Sustainability Hot Spot Analysis: A streamlined life cycle assessment towards sustainable food chains

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Abstract: *In order to take full advantage of sustainability opportunities technological and organisational progress has to be provided with an appropriate direction. New policy approaches, concepts and practical tools are needed to govern agro-food systems development towards sustainability. Especially, accounting for the social dimension of sustainability proves to be a challenge for corporate practitioners, due to its intangible, qualitative nature and lack of consensus on relevant criteria. We suggest the "Sustainability Hot Spot Analysis" (SHSA) as qualitative approach based on stakeholder involvement to integrate social and environmental dimensions along the entire value chain and to identify relevant aspects for a product specific sustainability management. This paper describes the development of the Hot Spot Analysis, which has first been developed by the Wuppertal Institute as reliable and low-cost tool for environmental assessments. In order to integrate the social dimension into the assessment the SHSA needs to prioritise also social themes based on their relevance for each particular life cycle phase. For each life cycle phase and each life cycle aspect the relevance needs to be specified as low, medium or high based on scientific data gathered through literature reviews and stakeholder analyses. This enables the development of a matrix of themes and the phase specific relevance as decision-making support. The paper illustrates single steps and results of the Sustainability Hot Spot Analysis for a case study application to the strawberry value chain. Furthermore the paper discusses the strengths and weaknesses of the tool within a broader context of alternative tools and approaches to shift agro-food systems towards sustainability.*

Keywords: *Hot Spot Analysis, food chain, sustainability, LCA, value chain, environmental and social impact*

Introduction

The food sector demands large amounts of resources (Hahlbrock, 2009; Mauser, 2008; World Watch Institute, 2006) and is linked to high impact in ecosystems (Schmidt-Bleek, 2009; Hahlbrock, 2009). Due to an increasing world population and changing nutrition patterns the global demand for food products will further increase (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2007). There is only a very limited number of detailed studies on single products or entire product chains in the food sector, even though the agricultural industry and „nutrition" as a field of needs are high impact sectors from an environmental perspective (Baedeker et al., 2008).

For practical decision-making, there is a demand for simple, indicatory management and controlling instruments that are based on aggregated information in order to identify environmental and social impacts without being cost or time intensive (Baedeker et al., forthcoming). Established methodologies like environmental life cycle assessment (eLCA) are too time intensive for applying them for all production processes or all products of a company. In fact, there are a few eLCAs publicly available for products of the food industry. For material intensity analyses based on the MIPS-concept (MIPS = Material Input per Service unit), there are also only some examples applied to entire food product chains (Kaiser et al., 2008; Kauppinen et al., 2008a; Kauppinen et al., 2008b). In order to estimate the input oriented impact on the environment caused by a product or service, MIPS indicates the quantity of resources (named "materials" in the MIPS concept) required for this product or service. A MIPS analysis covers the entire life cycle of a product or service but is still less labour-intensive than a complete eLCA (Ritthoff et al., 2002; Lähteenoja et al., 2006; Kuhndt, et al., 2008, Lettenmeier et al., 2009). Additionally, there is a lack of respective social impact analyses. UNEP (2009) has developed a framework for social LCA (sLCA) but case studies have not been published so far. Table 1 shows the main characteristics of selected assessment approaches, including two types of Hot Spot Analyses, one that covers solely environmental (Hot Spot Analysis) and one that covers both environmental and social aspects (Sustainability Hot Spot Analysis, SHSA).

Table 1: Main features of selected life cycle assessment approaches (description of environmental assessment approaches based on Baedeker et al., forthcoming).

	Environmental assessment			**Social assessment**	**Environmental and social assessment**
Methodology (Main reference) **Main features**	**Hot Spot Analysis** (Wallbaum and Kummer, 2006)	**MIPS (Material Input per Service unit) Analysis** (Schmidt-Bleek, 2009; Ritthoff et al., 2002; Lettenmeier et al., 2009)	**Environmental-Life Cycle Assessment (eLCA)** (ISO 14041)	**Social Life Cycle Assessment (sLCA)** (UNEP, 2009)	**Sustainability Hot Spot Analysis (SHSA)** (this paper)
Short description	Elaboration of the most relevant factors or phases influencing resource use in the life cycle / product chain	Analysis of the physical material flows during the life cycle of a product or service. Material flows are understood as the central background of environmental impacts	Analysis of mainly emission- and energy-based environmental impacts during the life cycle	Analysis of social impacts along the life cycle	Elaboration of the most relevant factors or phases influencing resource use, further environmental and social impacts in the life cycle / product chain
Aspects covered	Environmental aspects of different life cycle phases, according to available literature	Input side of production and consumption systems, aggregated flows of abiotics, biotics, top soil, water and air (oxygen)	Different environmental impacts like global warming, acidification, eutrophication, etc.	Different social impacts of importance to specific stakeholders, such as working conditions	Sustainability aspects of different life cycle phases, according to available literature
Level of depth	Rough overview over relevant aspects	Often calculated on the basis of existing average figures but process-specific calculation possible	Calculated on the basis of existing data bases and/or process-specific data	Calculated on the basis of existing data bases and/or process-specific data	Rough overview over relevant aspects
Origin of data used	Scientific publications	Published eLCA and other studies average material intensity coefficients or process-specific information	Published eLCA and other studies database and/or process-specific emission data	Published sLCA and other studies database, stakeholder assessment	Scientific publications, stakeholder assessment and verification in case of uncertainties
Suitability to companies	Requires knowledge of scientific literature. Provides an overview of relevant aspects of the product chain.	Requires understanding of MIPS concept. Relatively easy calculation possible using e.g. excel sheets. Enables comparisons between different options and value chain phases.	Requires special software and detailed information on the product studied. Can provide a detailed analysis of specific development options in processes and product chains.	Requires knowledge of scientific literature and data availability	Requires knowledge of scientific literature. Provides an overview of relevant aspects of the product chain.
Suitability for consumer information	Can be used to identify areas of high and low resource intensity issues from each other but not for comparing products.	Understandable concept, very suitable for comparison of product groups or consumption patterns. Applicable to product but cost intensive. Potential basis for labelling or indices.	Direct use would be too complex. Can be used as a basis for labelling or indices but remains cost intensive.	Direct use would be too complex. Can be used as a basis for labelling or indices but remains cost intensive.	Can be used to assess the significance of impacts of a product but not for comparing products.

The authors suggest the Sustainability Hot Spot Analysis (SHSA) as innovative practical tool for social and environmental assessments. The SHSA provides a reliable and robust decision-making tool and serves as practical controlling instrument. Based in the SHSA of food chains, the results can be used to improve the sustainability performance of foodstuffs along their life cycles. This integrated perspective on environmental and social aspects allows a holistic analytical scope, which corresponds with the complex nature of agro-food systems.

The paper firstly presents the methodology of the Sustainability Hot Spot Analysis as innovative tool to govern agro-food systems towards sustainable development. Secondly the steps of the methodology and their results are illustrated using a case study of a strawberry value chain. Finally, the paper concludes on the strengths and weaknesses of the tool to shift agro-food systems towards sustainability.

The methodology of the Sustainability Hot Spot Analysis

The Hot Spot Analysis (HSA) (Wallbaum and Kummer, 2006) intends to be a qualitative assessment instrument that estimates the resource intensity of a product along its value chain. Wallbaum und Kummer (2006) developed this basic HSA analysing the resource intensity of a product focusing on abiotic, biotic raw materials, water and energy.

The identification of “hot spots” along the whole value chain can be a first step before applying a more detailed MIPS analysis or even a deeper eLCA. Baedeker et al. (forthcoming: 7) suggest a step-by-step approach to develop the data base in general and bring sustainability and resource management into corporate practice: “As a first step, a ‘Hot Spot Analysis’ should be applied (Wallbaum and Kummer, 2006). This can be followed by a MIPS analysis, possibly including also other core indicators. A whole LCA approach can be applied at last, in case a more exact differentiation will be necessary, e.g. if detailed scenarios including also emissions and similar aspects are required. Every step needs to be concluded by “indicators for action” in order to create direct use for the respective company“.

The authors of this paper have elaborated a more comprehensive HSA approach with extended scope including additional ecological criteria and social impacts of a product, the Sustainability Hot Spot Analysis (SHSA). The main objective of an SHSA is to identify key issues of analysed categories, such as resource use, ecological and social challenges along the whole value chain, in a quick, reliable and life-cycle-phase-specific way. The results highlight so called „hot spots“ in the product chain and can be seen as starting point for detailed elaboration of efficient actions for improvement. Applying the SHSA, the main life cycle phases of product are analysed (see table 2). The environmental and social impacts of all life cycle phases and their relation are identified as well as the overall impact level of different social and environmental categories (raw materials, energy, water). The environmental and social “peaks” identified are defined as hot spots. An SHSA is performed in the five steps, which are described below.

Step 1: Defining life cycle stages and categories

The starting point of the SHSA is the definition of system boundaries for the analysis including the life cycle phases as well as the assessment scope including the social and environmental aspects covered. While a common description of social and environmental aspects may generally be appropriate for most products (see tables 3 and 4), the following four main life cycle phases according to the product need to be defined: raw material procurement (resp. agriculture when analyzing food chains), processing, use (incl. retail) and waste treatment.

Table 2: Life cycle phases of an SHSA for food

Agriculture	Processing	Use (incl. retail)	Waste treatment
This includes the growing and harvesting of fruits / crops.	This phase comprises possible processing of the product.	This includes the selling/retail of the product and the transport, handling, cooling and cooking by the customer.	This covers end-of life management of products including related transports and processes

The SHSA considers all environmental and social impacts directly connected to the product or service, its raw materials and intermediate goods. Impacts not directly connected to the product (e.g. maintenance of production or transportation machines) are not part of the analysis (Wallbaum and Kummer, 2006). Transportation and logistic processes are not presented as single phases but the resources and impacts connected to transportation will be accounted for in the respectively following life cycle phase. For example, the transport of agricultural products to the processing plant is allocated to the processing phase, the transport of the packed product to the retailer or consumer is allocated to the use phase.

In order to account for regional specific and local aspects in the evaluation of product chains, specific sourcing locations for each raw material are identified. The analysis usually needs to focus on the main (or outweighing) sourcing locations for a specific raw material in order to facilitate comparisons of a specific (more sustainable) product to average products. For the use of the SHSA in a corporate context, the analysis is specific to certain geographical areas in the agricultural phase but more general in the down-stream phases. The regions considered during the assessment of the agricultural phase are selected based on the raw materials' main sourcing locations and the main markets for the final products.

The tables 3 and 4 comprise the main environmental and social categories that need to be assessed along life cycle phases of a product. The seven environmental categories are split in basic aspects (resource intensity) and further environmental categories. Social categories comprise eight aspects.

Steps 2 and 3: Aspects and life cycle phase significance assessment

For each life cycle phase and each life cycle aspect the relevance needs to be specified as low, medium or high (step 2). Similarly step 3 analyses and specifies the relevance of the phases to each other. The basis for the analysis in the first three steps are scientific data gathered through literature review that provides facts about resource intensity, further ecological impacts and social impacts in the whole value chain or parts of it.

The assessment of the categories and allocation of assessment points is done on a scale from „no relevance“ (0 points) to „high relevance“ (3 points). If no data is available and thus allows currently no assessment the analyst should document that no sources have been found – this is treated as a 0 in calculations. Categories that are not applicable (n.a.) in the specific phase are also treated as a 0 in calculations, such as product quality, which is not applicable in the agricultural phase (see Table 5).

In order to compare the environmental and social impacts of one phase to another, step three is performed. This can be done based on available life cycle assessments to compare the importance of the agricultural, processing, use and waste treatment phases. In most cases it is appropriate to weight the environmental and social aspects separately. If detailed data is available, the significance for single environmental or social aspects, such as energy consumption can be identified. Table 5 shows results of the assessment for an example.

Table 3: Environmental aspects of SHSA (based on Wallbaum and Kummer, 2006, adapted)

Environmental aspect	Description
Raw materials (abiotic and biotic resources)	All materials used in this phase (e.g. use of pesticides, herbicides as well as fertilizers, chemicals etc. in the agricultural phase).
Energy resources	Energy used in the phase in terms of electricity and fuel.
Water resources	The amount of water used in growing / cultivation as well as for cleaning during production. Soil degradation is included in the "land use" aspect and emissions to water such as nutrients are included in the "emissions to water" aspect.
Land use	The amount of land used. This aspect also includes the biodiversity and soil degradation.
Waste	These are all excess solid wastes in the different life cycle phases.
Emissions to air (incl. greenhouse gas (GHG) emissions)	Chemicals released to air and also GHG emissions through electricity usage and transport. The GHG such as CO_2 emitted through electricity use and other sources such as livestock where relevant.
Emissions to water	These include chemicals and nutrients used for crop growing as well as the use of detergents during the use/consumption phase.

Table 4: Social aspects of SHSA (based on UNEP, 2009; GRI, 2006)

Social aspect	**Description**
General Working conditions	These include working hours, legal contracts, illegal workers, general working conditions.
Social Security	This includes contracts and obligatory social security provisions.
Training & Education	This includes aspects such as education on their rights as employers and also training on working with hazardous materials.
Workers health & safety	Occupational health and safety (hygienic working conditions)
Human rights	Child labour and young workers, discrimination (equal pay/benefits/opportunities between temporary and permanent workers; between foreign/migrant and local workers and between men and women), forced labour including discipline (harsh and inhumane treatment), Freedom of association, sexual harassment
Living Wages	Minimum wage / Living wage
Consumer health & safety	Health standards of product, product safety, information and transparency regarding health issues (allergens, nutritional value), warnings if some kind of use is restricted or hazardous, declaration of control mechanisms for health and safety
Product Quality	Longevity, use practicability for everyday life (quantities / portion of product offered, safe packaging, dosage and storing possibilities), transparency and information (reliable information, information adequate for main consumer group, voluntary information, e.g. complete information on ingredients), added value for society (purchase of product has positive effects on society, e.g. sponsoring of social projects, fostering of social suppliers, ethical orientation of producers)

Step 4: Identification of Sustainability Hot Spots

For a better visibility of the hot spots, the scores of steps 2 and 3 are multiplied by each other in step 4 so that the ecological and social hot spots can be identified (scores of 6 and 9 points, based on Wallbaum and Kummer, 2006). The environmental categories from step two are multiplied with the respective evaluation factor, the social categories with the factor social aspects. Table 5 illustrates the hot spot identification. For example, in the column agriculture the scores from step two, i.e. raw materials (3), energy (2), water (3), land use (3), waste (2), emissions to air (2) and emissions to water (2) are multiplied by the respective life cycle evaluation factor from step three, i.e. (3) for environmental aspects. Thus, the aspects raw materials, water, land use receive a high ranking (3 x 3 = 9), whereas the aspects energy, waste, emissions to air and water are ranked lower (2 x 3 = 6).

Step 5: Stakeholder evaluation and verification

Finally, external stakeholders and experts are consulted to critically review the results in terms of weighting and completion. Data availability for ecological and social impact analysis at product level differs. Whereas the ecological assessment can usually be based on relatively well available scientific literature and LCA studies, social LCA results and scientific literature about social implications of products are rare. Thus, the SHSA includes stakeholder evaluation and verification to ensure the robust, i.e. safe in terms of direction, sustainability assessment of products based on the experiences of the stakeholders and experts. Careful selection of stakeholders and experts should aim to bring a diverse number of perspectives into the evaluation.

The Sustainability Hot Spot Analysis of fresh strawberries

The SHSA has been applied in a case study on strawberries. The life cycle of strawberries comprise the agricultural phase (growing and harvesting of fruits), processing phase (processing of fruits, including washing), use phase (transport of the product to the retailer and further to consumer, the selling/retail of the fruits, handling disposing by the customer) and waste treatment phase (disposing by the customer and transport). The study focuses in the agricultural and processing phase on strawberries from Spain, Italy and the Netherlands as main import countries for Germany, which is the focus country of the use and waste treatment phases.

The results of SHSA can be structured in life cycle phases (Table 5). The analysis shows that the phases of processing and waste treatment are considered to be of low relevance.

The two main phases with medium or high relevance are the agricultural and use phase. These are described below.

Table 5. Results of the Sustainability Hot Spot Analysis for the strawberry case study

Assessing defined aspects within each life cycle phase (step 2)				
Life cycle phase Categories	Agriculture	Processing	Use	Waste treatment
Environmental aspects				
Raw materials	3	1	2	1
Energy	2	2	3	1
Water	3	1	1	1
Land use	3	1	1	1
Waste	2	1	1	1
Emissions to air	2	2	3	1
Emissions to water	2	1	1	1
Social aspects				
General Working conditions	3	2	3	0
Social Security	3	1	2	0
Training & Education	3	1	2	0
Workers health & safety	3	1	3	0
Human rights	2	1	1	0
Living Wages	3	2	2	0
Consumer health & safety	0	0	3	0
Product Quality	0	0	3	0
Assessing defined aspects between the different life cycle phases (step 3)				
Life cycle phase Categories	Agriculture	Processing	Use	Waste treatment
Environmental aspects	3	1	2	1
Social aspects	3	1	3	1
Identification of environmental and social hot spots* (step 4 and 5)				
Life cycle phase Categories	Agriculture	Processing	Use	Waste treatment
Environmental aspects				
Raw materials	9	1	4	1
Energy	6	2	6	1
Water	9	1	2	1
Land use	9	1	2	1
Waste	6	1	2	1
Emissions to air	6	2	6	1
Emissions to water	6	1	2	1
Social aspects				
General Working conditions	9	2	9	0
Social Security	9	1	6	0
Training & Education	9	1	6	0
Workers health & safety	9	1	9	0
Human rights	6	1	3	0
Living Wages	9	2	6	0
Consumer health & safety	0	0	9	0
Product Quality	0	0	9	0

* Calculations based on results of step 2 and 3 (multiplication).
Shaded areas highlight identified hot spots (evaluations higher than 6).

Environmental aspects with medium and high relevance

Within the agricultural phase, the environmental hot spots appear within all environmental categories. The use of *raw materials* for the cultivation is determined by the extensive use of pesticides, in particular of herbicides, fungicides and insecticides as well as mineral fertilisers (nitrogen, phosphorus, sodium). Monocultures may require high amounts of pesticides (Greenpeace, 2004). In the context of strawberry cultivation, plastic foils are used that are connected with a high resource input. They are used for covering the ground or the roofs of greenhouses (Baldock et al., 2000: 75). In the Spanish strawberry cultivation the foils are replaced every two years (Baldock et al., 2000: 76).

The artificial irrigation systems used for the strawberry cultivation e.g. in southern Spain are characterized by overexploitation of available *water* resources (Calatrava Leyva and Sayadi, 2005), resulting in decreasing water quality due to salt intake into the groundwater. The specialized production processes that cause damage to the soil structure and a reduction of the soil quality, thus there are hot spots associated with *land use*. A sustainable long-term use of soils is inhibited by means of land use inappropriate to the location and by the extensive application of mineral fertilisers and pesticides. Monocultural cultivation leads to intensified agriculture and a decrease in biodiversity. (COM, 2007)

Emissions into air (incl. GHG) are caused by emissions released upon production of mineral fertilisers and lime, soil treatment as well as illegally burned plastic foils. The emission of nitrous oxide (N_2O) from the soil is caused by the use of nitrogen containing fertilisers (Knickel, 2002: 192; COM, 2003: 6). Methyl bromide (CH_3Br) - which is used to combat nematodes - is recognised as an ozone-depleting substance. Its production and application is banned in the European Union since 2005 (Lopez-Medina, 2007: 408) but it is still in use worldwide as cost-effective alternatives are not always available (Baird and Cann, 2009). Large amounts of *waste* are generated by the use of plastic foils (Baldock et al., 2000). *Emissions into water* respective the groundwater are caused by the intake of pesticides and fertilisers. Finally, production of agrochemicals requires a high input of *energy* (Dinkel, 2008).

Within the use phase including retailing, environmentally most significant aspects are *energy* use for processing, storage and transport and related *emissions to air*. An optimised consumer behaviour (e.g. choosing fresh, seasonal products) could reduce the energy demand and CO_2 emissions by half (Jungbluth, 2007: 66). Further aspects are the use of *water* for the processing of fresh produce as well as the generation of *waste* by secondary and tertiary packaging for goods in transit.

The *consumption* of fresh fruits has continuously increased in Germany since 1999/2000 and has reached an amount of approximately 78 kg of fresh fruit per capita and 89 kg of vegetables per capita, including unsold quantities and imports (BMELV, 2009). A study in UK has shown that ca. 1,4 million tons of fresh fruit and vegetables are thrown away every year (WRAP, 2008: 4f), causing unnecessary emissions over the life cycle of these products, including production and disposal. Another aspect are pesticide residues on fresh produce that get into the water upon cleaning in households.

Social aspects of medium and high relevance

Within the agricultural phase, social hot spots are linked with all applicable social aspects. *General working conditions* have been reported as being inhuman for the approximately 45,000 to 100,000 workers on the fields of the Spanish region of Almeria (the main area for strawberry cultivation). Many employees only get short-term contracts (e.g. Wagenhofer and Annas, 2006). *Social security* is an issue related to the large number of immigrants working in the agriculture in southern Spain often without work contract. This is caused by a lack of domestic workers many of whom (a) have acquired higher education over the last years and prefer to work in other sectors, as (b) social status of fieldwork is particularly low in Spain (Mendy, 2008). Many workers do not get sufficient *wages* to ensure a minimum living standard. One reason is the competitive pressure on the European market that forces producers to pay lowest possible wages and sustain cost-efficient working conditions (Hamann, 2006; Bresciani and Valdés, 2007).

Training and Education is most relevant because information and training is a key to achieving change in practices and methods – particularly on appropriate, moderate and efficient use of inputs as well as provision and use of personal protective equipment. Only 26% of workers in Spain are aware of health risks of their work (Callejón-Ferre et al., 2009) *Workers health & safety* are of high relevance because many workers are exposed to mental stress as a result of piecework. Workers – family or hired, depending on regional context – are exposed to harmful toxins, primarily because they are not provided with or do not wear adequate personnel protective equipment while spraying chemical pesticides and herbicides (e.g. Islam, 2007). Discrimination and child labour are *human rights* abuses in strawberry cultivation. Where women are paid to work in fruit cultivation they are commonly paid less than male equivalents. Child labour is difficult to assess due to its informal character. Depending on the age of the child and nature of the activity – particularly whether it affects the child's health and schooling – this may not be acceptable under international standards (ILO core conventions).

Within the use phase, most relevant social impacts relate on the one hand to *general working conditions* and *workers health and safety* in the transport and retail sector. Many companies do not respect their workers rights for sufficient breaks and do not pay overtime. Examples of discounters keeping a watch over their employees using video-observance and prevent the establishment of workers councils exist (e.g. Hamann, 2006; Fishmann, 2006). Many employees are stressed psychically by piece-rate work e.g. on cashpoints. On the other hand consumer related issues occur such as c*onsumer health & safety* and *product quality.* Approximately 81% of Spanish strawberry samples show pesticide residues on the product, with 4% exceeding the legal limit. One problem results from the fact that many authorities such as the German Federal Office of Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, BVL) do not check test results for illegal substances in food products (see BVL, 2009). According to Greenpeace (2008), 9% of substances found on fruits and vegetables in the year 2006 were not approved and pose a threat to consumer health. Most imported strawberries are transported hundreds of kilometres so that freshness and storage life of strawberries is not balanced which influences product quality.

Sustainability hot spots of strawberry life cycle

As a result nine environmental and 13 social hot spots are identified: Most relevant regarding environmental impacts are the agricultural phase in terms of raw materials, water and land use as well as the use phase concerning energy consumption and related emissions to air. Most relevant regarding social impacts are the same life cycle phases: during agricultural phase every applicable aspect is identified as hot spot. In the use phase all aspects are hot spots except human rights. The example shows that the social impacts can be very relevant from a sustainability perspective, thus including social aspects into life cycle assessments is highly important.

Conclusions

The presented methodology of the Sustainability Hot Spot Analysis and the specific case study of the strawberry value chain have highlighted the benefits of combining the cause-and-effect based, value chain specific and integrated assessment. For practical application, the development of the SHSA can be adapted to specific user demands of key decision makers. Especially, companies are able to identify "hot spots" in their product chains in order to take countermeasures to shift product systems towards sustainability. The SHSA provides indicatory information and can serve as preparatory study for more detailed social and environmental LCA or MIPS analyses because it points out relevant needs for action where detailed data analysis must follow.

In the specific case presented here, a relatively large number of hot spots were identified in both the environmental and social analyses. However, this is no results of the application of the SHSA in general but it is due to the specific situation of the product analysed and shows that there are numerous needs and options for improvement in the value chain of strawberry. In other cases, only a small number of hot spots may be identified so that the options for improvements in the value chain are – else than in the case of the strawberry case – concentrated on a small amount of aspects.

For a widespread promotion of sustainable production and consumption patterns, the procedural approach illustrated in the case study can be transferred to other value chains. However, complementary approaches to promote sustainable development are needed at other levels. The SHSA might, for example, be applied to the macroeconomic level. This could be relevant for political decision makers, for instance in the context of land use competitions or as instrument to monitor entire agro-food systems. Monitoring and political actions at macro level are crucial, since the optimization of a single value chain needs taking into account ecological limits as well as non-negotiable policy objectives such as human rights. This means that optimization might not be successful if only single life cycle stages value chains are considered. Thus, system-wide perspectives complementing the life cycle perspective are needed in order to provide a suitable knowledge base for a transition towards more sustainable agro-food systems.

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