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Full Research Article

Sustainability comparison of a local and a global milk value chains in Switzerland

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Abstract. Local food generally has a positive image, supported among consumers by the perception of reduced negative impacts on the environment and other dimensions. However, a critical analysis of local food chains' performance in comparison with more global ones is still needed to objectively assess the real benefits and drawbacks of local and global food chains. A careful analysis needs to be conducted to compare the sustainability performance of local food value chains with global ones. In this paper, the methodology of selecting a set of attributes and indicators of performance to compare the multi-dimensional performance of a local with a global food chain is presented. A specific selection of attributes of performance around five sustainability dimensions (economic, social, environmental, health and ethical) is used to measure and evaluate two Swiss milk chains' performances and compare the local chain with the global one.

Keywords. Local, global, attributes, sustainability, indicators, milk

JEL codes. Q56, Q57

1. Introduction

Currently, there is an increasing consumers' interest about the impact of food products on the environment, on their health or on social aspects. Consumers' demand for "local" food has increased significantly as a consequence of their willingness to purchase quality products and to support local economy and its farms (Adams and Salois, 2010; King *et al.*, 2010). However, a critical analysis of local food chains' performance in comparison with more global ones is still needed to objectively assess the real benefits and drawbacks of local and global food chains.

In the last years several authors have stressed the need to set up metrics, such as indicators, to assess the sustainability of food systems (Ericksen, 2007; van der Vorst, 2006). In

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their article, Pretty *et al*. (2010) even express the question: "How can we develop agreed metrics to monitor progress towards sustainability in different agricultural systems that are appropriate for, and acceptable to, different agro-ecological, social, economic and political contexts?", which means that such systems of attributes of performance should also be transposable to other countries and contexts, in addition to being objective, holistic and multidimensional (Born and Purcell, 2006).

For the purpose of this paper, we take the conceptual framework proposed by Neven (2014), which proposes that a sustainable food value chain can be conceptualized as "the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society, and does not permanently deplete natural resources".

In this study, the sustainability impact is assessed on two milk value chains in order to compare a local chain with a more global one. Actually, a clear distinction between the local and the global remains very unclear because there is no strict definition of local food (Edwards-Jones, 2010). In this study, we have considered the six criteria listed in Brunori *et al*. (2016) to select the case studies: (i) spatial configuration, (ii) product identity, (iii) physical distance, (iv) size of operations, (v) governance, and (vi) technologies. The local and global cases should be as opposite as possible in a maximum number of criteria. The two case studies in the fresh milk sector that are compared through the sustainability assessment are further described in chapter 3.

2. Methodology: sustainability assessment for food value chains

Several methods for assessing sustainability already exist, such as life cycle assessment (LCA) that focuses on the environmental impacts of a defined product all along the production chain, or the response-inducing sustainability evaluation (RISE), focusing at a farm or firm level of assessment. However, these methods usually do not include a multidimensional assessment operated at the scale of the entire food value chain (from input suppliers to consumers). The inclusive approach of sustainability assessment (whole supply chain and all aspects of sustainability) is currently rarely conducted as sustainability is often reduced to its environmental aspect or the assessment remains at the farm level (Schader *et al*., 2014).

Therefore, there is a need to develop a methodological framework to assess the performance of food value chains as a whole, in a way that allows the comparison of all dimensions of sustainability between different chains. The method used in this study has thus this goal of evaluating the sustainability performance of food value chains and comparing a more local chain and a more global chain in the milk sector.

The methodology proposed by the Sustainability Assessment of Food and Agriculture systems (SAFA) Guidelines from the FAO (2013) was the starting point for the elaboration of our methodological framework and proposes 4 main steps (mapping, contextualization, selecting indicators, reporting) that were adapted as follows. These steps are also explained in Brunori *et al*. (2016).

1. Mapping: This step mainly focuses on the scope and definition of the system boundaries, in terms of spatial definition and identification of entities. In this case, it is

important that the compared value chains encompass the same entities and comparable scopes. These are defined and represented in chapter 3.

2. Contextualization: As suggested in the SAFA guidelines, information should be gathered on all aspects of the value chains under study and the surrounding context. Knowledge about aspects such as the flows within the chain, interactions between actors, prices, geographical situation of the sector and national physical and socio-economic contexts, will be crucial to select the relevant indicators (as described in the third step below) and benchmarks. This is in order to grasp what can be the influence of the context on the performance of the value chains. For this reason, additional information has been collected in relation to the context surrounding the cases by what can be called descriptive indicators or 'descriptors'. They concern agricultural policies, tax and subsidies' systems, food regulations or natural conditions being used to describe and further define the chain and its context, helping in the later comparison. These descriptors also concern the data for the criteria of local-global distinction.
3. Selecting Indicators: For the goal of comparison of a local and a global value chain, a list of indicators was developed from different sources and not only from the SAFA listing. Instead of using SAFA themes, own themes, (what have been designated as "attributes") were used. Attributes are aggregations of a wide range of sustainability criteria for assessment, identified through a media analysis exercise and a Delphi survey conducted in both countries (Schmitt *et al.*, 2014; Kirwan *et al.*, 2014), as described in Brunori *et al.* (2016). Sources were selected for their reference to how the performance of food value chains is viewed in the public, scientific, market and policy spheres and most frequent themes were identified through software of qualitative data analysis (Kirwan *et al.*, 2014; Schmitt *et al.*, 2014). These themes were refined into attributes of performance through a participatory process in which twelve key actors of the food sector were interviewed (Schmitt *et al.*, 2014). Because the sustainability assessment should be holistic and multidimensional (Ostrom, 2009), experts from socio-economical to natural sciences and stakeholders from all stages of the food supply chains were consulted to define attributes and afterwards benchmarks. Actors were asked to rank the proposed attributes in order of importance and to change or complete the terms used. The final list of 12 attributes was selected through this iterative process and is shown in table 1. Each attribute is thereafter assessed with two or more indicators, which contain specific questions addressed to obtain performance scores. The selection of the indicators was made according to feasibility, data availability and relevance, three criteria often quoted in the literature on sustainability assessment (Bockstaller *et al.*, 2009). **Feasibility** means that indicators can realistically be measured in quantitative and qualitative terms and scored in relation to a benchmark. According to FAO (2013, p.216), benchmarks are "values or qualitative descriptions of activities, used as the basis by which the performance of an enterprise is evaluated within an indicator domain to facilitate a rating of sustainability performance. Regional and/or sectorial averages, as well as defined average (standard) and best practice values can be used as benchmarks". Indicators were adapted from existing lists of indicators (SAFA, RISE, etc.) as these lists also give insights about how such indicators have been measured and what benchmarks can be applied. Further indica-

tors have been created according to the case and consulted stakeholders. **Data availability** means that certain indicators were suppressed after checking existing databases and possibilities to gather sufficient representative primary data. **Relevance** means that the selected indicators are relevant for the purpose of comparing local with global, and that means that indicators with a probable difference between the local and global chains were prioritized.

The selection of indicators is however specifically adapted to a Swiss context and concerns a dairy sector. Table 1 shows all indicators by attributes and the questions used for data collection. The benchmarks applied for the assessment, the specific units as well as references are listed in the extended table in Annex.

4. Reporting: This last step includes the data analysis and its visual representation and discussion. Data can be qualitative or quantitative, primary or secondary, and have been collected through semi-structured interviews, online questionnaires and secondary sources (details in Table 2).

   After entry of all data into a database (EXCEL sheets), the performance was calculated for both chains based on the average measures on all the actors of the supply chain's step concerning each indicator. A score on a percentage scale was calculated for each indicator according to the benchmarks of lower and higher performance. The process of scoring the indicators' performance is presented in figure 1 with the example of the indicator "Producers' income". It is a continuous indicator for which the performance is evaluated on a continuous scale between pre-defined values of what could be the highest performance (higher benchmark) and what can be considered as the lowest acceptable performance (lower benchmark). The performance is then calculated with a cross-multiplication as on figure 1 and as of Schmitt *et al.* (2014). The benchmarks are either available from standardized indicators (FAO, 2013) or can be adjusted according to context justification (step 1) and experts' consultation. For example, a veterinary scientist was consulted regarding animal welfare indicators, in addition to consulting Swiss statistics on farm animal treatment and programs. Most sources consulted to establish the benchmarks are from institutions of the agricultural sector, as the benchmarks need to be in the same relevant context as the data. This limits the use of peer-reviewed literature in the definition of the benchmarks. For example, comparing income with some worldwide standard would not make sense, as incomes in Switzerland are usually much higher than in other countries. References included the Swiss annual agricultural reporting (Federal Office for Agriculture (FOAG), 2013), the milk sector statistics (Union Suisse des Paysans, 2012), and reports (Federal Office for Agriculture (FOAG), 2014) or websites of institutions and organizations in this sector[1]. Benchmarks regarding practices were established following the SAFA indicators (FAO, 2013) or by simulating the worst case and best case scenarios like for the GHG emissions. The references used to define indicators and benchmarks are listed in the table in the Annex and the SAFA indicators are specified with their code (e.g. E 5.1.3).

   As it can be seen in the table in the Annex, some indicators do not have values as benchmarks, but rather a yes/no (e.g. "Differentiation of the product"), which

[1] swissmilk.ch; www.sbv-usp.ch; blw.admin.ch; etc

Table 1. Attributes and indicators for the sustainability assessment.

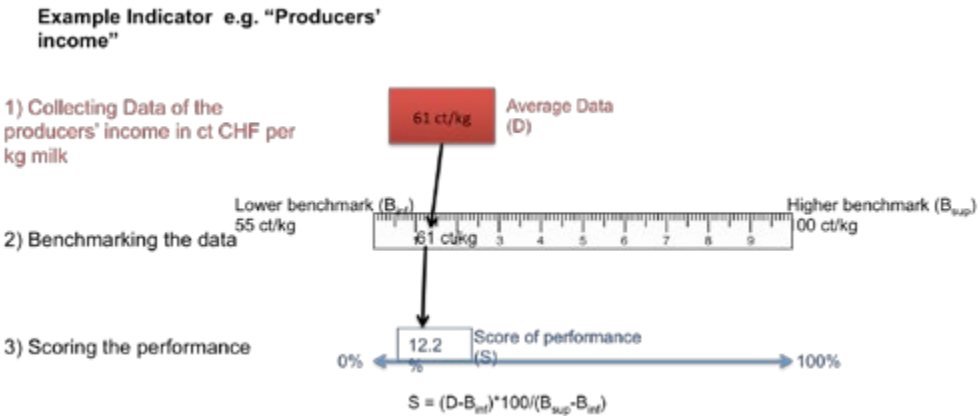
Attributes	Dimensions	Indicator	Question
Value Creation and Distribution	Economic	Differentiation of the product	Is the product clearly differentiated in order to increase its value?
		Producers' income	What is the price obtained by primary producers?
		Share of producers' price on sale price	What is the share of producers' price on the sale price?
Social Capital	Social, economic, ethical	Cooperative or association of producers in place	Do producers form cooperatives or associations to defend their interest?
		Interprofessional association or negotiation platform	Is there an inter-professional association or a platform for actors of the chain to meet and negotiate?
Working conditions	Social, economic	Average wage paid to farm employees	What is the salary paid to employees on farm?
		Average annual income of farmers	What is the average annual income? (Agricultural familial net income incl. direct payments)
Eco-efficiency	Environmental, economic	Production per lifespan of dairy cows	How long do you keep the dairy cows before slaughter? What is the average milk production per cow per year?
		Packaging material used	What type of packaging is used for the milk (multiple choice cf. categories)?
Climate change potential	Environmental, economic	Transport Greenhouse gas emissions	What transport means do you use to deliver your product? What is the distance of delivery?
		Production Greenhouse gas emissions	How much GHG is emitted on the farm-production stage?
Biodiversity	Environmental, health	Ecological compensation area	What is the percentage of the ecological compensation surfaces in relation to the total agricultural area?
		Crop rotations	How many crop rotations do you undertake on average per field?
		Locally adapted/resistant/ endangered crop varieties	Do you use locally adapted/resistant/ endangered crop varieties? (According to Pro Specia Rara)
		Area free of pesticide use	On what percentage of your total cropland area is no pesticides applied?
		GMO-free feed (certified) in the supply chain	Is the animal feed GMO free (labelled/certified) and do you renounce on the plantation of GMO crops?
		Breeding degree of the livestock	What breeds compose your dairy herd?

Attributes	Dimensions	Indicator	Question
Soil Preservation	Environmental, health	Growing of legumes in proportion of cropland surface	On what percentage of your cropland do you regularly grow legumes?
		Percentage of organic fertilizers in the total fertilizer application	What is the percentage of organic fertilizers in the total fertilizer application? (Mineral and organic)
Food quality & food safety	Health, ethical	Concentrated feed used per kg milk	How much concentrated feed do you give to your cows per year?
		Percentage of roughage in the animal feed	What is the percentage of roughage in the daily feed ration?
		Food safety standards from suppliers	Does the food chain actor have food safety insurance from the participants preceding them in the chain?
Transparency	Ethical, health	Proportion of information available to farmers	Which information is available to farmers (tick from: final price, type of product, place)
		Sufficient and clear Information available for consumers	What is the information available to consumers on packaging?
		Information made publicly available	What Information do you make freely available (online)?
Food Wastage	Ethical, environmental	Use of biogas plants	Is the farmyard manure and organic waste further processed in biogas plants?
		Use of byproducts from the food industry as animal feed (% of farmers)	Are byproducts from the food industry used as animal feed?
		Milk loss on farm	What percentage of milk is lost (not incl. converted as by-product)?
		Milk loss at processing	What percentage of milk is lost at processing stage?
Traceability	Ethical, economic, health	Traceability upstream of the supply chain	Is it possible to retrace the whole supply chain of the purchased products (incl. feed, package, etc)?
		Traceability downstream of the supply chain	Are the produced food products clearly marked so that the buyer can completely retrace them to their source?
Animal welfare	Ethical	Proportion of Participation in outdoor grazing program	Do you take part in the project Regular Outings?
		Life span of the dairy cows	What is the average age of the cow at slaughter?
		Proportion of Participation in loose housing program	Are the animals loose in the stable? (according to BTS program)
		Proportion of animals treated by Antibiotics in a year	What proportion of dairy cows is treated with antibiotics on average per year?
		Transportation duration to the slaughterhouse	What is the average transportation time to the slaughterhouse?

Table 2. Overview of the informing stakeholders and data collection procedures.

Chain	Actor	Data collection method
Local milk value chain	Cooperative	Interview 1.5 hour
	Farmers	Online survey sent to 53 farmers on a total of 75 farmers (17 answers)
	Retailer 1	Interview 1.5 hour
	Retailer 2	E-mail and telephone questionnaire
	Processor 1	E-mail questionnaire
	Input provider	Interview 1.5 hour
Global milk value chain	Farmers	Written questionnaire (5 answers) Secondary data
	Processor	Interview 1.5 hour
	Retailer	Interview 1.5 hour (in common with interview local chain)
	Input provider	Interview 1.5 hour (common with local chain)

Figure 1. Benchmarking system of indicators with the example of the indicator "Producers' income".



indicates that the indicator is qualitative and is not evaluated on a continuous numerical scale. Rather, the fact to fulfil the criteria as a whole is considered as the maximum performance. In this case, the performance does not vary but is either 100 or 0%. In some other cases (e.g., "Packaging material used"), the indicator is also qualitative but there are other stages of performance between "yes" and "no" and the categories for each percentage of performance are then given in the Annex. The last step consisted in analysing the differences of performance in each indicator between the local and the global chain.

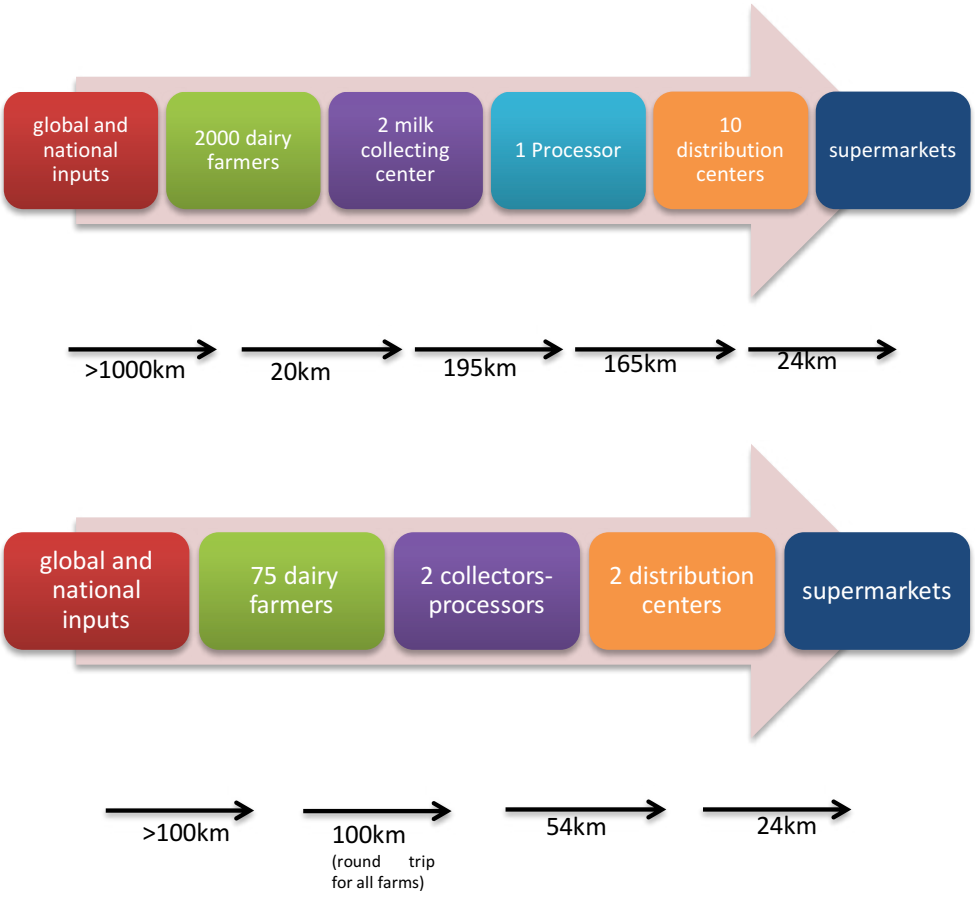
3. The Swiss milk case study

In Switzerland, two specific supply chains have respectively been chosen as "global" and "local" examples for comparison according to the six criteria of Brunori

et al. (2016). The two cases are described in this chapter and table 3 summarizes their characteristics in the six criteria, although the sixth criterion does not show a difference. The global supply chain is represented by a generic milk distributed all over the country by the supermarket owning the brand, thereafter named "global milk". The supply chain is composed of the steps presented in figure 2. These steps of the supply chain also limit the scope of the assessment by the indicators of sustainability. The milk may come from at least 2,000 dairy farmers. However, the processor uses "industry milk" for a whole segment of products from yogurts to desserts and so it was not possible to know in detail which quantities of milk are used for the global milk and from exactly how many producers it comes. The company processing and packaging the milk is also active at the international level, exporting specific products, but not the fresh milk. The company processes 265 millions kg milk per year but the exact part of fresh milk is not known, though it has been evaluated as around 11% during an interview. The supplying dairy farmers are located in three regions of Switzerland: the North-West around Basel, the North-East around St-Gallen, both assembling milk through collecting centres, and some more independent dairy farmers in the South-West range of Jura. These farmers are members of "milk centres" that are responsible for collecting and bulging the milk before delivery to the processor. Their governance is however rather weak and the price of industry milk has been falling constantly in the last few years. Thus the dairy farmers in this segment often have to produce a large quantity at a low production cost. They are mostly located in the low land and farm intensively with the type and quantity of input allowed within the Swiss agricultural legislation. The processing and packaging take place in South Switzerland and the milk is distributed all over the country. The distance can be evaluated as a minimum of 200 km between collecting centre and supermarket, and up to 500 km or more travelled within Switzerland. Fig. 2 shows the estimated average distances (according to interviews and road distances on google.maps) between some steps of the supply chain. In addition, a substantial distance is covered by inputs used as feed for the dairy farmers. They for example use soymeal feed from Brazil in the mix fed to dairy cows. Although the supply chain is mostly represented at the Swiss national level, it is the most "global" fresh milk product available to Swiss consumers and which can be contrasted in their purchasing decisions with the local milk described below.

The local supply chain on the other hand is represented by fresh milk sold as "Pasture milk", which is based on local resources and sold only in two defined regions by the same supermarket chain (which is divided in autonomous regions). The chain concerns a limited but increasing number of dairy farmers: 57 in the region Aare and 18 in the region Lucerne. In total the chain concerns approximately 13 to 15 million litres per year. One collector truck picks up the milk from the producers and one manufacturer packages it in each region and then delivers it to the distributing centre of the region. The total distance from farm to supermarket is evaluated between 40 and 100 km. In contrary to the global chain, dairy farmers are restricted in the use of imported feed and soymeal is specifically banned in this special regional milk chain. They have to follow a system of points attributed for good practices and if they do not obtain enough points they can be excluded from the supply chain (IP Suisse, 2015). However, some imported cereals like maize, might still be used (mostly from Europe) but the exact provenance is hard to

Figure 2. Supply chains of the two milk case studies (global above, local below).



monitor and highly variable. The next objective of the initiators of this product is then to also control the use of cereals for feed.

Concerning the social criteria of distinction between local and global, the main difference is that the local milk was an initiative from a farmers' association, thus united and represented by this cooperative defending their interests and also deciding on the code of practice. The local actors thus have a higher control on the governance of the value chain. The local milk is also clearly differentiated as a local product as it is sold under a label for regional products.

4. Results

The data collected and the scores of performance of both supply chains are presented in table 4. Of the 36 indicators, 20 obtained a better score in the local chain (56%), 7

Table 3. Description of the case studies along the criteria of local-global distinction (Brunori *et al.*, 2016).

Criteria	Global milk	Local milk
Spatial configuration	Widely spread production, 2 main collectors, 1 packaging hub and national consumption	Two separate regions with their own concentrated producers, common collecting and packaging and regional consumption
Product identity	Generic product (supermarket brand)	Differentiated with a label of regional origin and ecological quality
Physical distance	From 200 to 500 km or more (main supply chain). Global inputs	40 to 100 km (main supply chain) Controlled inputs (continental)
Size of operations	The biggest national enterprise in this sector, transforming 265 million kg milk per year (incl. other dairy products)	Two regional dairies, overall production of 13 to 15 million litres per year
Governance	Farmers weakly organized around regional collecting centers, the processor/retailer detains the decision power on price, processing, etc	Initiative of farmers organized in an association who manages a book of requirements and negotiate prices
Technologies	Most modern and automated technologies	Most modern and automated technologies

were equal and 9 were better in the global chain. These differences can also be seen in figure 3. On this chart the performance of the global chain has been artificially set to the middle of the scale (50%) and the performance of the local chain normalized to this score and limited between 0 and 100%. It can thus be seen in which indicators the local chain performs two times better or just slightly better, or worse than the global chain. We have set the global chain as reference because it is a conventional supermarket supply chain and the local chain is corresponding more to an alternative. On this radar, it is quite clear that the local chain is situated more at the outsides of the radar, thus showing higher performances. It is especially clear for the attributes transparency, soil preservation and food quality and safety. The local milk performs better for 6 attributes composed each by 2 to 4 indicators. It performs better in multiple dimensions like in the economic and social dimensions (value creation and distribution), in the environmental and health dimensions (climate change potential, biodiversity, soil preservation), and in the ethical and health dimensions (food quality and safety, and transparency).

In the economic dimension, which is concerned by the attribute "value creation and distribution", there are three indicators. The indicator "differentiation of the product" is a yes/no indicator concerning the clear promotion of the product with ecological and/or provenance aspects. The answer is yes for the local chain and no for the global chain, thus explaining the total difference in the score. For the two other indicators, it seems that milk producers in the local chain obtain a slightly higher price on the milk, even though the performance is really low for both chains (12 and 9%). But in proportion to the price of the final product in the supermarket local farmers get a lower share than in the global chain (local farmers get 60 cents out of CHF 1.55 (39%) and global farmers get 59.3 cents out of CHF 1.43 (43%) for a litre of milk). The increase of the retail price of the local milk is thus translated in a higher margin for the retailer.

Table 4. Data for indicators and performance scores.

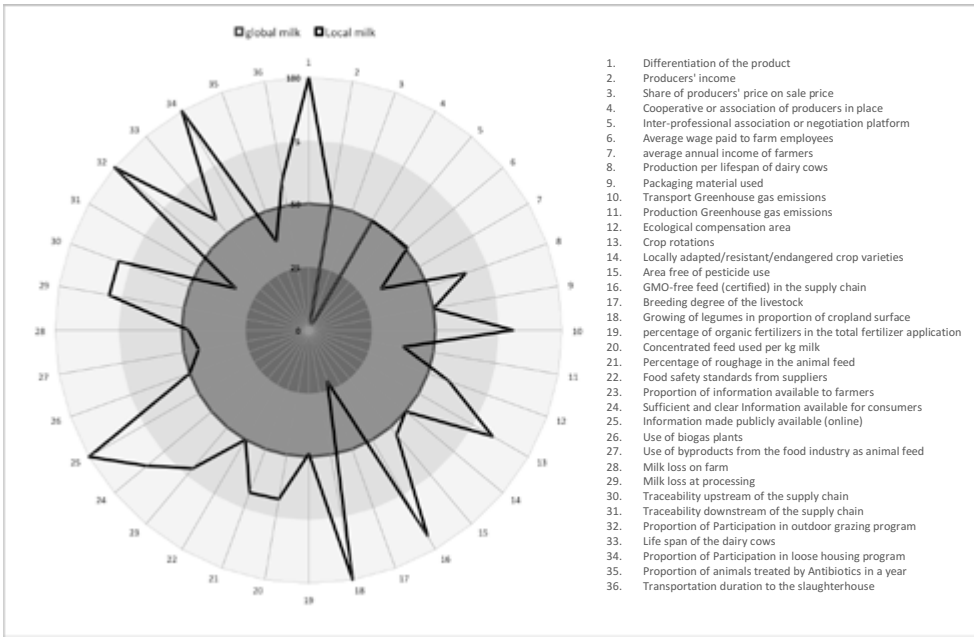
Indicator	Unit	Data		Score (%)	
		Global	Local	Global	Local
Differentiation of the product	no/yes	no	yes	0	100
Producers' income	ct/ kg milk	59.3	60.6	9	12
Share of producers' price on sale price	%	42.7	39.1	14	0
Cooperative or association of producers in place	no/yes	yes	yes	100	100
Inter-professional association or negotiation platform	no/yes	yes	yes	100	100
Average wage paid to farm employees	CHF	3200	3250	1	3
Average annual income of farmers	CHF	54 927	51 471	45	30
Production per lifespan of dairy cows	kg milk per lifespan	28 135	38 233	9	38
Packaging material used	categories	packaging from certified ecological production	packaging from certified ecological production	40	40
Transport Greenhouse gas emissions	CO_2eq./km	51.3	19.8	0	59
Production Greenhouse gas emissions	kg CO_2eq./kg milk ECM	1.1	1.5	69	53
Ecological compensation area	% of total agricultural area	11.8	13.3	41	52
Crop rotations	number of crop rotations	3	5.7	0	68
Locally adapted/resistant/endangered crop varieties	no/yes	no	no	0	0
Area free of pesticide use	% of crop land	27.9	33.5	28	34
GMO-free feed (certified) in the supply chain	no/yes	0	87.5	0	88
Breeding degree of the livestock	average of categories for all farmers	50	22	50	22
Growing of legumes in proportion of cropland surface	% of the total crop land	0	10.4	0	100
percentage of organic fertilizers in the total fertilizer application	% of total fertilizers used	71.4	69.7	71	70
Concentrated feed used per kg milk	g concentrated feed / kg milk produced	130.4	90.3	25	52
Percentage of roughage in the animal feed	% of total feed	70	77.3	33	58
Food safety standards from suppliers	no/yes	yes	yes	100	100
Proportion of information available to farmers	average of categories for all farmers	0	42.4	0	42
Sufficient and clear Information available for consumers	categories (%)	40	80	40	80

Indicator	Unit	Data		Score (%)	
		Global	Local	Global	Local
Information made publicly available	categories (%)	70	100	67	100
Use of biogas plants	no/yes	no	no	0	0
Use of byproducts from the food industry as animal feed	% of farmers	20	17.6	20	18
Milk loss on farm	%	1	1.5	90	85
Milk loss at processing	%	0.5	0.2	0	60
Traceability upstream of the supply chain	average of categories for all farmers	20	67.6	20	68
Traceability downstream of the supply chain	no/yes	100	66.7	100	67
Proportion of Participation in outdoor grazing program	% of participation (from all farmers)	69	100	92	100
Life span of the dairy cows	years	4.5	5	0	0
Proportion of Participation in loose housing program	% of participation (from all farmers)	23	70.6	77	100
Proportion of animals treated by Antibiotics in a year	% treated cows	17.5	35.8	100	90
Transportation duration to the slaughterhouse	minutes	46.3	42.9	82	86

The social dimension concerns two attributes and four indicators. The two indicators of the attribute "social capital" do not show any difference as both chains perform with 100%. In both cases cooperatives and inter-professional organisations are present to support farmers in the defence of their interests and to offer space for negotiations. Concerning the attribute "working conditions", farm employees are paid a little better in the local chain although the difference in performance is minimal (2%) and both are extremely low (1 and 3%). When looking at the annual income of dairy farmers in comparison with the national average in this sector, the ones in the global chain obtain a performance 15% higher. In summary, both chains obtain their equal share of indicators performing better in the social dimension.

The environmental dimension contains more attributes and indicators: four attributes measured by 12 indicators, but all of them are also relevant to other dimensions (cfr. table 1). The eco-efficiency is considered both environmentally - because the production of more with less is responsible in terms of resource use and planetary boundaries (Pretty, 2013) - and economically - because it can obviously reduce production costs. The first indicator in this attribute looks at the production per cow on their entire lifespan. Cows in the local chain live in average a half-year longer and also were reported to produce more per year so the local chain has a better performance. The second indicator concerns the material used for packaging: the most ecological and economical would be to have no

Figure 3. Performance of the local chain compared to the global chain.



packaging at all (re-used bottles) but actually both milks are packaged in similar paper-bricks, with however a label of ecological paper production (the FSC label). It is however not recyclable or reusable in both cases and both chains obtain a score of 40%. Regarding climate change impacts, the local chain performs better on limiting emissions from transport because of the much shorter distance travelled in the local chain. These scores were calculated from data about transport means and distance and using a life-cycle assessment database that gives coefficients of GHG emissions for transport means. For the second indicator "production greenhouse gas emissions", no direct measurement of GHG emissions on farms was possible and a secondary source was used. Sutter *et al.* (2013) compare two systems very similar to ours in Switzerland. As the local system produces less milk on the same area because of grass-based feed, more GHG, especially methane, are emitted at the production stage (Sutter *et al.*, 2013).

The biodiversity attribute contains six indicators and the global chain performs better in only one of them. A certain percentage of the farming surfaces must be set aside (non-cultivated): this is a requirement for being eligible to certain direct payments and that's why all farmers comply with this indicator. Interestingly, farmers in the local chain still had larger "compensation surfaces" (13.3% on average against 11.8%). The diversity of crops in the rotation is also much higher with an average of 7 crops for local farmers and only 3 for the global chain. Farmers in neither chains use locally adapted or rare varieties (according to the Pro Specie rara catalogue (2016)) and both perform 0% for this indicator. The use of pesticides is done on larger surfaces among farmers of the global chain although the difference is small (performance 28% *vs.* 34% in the local chain). The use of GMO is

controversial regarding sustainability and the Swiss legislation is one of the strictest in their restriction but still allows some amount in animal feed. Farmers in the global chain do not renounce to it and do not use certified GMO-free feed but 87.5% of farmers in the local chain do. Regarding traditional species conservation on farms, neither chains had many traditional dairy cows and most tend to have high-producing breeds like red Holstein.

Concerning the attribute Soil preservation, the local chain's farmers use much more legumes in their crop cultures, which give them the advantage in the first indicator. Concerning the proportion of organic fertilization, both chains have surprisingly very close scores (71 and 70%).

The attribute "food quality and food safety" covers the health dimension of the assessment. The two first indicators are linked to the fat quality found in the milk and in both cases the local chain performs better as the feeding of cows relies much more on fodder rather than concentrates. As a consequence the content of fatty acids in the milk, especially the omega3 to omega6 ratio, is healthier (Thomet *et al.*, 2011). There is no difference in terms of safety standards followed by both chains (both 100% performance in the last indicator of this attribute).

The four last attributes are linked to the ethical dimensions but also to the social or environmental dimensions. For all indicators of "transparency" the local chain performs around 40% better. These indicators were constructed with categories of information that should be available to farmers, consumers or the public about the product, its production and the enterprises in the supply chain.

For the attribute "food wastage", neither of the chains' farmers use a biogas plant (first indicator). Concerning the use of industry by-products as feed, farmers of the global chain seem slightly better, as well as in avoiding milk losses. At processing, the local processors seem better in avoiding milk losses during packaging.

In terms of traceability, the global chain has a better performance concerning the monitoring of traceability downstream of the supply chain (marking products which are sold) but a worse performance for traceability upstream of the supply chain (ability to know the origin of all components).

The last attribute "animal welfare" contains five indicators and the local chain presents higher performances in three of them. Farmers of the local chain participate in more animal-welfare voluntary programs and thus perform better in "Proportion of participation in outdoor grazing program" and "Proportion of Participation in loose housing program". They also perform better in the last indicator "Transportation duration to the slaughterhouse" probably due to their general geographical position closer to a major slaughterhouse in Basel. Both chains have cows who do not live for many years (4.5 and 5 years), so both get a null performance according to the benchmarks with a minimum at 5 years, but the local chain still performs a little bit better. Concerning animal health, farmers in the global chain seem to give fewer antibiotics and thus perform better in the indicator "Proportion of animals treated by Antibiotics in a year".

5. Discussion

The analysis of several chosen indicators shows a clear distinction between the Global and Local milk that reflects the difference concerning geographical flows, governance,

production systems and logistics. The local milk clearly performs better in terms of number of indicators.

This difference in performances can be explained in part by important factors that influence the performance score of several indicators, and were mentioned by most actors as relevant. These factors were the strategies in the choice of animal feed and the differentiation of the product. The animal feeding strategy for example influences the whole organization of farms by changing the possibilities of crop rotations, productivity per hectare and per cow, GHG emissions, animal welfare, fat quality in the milk, and also greatly influences the impact on biodiversity abroad where concentrated feed is produced. The differentiation of the product is a whole different marketing strategy that triggers a different supply chain arrangement and the sharing of information. It thus influences transparency, relation among actors, communication with the consumers and price. In contrast, the standardization of the product that is a strategy more typical of global products leads to a decrease of precise information available to consumers and of transparency as well as traceability (for consumers and farmers), but on the other side, it can help to decrease the production costs, reduce waste and deal better with consumption variations over the year. However, the inclusion of social and environmental externalities might balance this. Moreover, the local milk chain was still at the beginning of the initiative at time of data collection and is still expected to improve its performance. For the moment, some of the local milk sometimes has to be de-classified and is then mixed with other milks into generic brands. When this happens, a part of the added value due to the differentiation of the product is lost.

However, all in all, the efforts of this initiative to promote localness and ecological values around the local milk are shown to contribute to sustainability through our indicators.

In comparison with other studies, Binder *et al.* (2012) realized a sustainability assessment of the Swiss milk sector in general, which would correspond to our global case study. Their indicators are constructed differently and the data are used in a too different way to allow direct comparison with our indicators. However, it is worth to underline that both studies identify similar themes of sustainability like biodiversity, social capital, GHG emissions, hourly wages, etc. applicable to the same stages of the value chain. Furthermore, both studies identify similar critical issues and trade-offs, for example that the increase of the biodiversity in Switzerland (by increasing conservation surfaces) might impact biodiversity in Brazil through the production of concentrated feed and the deforestation linked to the cultivation of the corresponding soya and maize (Binder *et al.* 2012). This was however not the case in our local chain, as local farmers have larger conservation areas while feeding less concentrated feed at the same time. Interestingly, their study followed the same methodological process for the selection of indicators and benchmarking, which they call upper and lower boundaries of the sustainability range.

A first important result in this study consist as well in the nature of the attributes. In Switzerland, milk production is seen by various stakeholders as being important from all points of views (multi-dimensional), but the choice of the attributes themselves reflect the sensitivity that is peculiar to that country and sector. As in Binder *et al.* (2012), social topics like fairness of remuneration of farmers, social capital and working conditions, but as well environmental issues like climate change, biodiversity, soil, food waste and more ethi-

cal and health concerns like food quality, transparency along food chain and animal welfare, are topics that strongly came forward. It is also necessary to acknowledge that the choice of the examined "critical issues" of sustainability of the milk value chain is very hard to maintain objectivity, as the selection of the attributes integrates the stakeholders directly. It then becomes inevitably context-dependent, as they tend to give importance to what is relevant in their daily activities. The final selection is thus linked to that specific cultural and biophysical context. The validity of the specific analysis framework and subsequent results is thus limited to a certain sector and to a certain country. In contrary to Pretty *et al.* (2010)'s hope for a universal tool, we rather think that such indicator tools have to be context-related.

Therefore, the selection of the attributes and indicators really needs to be done in a participatory way and in connection with that context in order to be relevant (Van Passel and Meul, 2012; Binder *et al.*, 2010; Bossel, 1999). A participatory process moreover has the advantage to avoid misinterpretations of the issues and results, which is often the case in sustainability assessments, as noted by Gasparatos and Scolobig (2012). The choice of the key stakeholders is therefore crucial and the researcher has to be aware that the final list of indicators could change the results one way or another *(*Schader *et al.*, 2014).

The benchmarking of each indicator is also a crucial phase. It already requires a holistic vision of what the limits in performance of the chain are and could be in the most sustainable and most unsustainable cases and a good knowledge of the context.

The stakeholders interviewed during the attributes' selection phase often emphasized the economic aspects as being the most crucial because without a substantial profit nothing can be done. This leads to the issue of weighting the indicators according to their importance. We have chosen not to dedicate this study to the weighing and further averaging of the indicators because the detailed results and multidimensionality should not be lost. As Schader *et al.* (2014) wrote, there is often a trade-off between the precision of data that researchers can collect and the multi-dimensionality of an evaluation; we then tried to overcome this challenge by downsizing the amount of attributes according to their relevance in the specific context of the dairy sector, while keeping some precise indicators. However the results show that some indicators could have been set aside as they do not show any difference between the local and global chains, such as social capital.

Collecting data proved to be difficult for the very first (input provision) and last steps (distribution and consumption) of the supply chains in the study conducted. Indeed, some agricultural inputs are often imported through market channels that are hard to entirely trace and the sustainability of their production is even harder to assess. The end of the supply chain, with the biggest companies and sometimes the exportation of products, is also hard to be completely captured as stakeholders are harder to anonymise and fear more for the use of their confidential data. These two ends of the value chains are thus a sort of darker zones that deserve more attention in future sustainability assessments.

6. Conclusion

As seen in this study developing a set of attributes of performance to compare local and global food value chains, the process of selecting the appropriate indicators and benchmarks are crucial. An in-depth exploration of the context and the participation of stakeholders in an iterative process were thus required to define the attributes and focus on the most rel-

evant ones. The use of numerous interviews and the wide sources to contextualize and assess each chain's performance gives to the followed methodology great insight on each chain's critical issues and on the most relevant attributes to assess. However, at the indicator level, more work should be carried out to weigh them for aggregation; such a process could however be very time-consuming and reduce the transparency of the results and the objectiveness of the assessments. Nevertheless, the assessment succeeded in remaining multidimensional and in finding the critical issues that differentiate the local and global chains in their sustainability. The two major advantages of the studied "more local" chain in terms of sustainability are its marketing strategy to differentiate the product in terms of provenance and ecological label. This induces a more coordinated governance among producers and with the retailer. It also prompted a reflexion on the production's book of requirement and ecological practices on farms. A major impact on sustainability comes from the animal feeding strategy as a grass-based diet influences the rotation of cultures (soil preservation), the biodiversity in Switzerland and Brazil, the time animals spend outside (animal welfare), and even the nutritional quality of the milk fatty acids. However, the global chain might have the advantage to emit less GHG emissions per kilo milk produced but an LCA from input production to consumption would be more adequate to evaluate this specific question. The global chain also might be more efficient in terms of production costs as farmers in the global chain showed higher annual wages, but the local initiative is still at its beginning.

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ANNEX

Attribute	Indicator	Unit	Low benchmark	High benchmark	References for creation and benchmarks	Data Global	Data Local	Score Global (%)	Score Local (%)
Value Creation and Distribution	Differentiation of the product	no/yes	no	yes	SAFA (C 3.3.1)	no	yes	0	100
	Producers' income	ct/ kg milk	55 ct/kg	156 ct/kg	SAFA (C 1.4.1) USP 2012	59.3	60.6	9	12
	Share of producers' price on sale price	%	40%	60%	USP 2012, FOAG 2014[1]	42.7	39.1	14	0
Social Capital	Cooperative or association of producers in place	no/yes	no	yes	SAFA (S 2.2.1)	yes	yes	100	100
	Interprofessional association or negotiation platform	no/yes	no	yes	SAFA (S 2.2.1)	yes	yes	100	100
Working conditions	Average wage paid to farm employees	CHF/month	3170 CHF/month	6125 CHF/month	SAFA (C 1.4.1) USP 2012	3200	3250	1	3
	Aaverage annual income of farmers	CHF/year	44'772 CHF/year	67'158 CHF/year	Hoop &Schmid[2], Agroscope 2013, Expert O. Schmid	54 927	51 471	45	30

Attribute	Indicator	Unit	Low benchmark	High benchmark	References for creation and benchmarks	Data Global	Data Local	Score Global (%)	Score Local (%)
Eco-efficiency	Production per lifespan of dairy cows	kg milk per lifespan	25'000 kg milk	60'000 kg milk	Expert C. Notz	28 135	38 233	9	38
	Packaging material used	categories	Categories: conventional package - 0%/ recyclable packaging - 20% / packaging from certified ecological material - 40%/ packaging from recycled material - 60%/packaging from recycled certified ecological material - 80% / no packaging or reused packages - 100%	SAFA (E 5.1.3)	packaging from certified ecological production	packaging from certified ecological production	40	40	
Climate change potential	Transport Greenhouse gas emissions	CO_2eq./km	48.4 CO_2 eq./km	0 CO_2 eq./km	SAFA (E 1.1.2) benchmarks calculated from theoretical worse-case	51.3	19.8	0	59
	Production Greenhouse gas emissions	kg CO_2eq./kg milk ECM	2.5 kg CO_2eq./kg milk ECM (energy corrected milk)	0.5 kg CO_2eq./kg milk ECM	SAFA (E 1.1.2). Nemecek *et al.* 2008[3]	1.1	1.5	69	53

Attribute	Indicator	Unit	Low benchmark	High benchmark	References for creation and benchmarks	Data Global	Data Local	Score Global (%)	Score Local (%)
Biodiversity	Ecological compensation area	% of total agricultural area	6%	20%	SAFA (E 3.2.2), expert A. Fliessbach	11.8	13.3	41	52
	Crop rotations	number of crop rotations	3 crops	7 crops	SAFA (E 4.2.4). RISE[4] expert A. Fliessbach	3	5.7	0	68
	Locally adapted/ resistant/endangered crop varieties	no/yes	no	yes	SAFA (E 4.3.3) Pro Specie Rara 2016	no	no	0	0
	Area free of pesticide use	% of crop land	0%	100%	SAFA (E 4.1.2) RISE expert A. Fliessbach	27.9	33.5	28	34
	GMO-free feed (certified) in the supply chain	no/yes	no	yes	Jacobsen *et al.* 2013[5]	0	87.5	0	88
	Breeding degree of the livestock	average of categories for all farmers	categories: highly bred specy for intensive production -0%/ medium bred specy - 50%/ traditional specy - 100%	SAFA (E 4.2.2), Expert C. Notz	50	22	50	22	
Soil Preservation	Growing of legumes in proportion of cropland surface	% of the total crop land	0%	5%	expert A. Fliessbach	0	10.4	0	100
	percentage of organic fertilizers in the total fertilizer application	% of total fertilizers used	0%	100%	SAFA (E 3.1.1) expert A. Fliessbach	71.4	69.7	71	70
Food quality & food safety	Concentrated feed used per kg milk	g concentrated feed / kg milk produced	168 g	18 g	IP Suisse 2015	130.4	90.3	25	52
	Percentage of roughage in the animal feed	% of total feed	60%	90%	SAFA (E 1.1.3) expert C Notz	70	77.3	33	58
	Food safety standards from suppliers	no/yes	no	yes	SAFA (C 3.1.3 – 3.2.1)	yes	yes	100	100

Attribute	Indicator	Unit	Low benchmark	High benchmark	References for creation and benchmarks	Data Global	Data Local	Score Global (%)	Score Local (%)
Transparency	Proportion of information available to farmers	average of categories for all farmers	% of the following categories: final price, type of product, place of sale	SAFA (G 2.3.1)	0	42.4	0	42	
	Sufficient and clear Information available for consumers	categories (%)	categories each worth 20%: legally required information/ additional information on nutrition / additional information on animal husbandry conditions / Additional information of ingredients' sources / Other additional information	SAFA (C 3.3.1)	40	80	40	80	
	Information made publicly available	categories (%)	Categories each worth 20%: legally required information/ Information on enterprises' structure/ information on standards and processes/ Annual financial reporting/ corporate responsibility report/ Data freely available	SAFA (G 2.3.1)	70	100	67	100	

Attribute	Indicator	Unit	Low benchmark	High benchmark	References for creation and benchmarks	Data Global	Data Local	Score Global (%)	Score Local (%)
Food Wastage	Use of biogas plants	no/yes	no	yes	RISE	no	no	0	0
	Use of byproducts from the food industry as animal feed (% of farmers)	% of farmers	0%	100%	Beretta *et al.* 2013[6]	20	17.6	20	18
	Milk loss on farm	%	10%	0%	SAFA (E 5.3.4) Beretta *et al.* 2013	1	1.5	90	85
	Milk loss at processing	%	0.5%	0%	SAFA (E 5.3.4) Beretta *et al.* 2013	0.5	0.2	0	60
Traceability	Traceability upstream of the supply chain	average of categories for all farmers	categories: no - 0% / partially - 50% /yes - 100%	SAFA (C 3.3.2)	20	67.6	20	68	
	Traceability downstream of the supply chain	no/yes	categories: no - 0% / partially - 50% /yes - 100%	SAFA (C 3.3.2)	100	66.7	100	67	
Animal welfare	Proportion of Participation in outdoor grazing program	% of participation (from all farmers)	0%	75%	Expert C. Notz	69	100	92	100
	Life span of the dairy cows	years	5 years	8 years	Expert C. Notz	4.5	5	0	0
	Proportion of Participation in loose housing program	% of participation (from all farmers)	0%	30%	SAFA (E 6.2.1) Expert C. Notz	23	70.6	77	100
	Proportion of animals treated by Antibiotics in a year	% treated cows	90%	30%	SAFA (E 6.1.2) Expert C. Notz	17.5	35.8	100	90
	Transportation duration to the slaughterhouse	minutes	120 minutes	30 minutes	SAFA (E 6.2.3) Expert C. Notz	46.3	42.9	82	86

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