BioGreenhouse

Sustainability assessment tools for organic greenhouse horticulture

Lucia Foresi, Ulrich Schmutz, Assumpció Antón, Anja Vieweger, Martina Bavec, Matthias Meier, Muhammad Shahid, Nancy Peña, Richard Petrasek, Denis Stajnko, Tjaŝa Vukmaniĉ, Jan Landert and Rainer Weißhaidinger

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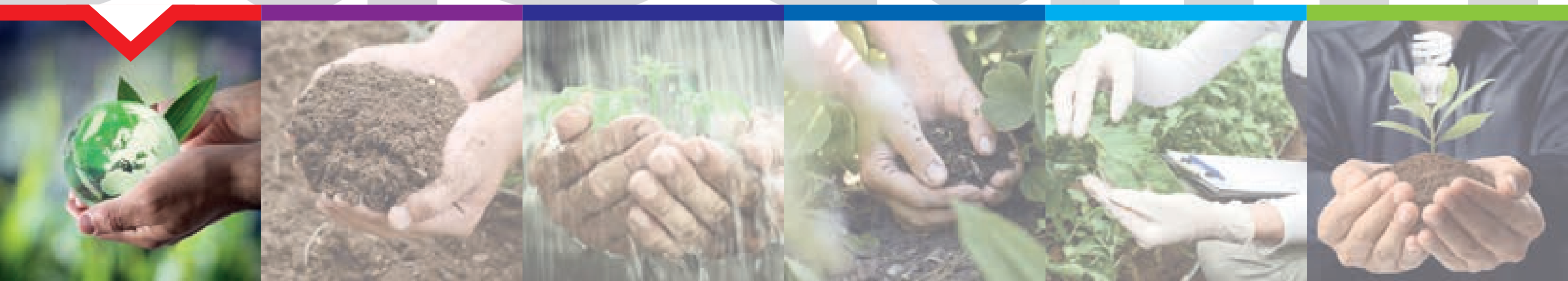
Sustainabillity



The writing team: This picture was taken at the final meeting to discuss this booklet, held in Maribor, Slovenia in September 2015. The location is on a bio-dynamic farm near the Croatian border. Left to Right: Matthias Meier, Martina Bavec, Ulrich Schmutz, Assumpció Antón and Lucia Foresi.

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Preface

In 2008, on the occasion of the 16th IFOAM Organic World Congress in Modena, Italy, about 25 participants expressed their interest in working together in the field of research and development for organic greenhouse or protected horticulture. In order to create this, a two-day workshop was organised in Cologne in 2009 to discuss the subject and the way collaboration could be formalised. At this workshop, 45 people from all over Europe and Canada were present. It was decided to work together in the field of organic protected horticulture concerning planting material, soil fertility, composting, water management, disease and pest management, climate control and energy conservation, and sustainability and standard development. The group also agreed to submit a COST (European Cooperation in Science and Technology) Action on the same subject. In mid-2011 the proposal "Towards a sustainable and productive EU organic greenhouse horticulture", BioGreenhouse in short, was submitted.

At the end of 2011, COST approved the proposal as COST Action FA1105 (www.cost.eu/COST_Actions/fa/FA1105 and www.biogreenhouse.org). This action aims to build a network of experts working in the field of organic protected horticulture and to develop and communicate, through coordinated international efforts, knowledge for new and improved production strategies, methods and technologies to support sustainable and productive organic greenhouse horticulture in the EU.

This project offered the framework and funds for the experts of the 27 participating COST countries and 2 COST neighbouring countries to meet and work together in working groups concerning the objectives of the action. One of these objectives is to assess indicators for the ecological, social and economic sustainability of organic greenhouse systems, and to assess the total factor productivity. This contrasts with reliance on non-renewable inputs, like fossil fuels or peat, with multiple outcomes like yield quantity and quality, and environmental and social services. These indicators could help in assessing to what degree organic greenhouse systems contribute to IFOAM's four organic principles of Health, Ecology, Care and Fairness. Thirteen experts from all over the action worked on this objective and together, they realised this booklet:
"Sustainability assessment tools for organic greenhouse horticulture"

It is an indispensable source of information for all people and institutes involved in the research of organic protected horticulture in Europe and worldwide. The booklet is intended for researchers, students, teachers, consultants, growers and policy makers. On behalf of the COST action Biogreenhouse, I want to thank the team of the authors and editors for the work they have done, their cooperative spirit and their perseverance. This work will for sure contribute to an improved experimentation, collaboration and exchange of information about sustainability in organic greenhouse horticulture, and help find ways to promote sustainability.

Rob J.M. Meijer
Wageningen UR Greenhouse Horticulture
Chair, COST Action FA1105 Biogreenhouse

1 Introduction

Recent decades of agricultural research and development have focused mainly on maximising growers' incomes through intensification of external inputs and increases in volume of production, while being less concerned with food quality and resources depletion (Raviv, 2010; Stefanelli *et al.* 2010).
In order to face such issues, a shift to a more quality-focused system would be preferred, opting to develop alternative and more environmentally friendly applied technologies and farming techniques, based on agroecological principles that respect biological cycles and use natural resources in a sustainable way (Alteri, 1995). Organic agriculture and horticulture has always tried to achieve this, however it too, often tries only to replace conventional external inputs with those certified organic, without really changing the production, distribution and consumption system – the food system.

Horticulture is considered a major contributor to food systems because it offers a wide range of high-value crops such as fruits, vegetables, nuts, mushrooms, spices and medicinal plants, which are all integral parts of a healthy human diet. Some diets only rely on horticultural products. However, when crops are grown inside protected structures, horticulture turns into a labour- and input-intensive farming system. Growing vegetables in these environments has raised many contrasting views between experts; on one hand, plants are protected from external agents, their living cycle modified, their quality potentially improved and yields increased, not to mention the all-year round provision of products (Pardossi *et al.* 2004; Simson and Straus 2010). On the other hand, it is argued that protected horticulture (non-organic and organic) requires a huge amount of energy and generates large quantities of wastes (Vox *et al.* 2010).

Organic greenhouse horticulture is the central issue of the COST Action FA1105 "BioGreenhouse", which was created to tackle multiple challenges spanning the different dimensions of sustainability:

- Designing sustainable strategies for irrigation and fertilisation.
- Implementing resilience, robustness and suppressiveness for pest and disease management.
- Integrating eco-system services, energy saving, replacing fossil fuels.
- Carbon neutral production and supply chains.

The main purpose of this COST action is to coordinate, strengthen and focus the activities of the partners involved. It improves the communication, offers a common agenda and a better knowledge exchange, shares new techniques, builds an improved dissemination network for organic greenhouse horticulture, while offering the basis for further collaboration in joint research proposals and support in the development of further private or EU-wide standards for the organic food and farming system.

Given the standard definition of sustainable development (is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (WCED, 1987)) from the 1987 Brundtland Commission, the necessity evolved into gaining a better understanding of the interactions between the environmental, social and economic dimensions of sustainability and challenging the scientific community to provide tools to assess sustainability, as an aid for decision-making and policy-makers (Ness *et al.* 2007). Although there is a growing interest towards sustainable food systems and their performance assessment, there is no common way to define or measure sustainability in the organic greenhouse sector, so presenting a shareable framework would be a step towards the quality of evaluations (Jawtusch *et al.* 2013).

This booklet describes different tools currently employed for sustainability evaluation, according to the field of expertise and experience of the authors. Each method serves a different purpose and covers different aspects of sustainability (environmental, economic, social or all together). This body of work will attempt to show the complexity of assessing sustainability in a comprehensive way, by giving a short background and describing the main features of each tool, and supplying the reader with a practical example of application whenever possible.

2 Life Cycle Assessment (LCA) and Social Life Cycle Assessment (S-LCA)

2.1 Life Cycle Assessment (LCA)

By Assumpció Antón, Matthias Meier and Nancy Peña

Introduction

Organic farming is defined as a method of obtaining agricultural products and food that puts particular emphasis on using the most natural products and environmentally-friendly techniques possible, preserving ecosystems, conserving resources and excluding all those techniques that can potentially damage the nutrient quality of the end product. On the other hand, the Life Cycle Assessment (LCA) tool has proven to be an accurate, objective and transparent tool to quantify environmental impacts, with its ultimate purpose of the damage assessment in the three areas of protection: (1) human health, (2) ecosystems and (3) natural resources (EU-JRC-IES, 2010). Therefore, there is a clear connection between the goals of organic farming and the purpose of LCA. Furthermore the integrated production policy of the European Union (EU) emphasizes the life cycle approach as the best framework for assessing the potential environmental impacts of products, highlighting the need for more consistent data and methods of consensus, which are crucial points to apply this tool in organic agricultural as we explain in this section.

First studies of LCA were applied to industrial systems where their influence in the global impact categories is more easily quantified. Lately a great interest in agricultural and food activities increased the LCA studies applied to this sector and in this case, their impact is highly related to more local impact categories, such as land and water use. The purpose of this chapter is the presentation of the LCA methodology focusing on possible drawbacks on the application of LCA to organic greenhouse production. Afterwards we highlight the main aspects that should be the focus for further research.

LCA Methodology

LCA evaluates environmental burdens associated with the life cycle of a product, process or activity by identifying and quantifying the flows of materials and energy required and their emissions to the environment and therefore their sustainability environmental impact. LCA can also evaluate and inform the implementation of strategies to reduce the environmental footprint of products, processes or services. LCA is an iterative process divided into four steps established under ISO standards (ISO 14040, 2006 and ISO 14044, 2006): 1) the objectives and scope of the study, 2) inventory analysis, 3) impact analysis and 4) interpretation (Figure 1).

In March 2010, European Commission Joint Research Centre published an international reference guide (ILCD handbook, EC-JRC, 2010) with the aim of providing a common basis for consistent, robust and quality-assured life cycle data and studies. In parallel a European network database: Network International Data Base, ILCD, was developed including a network database: Network International Data Base, ILCD. This guide aims to standardize the different methodological options to achieve more accurate results and consistent quality (EU-JRC-IES, 2010).

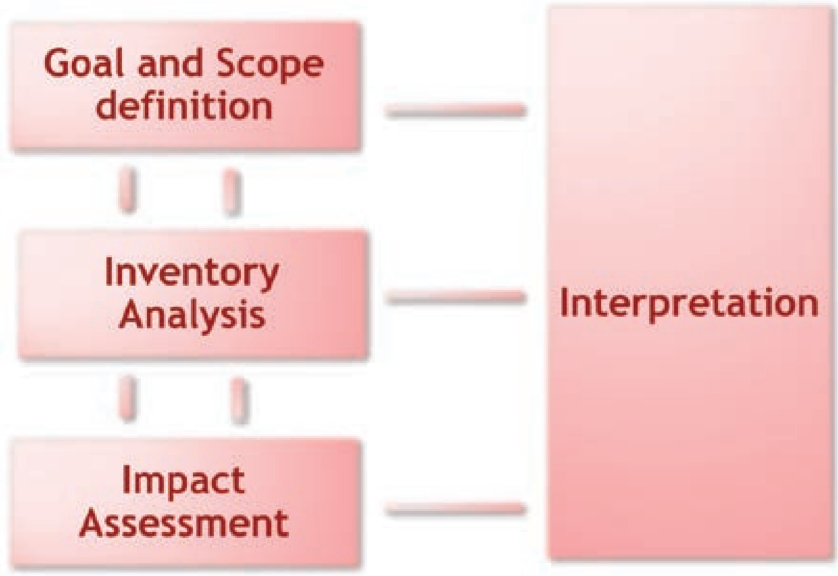

Figure 1 *Basic scheme of the LCA methodology.*

Goal and Scope

The first phase defines the purpose of the study and reasons why the study is completed, the schedule, the authors of the study, the recipient of information and public disclosure of the results or not. This phase also defines the choice of functional unit (FU), which must be specific and measurable for comparing between different products. The FU describes the main function of the process and it is used as mathematical reference to standardize the different inputs and outputs of the system (flows). In agricultural systems, total yield is commonly used as FU, in other studies area (hectare) is used as FU and other choices of FU are possible if they can be made specific and measurable.

Drawback: As the marketable yield in organic systems is often lower, as a result of less intensive inputs, the impacts will be higher or lower for organic systems depending on the choice of FU: weight of yield (e.g. kg or t) or area (e.g. ha or m^2), respectively. However, the main function of organic farming is not just producing a quantity of yield or area occupancy; in fact, organic farming is a method which aims towards providing high quality healthy food and additional environmental and social benefits.

Research proposal: It would be interesting to focus on food quality or nutrient aspects as FU, in order to make a better environmental assessment taking as a reference nutritional quality of the products and diets. Therefore, it is necessary to increase our knowledge of nutrients provided by organic products and their influence in human health or in specific diets Also their performance with regards to specific ecosystem indicators as FUs (e.g. soil health, farmland birds, etc.) and other public goods would be relevant for measuring and comparing the sustainability of organic production systems to other agricultural systems.

Inventory

In the second stage, the inventory is prepared through the collection of inputs and outputs of the different processes involved in the activity. Data collection on consumption (materials and energy) and emissions shall be conducted over the different stages of the life cycle of the product.

Drawbacks: Because agriculture and horticulture is an activity with high variability, in terms of temporal and geographical scale, the collection of representative data requires a big effort to assure representatives of activities. Organic growers are often especially diversified to fit best into their different marketing chains and therefore defining representative farms is challenging.

Different models (sometimes from very different regions) can be used to model emissions and therefore produce different results, mainly those related to nitrogen (N) and phosphorus (P) emissions which are relevant for carbon footprint and eutrophication categories. In addition, there is a lack of organic datasets in current databases, which is especially problematic for intermediate organic inputs.

Research proposal: To build specific and regional datasets for organic greenhouse horticulture. Agreement in modelling criteria for inventories (nutrient emissions, pesticide inventory emissions, allocation rules for co-products, recycling waste management criteria) would improve the coherence and comparability of data collection methods and data quality across Europe.

Life Cycle Impact Assessment

At the impact assessment stage results of the inventory are converted into the different environmental impacts through the characterisation factors (CF). Through CF, environmental flows from the inventory are converted into one reference unit and results are summed up to give the total indicator for each impact category. In the case of global impacts such as climate change or ozone depletion, we have common CF for all over the world that they are just depending on the flow itself. In accordance with ILCD assessment framework recommendations, models and CF can be considered as recommendable and satisfactory (EU-JRC-IES 2011).

However, there are other impact categories strongly dependent on local conditions; these categories need site-specific CFs depending on the place where activity is located, and obviously agriculture activities are also highly related to more local impact categories. Regarding organic horticulture there are two important categories: land use and toxicity, the former because the importance of organic farming in maintain soil and ecosystems quality and the latter because the toxicity rating of natural versus synthetic pesticides.

A lot of work is conducted in the frame of LCA studies to provide land use impact categories. Several initiatives (JRC, UNEP/SETAC, CSIRO, SAFA, etc.) are looking for the "best" indicators. The International Reference Life Cycle Data System Handbook (EU-JRC-IES 2011) and the ENVIFOOD Protocol (Food SCP-RT 2013)[1] recommend cautiously (level III) the method that considers soil organic matter (SOM) (Milà i Canals *et al.* 2007), because it is the most appropriate soil-quality indicator among the existing approaches to assess land-use impacts at midpoint level. Nowadays, EU-JRC are conducting a review of midpoint indicators focusing on soil quality and soil functions. Under the efforts of the UNEP/SETAC Life Cycle Initiative, the land use biodiversity taskforce aims to select and evaluate the most promising indicators and models to represent biodiversity features affected by land use (Teixeira *et al.* 2015).

Recently, new models have been developed to assess land use in terms of occupation, and transformation. The different eco-regions delineated by the WWF (World Wide Fund for Nature), have been classified as spatial units for calculating species loss caused by land use (Olson *et al.* 2001). In addition, biodiversity impact characterisation factors have been developed which adapt to the countryside species-area relationship adding a vulnerability score for each eco-region based on endemic richness and five taxonomic groups: plants, mammals, birds, amphibians, and reptiles (Chaudhary *et al.* 2015). This is done in accordance with six different land uses types: intensive forestry, extensive forestry, annual crops, permanent crops, pasture, and urban. Currently, it is not possible to differentiate between levels of agricultural intensity, and it is not yet possible to complete an assessment that compares organic agriculture land use with other types of agriculture.

In relation to toxicity, human toxicity assessment has been improved thanks to the dynamic crop model to assess human toxicity due to food ingestion of crops where pesticides have been applied (LC-Impact, 2009-13)[2]. This has been performed for the most common organic chemistry-based pesticide compounds (i.e. carbon containing) using seven crops (potato, rice, wheat, apple, tomato, lettuce, and passion fruit) as archetypes (Fantke *et al.* 2011), no values for inorganic compounds have been included yet. Regarding toxicity, a new version of USEtox v.2 characterization factors has been launched with new site-specific, subcontinental level, CFs including metals.

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1 http://www.food-scp.eu/files/ENVIFOOD_Protocol_Vers_1.0.pdf

2 http://www.lc-impact.eu/downloads/documents/Course_Human_Toxicity_Pesticides_-_Presentation.pdf

Drawbacks: In the "land use" impact category, it is currently not possible to differentiate agricultural intensity. Therefore, assessments to compare organic agriculture land use to other types of agriculture are not yet possible. Regarding toxicity the main drawbacks come from the lack of CFs of both natural products used as pesticides (e.g., azadirachtin), and inorganic pesticides such as copper compounds frequently used in organic agriculture. Due to the importance of surrounding environment for metals bioavailability, more detail in the modelling not only in inventory but also in impact assessment would be needed.
Research proposal: To advance in the provision of specific CF to differentiate intensiveness of agricultural activities for land use impacts and accounting emission models for toxicity of e.g. copper compounds, natural products and other public goods and ecosystem services.

Interpretation
The interpretation is the stage of an LCA that combines the results of the inventory analysis with the evaluation of the impact. The results of this interpretation are presented in the form of conclusions and recommendations to assist decision-making. This step helps identify and quantify what stage of the life cycle of the product generates the biggest environmental impacts. It allows the identification of opportunities for improvement of the studied system. Interpretation is also a critical review of the quality of the data and the discussion of the limitations of the analysis.

Drawbacks: The complexity and uncertainties associated with LCA studies makes the communication of results sometimes difficult, mainly to stakeholders at a practical level.

Research proposal: Calculator tools and Ecolabels have been popularised as communication tools. We propose the involvement in product category rules involvement as well as the development of a specific calculator tool. The EUphoros tool could be used as a good starting point and then highlighting the need of actualisation during the execution of the research proposal. Suggested functions to add to the EUphoros (www.wageningenur.nl/en/Research-Results/Projects-and-programmes/Euphoros-1.htm) tool are e.g.:
- More crops.
- Soil and soil based substrates in demarcated beds and containers.
- Certified organic fertilisers.
- Certified organic pest control.

2.2 Social Life Cycle Assessment (S-LCA)

By Mohammed Shahid and Ulrich Schmutz

Introduction

Currently more companies (from small to large) are looking for tools to develop a better understanding of social sustainability in order to achieve better overall sustainability. Normally, for a company to become socially responsible, it should go beyond the legal requirements (Norris, 2012). This is because, the impact on the lives of the people are naturally related to the conduct of the company, involved in the life cycle of the product or service provision (Dreyer *et al.* 2006).

Different tools and techniques were developed to assess social sustainability such as SIA (Social Impact Analysis), SROI (Social Return on Investment) and S-LCA (Social-LCA). A main characteristic of S-LCA, compared to other techniques, is that it covers the whole supply chain. It also helps to improve the social conditions of the involved stakeholders across the life cycle of a product and has implications on the process, systems and services beyond the product-bound impact. The objective of S-LCA is to promote the social conditions of the stakeholders along with the provision of socio-economic benefits of the product based on the entire life cycle of the product (Norris, 2012). From this is becomes clear that S-LCA goes well beyond the farm gate and that an S-LCA of e.g. organic greenhouse tomatoes sold directly to consumers e.g. through a community supported agriculture scheme (CSA) would look very different to one sold across the EU through a long supply chain. The production inputs of the organic tomatoes may be the same but the supply chains are very different.

Jørgensen *et al.* (2010) illustrated that the main functionality of the S-LCA is to provide decision support. This is helpful in the identification of direct and indirect effects on the stakeholders, products, processes and organisations. However, the relationship between social aspects and the chosen functional unit (FU) over the entire life cycle of the product along with the aggregation of results is more difficult (Martinez-Blanco *et al.* 2014) especially in comparison to environmental LCA as described above, which can also be called E-LCA. Petti and Ramirez (2011) discussing methodological and implementation issues of S-LCA also highlight that it helps decision makers through increasing knowledge of social issues in a life cycle of a product. Additionally, they agree with many other authors that there are few tools to assess social sustainability therefore, S-LCA as an emerging tool may help to fill a gap (Paragahawewa *et al.* 2009).

Brief history of LCA (E-LCA and S-LCA)

Work on LCA started in 1960-70s at the Recourse and Environmental Profile Analysis (REPA) and with the energy efficient research, after the first world oil crisis in the 1970s (Petti and Ramirez, 2011). The evolution of LCA happened in 1980s while the guidelines and universal standards were developed in the 1990s. In 1991, the society for environmental toxicology and chemistry (SETAC) published their framework for LCA. The debate on how to deal with social and economic aspects into LCA began in 1993 with the publication of a SETAC Workshop Report: "A Conceptual Framework for Life Cycle Impact Assessment" and the first reference of S-LCA can be found in 1995 within the summary report "The social value of Life Cycle Assessment" (Petti and Ramirez, 2011). The International Standards Organisation (ISO) published their first series on S-LCA in 1997 in the form of a set of standards and ISO 1440 extended to S-LCA. Furthermore, in 2002 the United Nation's Environment Programme (UNEP) started showing interest in S-LCA and in 2009 a working group was formed, which prepared their guidelines for S-LCA in 2009 (UNEP, 2009).

Life cycle thinking

The UNEP (2009) also reemphasises that "Life cycle thinking is about going beyond the traditional focus on production sites and manufacturing processes, so that the environmental, social and economic impact of a product over its whole life cycle". Following the "pillars of sustainability" (environmental, economic and social), life cycle thinking is divided in environmental-LCA, Life Cycle Costing (LCC) and social LCA. O' Brien *et al.* (1996) amalgamated social and environmental LCA and named it SE-LCA, but a combined LCA is not used very often. S-LCA follows the concept of environmental LCA. S-LCA has equally four components as shown in Figure 1 for LCA: Defining goal and scope, inventory analysis, impacts assessment and interpretation. However, there are also differences e.g. in E-LCA environmental impact tends to be negative while in S-LCA social impact can be negative or positive (Paragahawewa *et al.* 2009). S-LCA studies often assess the impact directly on workers or the society, whereas few studies assesses the consumer impact at usage stage, possibly because it is difficult to assess with S-LCA, as Grieβhammer *et al.* (2006) point out.

Organic horticultural business example

A S-LCA conducted e.g. on an organic horticultural business requires a face-to-face interview with the management of 1-2 hours. In addition, similar 1-hour interviews are required for all stakeholder groups: workers, consumers, local community, wider society and value chain actors (e.g. upstream and downstream suppliers).

Depending on the size of the business, especially for workers, value chain actors and consumers more then 10 interviews are required to capture their views. All interviews can usually be conducted within a month; telephone interviews in case of suppliers in the value chain can are also possible. The fact that less then 20% of the interviews and information is sourced from management makes L-SCA very different from other tools like SMART or LCA, which source information mainly from management or from literature or databases.

Advantages of social life cycle assessment

- S-LCA assesses social (including health and wellbeing) and socio-economic impacts using a life cycle perspective.
- Involves phases of a project life cycle that are not covered by other assessment tools.
- Avoids shifting problems between stages of life cycle or geographical areas.
- Enables stakeholders to make a choice between the products and its stage of development.
- Provides information on social and socio-economic aspects for: decision-making, instigating dialogue, production and consumption, performance improvement, utility enhancement, and wellbeing of stakeholders.
- S-LCA can (or should) be added or combined with an E-LCA of a product as the methodology and concept are similar and international standards on both methods exist.

Limitations of social life cycle assessment

- Does not provide information on whether a product should be produced in the first place.
- Does not have the ability to inform decision-making at (e.g. production or consumption) level.
- Helps to update incremental changes but on its own is unable to provide a breakthrough solution for sustainable living and consumption.
- S-LCA, like LCA, is "data hungry" and it takes effort to source the data from multiple stakeholders and to process and integrate them.
- Can be time-consuming tool as requires multiple stakeholders bearing different interests in the data collection, interpretation and integration.

3 Social Impact Assessment (SIA)

By Muhammad Shahid and Ulrich Schmutz

Social impact assessment (SIA) is an assessment method that assesses the consequential impact of an action in the future that cause an effect on individuals, organisation or a society. SIA was initially treated under the banner of environment impact assessment (EIA) therefore the framework of both assessment methods are quite similar. According to US principles and guidelines SIA is a decision making tool and helps to offer information to different communities and agencies about social and cultural factors that should be considered while the decision is under process. Additionally, it helps decision makers to incorporate local values and knowledge into decision making under the influence of local, regional and national interests.

History of SIA

The term SIA first appeared in literature during EIA of Trans-Alaska pipeline. In 1992 a group of social scientists formed the International Committee on Guidelines and Principles for SIA under the NEPA who developed the SIA guide and principles. The International Committee on Guidelines and Principles for SIA define SIA as "all social and cultural consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs, and generally cope as members of society".

What are social impacts?

SIA does not cover only the limited issues bound to EIAs (Vanclay, 2003) but also diverse issues such as financial, impacts on family life, jobs and demographic changes. Vanclay provides a simple way of conceptualising social impacts, stating that it is a change in one of the followings:

- People's way of life.
- Their culture.
- Their community.
- Their political systems.
- Their environment.
- Their health and wellbeing.
- Their personal and property rights.
- Their fears and aspirations.

SIA principles and guidelines

According to the U.S. principles and guidelines from 2003 SIA has 6 basic principles:

1. Achieve extensive understanding of local and regional populations and settings to be affected by the proposed action, program or policy.
2. Focus on the key elements of the human environment related to the proposed action, program or policy.
3. The SIA is based upon sound and replicable scientific research concepts and methods.
4. Provide quality information for use in decision-making.
5. Ensure that any environmental justice issues are fully described and analysed.
6. Undertake project, program or policy monitoring and evaluation and propose mitigation measures if needed.

How to conduct a SIA

SIA is an extensive process that may need a large number of people to involve to collect, interpret and analysis of data. For this reason Becker (2001) proposed a large chart to conduct SIA for a large-scale project. The author split SIA into an initial phase and a main phase. The initial phase in an SIA project consists of 5 main stages: Problem analysis and communication strategy, system analysis, baseline analysis, trend analysis and monitoring design, project design. The main phase in an SIA project consists of 8 main stages: Scenario design, design strategy, assessment of impacts, ranking of strategies, mitigation of negative impacts, reporting, stimulation of implementation, auditing and ex-post evaluation

Benefits of SIA

- It helps to understand the consequence of an action on the lives of persons, communities or regions
- It provides both quantitative and qualitative indicators of social impacts that help decision makers and common citizens alike.
- It is based on local knowledge so conflicts might be minimised
- It not only identify the shortcomings of a project, but presents alternatives
- The methodology of SIA can be applied to a wide range of projects

Drawbacks of SIA

It is can be a long process as many stakeholders and different phase have to be considered

Example of a SIA

The following is and example of a short sustainable impact assessment was used to assess different short food supply chains using five indicators for each dimension of sustainability: Environmental, Economic and Social. The indicators were defined using an expert panel within a European EU FP7 research project (Wascher *et al.* 2015). The concept of the Social Impact Assessment was therefore widened to cover the Environmental and Economic dimensions of short food supply chains.

Environmental sustainability

1. **Enhance eco-efficiency in abiotic resource use (land/soil, water, nutrients):** each food chain type is related to certain farming or gardening systems, which may use abiotic resources more efficiently or not (good input-output-relation under given regional conditions).
2. **Enhance provision of ecological habitats and biodiversity:** each food chain type is related to certain practices, which may enhance the provision of ecological habitats (hedges, trees), cultivate a wider range of crops and livestock including breeding of traditional or rare species and increase biodiversity in the farming system and beyond.
3. **Animal protection and welfare:** Farming systems connected to certain food chains may result in different conditions for livestock.
4. **Reduction of transportation distance and emissions:** a chain type may be related to a shorter transportation distance ("food miles") and possibly a different mode of transport with less emissions and use of road infrastructure (e.g. trains versus trucks).
5. **Recycling and reduced packaging:** a chain type may be related to reduction in the amount of packaging along the whole food chain and be able to recycle most or all of the input materials.

Economic sustainability

1. **Generating employment along the food chain:** a chain type may create or enhance paid jobs (full- and part time, including opportunities for self-employment and volunteering) within the metropolitan region.
2. **Generating long-term profitability:** a chain type may generate income and surplus for the actors along the value chain, which can be reinvested and support the long-term economic viability of the all types of food enterprises along the chain.
3. **Regional viability and competitiveness:** a chain type may be related to regional multiplier effects in the metropolitan and nearby rural areas through e.g. regional value added, generated income and employment, tax revenues etc.
4. **Enhance transport cost-efficiency from producer to consumer:** a food chain type may enhance or reduce the cost-efficiency of transport, which includes e.g. adequate vehicles, capacity utilisation, reducing the number of trips and unloaded drives etc.
5. **Reduction of food waste and losses:** a chain type may support the reduction of food waste or harvest losses (e.g. due to marketable yield size) at production stage, but also waste along all stages of food production, supply including consumption at home or out of home (restaurants etc.).

Social sustainability

1. **Food safety and human health:** a food chain type may result in the absence of pathogens and pollution in the food. Food may comply more or less with legal limits regarding microbiological, chemical or physical hazards.
2. **Food quality (freshness, taste and nutritional value):** a food chain type may result in the provision of food, which is fresh, tasteful and has good nutritional value.
3. **Viability of food traditions and culture:** a food chain type may result in the increased or decreased preservation of cultural distinctiveness, seasonal variation and local food traditions. This includes the knowledge about its preparation and cultural role including religious, ethnic or spiritual purposes.
4. **Transparency and traceability:** a food chain type may result in the increase or decrease of both. Transparency refers to information for the consumer about the way the food is produced and distributed.
   Traceability refers to the availability of information at each stage of the supply chain Examples are direct trust-based consumer-producer relations or the use of labelling schemes (e.g. regional & fair, PDO, PGI, organic) or tracking of produce with smart codes and website information.
5. **Food security and food sovereignty:** a food chain type may result in the increase or decrease of both.
   Food security refers to the availability and accessibility of food, meaning that all people, at all times, have physical, social and economic access to sufficient food. Food sovereignty goes a step further and means that people also have the right to have "a say" or "ownership" (sovereignty) on how their food is produced, processed and supplied, including e.g. how profits, risks and public research inputs are distributed.

4 Social Return on Investment Methodology (SROI)

By Ulrich Schmutz

Introduction
A 'social return' can be defined as a positive outcome of a project intervention, or policy, for people - individuals, communities and society. Some of the social outcomes can be difficult to assess in monetary terms, and yet they often have to be compared with financial returns. Tools to measure social and environmental outcomes have therefore been developed and the social return on investment (SROI) method is one of these (NEF, 2009, SROI Network – Social Value UK, 2012).

SROI is a rigorous measurement framework that helps organisations to understand and manage the social, environmental, and economic value that they are creating. Rather than focusing on revenue or cost savings for one stakeholder, the methodology takes into account and values the full range of benefits to all stakeholders. SROI is an outcomes focussed methodology, in other words it seeks to understand and value the most important changes of a project or programme. SROI is also stakeholder driven, relying on consultation with those who are experiencing change and ensuring that recommendations are made to facilitate targeted and effective change for society.

The main stages of a SROI are:
1. Establishing scope and identifying stakeholders.
2. Exploring and mapping the outcomes.
3. Evidencing outcomes and giving them a value.
4. Establishing impact and calculating the SROI.

Once the stakeholders are identified and the outcomes mapped the SROI finds a financial proxy for the value of an outcome before taking into account factors such as 'additionality' (additional benefits compared to a base-line) and inflation. For example, a stakeholder group comprised of a group of volunteers might have one of its mapped outcomes, as 'Improvements in confidence and self-esteem'. The cost of a training course to achieve a similar or comparable outcome would then serve as a useful financial proxy to assess the monetary value of this outcome. Expert assumptions are then made to estimate the duration of the effect (1 year or 5 years) and percentages of Deadweight, Attribution, Displacement and Drop-off.

These four factors are defined as:
- 'Deadweight' - What would have happened anyway?
- 'Attribution' - How much of the outcome can be attributed to the intervention or how much is due to external factors or other interventions in the area?
- 'Displacement' – Has any outcome been created at expense of others?
- 'Drop-off' - Percentage decrease of the outcome per year

Another assumption is the discount rate for multi-year effects, and this is usually set at 3.5%. All these assumptions can be tested in a sensitivity analysis showing what-if SROI results for other assumptions and percentages.

Case study: SROI of practical organic growing (Master Gardeners)
The Master Gardener Programme by Garden Organic in the UK is a scheme that provides a proven, practical starting point for people to start growing their own food. It's a way of learning by sharing others' experience. Master Gardeners are 'Masters' at inspiring lasting, practical action so people benefit from growing their own food. They believe everyone can grow, whether in a garden or allotment, or on communal land.

Figure 2 *Master Gardeners in practical training (Source Garden Organic, 2014).*

In 2014 an SROI evaluation (Schmutz, Courtney and Bos, 2014) of the Master Gardener Programme was conducted using data from a previous evaluation of the social and environmental benefits gathered by Coventry University (Garden Organic, 2014, Courtney, 2014). In addition, workshops and interviews with Master Gardeners and householders were held to develop the 'theory of change' and to explore the short, medium and long term outcomes of the programme. Once the outcomes were explored and mapped, financial proxies were used to value the outcomes. For the calculation of the SROI, adjustments were also made for a number of other factors affecting the values; inflation, duration of the outcome, what would have happened anyway and what could be attributed directly to the Master Gardener programme. The adjusted values were then added up and the SROI ratio calculated.

Total investment in the Master Gardener Programme	1.2 million Euro
Total value of benefits produced	12.8 million Euro
SROI ratio	**€ 10.70 : € 1.00**

The SROI analysis revealed that over a third of the societal return from the Master Gardener Programme was through 'health and wellbeing', followed closely by 'community and life satisfaction' and 'food eating and buying'. Compared to these three major outcomes the economic benefit value derived through 'skill base and employability' and 'food recycling and composting' outcomes were much smaller (Figure 3).

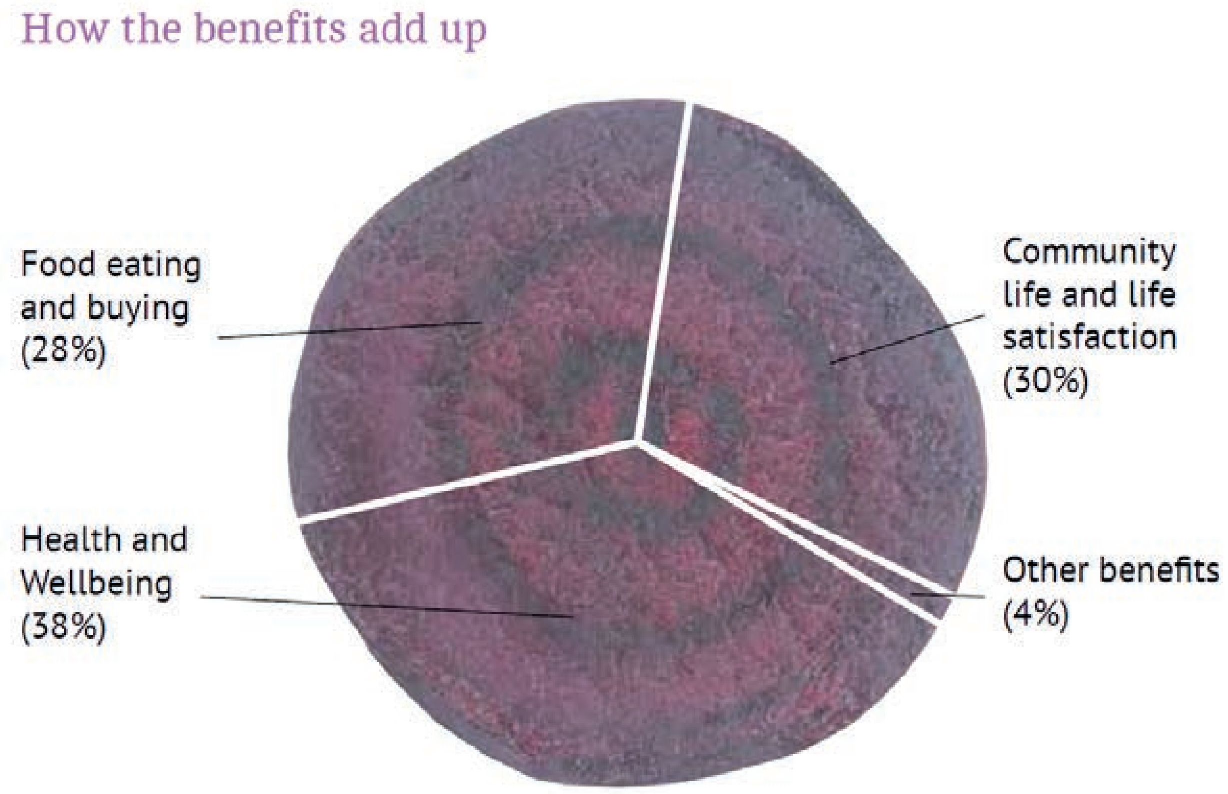

Figure 3 *Monetary breakdown the social return of the Master Gardener Programme (Source: Garden Organic, 2014).*

Benefits of SROI

A SROI can deliver many benefits. Firstly it provides 'hard figures' (usually expressed in currency terms) which most of us, and especially funders, are familiar with. It forces projects to collect social and environmental data, engage stakeholders and monitor outcomes. It gives a standardised framework on how to evaluate outcomes, and a decision support tool for the governance of projects including planning and sensitivity analysis. For public health, monetary values can more easily be compared with alternative interventions or prescriptions.

Limitations of SROI

The main limitations are the cost and skills to perform the method, the assumptions, which can be arbitrary, and the temptation that outcomes are exclusively judged in terms of their financial return and thus over-interpreted. Sometimes it is not possible to accurately capture all the important outcomes, and it may not always be appropriate to attach monetary values to certain outcomes.

4.1 Comparison of the social methods Social Life

By Muhammad Shahid and Ulrich Schmutz

Question addressed:	S-LCA (see section 2.2)	SIA (see section 3)	SROI (see section 4)
What is the main target of the tool?	Measures different social impacts occurring in entire supply chain of a product.	SIA is an assessment method that helps in analysing, monitoring and managing the social consequences of a development.	SROI is a method that values what stakeholders values and gives them a financial value
What is the goal of the tool?	To promote improvement of social conditions throughout the life cycle of a product.	To promote ecologically, socially, culturally and economically sustainable and equitable environment.	To help stakeholders to assess their contribution towards social environmental and health achievements.
What is the main structure of the tool?	SLCA only follows the skeleton of E-LCA however it assesses social sustainability throughout the lifecycle of a product.	SIA is more than the prediction step within an environmental assessment framework.	SROI does not follow the environmental assessment framework it is driven by the theory of change of stakeholders.
What does the tool endorse?	SLCA does not endorse decisions of centralisation or decentralisation.	SIA endorses that the decision making power in an organisation/project should be decentralised.	It is not the scope of SROI to endorse decision capacities. However, it endorses to involve all possible stakeholders in the process of change
What are the principles and guidelines of the tool?	SLCA is grounded by the principle of improvement to enhance the socio-economic performance of the product throughout its life cycle. However, the main principle is based on the human wellbeing and dignity that is the outcome of social sustainability during a life cycle of a product.	SIA guidelines are integrated within six principles focusing on; 1) understanding of local and regional settings, 2) dealing with the key elements of the human environment, 3) using appropriate methods and assumptions, 4) providing quality information for decision making, 5) ensuring that environmental justice issues are addressed and 6) establishing mechanisms for evaluation/ monitoring and mitigation.	SROI guidelines based on seven key principles; 1) involve stakeholders, 2) understand what changes, 3) values the things that matter, 4) only include what is material, 5) do not over claim, 6) be transparent and 7) verify the results.
What is the fundamental focus of the tool?	SLCA is about going beyond the traditional focus on production sites and manufacturing processes so that the environmental, social, and economic impact of a product over its entire life cycle, including the consumption and end of use phase, is taken into account.	The focus of concern of SIA is proactive in nature than reactive as it helps in better development outcomes, not just the identification or mitigation of negative or unintended outcomes. It assists communities and involved stakeholders to maximise the positive and minimise the negative consequences.	SROI focuses and emphasises on the need to measure value from the bottom up, including the viewpoint of various stakeholders.

Question addressed:	S-LCA (see section 2.2)	SIA (see section 3)	SROI (see section 4)
What is the methodology behind the tool?	The intended application of S-LCA is to identify social "hotspots" and the options for reducing the potential negative impacts and risks involved throughout the supply chain, including the development of specifications, procedures, reporting marketing, strategic planning, or development of public policies.	The methodology of SIA can be applied to an extensive range of planned (and unplanned) interventions, and can be commenced on behalf of a wide range of actors.	The assessment method helps to give a holistic return on investment or price: To assess the applicant's understanding of creating social, environmental or economic value and in forecasting value,
What is the tool's main contribution?	There is no restriction, when SLCA can be carried out. It can be in the beginning of the process or during the processing period.	SIA contributes to the process of adaptive management of policies, programs, plans and projects, and therefore needs to inform the design and operation of the planned intervention.	SROI analysis is often carried out on an annual basis, corresponding with annual financial accounting timescales. It can also be used retrospectively and for forecasting.
What is the range of application of the tool?	SLCA based locally and varies from site to site and product to product e.g. a same product at two different manufacturing facilities may have similar LCA but SLCA may be dissimilar.	SIA based on local knowledge and endorses participatory processes in order to analyse the apprehensions of affected and interested parties.	SROI always utilises local knowledge and mostly effective for highly social programs such as; displacement, unemployment and crime rate assessment.
What are the main results of the assessment?	SLCA is a combination of social impact assessment and lifecycle costing. Therefore, it helps to assess economic and social sustainability in a paradigm of product life cycle.	The good practice of SIA accepts that social, economic and biophysical impacts are inherently and intimately interconnected.	SROI deals with social, health and environmental issues (everything that is valuable to stakeholders) and converts social and environmental achievements into currency, and hence makes them comparable to financial achievements or dis-achievements.
What is the spatial / temporal frame in which the tool can operate?	S-LCA is very much site specific and past activities cannot be used as reference.	Impacts occurred due to past activities are analysed in order for the SIA method to learn and grow.	In SROI, past activities are used as a reference, comparison and proxies measures.
What does the tool cover, in terms of supply chain?	The scope of S-LCA covers the whole supply chain. However, it could be site or process specific.	The scope of the SIA is very much site specific. However, it includes accumulation of data from different sources.	The scope of the SROI is very much project/site specific. However, it includes accumulation of data from different sources.
Does the tool follow other methods' guidelines or principles?	SLCA follows the skeleton of LCA. However, it has its own set of principles and guidelines.	SIA works under the EIA (Environmental Impact Assessment) framework	SROI has its own set of principles documented in shared international networks and databases. The assessment techniques are base on methods such as global reporting initiative (GRI), Account-Ability Standards and EIA.

5 SMART - Sustainability monitoring and assessment routines

By Matthias Meier, Jan Landert, Rainer Weißhaidinger and Richard Petrasek

SMART[3] – Sustainability Monitoring and Assessment RouTine – is a sustainability assessment method specifically designed for the agricultural and food sector. It has been developed at the Research Institute of Organic Agriculture, Switzerland against the background that the term sustainability is often used inconsistently. In the food sector, a growing number of suppliers label their products as sustainable without a common understanding of sustainability. In addition, consumers often do not know how agricultural and processed food products were produced because of a lack of transparency. Because the concepts f sustainability vary from case to case, it has not been possible to compare the sustainability performance of farms and processors within the food sector with each other to provide a basis to consumers to make informed decisions.

Therefore, SMART was developed to allow farms and companies in the food sector to assess their sustainability performance in a credible, transparent and comparable manner. Regarding the implemented definition of sustainability, SMART builds upon the SAFA Guidelines[4] (Sustainability Assessment of Food and Agriculture systems) of the FAO. This guarantees the global acceptance and applicability of the tool. While SMART is fully compliant with the SAFA Guidelines, it provides an efficient manner to apply them in practice.

Sustainability in food and agriculture systems, as defined in the SAFA Guidelines, includes environmental integrity, economic resilience, social well-being and good governance (FAO, 2013). These four sustainability dimensions are further specified by 21 themes (Figure 4.) that in turn are differentiated into 58 sub-themes. For each of the sub-themes, FAO has defined a goal for sustainable practises. SMART defines indicators, which measure the degree of goal achievement for each of the sub-themes.

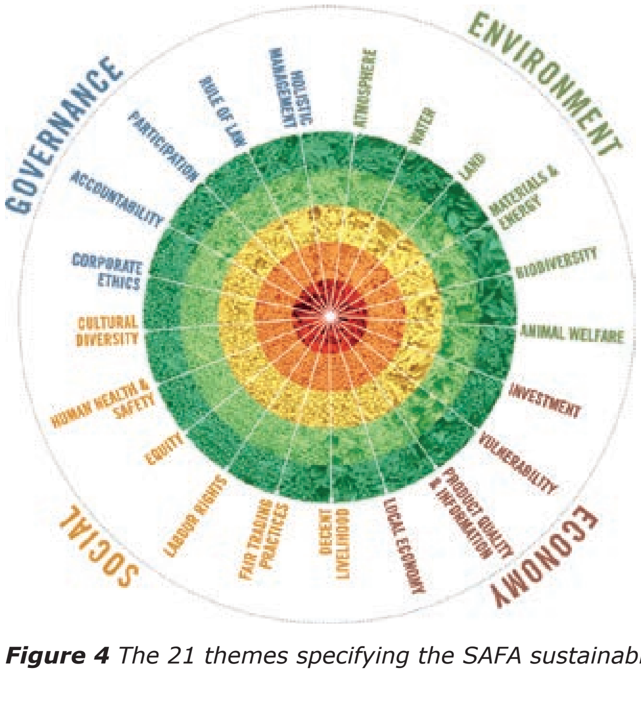

***Figure 4** The 21 themes specifying the SAFA sustainability dimensions (FAO, 2013).*

3 http://www.fibl.org/en/themes/smart-en.html

4 http://www.fao.org/nr/sustainability/sustainability-assessments-safa/en

As for SMART, the aim of the SAFA Guidelines is to harmonise sustainability assessments in the food sector and make sustainability assessments of companies more transparent and comparable (Schader *et al.* 2014). The guidelines outline a procedure for an integrated analysis of all dimensions of sustainability, including the selection of indicators and rating of sustainability performance (FAO, 2013). Based on the SAFA sub-theme goals, specific sets of indicators for farms and companies have been elaborated for SMART to assess the sustainability along the whole supply chain.

The relevant indicators for a specific company or farm to be assessed are determined prior to a SMART assessment based on e.g. the business or the farm activity, respectively. Accordingly, context-specific indicators are compiled individually for each farm or company. If in a specific case one or several SAFA sub-themes are deemed irrelevant for the assessment (e.g. the sub-theme animal health in the case of a vegetable growing farm) they will not be rated. However, for reasons of transparency exclusions have to be explained in detail. This procedure is not only in line with the SAFA Guidelines, but also with other standards as for example the Global Reporting Initiative GRI-G4 (www.globalreporting.org).

The assessment within SMART involves a weighting of the indicators according to the level of impact on the goal-achievement of the various SAFA sub-themes. Furthermore, the indicators cover not only the activities on a farm or a company's premises but also the entire sphere of influence (Figure 5). In the case of a company in the food sector, the potential influence of the respective company on its supply chain is considered. The sphere of influence usually depends on the respective position of the company within the supply chain, its size and its market power. The sphere of influence is identified at the beginning of a SMART assessment.

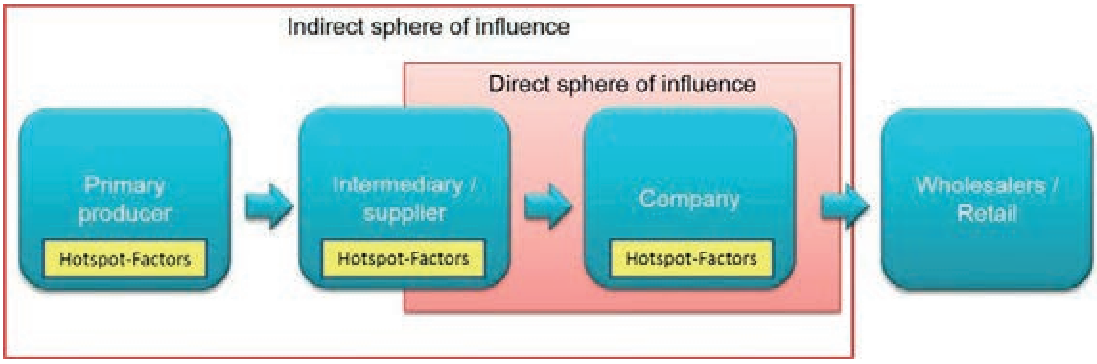

Figure 5 *Direct and indirect sphere of influence of a hypothetical medium-sized production company. Hotspots (or Hotspot-Factors) are commonly called areas of high or low sustainability performance.*

The sphere of influence is differentiated between the direct and indirect sphere of influence. The direct sphere of influence includes all processes that take place on the company`s premises as well as all processes that take place at suppliers or buyers on which a direct influence exists, e.g. in the form of close business relations or even mutual dependence. The indirect sphere of influence includes all areas in which actions of the assessed entity only have an indirect impact, as for example, when buying agricultural raw material from intermediaries. In the case of a farm, the origin of the farm inputs is assessed. The integration of the indirect sphere of influence into a SMART assessment is crucial since the most important environmental and social impacts of operations often occur in preliminary stages of the supply chain. In the figure above, an example of the sphere of influence of a food processing company is shown.

SMART is a so called distant-to-target method as it measures, as already mentioned above, to what extent a farm or company has met the sustainability objectives for each of the 58 sub-themes defined in the SAFA-Guidelines. The maximum state for each objective referring to the sub-themes is defined by experts and expresses optimal sustainability. As shown in Figure 6, the achievements of the objectives are assessed using a five level scale from zero (red meaning unacceptable) to four (dark green meaning best, i.e. objective fully achieved). This scale is also used for the display of the assessment in radar charts, showing the results as percentage figures.

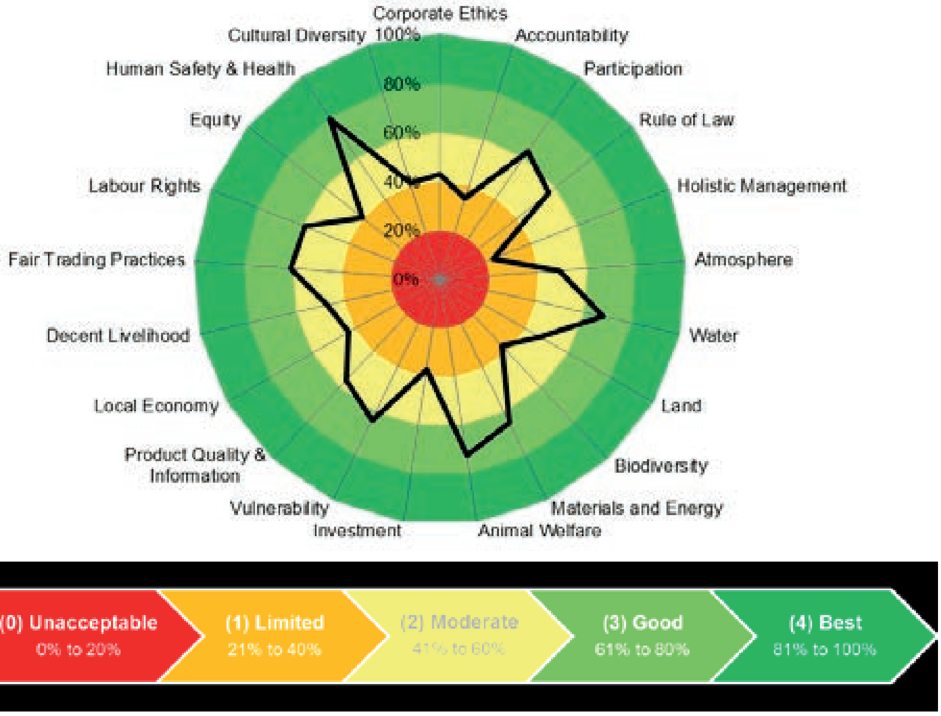

Figure 6 *Example of a radar chart as output of a SMART assessment with ratings for each of the 21 SAFA themes.*

A SMART assessment is based on a wide range of data available within companies or farms that usually exists in written form. These include for example data from certifications, audits, carbon footprints or from LCAs. However, a SMART assessment always includes an inspection and an interview with the farm or company manager. In the case of a farm inspection, the interview will usually not take longer than 2-3 hours.
In order to provide SMART sustainability assessment services, FiBL founded the spin-off Sustainable Food Systems Ltd. (SFS)[5], which now is the owner of the license rights and rights of use of SMART. The SFS is owned by FiBL Switzerland, Germany and Austria.

5 http://www.sustainable-food-systems.com/

Case example: SMART assessment of ornamental plant producing companies with greenhouses.
In 2014, nine ornamental plant-producing companies in Switzerland were assessed using SMART. All of them had greenhouses installed to grow their ornamental plants. The insulation of those greenhouses and the share of renewable energy, for example, had a direct effect on how they scored in the SAFA sub-theme energy use within the theme "Materials and Energy". This explains to a large extent the variation in the performance within this sub-theme. However, some of the other sub-theme had even higher variation, indicating that improvement in those sub-themes can be equally rewarding for the greenhouse companies.

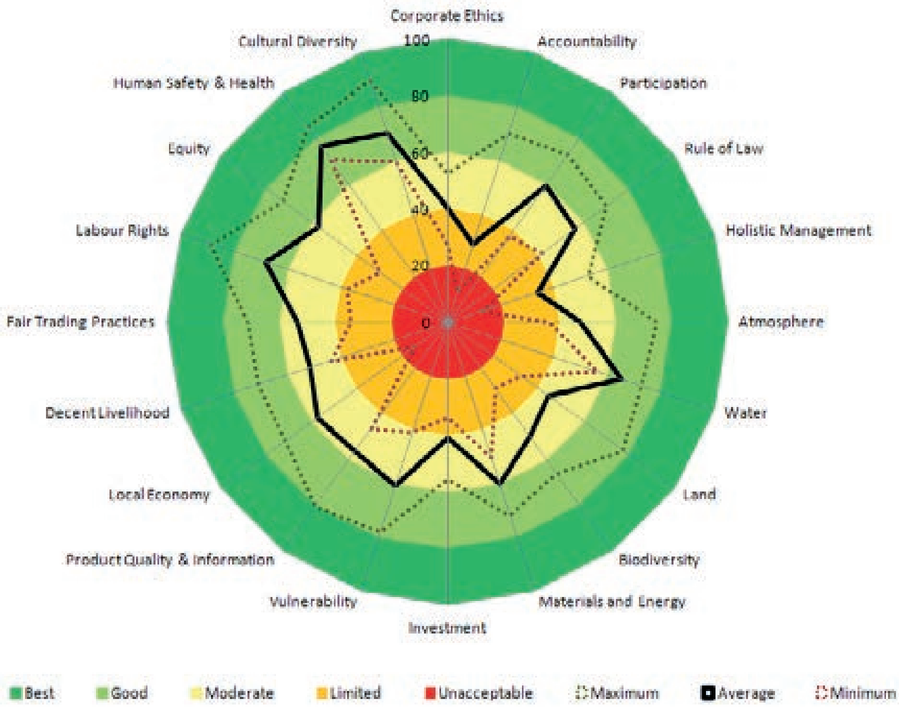

Figure 7 *Average, minimum and maximum score in the SAFA dimension environmental integrity for the nine ornamental plant producing companies assessed in Switzerland, 2014.*

6 Public Goods tool (PG)

By Lucia Foresi and Anja Vieweger

The Public Goods tool (PG tool) was developed in 2010-2011 (Gerrard *et al.* 2011) as part of a project funded by the United Kingdom government and Natural England (a government agency for the natural environment in England), to provide a simple, measurable and accessible way to show public goods that come from different farming systems. As part of the development process, a stakeholder workshop was held involving researchers, advisors and Natural England representatives. It identified a variety of agriculture-related "public goods" in England against which the tool would assess each individual farm: soil management, biodiversity, landscape and heritage, water management, manure management and nutrients, energy and carbon, food security, agricultural systems diversity, social capital, farm business resilience, and animal health and welfare.

These areas, known as "spurs", were chosen to account for a range of benefits spreading across social, environmental and economic issues. The tool has been designed to be used on-farm with an advisor gathering data through an interview with the farmer; it has been constructed as a computer spreadsheet workbook with a worksheet for each spur. In addition, there is an initial data sheet collecting general farm information used in multiple spurs and a sheet for results, which provides graphical representations of the farm's assessment as soon as the interview is completed.

Each spur is assessed by asking questions based on a number of key "activities", which allows the advisor to evaluate the detailed ways in which the farm provides each public good. The choice of activities was influenced by a desire for the collected data to be of a type that a farmer would have in their farm records already, and to give enough in-depth information while being direct to the point; they were also selected to have balance between quantitative and qualitative data. This allows the assessment to be completed within 2-4 hours so as not to interfere too extensively with the farm activities.

Each question is given a score between 1 and 5, where 1 is the lowest mark (no benefit is provided) and 5 is the highest score; some scores have a not applicable option (n/a), whenever a farmer cannot possibly provide that benefit. The scores for each spur are obtained by averaging the scores of all its activities, which are then shown on a radar diagram (with mean, minimum and maximum values), allowing farmers to see where they are performing well and which areas could be improved. A bar chart showing all the activities and their final scores gives more detailed information so that farmers can identify specific activities to work on to improve the score in the future. For further references, see Anon (2014) and Gerrard *et al.* (2012).

Spurs and activity description

Soil management. It assesses a farm's performance in monitoring soil organic matter and nutrient levels (through soil analysis), in addition to evaluating the amount of damage due to erosion (questions based on guidelines).

Biodiversity. It assesses how well the farm is managed in relation to environmental stewardship and encouraging native wildlife. The activities assessed are agri-environmental participation, BAP (Biodiversity Action Plan) habitats and SINCs (Sites of Importance for Nature Conservation), SSSIs (Sites of Special Scientific Interest), conservation plan, awards and habitat.

Landscape and heritage. It assesses how well a farm contributes to the preservation of the countryside and its heritage. The activities assessed are historic features, JCA (Joint Character Area) and landscape features, and management of boundaries.

Water management. It is assessed through the measures taken to reduce pollution, the source of water used and the efficiency of irrigation systems put in place (questions based on guidelines).

Manure management and nutrients. It spreads over two worksheets: the first is an NPK budget that takes information from the initial data collection sheet and calculates a 'farm gate' balance for these macronutrients, while the second contains more qualitative questions about the management of nutrients, manure and wastes on the farm.

Energy and carbon. It spreads over three worksheets. The first focuses on the farm's fuel and electricity use, recording both the total amount used and the amount attributed to the various types of enterprise (e.g. arable, beef and sheep, dairy, poultry and pigs, horticulture). The second shows the farm's performance in terms of MJ of energy per head of livestock, or per hectare, in comparison with energy and carbon benchmarks mentioned in national guidelines; the final sheet asks more qualitative questions regarding the farm's energy use.
Food security. It assesses the contribution of the farm to food quality and availability of food in the local area. The activities assessed are total productivity, local food, off-farm feed, food quality awards, food quality certification and production of fresh produce.
Agricultural systems diversity. It determines to which extent the farm is incorporating a range of crop varieties and animal species in its production methods.
Social capital. It assesses the farm's engagement with the community and the benefits it provides to it, from public access to training its employees. The activities assessed are employment, skills and knowledge, community engagement, CSR (Corporate Social Responsibility) initiatives and accreditations, public access, human health issues.
Farm business resilience. It assesses the financial resilience of the farm as a business and whether it is a long-term prospect, using two activities: financial viability and farm resilience.
Animal health and welfare. It assesses how the farmer manages their livestock in order to ensure their health and welfare. The activities assessed are staff resources, health plan, animal health, housing and biosecurity, and ability to perform animal behaviour.

Case Study: Tolhurst Organic Partnership C.I.C.

Tolhurst Organic Partnership C.I.C.[6] is located just outside the village of Whitchurch-on-Thames, in South Oxfordshire, UK, and it is situated in the Hardwick Estate, with 8 ha in two fields and 1 ha in a 500-year-old walled garden. It is one of the longest running organic farms in England, holding the Soil Association[7] certification and having been the first one to obtain the Stockfree Organic[8] logo in 2004, indicating farming free from all animal inputs which can be marketed as vegan organic. It was also the first business to be part of the Vegan Organic Network (VON)[9], which produced the first set of stockfree organic standards in the world in 2007. Iain Tolhurst is one of the founder members of the Thames Organic Growers[10], and his farm was registered as a Community Interest Company (C.I.C) in May 2014.

Figure 8 *Iain Tolhurst explaining woodchip based composting to replace peat as a growing media.*

6 http://www.tolhurstorganic.co.uk/
7 http://www.soilassociation.org/
8 http://www.stockfreeorganic.net/
9 http://veganorganic.net/
10 http://www.thamesorganicgrowers.org/

In 2007, the total carbon footprint of the farm was calculated[11]. Results showed that it is approximately 8 tonnes, which is the same as the average household (2.2 persons) in the UK has. The farm produce was rated being 90% more efficient than conventional supermarket produce.

The following paragraphs show the detailed results of the assessment done using Public Goods tool in March 2015, including the final graphical representation (Figure 9).

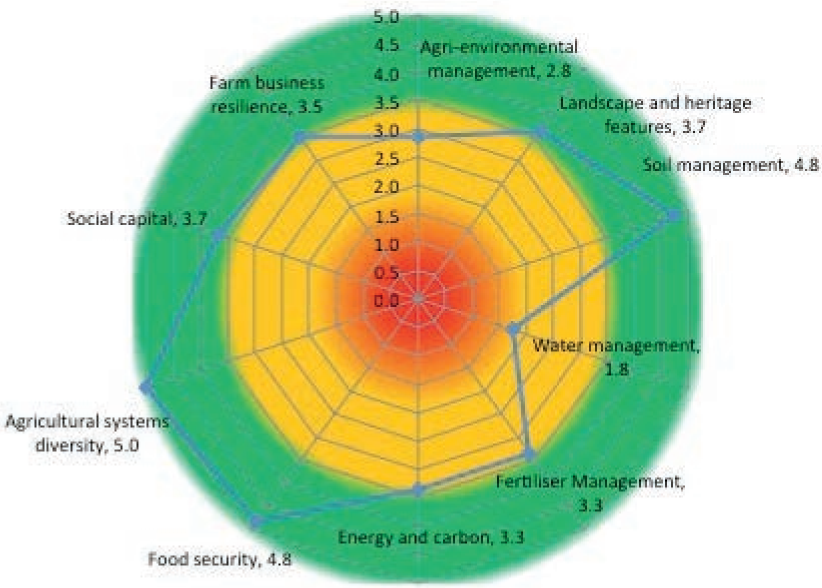

Figure 9 *Graphic results of the sustainability assessment done via Public Goods tool in March 2015.*

Soil management. This spur got one of the highest scores (4.8/5). Soil is analysed annually and is never left uncovered due to the use of green manures and undersowing. Compost produced on farm is used as growing media for plant propagation (Figure 8) and is added to the soil.

Agri-environmental management. This spur got an average score (2.8/5). Although the farm does not fall under specific environmental schemes or have an up-and-running conservation plan, alternative measures are used to maintain biodiversity. Various ecological structures (e.g. beetle banks, hedges, field margins) are present and managed all around the farm, to serve as refuges for natural predators and a source of food for wild animals, and no chemical substances are employed for pest control. The farm also established an agroforestry system in half of its field production area in 2015; this will, apart from a further diversification of produce from the land (e.g. apples, nuts, wood), further improve the effect on biodiversity and ecosystem services.

Landscape and heritage features. The score for this spur was quite high (3.7/5). Low scores were received for not comprising any historical features on the farm or reflecting the Joint Character Area in any measure. However, they were outmatched by the top scores received by the presence of 500 m of hedges with mixed indigenous species and shrub planted, and a total 1,800 m of hedgerows that reduce pest attacks and keep a healthy balance of predators. Moreover, the farm is classified as an AONB (Area of Outstanding Natural Beauty). Water management. This spur got the lowest score of the whole assessment (1.8/5): irrigation is used for a period of 20 weeks every year (spring-summer) and water is directly abstracted from the aquifer; currently, no rainwater is harvested, no localised irrigation system is in use and there is no management plan in action (i.e. protection against floods and runoff, water pollution).

11 Carbon footprint results are from an audit by Prof. Tim Jackson (BBC Climate Change special programme, March 2007); source: www.tolhurstorganic.co.uk).

Fertiliser management. This multi-sheet spur got a more-than-average score (3.3/5). As mentioned before, green manures are an important part of the rotations and are present all-year round, so the soil remains constantly covered. In terms of nutrients, their levels are periodically monitored through a budget-like software; according to the assessment, there is a general K deficit, which could be solved by applying wood ash as a natural fertiliser. The only wastes the farm produces are all organic, amounting thoroughly 250 m^3 per year, and they are recycled as compost, whose major nutrients are measured.

Energy and carbon. Like the previous one, this multi-sheet spur got a more-than-average score (3.3/5). In terms of consumptions, the total energy goes on fuel for tractors, delivery vehicles, and other machinery (approx. 1500 litres/year) and electricity is used for lighting buildings, providing facilities for plant growing, and other odd jobs (3400 kWh/year). On-farm energy use and greenhouse gases production are periodically monitored; also, alternative methods for energy production are being considered but none of the energy currently used on-farm comes from renewable sources.

Food security. This spur got one of the highest scores (4.8/5). Growing local fresh produce, while reducing the aid of external inputs to a minimum, is a fundamental part of the farm's philosophy, and all the vegetables produced are sold to local families and communities.

Agricultural systems diversity. This spur got the highest score of the whole assessment (5/5). The farm grows 300 different crops, between vegetable species and varieties, all-year round on approximately 9 ha of land, and it manages to supply fresh produce for an average of 50 families per ha.

Social capital. The score for this spur was quite high (3.7/5). In an average year, the farm produces at least 85% of the value on its land and delivers fresh in-season vegetables and fruit through the Neighbourhood Rep Scheme, which runs the drop-off points. Employees are well trained and highly qualified. Access to the farm is not public but a number of different means of communication are employed to promote community engagement, such as farm walks, research projects, farmers' markets, open days.

Farm business resilience. The score for this spur was high (3.5/5). Even though the sources of income for the farm are multiple, net assets tend to stay the same through the years, giving the farm not many chances to make investments, so the business is generally surviving.

Animal health and welfare. Since the farm is Stockfree Organic and produces vegetables without using animal inputs, this spur is considered not applicable and was not included. For this analysis, it did not receive any scores. However, it can equally be argued that no animal was harmed or its welfare compromised in any way for the production and therefore this spur should receive full marks, especially when comparing it with livestock farms.

The results were presented to the grower and discussed and although many spurs showed very high scores for public good delivery (food security, systems diversity), there were others which showed weakness (like water management). The grower was already aware of this, but not of the extend of the weakness compared to the other high scores. In the meeting following the assessment options on how to better address water management in a region of England, which in some years has only 450 mm of rainfall and in others can be flooded, were discussed. Options include underground rainwater harvesting, grey water use or natural swimming pools.

7 Ecological Footprint

By Denis Stajnko, Tjaŝa Vukmaniĉ and Martina Bavec

The concept of a footprint could be represented with the simple example of a person walking ruthlessly on the meadow and leaving foot traces behind him – no grass will grow there for a long time. If this person was more careful, ground vegetation could regenerate more quickly. In other words, the ecological footprint is a measure of how much human activity changed and charged the nature. The more raw materials are consumed and pollutants are produced, the greater the environmental pressure. The ecological footprint estimates the biologically productive area needed to produce materials and energy used by the population of a certain region. This calculated area is then compared to the available area to a certain population or individual, which is called biocapacity. Biocapacity represents the productive land and/or water of a region. If the ecological footprint is greater than the biocapacity, human consumption exceeds natural carrying capacity (Haberl, 2001). Data used for calculation of the ecological footprint usually rely on statistical information. Beside these tools, we also know other methods based on actual data and more appropriate to evaluate individual production process like Life Cycle Assessment (LCA), as described in chapter 2 of this booklet (Heijungs *et al.* 1992).

With the help of an ecological assessment, it is possible to analyse processes (material or energy flows). The idea is to determine a surface to sustainably embed a process in the ecosphere also called the Sustainable Process Index (SPI), which evaluates processes according to environmental capacity (Narodoslawsky and Krotscheck, 1995). The results of ecological footprint calculations can be interpreted on a per-unit-of-product basis (kg) or equivalent area (ha) (van der Werf *et al.* 2007). None of the current ecological assessment methods is telling the "whole truth" because they depend on a value system and certain predictions how this process can affect the environment. However, they point to important environmental aspects and provide a useful decision support. Depending on scientific discipline, there are different definitions of what is ecologically correct, and therefore there are different models to calculate the carrying capacity of planet Earth and different approaches to different ecological dimensions.

One of various ecological footprint evaluation methods is the Sustainable Process Index (SPI), which was developed by Krotscheck and Narodoslawsky (1995). With this evaluation, it is possible to create an entire life cycle of a particular product or process in the form of process chains, which can be updated and improved over and over again. The footprint of the SPI method calculates the actual surface needed for some specific process (Figure 10). It is based on the concept of "strong sustainability", assuming that a sustainable economy builds only on solar radiation as natural input. Most natural processes are driven by this input and the earth's surface acts as the key resource for the conversion of solar radiation into products and services. Global surface area is, however, a limited resource in a sustainable economy, and anthropogenic as well as natural processes compete for it. Therefore, the area required to embed a certain process sustainably into the ecosphere is a convenient measure for ecological sustainability; the more area a process needs to fulfil a service, the more it "costs" from an ecological sustainability point of view. This evaluation method has been customized for agriculture (Narodoslawsky and Krotscheck, 1996). The ecological footprint can be expressed in ha per ha of production area or in ha or m^2 per t or kg of agricultural produce per year. In this case, it is called the Ecological Efficiency Index (EEI).

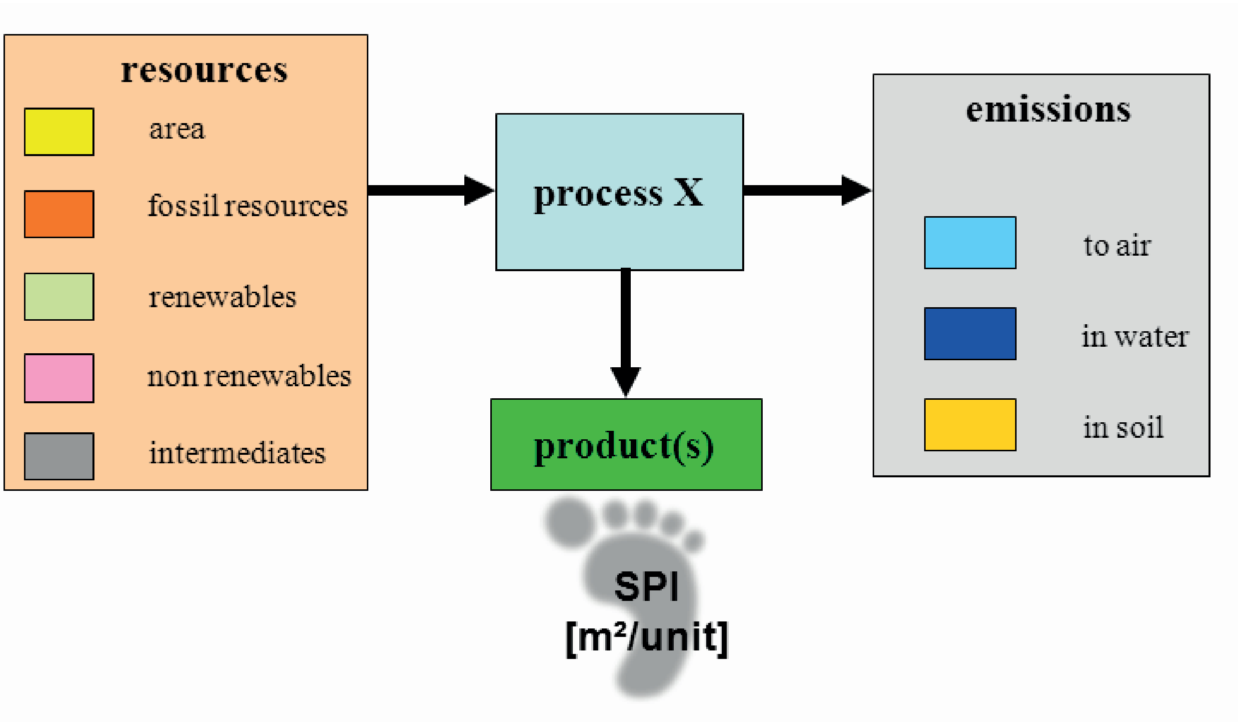

Figure 10 *Sustainable Process Index (SPI) calculation, material and energy flows of a process (SPIonWeb).*

At the Technical University of Graz (Austria) the SPIonWeb tool (http://spionweb.tugraz.at) was developed for estimating the ecological footprint, CO_2 (kg) emissions and GWP (global warming potential). The ecological footprint of each production or transport system and for other products or services is estimated by including environmental impacts related to fossil-C (kg CO_2 ha^{-1}), air, water, soil, non-renewable, renewable and area resources.

According to the SPIonWeb tool, the calculation of fossil-C assumes sedimentation of carbon to ocean beds, which requires about 500 m² of sea ground per year to put 1 kg of carbon back into the long-term (fossil) storage of the seabed. The footprint for emissions to water is based on a replenishment rate, which is based on the precipitation rate in a specific geographic region of the compartment and a natural concentration of the emitted substance. The footprint for emissions to soil is similar to the footprint for emissions to water, and it is calculated based on the regeneration rate of the compartment soil calculated as compost generated from grassland and the natural concentrations of the emitted substances in the top soil. The footprint for emissions to air does not have a natural replenishment rate as do the other compartments, but the natural emissions of gaseous substances by forests are taken as a reference. CO_2 (kg) emissions are calculated from the "area for fossil carbon", where the extracted fossil carbon and carbon based materials are assumed to be oxidized to CO_2 over the life cycle and finally to end up as CO_2 emission to the atmosphere. GWP potentials are calculated on the basis of GWP factors, where material flows of GWP are calculated by multiplying the GWP factor of the components in the flow and their respective inventory. The sum of CO_2 life-cycle-emissions and other GWP relevant impacts is the total GWP measured in kg CO_2 equivalent (Narodoslawsky and Krotscheck, 1996). Moreover, the ecological footprint expressed in GWP (global warming potential) is another important measure for evaluating the impact of processes on the environment. The sum of CO_2 life-cycle-emissions and other GWP relevant impacts yields the total GWP measured in kg CO_2 equivalent (Cooper *et al.* 2011). In the case of evaluating sustainability of agricultural production systems using ecological footprint the effect on biodiversity and quality of products or food is not included.

Influence of production system and energy source on the ecological footprint

Intensification is one current trend in agriculture, which is even more pronounced in greenhouses. It can be characterised as external input intensive, aiming for high yields, by using high amounts of resources such as nutrients, light, heating, carbon dioxide and other external inputs such as plastic mulches, containers, packaging materials etc. Excessive increases in production intensity can undermine the sustainability of greenhouse production, and this is could also be true for some organic greenhouse production types. In general, greenhouses are environments that can be controlled to a much higher degree than outdoor fields. Temperature, light, air humidity, water supply and carbon dioxide in the air can be regulated. In some modern greenhouses, even the access of pests and pathogens can be restricted or prevented. There is also soilless production, either in substrates of organic or inorganic materials or as hydroponics, but the inorganic growing media and hydroponics are excluded in certified organic cropping (EGTOP, 2014). According to LCA principles ecological footprint calculations also include, all construction materials (glass, plastic, steel, pipes, and ground), equipment (heating, irrigation, and ventilation) and materials (fertilizers, growing media, substrates, pesticides, type of energy for heating, mulch foil).

In order to improve local production we analysed several production methods and systems: glasshouse soilless with additional heating, PE polytunnel with additional heating, open field integrated vegetable production, organic farming under a PE polytunnel with additional heating and organic farming, under a PE polytunnel without additional heating (Tables 1 and 2). Stajnko (2015) calculated ecological footprints of some alternatives in type of energy and compared: heating with extra light oil (ELO) with 100 kW boiler for 1.000 m^2 using fan-jet in plastic tunnels and pipes in glasshouse, wood chips in plastic house instead of ELO and geothermal energy from 1,500 m depth bore instead of ELO in glasshouses.

Table 1

Description of different tomato production systems included in ecological footprint calculations.

Production system	Yield (kg/ha)	Vegetation period (months)	Harvesting period (months)
Glass greenhouse - soilless	495,000	11	9
Polytunnel (PE plastic)	275,000	8	6
Field production – not protected	127,000	6	4
Organic production under PE plastic	57,000	6	4

Table 2

Ecological footprint, CO_2 emissions and global warming potential (GWP) pro kg tomato dependent on different production systems (ELO heating with extra light oil).

Production system	Ecological footprint (m^2/kg)	CO_2 (kg)	GWP (kg)
Glass greenhouse – soilless ELO	110.97	0.6435	0.9591
Polytunnel, black mulch foil – soilless ELO	20.00	0.0831	0.4887
Polytunnel, black mulch foil – not heated	18.26	0.0681	0.4743
Open field production, black mulch foil – integrated	19.42	0.0673	0.5023
Organic production under PE plastic – not heated	13.46	0.0419	0.0645
Organic production under PE plastic – heated	16.75	0.0689	0.1006

There is also concern about the trend of intensification of vegetable production under protected area and the increasingly long distance food chains. The majority of consumers expect that vegetables have high external and internal values, which do not damage environment, but a detailed insight shows the exact opposite. Choosing proper production methods could have important effects on the ecological footprint and our results show is much lower with organic farming methods compared to conventional methods (i.e. soil les, integrated). Organic farming also reduces the global warming potential and CO_2 emissions. Although the yield ratio between organic and hydroponic tomato production was almost 1 to 10 times (Table 1), the ecological efficiency performance is better in organic production amounting 16.75 m^2/kg tomato compared to soil less production amounting 110.97 m^2/kg tomatoes (Table 2). Based on these results, these recommendations are suggested: (a) local organic production under protected area should assure maximal quantity for consumers and the lowest ecological footprint per kg; (b) heating with expensive fossil fuels can be successfully exchanged with other kinds renewable energy sources in form of geothermal energy, waste processing heat, wood chips and other biomass chips (Stajnko, 2015).

Influence of transport distance on ecological footprint – A example case-study in Slovenia
In Slovenia and other EU countries there is much long distance transport of vegetables. Long distance transport of vegetables is used not only in conventional but also in organic farming, even though the idea of organic farming is "local production for local consumption" and "seasonal" production.

For the evaluation of the transportation impact of fresh tomatoes, Stajnko and Naradoslawsky (2014) used the following transport scenarios: (a) local production and consumption within a maximum range of 50 km (Slovenia); (b) regional production with 250 km transport distance (Slovenia); (c) cross border transport from northern Italy (1,000 km); (d) transcontinental transport (2,500 km) from Almeria (Spain) to Slovenia. When analysing the truck transport different loads appeared depending on the distance and costs. Thus, in local production a 16 t truck, in regional transport a 28 t truck and in cross border and transcontinental transport a 40 t truck was assumed for the analysis (Stajnko and Naradoslawsky, 2014).

Transport is not directly dependent on the production method, but there is a strong connection with particular distribution networks and linked transport regimes. As seen from Table 3, transport increases the ecological footprint when transport distance is increased. The increase depends mostly on tons/kilometres (t/km) and the capacity of trucks used for a particular destination and quantity of product. For this reason, the transport of 1 kg of tomato from Almeria (Spain) to Slovenia leaves the largest footprint 177.7 m^2/kg per year for a 2,500 km long distance. This exceeded the cross border transport of 125.6 m^2. In the case of regional transport the footprint is much lower and lies at 17.8 m^2, which is only 10 % of the transcontinental transport. The lowest footprint, 5.4 m^2 is left by local transport (50 km) and the use of smaller trucks. Even though, local production is favourable to all other systems, it is currently difficult to assure such short transport for all consumers in Slovenia due to urban areas and specific optimal growing conditions for tomatoes, which require daytime temperatures between 27-30^{o}C.

Table 3
Ecological footprint (m^2 per kg per year), CO_2 (kg) emissions and GWP (kg CO_{2eq}) caused by transport of 1 kg fresh tomato and indexes (L = Local, was set as 100%).

Transport distance	Footprint (m^2/kg)	Index of footprint (L=100%)	CO_2 (kg)	Index CO_2 (L=100%)	GWP (kg CO_{2eq})	Index GWP (L=100%)
Transcontinental 2,500 km	177.7	3265	0.75	3205	2.34	2968
Cross border 1,000 km	125.6	957	0.21	933	0.60	765
Regional 250 km	17.8	326	0.08	320	0.02	297
Local 50 km	5.4	100	0.02	100	0.08	100

Increasing transport distances directly also affect CO_2 (kg) emissions (Table 3). Again, it depends mostly on tons/kilometres (t/km), thus the transport of each kilo tomato from Almeria (Spain) to Slovenia leaves 0.75 kg CO_2 emissions for a 2,500 km distance. This exceeded the regional transport 10 times, i.e. 0.075 kg CO_2. Generally, CO_2 released in transport affected the total CO_2 increase mostly due to the combustion of fossil-C. The additional global warming potential (GWP) share caused by transport follows the example of the other two measures. The biggest GWR is left by transcontinental transport and it amounts to 2.34 kg, followed by the cross border transport (0.60 kg). Regional and local transport left much lower GWP. Comparing the relative increase of CO_2 emissions with the relative increase of GWP (Index values in Table 3 based on local=100) the GWP effects are slightly smaller. The main reason lies in the fact that GWP potentials are based not only on CO_2 life-cycle-emissions, but also on other GWP relevant impacts.

Currently, the main reason for a lengthy transport (from Spain or Italy) is the favourable regional climate in southern Europe, which allows open field and PE tunnel production from late spring to the end of autumn without additional heating, and glasshouse production with minimal ELO heating. In addition, full cost accounting for the depletion of water recourses and negative externalities like nitrogen leaching or impact on the landscape are currently not included in the low prices of long transport greenhouse vegetables. Lower outdoor temperatures in Central Europe can be offset to some extent by the application of alternative renewable energy sources, which together with a reduction in transport distances might significantly affect the ecological footprint, CO_2 and GWP.

In the evaluation of the ecological footprint of transport the fossil-C is the most prominent Sustainable Process Index (SPI) resource among all resources captured in SPI calculations and its value was estimated to 57.5 to 58.6%, respectively. The second most important category represents the air (29.2 to 29.6%) and the third water with 12.7 to 11.4%, respectively. Transport also has a significant impact on the air/water emission ratio, with a generally decreasing importance of emissions to water and an increase in emissions to air. The air part was mostly reduced in cross border transport, where it went down from 29.6% to 28.5%, while the water impact rose from 11.4% to 14.6%. The main reason lies in the combustion of Diesel fuel used for the transport of 1 kg of tomatoes at a distance of 1 km. This is relatively bigger in the 50 km transport by a 18 t truck, but smaller for cross border 1,000 km long transport with a 40 t truck. In all other SPI categories, no clear changes were detected in any production system (Stajnko and Naradoslawsky, 2014).

Conclusion

Based on this case study on tomato production and transport we conclude that local and regional production results in a much lower ecological footprint and global warming potential compared to long distance (transcontinental) transportation. Although the yield ratio between organic and soil-less (hydroponic) tomato production was assumed as almost 1 to 10, the ecological efficiency performance is better in organic production. A more efficient use of external inputs has to maintain the public trust in the sustainability of greenhouse production including organic greenhouse production, which should be consistent with the organic principles

8 Carbon footprint calculators

By Ulrich Schmutz

Background

Carbon footprint calculators are one way of measuring the amount of carbon generated by agricultural businesses, and the carbon sequestered by the soil and biomass on the land. There are several free online examples of carbon calculators available to farmers and growers (Soil Association, 2012 and 2013) and as one example we describe and discuss the Farm Carbon Calculator (www.farmcarbontoolkit.org.uk/carbon-calculator). This was initiated by organic horticultural growers in the UK and hence provides a better understanding of organic horticulture then most other calculators available in this category. The calculator is in version 3.0 and it has been designed by farmers for farmers; it is very user-friendly and displays results clearly enabling good understanding of carbon emissions. It is comprehensive and takes in carbon sequestration, backed up by scientific studies (www.cffcarboncalculator.org.uk/calculator-introduction).

The Farm Carbon Cutting Toolkit (FCCT) is a non-profit organisation dedicated to helping reduce the greenhouse gas emissions and increasing carbon sequestration. Initially the Carbon Calculator was created by organic growers Jonathan Smith and Mukti Mitchell in September 2009 and includes research by Rupert Hawley and Jenny Hall. It was updated in October 2010 by Jonathan Smith. The latest version, version 3.0 has been led by organic grower and FCCT Directors Jonathan Smith and Adam Twine with assistance from Dr Ulrich Schmutz of Garden Organic and CAWR, Coventry University and is supported by organic stakeholders including growers and UK charities like Garden Organic and Soil Association.

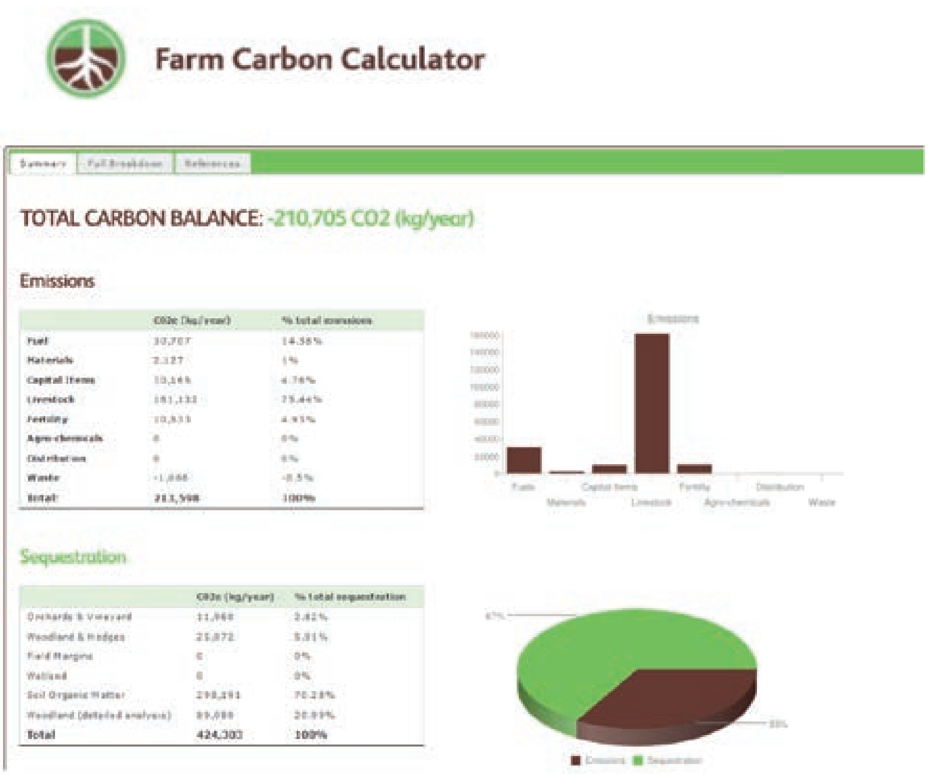

***Figure 11** Screenshot of the Farm Carbon Calculator*

Interpretation
One of the main aims of the calculator is to "speak" in language farmers and growers can understand because ultimately it is them who can make decisions on their farm to change their management practices and improve their carbon footprint. The website has therefore background resources available to farmers where they can self-educate them about all issues around carbon footprinting. The Soil Association (2012) describes version 2.0 as "simple and easy to use, requiring basic computing stills". It takes about an hour to complete provided the data needed is to hand. The carbon calculator uses a broader scope to a whole farm calculation than other available tools, taking into account sequestration and embedded emissions (i.e. in farm machinery and building/ infrastructure materials) to a greater extent. The calculator's database uses data from over 30 sources including IPCC 2006 and Defra GHG Conversion factors. A report is produced displaying the results of the calculation, which indicates the level and type of emissions attributable to the various areas of the farming system. The result indicates the annual whole farm emissions in CO_{2eq} as well as total emissions of CH_4, N_2O and CO_2.

As scope the handbook for producer support (Soil Association, 2012) has the following summary of the scope of the calculator regarding direct emissions (scope 1), emissions associated with energy use (scope 2) and indirect emissions (scope 3):

Table 4
Summary of the scope of the carbon calculator regarding direct emissions (scope 1), emissions associated with energy use (scope 2) and indirect emissions (scope 3), modified from Soil Association (2012).

Scope 1 Direct emissions from sources that are owned or controlled	• Fuel and energy use (on farm and contracted) • Livestock • Manure management/storage • Cropping areas, history and yields • Incorporated crop residues • Lime • Fertility and biomass inputs • Carbon sequestration by woodland, soils, wetland, uncultivated areas and farm habitats • Land use changes
Scope 2 Emissions associated with the generation of purchased energy used on the farm	• On-farm energy production (electricity, bio-gas, heat) • Off-farm energy purchase
Scope 3 Indirect emissions associated with the production, processing and distribution of inputs in to the farming system also includes embedded emissions in machinery, building materials and infrastructure.	• Production of imported fertility • Embodied energy in building materials, greenhouses, polytunnels • Vehicles, consumables and infrastructure. • Off-farm processing • External distribution systems

Drawbacks: Since there are several different tools farmers and growers may get confused which tool to use. The tools also have different foci e.g. the FCCT described above was developed by organic horticultural growers, hence the tool is more detailed on horticulture, polytunnels and greenhouses but not so much on conventional agriculture and livestock farming. In version 3.0 those features have been added to the tool but its origins in organic horticulture cannot be denied. Another problem is, that free web-tools make it easy for the tools to spread, however it makes continuous maintenance und updating difficult, as funding has to be found for each new version. On a more general note all carbon footprint tools only address carbon and carbon equivalent emissions and they are less comprehensive then LCA.

Advantages: On the other hand, the tools address the management options a farmer or grower has on a whole farm and by focussing only on carbon emissions it makes it less complicated and confusing for the grower. By including embedded emissions, on-farm energy generation and options for carbon sequestration it makes the grower think on a much wider level within the wider rotation and diversity of the farm and its supply chain, rather than just looking at e.g. the LCA of one specific crop like greenhouse tomatoes.

9 Conclusions and outlook

By Lucia Foresi and Ulrich Schmutz

Categorising existing tools and searching for new insights
This handbook mainly reports on the first-hand experience the authors and members of the COST action have with sustainability assessment tools. This booklet is not a comprehensive review of all tools available and there are further tools which could not be covered in detail e.g. http://efoodprint.com, www.coolfarmtool.org, and http://waterfootprint.org. The tools presented and discussed in this handbook might be split into three categories (the order of chapters follows this categorisation):

1. Academic and advisory tools for specific dimensions of sustainability: LCA, S-LCA.
These tools are often too complicated for an online self-assessment and require a considerable amount of quantitative and qualitative data. They are robust and developed further by international standards and research.

2. Holistic academic and advisory tools for all dimensions of sustainability: SIA, SROI, SMART, PG.
These tools are also too complicated for an online self-assessment, but can be completed by an advisor or consultant. They require a considerable amount of quantitative and qualitative data and are developed by international standards and research. SROI methodology is unique as it can be used in addition to the other assessment tools and produces a financial value (or full cost price) of social, health, wellbeing and environmental outcomes which then can be compared with economic outcomes.

3. Practical tools for farmer and grower online self-assessment: Ecological footprint, Carbon footprint.
These tools are more practical and require less data input, they often focus on only one issue of sustainability e.g. carbon emissions within the environmental dimension of sustainability. Practical tools give decision support to growers, where and how to improve the management of the farm or greenhouse and may therefore have the highest impact by triggering change on the ground.

Researching resilience and understanding farmers' and growers' perspecitives
None of the above tools was specifically developed for the needs of organic greenhouse horticulture. Most tools address sustainability, but they do not specifically address resilience (with the exception of the PG tool which addresses it only as farm business resilience). Therefore, the lack of specific sustainability and resilience assessment tools for organic greenhouses could be the starting point for finding additional suitable indicators for such a specialised farming system, thus building a set of case studies in different European countries. The employment of specifically constructed questionnaires and semi-structured interviews, using existing methods as references, would be advisable in order to understand how farmers and growers perceive concepts like sustainability and resilience and eventually devise additional methods that could be adapted to different realities across Europe. Resilience and sustainability have often been studied from researchers' perspectives, but the farmers' and growers' perspectives are less well understood.

In addition, it would be desirable to further understand the limiting factors for organic yields (i.e. nutrient and water limitations, pests and diseases) and to compare them to conventional yields (de Ponti *et al.* 2012), however those levels which would be achieved without external fossil fuel and fertility inputs. This will give long-term yield targets for a time when fossil fuels or other harmful inputs (pesticides, artificial fertilisers) are not available to any farming system.

The European Union is currently lacking detailed statistics on areas devoted to organic protected vegetable production. Tittarelli *et al.* (2014) estimate that 5,000 ha of greenhouses are managed organically within the EU. The authors also state that there is an on-going "conventionalisation" of organic practices, since farmers tend to employ organic fertilisers permitted by the regulations rather than resort to agronomic techniques building their own soil fertility and becoming less dependent on external inputs. As Scialabba (2013) highlights, diversification in organic systems is a fundamental part of a preventive and risk-reducing strategy for adaptation to climate change; in the specific case of horticulture, agro-biodiversity is the key to diversification of crops and diets, and ultimately to human survival and wellbeing (Lutaladio *et al.* 2010).

Darnhofer *et al.* (2010) assert that a shift of the emphasis from production and efficiency to learning and adaptability is strongly needed. The pursuit of resilient and sustainable organic horticulture will also require an increase in knowledge-intensive innovations (social and technical), that support decision-making at farm level. Organic agriculture and horticulture can contribute to social equity, through avoidance of issues like loss of soil, water contamination, biodiversity erosion, GHG emissions and pesticide poisoning; they also support employment in rural areas, since they make better use of local resources, thus facilitating access to market for smallholders and relocating food production in marginalised areas (Scialabba, 2013).

Organic horticulture specifically contributes to food security and food sovereignty of rural and urban poor areas; it can be started with initially low costs, and products have high market value, playing an important role for local economic development. In both developed and developing countries, diversification of diets through much more horticultural products can help fighting malnutrition and obesity (Lutaladio *et al.* 2010). Recent economic research in developed countries indicates that doubling of vegetable and fruit consumption (beyond an average 5-a-day recommendation) can increase happiness and wellbeing (Blanchflower, Oswald and Stewart-Brown, 2013). This is particularly interesting as doubling of income or wealth beyond a certain average level has no such influence on happiness and wellbeing (Oswald pers. comm.).

Outlook – beyond the "safety net"

It is clear that organic farming systems need to differentiate themselves from conventional ones and a key action would be to follow agroecological principles (i.e. use of locally adapted varieties, renewable growing media and mulching resources, employment of crop rotations and companion planting) in the production system. But crucially political agroecology has also to play a part in the food system achieving more sovereignty (ownership) of how produce is marketed, transported and sold and how consumers can interact and share the risks of production. Organic principles at their core are not only about production; they include the whole food system including diets, the natural environment and sustainable consumption. Many actors in today's organic market seem to have forgotten the roots of the organic movement and define organic purely as a legal standard, which it clearly is. In fact it is the only legally defined and protected food system in the EU. But this legal protection is only a base-line a "safety net" which protects organic from questionable and on many accounts old-fashioned technologies, developed and heavily promoted in the last century (e.g. artificial fertilisers, pesticides, genetic modification, hydroponics). If the organic movement wants to be of relevance and grow it needs to rise to the challenge and change and transform the food system, not conform to it by simply replacing conventional inputs with certified organic inputs.

It is exactly on these transition pathways, escaping "conventionalisation" where the social, environmental and wellbeing tools like S-LCA, SROI, SMART and PG can help with guidance and decision support. A better understanding of organic growers' perspectives on sustainable and resilience within these transition pathways is equally important.

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Notes:

Notes:

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