>Land use history</u>			
Land use changes last 20 years		x	forest to arable or grassland and vv
Past farm management		x	crop/manure combinations
<u>Energy and fuel use</u>			
Type	x		
Amount	x		
<u>Energy production on farm</u>			
Type	x		
Amount	x		
<u>Environment and terrain</u>			
Size of watercourses		x	may be simplified to 4 classes, dep. on width x depth
Slope ratio		x	simplified into 4 classes
<u>Weather</u>			
Estimated rainfall year type	x		3 classes: wet, normal or dry
Evapotranspiration		x	field sensors
<u>Biodiversity</u>			
Range of conditions on farm, benefitting biodiversity	x		From list, for instance non-cropped area, presence of hedges
Management measures taken for benefit of biodiversity	x		From list, for instance field margins, maintenance of hedges

Background data

Climate data

Emission factors (IPCC Tier 2)

Energy mix per country or country specific emission factors per energy carrier

Country specific N-deposition data

Default land use change

Soil characteristics (from soil maps)

soil types

organic matter content

pH

CEC

Wheater

rainfall (5 year and monthly average)

rainfall shortage or surplus (5 years average)

evaporation

air temperature

wind speed

Crop characteristics (averages per region and per crop)

yield

primary production and harvest indices

Kc values

root depth

N-fixation

transpiration reduction factors (FAO)

amount of crop residues

N and P content of crops and residues

height in relation to pesticide interception

humification coefficient of crop residues

dry matter content

Fertilizer and manure

farm activity data and related emission (e.g. from manure application)

country or region specific emissions of inputs

composition of organic manures and fertilizers

humification coefficient of manure

Pesticides

Basic characteristics of pesticides: % active ingredient, metabolites, toxicity, persistence, adsorption etc

Further characteristics of pesticides combined with application circumstances (soil and surface water types, application methods, weather)

Maximum Acceptable Concentration (MAC) per active ingredient

predicted concentrations in groundwater at different circumstances and MAC's

predicted concentrations in soil at different circumstances and MAC's

spray drift emission factors per application method (possible simplification to 10 types)

run-off emission factors per slope ratio (may be simplified into 4 classes)

Environment and landscape

surface water types

surface water characteristics (3 types depending on width and depth of water bodies)

slope ratio (may be simplified in 4 types)
Region specific N in surface water

Livestock characteristics

composition of feed concentrates (ingredients)
dry matter content of feed ingredients
average share of country of origin in feed ingredients (from import/export stats)
average country specific yields of crops used as feed ingredients
N and P content of: eggs, milk, meat, feeds, animals

Annex 2: Benchmark of promising tools against SPA

	Cool Farm Tool	Climate Yardstick	Environmental Yardstick for Pesticides	PRIME	Water Footprint Calculator 2010	Gaia Biodiversity Yardstick
	Single issue tools					
Description of tool	GHG calculator that quantifies the agricultural carbon footprint of production.	Free online greenhouse gas calculator developed by CLM.	Online tool to evaluate pesticide risks from CLM (since 1990 and updated every 3 months, subscription fee).	Online tool to evaluate pesticide risks. First official version will be launched in 2014.	Tool to determine the water required for goods & services.	Biodiversity yardstick developed by CLM.
Owner group	http://www.coolfarmtool.org	http://www.clm.nl/en/themes	http://www.clm.nl/en/themes	http://ipmprime.org/cigipm	http://www.waterfootprint.org/?page=cal/WaterFootprintCalculator	http://www.clm.nl/en/themes
SPA alignment	Green = entirely compliant; light green = almost compliant, orange = contains elements of SPA approach, red = not compliant. White: issue not included.					
<i>Climate & Energy</i>	+	+		+		
<i>Pesticides</i>			+	+		
<i>Soil quality</i>						
<i>Water quantity</i>					+/-	
<i>Nutrients</i>						
<i>Biodiversity</i>						+
<i>Land use</i>						
<i>Animal Welfare</i>						
Explanation score on methodology	Calculation methodology good fit, although product-based (LCA), not farm-based. Not all indirect/embedded emissions, e.g. production of energy carriers, detergents, seeds, plant nursery and feed, are incorporated	Methodology good fit, farm-based approach. Some limitations on boundaries.	Methodology fits with the more in-depth "preferred methodology" for pesticides.	Excellent fit with SPA "simplified methodology" for pesticides. Also good fit with more in-depth "preferred methodology", but because of relative ranking, the relation with the potential environmental risk is not visible in the presentation of the outcomes.	SPA preferred methodology for water requirement is part of the Water Footprint calculation. But Water Footprint not available at farm level.	Good fit of methodology. Questions and scope NW-European.
Strenghts	Covers all sectors and applicable on global scale. Most input data available to farmer.	Free online tool, available for dairy, arable, vegetable and pigs. Very user friendly, easy to understand for farmers. Central data storage.	Simple tool to compare pesticide risks and to be used as benchmark and evaluation tool on crop or farmlevel. Scores on several environmental compartments (aquatic, soil life etc). Easy to use and available on the internet. All crops.	Simple tool to compare pesticide risks. Scores on several environmental compartments. It also gives info on the effectiveness of various methods for reducing pesticide risk. Contains a mapping tool. Scores are calibrated against documented field impacts (in USA). All crops.	Broad support, well founded approach to water impacts, online.	Only known tool of its kind. Online. Easy to understand for farmers. Arable and dairy.
Weaknesses	Online available as a webbased tool at beginning of 2014. The online tool is more user-friendly than Excel based version. Some parts are complex to fill in for an average (computer literate) farmer, especially the livestock part is difficult for farmers. Apart from clear results (graphs and tables) no additional feedback to farmer.	Applicable to "western" farmers only; current background data cover NL and DK. Online version gives graphic results but no additional feedback to farmer.	Mainly based on EU and NL data, though already internationally used.	Shows relative impact, not the real impact. Partly based on US specific data, but already internationally used.	Not available for use at farm level.	Based on agriculture practices and biodiversity in N-W Europe. Additional feedback to farmer not yet in current version.

	SAFA	Fieldprint Calculator	Simpatica	RI SE 2.0	Agri Yield Management System	Quickfire (related to Greenlight, CropWalker)	Land db/ Ag connections
	Multiple issue (integral) tools				Farm management systems		
Description of tool	Tool to facilitate the overall Sustainability Assessment of Food and Agricultural Systems. Multiple issues. Tool is designed for use by single farm businesses or by food companies.	Online tool to assess overall sustainability performance. Multiple issues.	Software for crop management calculating environmental impacts for small holders.	Very complete sustainability assessment system requiring discussion with farmer(s).	Record keeping system with sensor-collected data and calculation of indicators for soil, fertilisation, irrigation...	Audit and self assessment tool calculating environmental impacts. Most data are qualitative.	Crop management system with sensor-collected data and calculation of indicators.
Owner group	http://www.fao.org/nr/sustainability/sustainability-assessments-safa	http://www.fieldtomarket.org		http://www.hafl.bfh.ch/fileadmin/docs/Forschung_Dienstleistungen/Agrarwissenschaften/Nachhaltigkeitsbeurteilung/RISE/Publikationen/RISE_Poster_1.pdf	http://www.dacom.nl/index.php/en/	http://en.muddyboots.com/cw/test	http://www.agconnections.com/products-and-services/land-db
SPA alignment							
<i>Climate & Energy</i>	+/-	+	-	+/-	+/-	+	
<i>Pesticides</i>	-		+/-	-	+	-	-
<i>Soil quality</i>	+/-	+/-		+/-	-	-	
<i>Water quantity</i>	+/-	+/-	+	-	+/-	+/-	+/-
<i>Nutrients</i>	+/-		+/-	+	+	+/-	+/-
<i>Biodiversity</i>	+			+/-		-	
<i>Land use</i>	-	+/-	+				
<i>Animal Welfare</i>	-			+/-			
Explanation score on methodology	SAFA covers many more issues; output scoring different from SPA. However, background calculations in some cases (roughly) in line with SPA. Climate & Energy requires net balance of GHG emissions. Soil quality: balance of organic matter input and output is demanded, not expressed in % SOM. Acidity included. Water requirement can be deduced but irrigation efficiency cannot. Nutrient balances are calculated. Biodiversity: encompasses a wide range of biodiversity improving practices, like SPA. Land use change is looked at, not square meters land required for crop or fodder production. Animal welfare focuses on management measures. Animal health does look at share of the animals treated with medicine.	GHG aligned with SPA; land use close. Soil organic matter incorporated as index (RUSLE 2 and SCI) indicating if organic matter is declining or increasing. Erosion is more elaborately assessed with RUSLE2 than is done in SPA. Acidity is not assessed. Water quantity assessed in term of irrigation water, excludes rainwater and irrigation efficiency. Water quality (nutrients, pesticides implicitly) and biodiversity to be included soon.	Pesticide methodology fits (SPA "simplified"), carbon no fit, water use in line with WFP network. Nutrients not a complete balance only fertilisers. In 2014 nutrient balance will be expanded. Land use is in Simpatica. Other issues are optional.	Climate excluding emissions from inputs, pesticides based on tox and persistence. Soil does cover organic matter balance and pH. Water is qualitative. Nutrients based on N and P balance. Animal health section covers % mortality and use of medicine in general terms. Biodiversity covers some questions also included in SPA.	Climate and water methodologies are being developed (in line with SPA) Soil: pH and erosion risk not included	Methods included depends on the clients wishes. Score can be quantitative as well as qualitative. Quickfire is mostly a data gathering tool. Climate: Cool Farm Tool. Pesticides: active ingredients only. Water: irrigation.	Pesticides: only kg used, not the environmental impact; Water: irrigation only.
Strengths	Holistic approach to sustainability (includes wide arrange of themes). Simple tool to (down)load, customize, fill out etc.. Clear output.	User-friendly tool, easy to access, clear display of result, feedback by benchmarking (county, state, national) on scale, background documentation with advice.	Universal use; very flexible. Inclusion of additional themes, languages, units, currencies and objects (crops, products, activities...).	Very complete. Expresses all sustainability issues in numerical scores.	Complex , but user friendly interface. Good explanations. Combines a lot of data for several purposes.	Operates globally, multilingual, already used in supply chain of different companies.	Combines advice (very interesting for farmer), record keeping (less interesting for farmer) and calculation on a few sustainability indicators.
Weaknesses	Not user-friendly is: there is complex data (measurements, sampling, calculations) required instead of readily available farm data for some of the environmental performance indicators, which renders the use of yet other tools indispensable.	USA-based, only a limited amount of (commodity) crops.	Very detailed information required; every operation is documented. Close to farm management system rather than sustainability tool.	Not online. Relies on one-on-one interviews for data collection; system can only be filled in by external advisor.	Does not include climate change, water footprint and biodiversity (yet).	Mainly used as an audit management system; not very user friendly yet.	Pesticides and manure/fertilizers: only use, not environmental impact.

Annex 3: Comparison of FAO's SAFA and SPA

Early 2014 the UN's Food and Agriculture Organisation (FAO) published the Sustainability Assessment of Farm and Agricultural systems (SAFA) indicators, guidelines and tool. This currently is the most comprehensive set of indicators and assessment methodologies for food and agriculture. The SAFA tool was not included in the original review of tools described above. Therefore, we provide a concise review of SAFA here.

The SAFA tool incorporates all SAFA indicators, and calculates and scores these based on the SAFA Guidelines. The tool provides a holistic framework for assessing sustainability performance in the food and agriculture sector, including crop and livestock production, forestry and fisheries.

Data are entered in the tool at the level of individual food and agriculture enterprise or their advisors/cooperatives regardless of their size or geography. The tool produces scores in a 5-level rating system, ranging from best (green) to unacceptable (red), reported through a polygon (spider web) and bar charts.

Assessment of the tool in relation to SPA

The SAFA approach is very complete. This makes it formidable in scope, but also quite a challenge to entirely fill in. It is a simple tool to (down)load, customize, fill out etc. It is practical in use, and has clear output. A computer-literate farmer can fill out most of the qualitative questions. However, farmers will have trouble with the quantitative ones, notably when these themes require quantitative data from measurements that are not routinely done on the farm (for instance, water quality measurements), or data derived from external, non-specified calculator tools (for instance a carbon calculator). In sum, it is only moderately user-friendly.

The time required to do a SAFA assessment depends on choices made by the user and on data availability. FAO indicates that it may take from a few days to a few weeks to complete, depending size of operations or assessment scope etc.

The tool is meant for fact-finding and analysis, not for farm management support. It provides no additional feedback or advice, except for an open question on what the user may want to improve in the future.

Review of calculation methodologies against SPA

All output from the tool is captured by a 5-scale rating, ranging from dark green (best) to red (unacceptable). As such, the tool differs from SPA, which prescribes more targeted numerical scores (e.g. environmental impact scores for pesticides) or actual outcomes (e.g. kg of CO₂/eq). In some cases however, the SAFA-rating does depend on underlying calculations, e.g. a nutrient or carbon balance. We have reviewed the tool keeping these underlying methodologies and output data in mind: numbers are generated, but they are hidden by the green-to-red scoring system. The conclusions on methodologies are the following.

- Climate & energy: SAFA produces net balance of GHG emissions as output, not CO₂eq/kg product. However, since these are calculated from a (non-specified) carbon tool, the CO₂eq/kg should not be too difficult to deduce – in particular if the chosen tool is SPA-proof.... Largely in line with SPA.
- Pesticides: tool only verifies if category I substances are used. Different from SPA.
- Soil quality: Input-output balance of organic matter is demanded, but output states whether the balance is positive or negative, not expressed in % SOM. Soil acidity also included. Practices to maintain soil quality, including erosion prevention, are included. Partly in line with SPA.
- Water requirement may be deduced from information in SAFA (if you have the underlying calculation!) but irrigation efficiency cannot. Partly in line with SPA.
- Nutrient balance is included, though final scoring based on whether "balance deviates more than 10% from zero". Largely in line with SPA.
- Biodiversity: encompasses a wide range of biodiversity-improving practices. As such very much in line with SPA in thinking (though not in resulting scoring).
- Land use: land use change is looked at, not square meters land required for crop or fodder.
- Animal welfare: focus on practices. Animal health does look at veterinary medicine use.

The following table illustrates the alignment with the SPA indicators and methodologies.

Themes	Subthemes	ENVIRONMENTAL integrity Indicators	SPA Alignment							Explanation
			Climate & Energy	Pesticides	Soil quality	Water quantity	Nutrients	Biodiversity	Land use	
E1 Atmosphere	E 1.1 Greenhouse Gases	(E 1.1.1) GHG Reduction Target (E 1.1.2) GHG Mitigation Practices (E 1.1.3) GHG Balance	+							General: where indicators score light green, calculations (roughly) in line with SPA are incorporated in SAFA. Not dark green because output scoring in SAFA is different from output values in SPA. Net balance of GHG emissions as output, not CO2eq/kg product. Should not be difficult to deduce.
	E 1.2 Air Quality	(E 1.2.1) Air Pollution Reduction Target (E 1.2.2) Air Pollution Prevention Practices (E 1.2.3) Ambient Concentration of Air Pollutants								
E2 Water	E 2.1 Water Withdrawal	(E 2.1.1) Water Conservation Target (E 2.1.2) Water Conservation Practices (E 2.1.3) Ground and Surface Water Withdrawals				+				"Share of withdrawals as % of total renewable water" instead of kg/ha or kg/kg. Should not be difficult to deduce.
	E 2.2 Water Quality	(E 2.2.1) Clean Water Target (E 2.2.2) Water Pollution Prevention Practices. (E 2.2.3) Concentration of Water Pollutants (E 2.2.4) Wastewater Quality (E 3.1.1) Soil Improvement Practices								Water quality sampling, not calculated impact or risk. Improvement practices, including erosion prevention, are incorporated and rated in this indicator.
E3 Land	E 3.1 Soil Quality	(E 3.1.2) Soil Physical Structure (E 3.1.3) Soil Chemical Quality (E 3.1.4) Soil Biological Quality (E 3.1.5) Soil Organic Matter								Soil acidity is included in wider soil quality testing. Net balance of imported organic matter as output, not expressed in % SOM.
	E 3.2 Land Degradation	(E 3.2.1) Land Conservation and Rehabilitation Plan (E 3.2.2) Land Conservation and Rehabilitation Practices (E 3.2.3) Net Loss/Gain of Productive Land								Improvement practices, including erosion prevention, are incorporated and rated in this indicator. Plan not asked for in SPA methodology.
E4 Biodiversity	E 4.1 Ecosystem Diversity	(E 4.1.1) Landscape/Marine Habitat Conservation Plan (E 4.1.2) Ecosystem Enhancing Practices (E 4.1.3) Structural Diversity of Ecosystems (E 4.1.4) Ecosystem Connectivity (E 4.1.5) Land Use and Land Cover Change								Land use <i>change/conversion</i> is looked at, not m2 land required for crop or fodder production. Plan and target not asked for in SPA methodology.
	E 4.2 Species Diversity	(E 4.2.1) Species Conservation Target (E 4.2.2) Species Conservation Practices (E 4.2.3) Diversity and Abundance of Key Species (E 4.2.4) Diversity of Production								Biodiversity scores dark green, because output scores in SPA are not strictly defined. So implicitly SAFA and SPA are much alike on this issue. Having the right questions and data inside SAFA suffices for dark green.
E5 Materials and Energy	E 5.1 Material Use	(E 4.3.1) Wild Genetic Diversity Enhancing Practices (E 4.3.2) Agro-biodiversity in-situ Conservation (E 4.3.3) Locally Adapted Varieties And Breeds (E 4.3.4) Genetic Diversity in Wild Species (E 4.3.5) Saving of Seeds and Breeds (E 5.1.1) Material Consumption Practices (E 5.1.2) Nutrient Balance								N&P balance included, though final scoring based on whether "balance deviates more than 10% from zero" instead of kg/ha or kg/kg product.
	E 5.2 Energy Use	(E 5.1.3) Renewable and Recycled Materials (E 5.1.4) Intensity of Material Use (E 5.2.1) Renewable Energy Use Target (E 5.2.2) Energy Saving Practices (E 5.2.3) Energy Consumption (E 5.2.4) Renewable Energy								
E6 Animal Welfare	E 5.3 Waste Reduction and Disposal	(E 5.3.1) Waste Reduction Target (E 5.3.2) Waste Reduction Practices (E 5.3.3) Waste Disposal (E 5.3.4) Food Loss and Waste Reduction (E 6.1.1) Animal Health Practices								
	E 6.1 Animal Health	(E 6.1.2) Animal health								More diverse practices for different animals compared to SPA. Might partly be covered under question "What share of the enterprise's animals are healthy and have not required any treatment with veterinary drugs against illness or disease?"
	E 6.2 Freedom from Stress	(E 6.2.1) Humane Animal Handling Practices (E 6.2.2) Appropriate animal husbandry (E 6.2.3) Freedom from Stress								More diverse practices for different animals compared to SPA. More diverse practices for different animals compared to SPA.

Annex 4: Steering Committee and external experts

The following people were involved in the process of determining SPA version 1.0.

Steering committee

Ernesto Brovelli	- The Coca Cola Company
Richard Burkinshaw	- Kellogg
Kimberley Crewther	- Fonterra
Hal Hamilton	- Sustainable Food Lab
Richard Heathcote	- Heineken
Selwyn Heilbron	- SAI Platform Australia
Ian Hope-Johnstone	- PepsiCo
Don Jansen	- Wageningen University and DE Foundation
Yves Leclerc	- McCain
Sarah Lewis	- The Sustainability Consortium
Daniella Malin	- Sustainable Food Lab
Sikke Meerman	- Unilever
Nathalie Ritchie	- Mondelēz
Gail Smith	- Unilever
Frederika Somers	- Novus
Jolanda Soons	- Lamb Weston Meijer

The project was supported throughout by Emeline Fellus, Peter Erik Ywema and Brian Lindsay from SAI Platform.

In addition, a broad group of stakeholders including environmental NGOs and academia were consulted when drafting SPA 1.0, and a second group specifically on animal welfare for SPA 2.0.

Annex 5: About SAI Platform and CLM

SAI Platform

The Sustainable Agriculture Initiative (SAI) Platform is a platform created by the food industry to support the development of sustainable agriculture worldwide. Founded in 2002 by Nestlé, Unilever and Danone, SAI Platform in 2012 counts 40 members, including one fifth of the top 100 world food industries. All members share the same view on sustainable agriculture seen as a "productive, competitive and efficient way to produce agricultural products, while at the same time protecting and improving the natural environment and social/economic conditions of local communities". They cooperate in a pre-competitive manner to develop and identify strategies and tools facilitating the adoption of sustainable agriculture.

The latest services and deliverables produced include: Principles and Practices for the Sustainable production of Arable and Vegetable Crops, Coffee, Dairy, Fruit and Water; a Benchmark Study of Agriculture Standards and a Short Guide to Sustainable Agriculture. The Platform also partnered-up with one of the top Business Schools in the World – IMD – to develop the first and only training for Executives on Sustainable Sourcing. Furthermore, seminars and webinars are proposed to members throughout the year on a wide range of subjects related to sustainability, such as water management, certification schemes, the use of videos for farmer training etc.

www.saiplatform.org

CLM (Centre for Agriculture and Environment)

CLM is an independent consultancy working in the field of sustainable food and farming and rural development. CLM provides advice to governments at all levels- from the European to the local level. In addition, CLM works for and with companies such as McCain, Heineken and Unilever, and for environmental and farmer's organizations. Its expertise is rooted in professional practice, supported by CLM's network of 250 farmers and other rural entrepreneurs. In addition, the organization has extensive experience and expertise in communication and process facilitation.

CLM has ample experience in developing and benchmarking methodologies for measuring sustainable farming. CLM has published several tools, such as the Soil Carbon module, the Climate Yardstick, the Environmental Yardstick for Pesticides, the Gaia Biodiversity Yardstick and the Ammonia-Yardstick for dairy. CLM also built more integrated systems, like the "Kringloopkompas" used for the milk production for Ben&Jerry's and the BRP, currently incorporating eight sustainability issues in dairy. Together with Alterra Wageningen UR, CLM produced the international tool BioESoil, which assesses the impacts of bio-energy on soil quality.

CLM was established in 1981 and is based in Culemborg, Netherlands.

www.clm.nl