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How the organic food system contributes to sustainability

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ABSTRACT

Despite many agricultural systems and most food companies claiming to be sustainable, recent studies show that the planetary boundaries have been exceeded mainly by food production and consumption. Against the background of a looming 9.6 billion people in 2050, many scientists argue for a further intensification of agricultural systems.

Organic food systems may offer an alternative approach towards sustainability. Many studies on organic agriculture suggest that organic practices are less harmful for the environment, may foster social well-being and may lead to economic resilience. Others argue that organic systems yield on average about 20 percent less than comparable conventional systems. On the bottom line, this may even lead to higher environmental impacts, land use and pressure on natural ecosystems and put global food availability at risk.

This paper aims at providing an overview of the contribution of organic food systems to sustainability distinguishing between different levels. Using (i) the SAFA Guidelines and (ii) the three sustainability strategies of efficiency, consistency and sufficiency as a framework, we assess how organic food systems can contribute to sustainability.

We distinguish between the operator level, the product level and the spatial/policy level. We show that the operator level (i) focuses on consistency and allows covering the widest range of sustainability themes. At the product-related level (ii), only specific environmental themes can be covered and the efficiency is the central issue addressed by the studies. The spatial/policy level (iii) addresses all three sustainability strategies, as food security and systemic changes such as dietary patterns and food waste are considered, but is often too general for looking at many social themes of sustainability.

Results show that organic food systems perform well with respect to environmental performance at the operator and spatial/policy level, while results at the product level are more heterogeneous, as yields are often lower. Differences between organic and conventional systems vary between different regions and product types. The economic performance can be judged at operators' level, which reveals context-specific differences in profitability, depending on product type and regional context. However, apart from profitability, organic food systems may provide further benefits in terms of economic resilience due to the cradle-to-cradle principle. At the spatial/policy level, food availability and food security play important roles. Global studies show how organic food systems can provide sufficient food if demand patterns change towards less resource-consuming products. The social dimension is very context-specific and cannot be judged in general.

We conclude that organic production impacts the entire food system and that organic agriculture can contribute to the efficiency, consistency and sufficiency strategies. Yet, innovation and further development of the organic system is indispensable for addressing future challenges.

INTRODUCTION

Despite agriculture's and most food companies' claim of being sustainable, recent studies show that the planetary boundaries have been exceeded mainly by food production and consumption (Rockström *et al.*, 2009). Furthermore, social well-being and the economic resilience of the farming sector are at stake in many countries. Against the background of a looming 9.6 billion people in 2050, many scientists argue for a further intensification of agricultural systems (Godfray and Garnett, 2014; Tilman *et al.*, 2011).

In order to address these challenges, efficiency, consistency and sufficiency can be distinguished as three fundamentally different strategies (Schaltegger, Burritt and Petersen, 2003). The efficiency strategy tries to optimize the relationship between the negative impacts of a system and the outputs that a system generates. The consistency strategy tries to bring production systems closer to natural systems or sustainability principles. Finally, the sufficiency strategy addresses the consumption side by reducing negative impacts on resources.

Organic food systems may offer an alternative approach towards sustainability. Many studies on organic agriculture suggest that organic practices are less harmful for the environment, may foster social well-being and may lead to economic resilience (Schader, Stolze and Gattinger, 2012). Others argue that organic systems yield on average about 20 percent less than comparable conventional systems (Seufert, Ramankutty and Foley, 2012). On the bottom line, this may even lead to higher environmental impacts, land use and pressure on natural ecosystems and put global food availability at risk (Tuomisto *et al.,* 2012).

This paper aims at providing an overview of the contribution of organic food systems to sustainability distinguishing between product, operator and spatial/policy level. Using (i) the SAFA Guidelines and (ii) the three sustainability strategies of efficiency, consistency and sufficiency (Schaltegger, Burritt and Petersen, 2003) as a framework, we assess how organic food systems can contribute to sustainability.

DIFFERENT LEVELS FOR SUSTAINABILITY ASSESSMENTS

With the increasing importance of the notion of sustainability in the discussion of future food systems, different interpretations have caused confusion among food producers, consumers and even scientists (FAO, 2013; Godfray and Garnett, 2014; McDonald and Oates, 2006). This confusion may largely be associated with differences in the scope and perspective of the assessments (Schader *et al.,* 2014a). Especially with respect to evaluating complex systems such as organic food systems, which impact both production and consumption, methodological differences in the assessment lead to different and seemingly contradicting results (Meier *et al.,* 2015; Schader, Stolze and Gattinger, 2012).

Recent efforts to generically define sustainability (FAO, 2013) and classify sustainability assessment approaches (Schader *et al.,* 2014a) aim at decreasing this confusion and clarifying the differences between the most common approaches and tools for assessing sustainability. In this paper, we distinguish between the operator, the product and the spatial/policy level.

The **operator level** looks at the sustainability performance of a company or a farm using indicator sets. The SAFA Guidelines (FAO, 2013) offer a globally applicable framework for a comprehensive view on sustainability, covering four dimensions (good governance, environmental integrity, economic resilience and social well-being) with 58 (sub)themes (Table 1). According to the SAFA Guidelines, sustainability assessments should not merely include the place where the operator is located but also consider other companies or farms that are influenced by its decisions. For instance, a dairy company can have a strong influence on its suppliers and how they produce. So, those dairy farms can be taken into account for an operator-level sustainability assessment, especially because a large fraction of the environmental and social impacts can be associated with the agricultural production processes (Bystricky *et al.,* 2014).

We show that the operator level allows covering the full range of sustainability themes. However, assessments at this level primarily look at the consistency of the companies with sustainability principles. Efficiency can only be assessed if product-related assessments are included. The sufficiency strategy is not covered within the framework of the SAFA Guidelines.

The dominant approach for conducting **product-level assessments** is life cycle assessment (LCA) (Finkbeiner *et al.,* 2010). LCAs relate environmental impacts of a production system to the so-called functional unit, which is mostly the provision of defined amount of a specific kind of food (ISO, 2006a, 2006b). There are a number of environmental impact categories such as global warming potential, eutrophication and acidification covered by the usual LCAs but impacts on

Table 1: Comparison of product, operator and spatial/policy level sustainability assessments

Level	Approaches	Tools	Coverage of topics	Efficiency	Consistency	Sufficiency
Operator level	Indicator based approaches, life cycle assessment	e.g. SMART, RISE	all dimensions	(yes)	yes	no
Product level	Attributional life cycle assessment	e.g. Sima Pro, GABI	selected environmental topics	yes	(yes)	no
Spatial / policy level	Economic modelling, consequential LCAs	e.g. SOL-m, FARMIS, CAPRI	Predominantly environmental and economic dimensions	yes	yes	yes

Source: based on Schader *et al*. (2014a).

biodiversity and soil fertility, for instance, are difficult to relate to a product-related functional unit (de Baan, Alkemade and Koellner, 2013; Jeanneret *et al.,* 2008; Milà i Canals *et al.,* 2006). However, when comparing organic and conventional food systems, these themes are important for differentiation between the systems. Furthermore, concepts for evaluating social and economic impacts within an LCA framework are still at their infancy (Finkbeiner *et al.,* 2010).

With respect to the three main sustainability strategies (efficiency, consistency and sufficiency), a product-level assessment predominantly addresses efficiency. Only selected aspects of consistency can be taken into account. The sufficiency strategy would mean dismissing the concept of a common functional unit but looking at different functional units or defining a more general functional unit.

With **spatial-/policy-level assessments**, not a single operator or product is assessed, but all operators within a geographical region or the impacts of a policy on all operators affected by it. For instance, if a conversion to organic farming is analysed at spatial/policy level, it is not sufficient to look at single products or at single farms. However, apart from the general view on a region, this level of assessment also allows looking at specific products or farm types more closely.

At a spatial/policy level all environmental and economic issues can be addressed. Social issues are often context-specific and therefore hardly generalizable, except some general considerations that result from changes in product prices and input (e.g. labour) demand. Contrary to the other two levels, the spatial/policy level allows the consideration of sufficiency aspects besides issues of consistency and efficiency, as nutrition patterns can be examined and economic considerations of changing demand and supply patterns can be integrated in the analysis.

SUSTAINABILITY PERFORMANCE OF ORGANIC FOOD SYSTEMS AT DIFFERENT LEVELS

The above description of different levels of sustainability reveals that often fundamentally different aspects are considered and different perspectives are taken in a sustainability assessment. Moreover, as differences between organic and conventional systems vary between regions and product types, general statements on the sustainability performance of organic agriculture need to be made with particular care. We therefore present an overview of studies from the different levels illustrating the sustainability performance of organic agriculture.

Operator level

From an operator level, environmental assessments reveal that organic farming performs better, i.e. has less environmental impacts, with respect to biodiversity and landscape, resource depletion, climate change, ground and surface water pollution, air quality and soil fertility. However, Table 1 shows a wide variation between the studies.

With respect to subsequent supply chain stages (transport, processing and retailing), no general statements can be made as the performance of organics is largely related to the specific operator or supply chain.

The economic performance of organic agriculture is often understood in different ways and no uniform assessment method has been established so far. For instance, the economic performance

Organic agriculture is	Much better	Better	Equal	Worse	Much worse
Biodiversity and landscape		●			
Genetic diversity			●		
Floral diversity		●			
Faunal diversity		●			
Habitat diversity		●			
Landscape			●		
Resource depletion		●			
Nutrient resources		●			
Energy resources		●			
Water resources			●		
Climate change		●			
CO_2		●			
N_2O			●		
CH_4			●		
Ground and surface water pollution		●			
Nitrate leaching		●			
Phosphorous runoff		●			
Pesticide emissions	●				
Air quality		●			
NH_3		●			
Pesticides	●				
Soil fertility		●			
Organic matter		●			
Biological activity	●				
Soil structure			●		
Soil erosion		●			

Figure 1: Relative environmental performance of organic farming at operator level
Source: based on Schader, Stolze and Gattinger (2012).

could be interpreted from an operator's goal to have a profitable and economically resilient business, but also from a societal perspective in the sense of what the operator contributes to societal goals (Schader *et al.*, 2014a). However, since the latter perspective would include the social and environmental impacts monetized, we concentrate on the first perspective here. The economic performance from an operator's perspective thus comes down to the question whether the yield gap (Seufert, Ramankutty and Foley, 2012) and the higher costs for labour compared with conventional farming can be compensated by the sum of (a) price premiums, (b) savings from purchasing less physical inputs and (c) policy payments, e.g. agri-environmental schemes in Europe (Schader, 2009). Also here, it depends very much on the farm type and regional context that one is looking at, but many cases have been reported where organic farming is competitive or even outperforming conventional counterparts (Nemes, 2009). Nevertheless, the slow uptake of organic farming practices indicates no substantial improvement of profitability in most regions of the world. However, it should be stressed that sound datasets to judge profitability are missing for many countries.

But economic resilience is not only a question of profitability. Issues such as the long-term stability of production, supply and markets are also affecting the economic resilience (FAO, 2013). Here, organic farming seems to have advantages compared with conventional farming, as it is less reliant on external inputs and has a stronger ability to conserve natural resources, e.g. soil (Gattinger *et al.*, 2012).

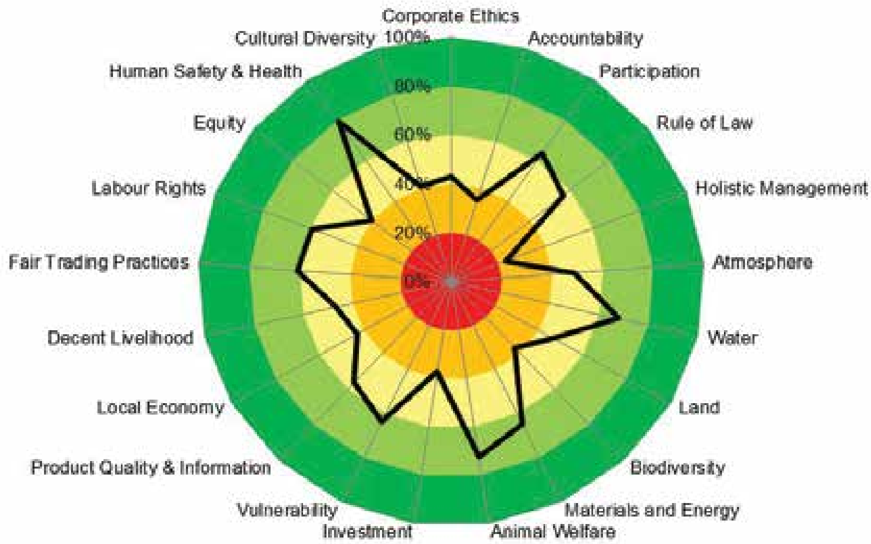

Figure 2: Exemplary summary of a full sustainability assessment of a food company with SMART
Source: FiBL and SFS (2014).

Social performance of organic farming is also influenced by local conditions. So it is very difficult to draw general conclusions. Nevertheless, if a sufficiently large number of organic and conventional operators can be assessed with an indicator set that ensures comparability, a comparison of all aspects of the sustainability could be conducted. Therefore, FiBL created the Sustainability Monitoring and Assessment Routine (SMART), which allows assessing both food companies and farms against the 58 themes specified in the SAFA Guidelines (Jawtusch *et al.*, 2013). Currently, sustainability assessments at farm and company level are conducted. This research will empirically show in which themes organic operators perform better, worse or equal to conventional operators. Figure 2 shows an example of the summary of a complete sustainability assessment of a food company with SMART. With this approach of benchmarking companies and farms against absolute sustainability objectives, even well-performing companies fail to reach maximum scores with respect to many subthemes.

Product level

The product-related environmental performance substantially differs from the operator-related one. The main reason for this difference is the relationship of the performance to a functional unit, which is usually related to the production quantity. The yield gap of 0–40 percent (on average 20–25 percent), depending on which product one is looking at (de Ponti, Rijk and van Ittersum, 2012; Ponisio *et al.,* 2015; Seufert, Ramankutty and Foley, 2012), is sometimes overcompensating the better environmental performance of organic farming (Meier *et al.,* 2015; Tuomisto *et al.,* 2012) (Table 2).

The study of LCA-based comparisons of the environmental performance by Meier *et al.* (2015) also reveals a wide variation between the studies. Table 3 shows the variability of results for dairy production. Details on beef, pig, poultry, egg and plant products can be found in Meier *et al.* (2015).

As explained above, the empirical evidence and the methodological discourse regarding the social and economic product-related sustainability assessment is currently too weak to present conclusions.

Policy level

At the policy level, more general research questions can be dealt with, as apart from production-related aspects also changes in demand patterns can be taken into account (Schader *et al.,* 2014b). This level often calculated scenarios from a resource-use perspective either globally or for specific countries or regions (Schader *et al.*, 2014a).

Table 2: Product-related environmental performance of organic agriculture compared with conventional agriculture

Livestock products[b]	Relative difference organic/integrated on per product unit[a]			
	Milk	Beef	Pork	Poultry
Energy demand	–5%	–2%	–24%	–8%
Global warming potential (GWP)	–12%	–8%	–25%	–18%
Ozone depletion	–3%	–8%	–39%	–17%
Eutrophication potential	–13%	–1%	+4%	+4%
Acidification potential	–12%	–13%	–30%	–21%
Heavy metals, water	–30%	–48%	–81%	–79%
Heavy metals, soil	–165%	–261%	+405%	–79%
Pesticide use	–100%	–99%	–100%	–100%
Water use	–69%	–76%	–73%	–73%
Land use	–1%	–23%	–32%	–32%
Fruist & vegetables[b]	**Tomatoes**	**Carrots**	**Strawberries**	**Pears**
Energy demand	–71%	+12%	+61%	+26%
Global warming potential (GWP)	–78%	–9%	+39%	+10%
Ozone depletion	–69%	–46%	+8%	–50%
Eutrophication potential	–17%	–69%	–65%	–85%
Acidification potential	–86%	+13%	+84%	+17%
Heavy metals, water	–97%	–60%	–25%	+60%
Heavy metals, soil	+306%	+2410%	+5981%	–29%
Pesticide use	–53%	–100%	–96%	–100%
Water use	–28%	+51%	+64%	+5%
Land use	+37%	–38%	–117%	–117%
Arable crops[c]	**Barley grains**	**Soybeans**	**Wheat grains**	**Potatoes**
Energy demand	–6%	–10%	–11%	–5%
Global warming potential (GWP)	+18%	–12%	–9%	+88%
Ozone depletion	–66%	–54%	–81%	–68%
Eutrophication potential	+54%	–26%	+80%	+39%
Acidification potential	–57%	–59%	–59%	–9%
Heavy metals, water	–77%	–65%	–79%	–54%
Heavy metals, soil	+333%	–105%	+665%	+1102%
Pesticide use	–100%	–100%	–100%	–100%
Water use	–65%	–54%	–68%	–12%
Land use	0%	–36%	–4%	+1%

[a] basic: conventional
[b] Inventories from LCI database of ESU-services only (Jungbluth *et al.*, 2013)
[c] Inventories from ecoinvent v2.2 (Nemecek *et al.*, 2007)
Source: Meier *et al.* (2015).

Fundamental questions that have been raised with respect to organic agriculture are: Can organic food systems feed the world? What environmental impacts would organic have? What boundary conditions would need to be met? These fundamental questions have not yet been answered in sufficient depth.

Preliminary results using the SOL-Model (Schader, Muller and Scialabba, 2014) show that organic food systems show the potential of organic farming for feeding the world sustainably under different conditions (Schader *et al.*, 2014b). Table 4 shows different scenarios for 2050 that assume a conversion to organic agriculture and/or a substitution of human-edible feedstuffs with forage not grown on arable land and food waste. These scenarios demonstrate that organic food systems could feed the world even in 2050, if the trade-off between food and feed production is resolved. One way of resolving this trade-off would be to drastically reduce the feedstuffs grown on arable land, which generates a natural boundary for the size of the livestock sector and ultimately leads to lower consumption of livestock products (Schader, Muller and Scialabba, 2014; Schader *et al.*, 2014b). Such a scenario would lead both to an improved availability of energy and protein and a wide range of environmental benefits (Table 4). Social benefits, apart from the indirect impacts from changes in food availability and resource use, are difficult to assess at global level.

Table 3: Variability of product-related environmental performance of organic dairy production

Impact category	Relative difference organic/conventional on per area unit and year[a]	Relative difference organic/ conventional on per product unit[a]	# of studies
Milk			11
Energy demand	–70 to –39%	–56 to –7%	8
Global warming potential (GWP)	–67 to –13%	–38 to +53%	10
Eutrophication potential	–76 to –2%	–66 to +63%	7
Acidification potential	–51 to –2%	–13 to +63%	7
Ecotox terrestrial	–76%	–59%	1
Pesticide use	–100 to –94%	–100 to –89%	3
Productivity	–47 to –6%		11
Land use		+6 to +90%	11

Environmental impacts on per area unit were calculated if not explicitly given in the studies.
[a] Basis: conventional
Source: Meier *et al*. (2015).

Furthermore, at policy level, economic evaluations can be conducted using economic models (Mittenzwei *et al.*, 2007; Sanders *et al.*, 2005; Zimmermann, 2008). For instance, policies that address aspects of environmental sustainability, e.g. the agri-environmental schemes in Europe, can be assessed for cost-effectiveness, the financial support for organic farming being one of these policies. Specifying economic and environmental data, a comprehensive analysis of organic farming as an agri-environmental policy and as a farming system can be done (Schader, 2009). Such an analysis for Switzerland shows that the payments for organic agriculture as an agri-environmental policy are competitive with other environmental payments from a policy-maker's perspective (Table 5). This is specifically due to the fact that policies to support organic farming address a wide range of objectives linked to environmental sustainability (Schader *et al.*, 2014c). Furthermore, there are synergies between the multitarget policy of organic agriculture support and targeted agri-environmental payments (Schader *et al.*, 2013).

CONCLUSIONS

This overview has shown that the sustainability performance of organic food systems needs to be analysed at different levels. Assessments at different levels deliver different information with partly contradicting information.

Results show that organic food systems perform well with respect to the environmental performance at the operator and spatial/policy level, while results at the product level are more heterogeneous, as yields are often lower. Differences between organic and conventional systems vary between different regions and product types. The economic performance can be judged at operator level, which reveals context-specific differences in profitability, depending on product type and regional context. However, apart from profitability, organic food systems may provide further benefits in terms of economic resilience due to the cradle-to-cradle principle. From a spatial/policy level, food availability and food security play important roles. Global studies show organic food systems can provide sufficient food if demand patterns change towards less resource-consuming products. The social dimension is very context-specific and cannot be judged in general.

This paper demonstrated that organic production impacts the entire food system and that organic agriculture can be part of efficiency, consistency and sufficiency strategies. Yet, innovation and further development of the organic system is indispensable for addressing future challenges.

Improvements in data availability and data quality as well as methodological advances at operator, product and spatial/policy level are urgently needed to get a more comprehensive picture of the sustainability performance of organic food systems. Furthermore, a stronger linkage of the different levels is needed in order to increase the consistency between results of assessments at different levels. For instance, the SOL-Model provides quantitative data for such scenarios and will be further developed to provide also country- and product-specific figures for environmental impacts. These could feed both into LCA databases and operator-level assessments such as SMART. Nevertheless, it is important to stress that all three assessment levels have their blind spots as none

Table 4: Overview of impacts of a global conversion of livestock production to organic management on food availability, the environment and human diets calculated with SOL-m

Indicator	Base year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	2005-2009; current situation	2050; baseline according to official FAO forecast	2050; 50% reduction of concentrate use	2050; 100% reduction of concentrate use	2050; full conversion of livestock to organic management	2050; Scenario 3 and 4 combined
Agricultural land	→ (yellow)	↗ (yellow)	↘ (yellow)	↘ (yellow)	↑ (red)	↘ (yellow)
Human population	→ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Avaliable food energy for human consumption	→ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Avaliable food protein for human consumption	→ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Share of livestock products	→ (yellow)	↑ (green)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Share of plant products	→ (yellow)	↘ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Nitrogen surplus	→ (yellow)	↑ (red)	↗ (yellow)	↓ (green)	↓ (green)	↓ (green)
Phosphorus surplus	→ (yellow)	↓ (green)	↑ (red)	↗ (yellow)	↓ (green)	↓ (green)
Energy use	→ (yellow)	↑ (red)	↘ (yellow)	↓ (green)	↗ (yellow)	↓ (green)
Global Warming Potential (GWP)	→ (yellow)	↑ (red)	↑ (red)	↓ (green)	↓ (green)	↓ (green)
Land degradation potential	→ (yellow)	↑ (red)	↘ (yellow)	↘ (yellow)	↑ (red)	↘ (yellow)
Deforestation pressure	→ (yellow)	↑ (red)	↓ (green)	↓ (green)	↑ (red)	↓ (green)
Toxicity potential	→ (yellow)	↑ (red)	↘ (yellow)	↘ (yellow)	↓ (green)	↘ (yellow)
Grassland overexploitation	→ (yellow)	↑ (red)	↑ (red)	↗ (yellow)	↑ (red)	↗ (yellow)
Biodiversity	→ (yellow)	↑ (red)	↗ (yellow)	↑ (green)	↑ (green)	↑ (green)

The direction of the arrows specifies whether the paramer will increase in a scenario
Green arrows indicate a development that is considered beneficial from a societal perspective
Red arrows indicate a development which is considered detrimental from a societal perspective
Yellow arrow indicates constant trends or minor changes (less than 5%) according to the preliminary SOL-m calculations
Source: Schader *et al.* (2014b).

Table 5: Cost-effectiveness of organic agriculture support payments and single-target agri-environmental measures (AEM) in Switzerland for pursuing relative improvements (RI) in achieving agri-environmental policy targets

Indicator		Unit	Organic farming	Combined AEM		
				On all farms	On organic farms	On conventional farms
Cost (C)	Public expenditure	CHF/ha*year	66.58	73.17	23.11	78.62
Environmental effects (E)	Reduction of energy use	%*	5.28	1.50	3.76	1.38
	Improvement of habitat quality	%*	5.34	18.05	17.88	18.08
	Reduction of total eutrophication	%*	3.42	2.18	3.22	2.10
	Average improvement	%*	4.68	7.24	8.29	7.19
Abatement/ Provision cost (ABC)	Reduction of energy use	CHF/%RI**	12.61	48.94	6.14	56.88
	Improvement of habitat quality	CHF/%RI**	12.47	4.05	1.29	4.35
	Reduction of total eutrophication	CHF/%RI**	19.45	33.60	7.17	37.37
	Average improvement	CHF/%RI**	14.22	10.10	2.79	10.94

* relative improvement of the indicator due to the policy instrument
** CHF/year*1% improvement of the indicator
Source: own calculations based on Swiss FADN and SALCA data, Schader *et al.* (2014c).

of the approaches is able to cover all aspects of sustainability and all three sustainability strategies in sufficient depth. Therefore, when selecting tools for sustainability assessment of organic food systems, the purpose of the assessment needs to be specified exactly before selecting a level or even a specific tool for sustainability assessment.

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