Common method and indicators for sustainability assessment

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Abstract

This chapter summarizes the common method and indicators used to assess the sustainability performance of Food Quality Schemes (FQS) and their reference product throughout this book. In particular, it contains the list of 23 indicators used to assess sustainability in food and agri-food value chains. This list was obtained on the basis of literature review and the FAO's Sustainability Assessment of Food and Agriculture systems (SAFA) indicators (FAO, 2013). The chapter presents the assumptions and choices, the process of data collection and the indicator estimation methods designed to fulfill the objective of assessing the three sustainability dimensions within a reasonable time constraint, namely three person.months for each food quality scheme and its non-certified reference product. In particular, several prioritizations were set regarding data collection (indicator, variable, value chain level) together with a level of representativeness (country and sector) specific to each variable and product type. This chapter also summarizes how relatively common variables (e.g., number of animals per hectare, …) collected for each case study are combined into indicators (e.g., carbon footprint), thus providing the keys for their interpretation in subsequent chapters.

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General points on indicators and their analysis

Overview of indicators and minimal systematic comparison

This chapter describes the indicators used in the Horizon 2020 Strength2food project to measure the sustainability level of food products with very different characteristics: fresh, processed, organic, designated by Geographical Indication and conventional. The choice of indicators was made on the basis of the SAFA methodology (Sustainability Assessment of Food and Agriculture systems) developed by FAO (FAO, 2013) to measure the sustainability of food production.

With the SAFA methodology, the FAO presents a holistic approach and provides a list of 116 sub-dimensions grouped by the contribution given to sustainable development in environmental, social, economic and governance aspects for the production of crops, livestock, forestry, fisheries and aquaculture enterprises. For each indicator, SAFA provides guidelines on how to consider each sub-dimension, including which indicators are could be relevant and useful references on how to implement them. SAFA however is primarily focused on processing firms and stops short of formulated a complete method which goes from primary data collection to indicator estimation and interpretation.

The Strength2food indicators presented in this chapter operationalize a subset of SAFA indicators, complementing them along the following three lines:

- ✓ Most SAFA indicators cannot be directly implemented from the SAFA indicators report: they require the definition of specific data to be collected and calculation or aggregation methods which are not explicated in the report (although the report sometimes refers to existing tools allowing to do it). The Strength2food method defines all necessary data and variables, and provides the associated calculators or aggregation methods, together with a data storage and source traceability system.
- ✓ Many SAFA indicators require a substantial amount of data. This is because they were designed to be collected for a single firm, which makes it difficult to cover more than a few indicators for an entire value chain within 3 person-months. The Strength2food method simplifies indicators by prioritizing data collection on the key drivers of the indicators, by providing default values for many non-key but necessary variable and, where necessary, by restricting the scope of an original SAFA indicator down to the scope for which data is most accessible. As a result, it allows in most cases to estimate 23 sustainability indicators across the three sustainable development pillars for both a specific product produced by several firms and a generic reference product in 3 person-months.
- ✓ Finally, several SAFA indicators rely only on the subjective views of specific stakeholders. Where stakeholder views are a necessary part of the indicator (eg. bargaining power distribution), the Strength2food indicators combine stakeholder views with objective data.

To make the collection of information and the subsequent analysis on the 27 case studies of the Strenght2Food project efficient, operational choices were made with respect to the type of indicators and their management. One of the most important choices is the distinction between "systematic indicators" which should be computed on all case studies and "complementary indicators" which concern only a subset of case studies, often based on data availability. The systematic indicators were 13 in total (4 for economic; 4 for environmental; 5 for social), while complementary indicators where 10 in total (5 for economic; 3 for environmental; 2 for social). For a fine assessment of all 23 indicators, around 150 variables were collected (Table 1).

Table 1. List of indicators for sustainability assessment

	Sustainability pillar	Indicathor type	Indicator sub-type	Level of analysis along the value chain
Systematic	Economic	Price premium	Price premium	One value per level of the value chain
		Profitability and value added distribution	Gross Operating Margin	
		Trade	Share of value exported within Europe	Single value for the whole value chain
		Local multiplier	Local multiplier	
	Environmental	Foodmiles	Distance travelled per unit of product	One value per level of the value chain
		Carbon footprint	Carbon footprint per unit of product	Single value for the whole value chain
		Water footprint	Blue water footprint (surface and ground water consumption)	
			Grey water footprint (water pollution by nitrates)	
	Social	Employment	Labour to production ratio	One value per level of the value chain
		Governance	Bargaining power distribution	
		Social capital	Educational attainment	
			Generational change	
			Gender equality	
Complementary	Economic	Profitability and value added distribution	Gross Value-added	One value per level of the value chain
		Profitability and value added distribution	Net result	
		Trade	Share of value exported outside Europe	Single value for the whole value chain
			Share of volume exported within Europe	
			Share of volume exported outside Europe	
	Environmental	Foodmiles	Emissions from transportation per unit of product	One value per level of the value chain
		Carbon footprint	Carbon footprint per hectare	

		Water footprint	Green water foot-print (rainwater consumption)	
	Social	Employment	Turnover to labour ratio	One value per level of the value chain
		Social capital	Wage level	

Analysis of indicators

In multi-criteria analysis such as those undertaken here, there are two ways to look at the indicators: one can either combine them into a single composite indicator or use radar charts or similar display formats (Bockstaller et al., 2015; Rigby et al., 2001). Both have pros and cons in relation to the objective of the research. A composite indicator allows for a synthetic performance score for the system under study why for an quick evaluation also by non expert policy makers but results. However, this benefit is obtained at the expense of a substantial information loss. In particular, one may miss threshold effects such as a system which is performing quite well overall but which seriously underperforms in one of the dimensions. In addition, the assumptions necessary to add up the “apples and pears” heavily weigh on the final results: should an equal weigh be applied to the economy and the environment? Should environmental indicators be converted into euros? If so, which externality valuating technique should be used? And many other fundamental questions (Gan et al., 2017).

Considering the objective of this research, in describing the contribution of each indicator to the sustainability of the value chain, we decided not to combine indicators and instead resort to radar charts. Each chapter thus contains one radar chart summarizing the sustainability assessment comparing the product under Food Quality Scheme with a reference product (the zero level) in percentage variation (Figure 1), followed by its interpretation. Each branch presents the performance of the value chain, averaged across the chain levels (eg. farms and processors), for one of the systematic indicators. For the environmental indicators for which lower is better, the opposite of the difference (e.g., +20% when the carbon footprint is 20% lower) and the supply chain total – rather than supply chain average – are displayed.

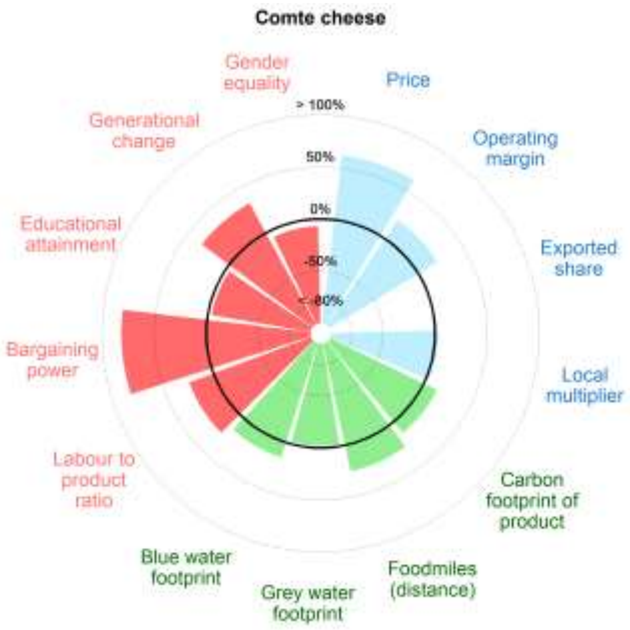

Figure 1. Sustainability performance of PDO Comté cheese

Reference, data collection and metadata documentation

Selection of a reference product/case: elements of guidance

To provide a basis for comparison, each sustainability indicator has been estimated for the same product category (for example cheese) in two different value chains: specific quality (organic or geographical indication) and generic quality (reference product). In order to define the reference, the following guidance, composed of two objectives and three constraints, was applies. The two objectives are:

- ✓ Comparability of contexts: the two cases (food quality scheme and its standard reference) should be produced in territorial contexts (in terms of location) as similar as possible;
- ✓ Comparability of the products: the two products/basket of products (food quality scheme and their standard reference) should be as comparable as possible.

These objectives should be sought until one of the three following constraints are met:

- ✓ Data resolution limit: data for the reference are only available at a larger scale than for the case studied.
- ✓ Confusion of the case and its reference: for example, for an apple under geographical indication (GI), the reference would ideally be the production of ‘standard’ apples in the same area. Nevertheless, if almost all the apple production of that area is under GI, a reference should be chosen at a larger scale (regional or even national scale).
- ✓ The case studied is the only one of its type: with the example of an apple under GI, the ideal reference would be a standard apple of the same variety. Nevertheless, as mentioned for geographic scale, data may be scarce at this detailed level (variety), or even all the apples of this variety may be sold under GI. In this case a suitable reference would be one, or a mix of, the main varieties.

In practice, the choice of a relevant reference by case study conductors will strongly depend on data availability, so that a national average can be used if a more suited reference cannot be documented. Moreover, a mix of specific references and national averages can be used. For example, looking at the Comté cheese, some variables (e.g. price of milk, price of cheese, …) may be specific to Emmental, a non-certified ripened, hard, cow-milk based cheese, while national averages are used for other variables (e.g. quantity of mineral fertilizer per hectare, share of exports over total production, …) for which Emmental-specific data are not readily available.

Note that the use of the reference is primarily to interpret the results from the case so even if the reference presents some peculiarities, this can be accounted for in the discussion of results. Indeed, although we opted for real *relative references* in Strengh2Food, many performance assessments use *normative references*, that is references which correspond to fictive cases or to targets to be reached (Acosta-Alba and Van der Werf, 2011).

Data collection

Two angles of prioritization

Two distinctions were made to convey a sense of priority for data collection:

- ✓ **Systematic vs complementary indicators**: systematic indicators were to be computed for all case studies while complementary ones could be restricted to a subset of cases which are particularly interesting;
- ✓ **Key vs secondary variables**: a reasonable approximation of the indicator can be obtained from key variables data, while obtaining values for secondary variables would create even more precise estimates.

Which firms belong to the value chain?

When firms are making only part of their turnover from the FQS product – e.g. a freezing plant which is freezing and packaging all kind of fruits, including the FQS (organic raspberries) – criteria are needed to determine whether they belong to the FQS value chain. The key recommended criterion is that the firm makes at least 50% of its turnover from the FQS product. As such, most firms at retail level will be excluded. However, a few systematic or ad hoc exceptions are made:

- ✓ The retail level is included for two economic indicators, namely price premium and export;
- ✓ A firm/value chain level can be retained on an ad hoc basis when its impact on an indicator is substantial (eg. impact of freezing on the carbon footprint of frozen raspberries);
- ✓ A firm/value chain level can be retained on an ad hoc basis when stakeholders consider it as part of the value chain despite it making less than 50% of its turnover from the product.

In other words, most of the data collection/gathering effort should be spent on *key variables which contribute to systematic indicators*, while the rest should only be provided if data is readily available, and should not be the object of a dedicated data collection effort.

Relying on existing sources of information

In general, given the resource and time constraints, most variables were designed to be common enough to be obtained from existing studies, reports and databases. A good strategy for a comprehensive overview of existing sources, may be to conduct a few (3-5) interviews with key stakeholders in the chosen case study's value chain.

Default values

In parallel to case-by-case data collection, an effort was made to obtai national average values for as many variables as possible, and cover all the sectors studied (dairy, meat products, seafood/fish, cereals, fruits & vegetables). These values do not refer to specific products but to larger product categories which can be identified in systematic surveys. For this purpose, databases with pan-European coverage, such as the Farm Accountancy Data Network (FADN) and different surveys and datasets available via Eurostat database (i.e. Farm Structure Survey, Structural Business Statistics, Labour Force Survey, etc.) have been explored.

These default values were could be used in three different manners:

- ✓ To check that the collected data for the case and/or its reference is of a reasonable order of magnitude;
- ✓ To estimate indicators for a "national average" reference product;

- ✓ To save time on data collection when there is evidence (eg. expert judgement) that a given variable is not significantly different from the national average.

This last option was infrequently used and, in all cases, data sources for each variable and product are transparently documented in the data repository (https://www2.dijon.inra.fr/cesaer/informations/sustainability-indicators/).

Quality checks in data collection and indicator estimation

Principles

Considering the scale and the complexity of the Strenght2Food project (measuring the sustainability level of 44 products using 23 indicators referring to the environmental, economic and social dimensions of sustainability), an organizational model was developed. It consider three operational phases and three different researcher profiles which specific relationship and responsibilities.

The most important principle of the procedure for data collection and indicator estimation is an early and repeated interaction between the case study conductor and the indicator coordinator (Figure 2). The case study conductor is responsible for collecting the data and ensuring its traceability, which implies creating a repository with all source files and intermediary calculations. The indicator coordinator is responsible for the quality check of the data provided (e.g. verifying, together with the case study conductor, the original source when an order of magnitude seems wrong, etc.) and for providing the case study conductor with the estimated indicator(s). Both are responsible for interpreting the results.

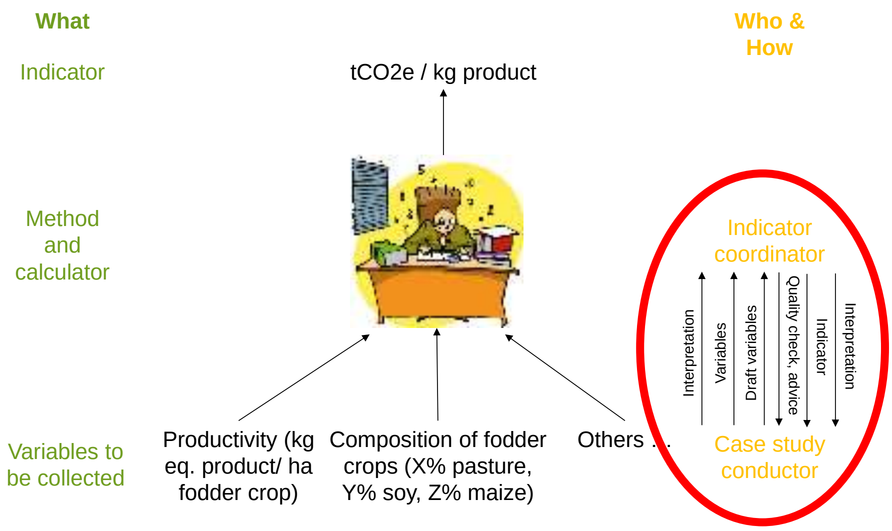

Figure 2. Organisation of data collection and indicator estimation and interpretation

Example of data collection agenda

Based on the experience gained on the three pilots, the following agenda was recommended for data collection:

- ✓ Identify 4-6 key stakeholders likely to know of many and diverse sources of information, starting with the product syndicate (Defence and Management Organisation for GIs);
- ✓ Send them an e-mail asking for documents;
- ✓ Look for variables in the documents, following the prioritization strategy;
- ✓ Interview the 4-6 stakeholders, focusing on the key variables still missing and the indicators/variables/levels you are most interested in. And early interview with the product syndicate will likely be helpful for the identification and contact of the other key stakeholders;
- ✓ Set up a stakeholder survey if necessary for the variables that could neither be obtained from secondary data nor from expert judgement during the interview;
- ✓ Make use of the indicator coordinators throughout the process: to identify possible data source, to request default values, to avoid misunderstandings on the requested variables or on the method to estimate the indicators, …

Tips for data collection

In addition to the road-tested example of data collection agenda presented above, here are a few tips for data collection which were used:

- ✓ Comparability of sources: to the extent possible, it is preferable to use the same source of data for related values (eg. fertilizer amount and crop yield). In particular, it is preferable that for a given variable (eg. price), values for the Organic/GIs and its reference come from the same source where authors have likely put some effort into ensure that the comparison is *caeteris paribus*. Along those lines, when eliciting expert judgement, it is preferable to ask for the difference between FQS and its reference rather than asking for absolute values.
- ✓ Prioritization:
    - o Begin with key variables necessary to compute systematic indicators at key levels of the value chain
    - o Rely on existing sources of information: existing documents (articles, reports, code of practice/technical specifications, …) and databases

  - Conduct 4-6 interviews to obtain more secondary data and/or primary data

- ✓ It may be convenient to focus on key areas of production (eg. three main regions producing Parmigiano) or key processors (eg. the three firms making up 80% of market share) to save time. Indeed, regional authorities of key areas may have readily available data which do not exist for smaller areas.
- ✓ Metadata documentation: record the source/reference, the type of value (average, min, max, …) and the time period in the excel template and deposit the original documents and, where relevant, the intermediary calculations, in a dedicated repository;
- ✓ Access to AMADEUS and/or its national counterpart helps a lot with the processing levels for Ec1 and So1 (and Ec2, to a lesser extent);
- ✓ Regulators, auditors and accountants are likely institutions with data on the variables sought.

Metadata documentation

For each variable value, two metadata were documented:

- ✓ the source/reference for the values (e.g., Dupond et al., 2010);
- ✓ to which time period the variables values correspond. Time periods should be as recent as possible, and to the extent possible, similar between different variables. When relevant and available, time-series and/or multi-year averages can be used.

In addition, all original documents from which the data are sourced and the intermediary calculations (eg. excel or word documents) have been stored in an online repository so that both the case study conductor and the inidcator coordinator can go back to them easily to double check some values or interpret the results.

Summarized description of indicators and their purpose

The indicators used in each case study throughout this book are briefly described in this section. More details of the feature and the computational methodology for each indicator, together with the detailed list of key and secondary variables used to estimate them and the most important data sources, is provided in Bellassen et al. (2016).

Economic Indicators

Price

The price indicator answers to the question whether FQS products benefit from a price premium, testifying that at least some consumers recognize its higher quality and are willing to pay more for it. The prices may be directly available, if not they must be calculated using turnover and quantity.

This indicator is computed for each level of the value chain. Prices should be representative of the value chain, in terms of volume, actors and according to possible seasonal variations, so that ideally they should be average prices weighed by the relative importance of each distribution channel.[5] The main stages of the value chain have to be considered depending on the type of product.

Profitability and value distribution

The actual profitability also depends on the costs incurred. Three classic analytical accounting indicators (Gross Value-Added, Gross Operating Margin, Net Result) are computed for each FQS and its standard reference (Chatellier, 2002; Chatellier and Delattre, 2003; France AgriMer, 2011). Intermediate consumption, subsidies and wages are the costs where the most important differences are expected between FQSs and their reference products.

Either these three classical indicators have already been computed and published in an existing documents (i.e. FADN report, AMADEUS, etc.) or they can be computed based on the variables, as presented in

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[5] For example, if 25% of the total volume is sold in national supermarkets at price a, 50% by direct selling at price b and 25% is exported at price c, the average price will be (0.25*a + 0.5*b + 0.25*c). The same logic applies for different presentation and type of products (raw or processed product, packaging, more or less aged, etc.).

Figure 3.

Figure 3. Conceptual model for distribution of costs and margins in a value chain

Indicators are defined per unit of turnover. These indicators are computed at the main stages of the value chain which allows analyzing the distribution of:

– revenues along the value chain
– gross margin along the value chain

- prices along the value chain (computing price premium = (priceFQS – priceReference) / priceReference)

NB: for operators involved in several productions, one must assess whether they are considered as part of the value chain. The key recommended criterion is that the firm makes at least 50% of its turnover from the FQS product (see above).

International trade indicators

The ratio of the products exported (volume or turnover) to the total production provides some information on market dynamism. The following indicators are relevant for investigating the contribution of the FQS to the national and European trade balance. These indicators are related to the final product.

- $\%\ export_{Vol} = \frac{\text{Export Volume}}{\text{Total turnover Volume}}$
- $\%\ export_{Val} = \frac{\text{Export Value}}{\text{Total turnover Value}}$

Local multiplier

Method to compute the indicator

The methodology comprises three steps of analysis and starts from the stage of the product supply chain where the most value added is produced (i.e. downstream supply chain value). This point is named LM1. For FQSs, LM1 should be the producer or processor/manifacturer whose output is the final product in nature before being sold to the wholesaler (e.g., ripened cheese rather than milk, pasta rather than wheat, …).

Definition of the Local Area

The local area for Geographical Indications is the area included in the technical specifications. In the case of organic products the local area is the NUTS2 region surrounding where the firm is located or a circle of 50 km radius around the processor considered in LM1. If administrative boundaries are easier for the interviewer to use, then relevant administrative area summing up to around the same surface (8 000 km^2) can be used instead. It is important to give evidence of the criteria employed to define the Local Area.

Collection of the information

LM1 compilation: this section requires the provision of “balance sheet-type” operative data for the firms at the stage of the product supply chain where the most value added is produced (i.e., processor of the agricultural commodity). In particular, three types of cost categories should be provided:

- ✓ Total Payroll (labour costs);
- ✓ Total Core Input Costs (CI – cost of the agricultural input to be processed). In the case of Parmigiano Reggiano, for example, it is the cost for the milk to be processed.

- ✓ Total Non Core Input Costs (NCI – all costs of the firm except those for labour and the Core Input). These cost items include, for example: electricity, fuel, …;

LM2 compilation: still looking at the costs of the LM1 firms, this part consists in estimating the share of labour and each inputs costs sourced within the local area.

To make the indicator comparable across value chains and robust to organizational arrangements (eg. number of juridically differentiated intermediaries involved in selling a given input), the firms considered as suppliers are those which are actually changing the nature of the input (eg. farmers which turn feed into milk rather than intermediaries shipping milk, refineries turning oil into gasoline rather than petrol stations, …).

When the number of processor levels varies between a FQS and its reference product (e.g., raw cheese manufacturer and ripener in the FQS vs a single cheese manufacturer in the reference product), processor levels should be aggregated such that they remain comparable. For example, if breeders constitute one LM2 supplier type in the reference case, they should also represent one LM2 supplier type in the FQS.

LM3: The aim of this section is to calculate the amount of money spent at the local and non local level by the local and non-local employees of LM1 firms, and by local and non-local suppliers of the core input.

Environmental Indicators

Carbon footprint

Two indicators will be computed for each FQS and its standard reference. Both require to define precisely which is the product in the supply chain considered (e.g. milk or cheese?). This definition needs to be specified by the case study conductor.

Product carbon footprint, in tCO2e per kg of product

This indicator is the most intuitive and common one for product-oriented carbon footprinting (Röös et al., 2014). It corresponds to SAFA indicator E 1.1.3. Under the rather common assumption of fixed demand in quantity for the product, and in our case full substitutability between the FQS version and its reference, one of the advantages of this indicator is to control for carbon leakage (Colomb et al., 2012).

Carbon footprint of production area, in tCO2e per hectare of utilized agricultural area (UAA)[6]

This indicator is more oriented towards the upstream of the supply chain. The implicit assumption is that the area used to produce the product is fixed and that demand in quantity will adapt to production levels. For example, if the FQS supply chain is less productive on a per hectare basis, this indicator assumes that overall product consumption decreases as the share of FQS rises. Thus productivity losses are implicitly assumed to be offset by decreased consumption in the overall carbon footprint of the supply chain.

In a way, the implicit economic assumptions behind these two mainstream indicators correspond to two unrealistic extremes: fixed demand and full substitutability (tCO2e/kg of product) or elastic demand and no substitutability (tCO2e per hectare). Hence the usefulness of computing both.

Method to compute the indicators

The producer (farmer) is the main part of the supply chain considered in the indicator for three reasons:

- ✓ 83-88% of the carbon footprint of the food sector occur at the production stage (Röös et al., 2014; Weber and Matthews, 2008). The collection and processing stages are therefore negligible in the general case;
- ✓ the relative impact of transportation can be important for alternative products based on roots, cereals and vegetables (Röös et al., 2014). For this reason, the carbon footprint of the collection stage, potentially very different between FQS and non-FQS, will be derived from the foodmiles indicator (see below);
- ✓ the difference in energy demand between processes in FQS and non-FQS supply chains is likely negligible.

Based on this rationale, most farm-level variables are classified as “key”[7] while most variables pertaining to other levels are classified as “secondary”. An exception is made for vegetal products where process-related or transportation-related emissions may be substancial.

The two indicators are computed using the Cool Farm Tool (Hillier et al., 2011). This method and the Cool Farm Tool allow to follow the Life Cycle Assessment (LCA) principles and to address the key methodological issues of LCAs as listed in JRC (2010):

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[6] Adapted for seafood: either irrelevant (for wild fish) or UAA replaced by area of fish/seafood farms.

[7] Based on expert practice of carbon footprint calculation, some farm-level variables are nevertheless classified as secondary when they tend to represent a negligible fraction of the total footprint.

- ✓ Which LCA modelling principle to follow (i.e. attributional or consequential)? -> attributional in our case
- ✓ Which LCA method approaches to employ for solving multifunctionality of processes (i.e. allocation or system expansion/substitution)? -> allocation in our case
- ✓ System boundaries: the definition and application of system boundaries and of quantitative cut-off criteria (including the question which kind of activities to include in LCA);
- ✓ Functional unit definition;
- ✓ etc.

LCA is however a standardized procedure which is very time consuming when properly implemented. Given the constraints of the project, we cannot conduct a full-fledged LCA on the studied products.

Specific case of unfed seafood and fish

The emissions sources of seafood and unfed fish are very different from other food products. Accordingly, the key variables to focus on are different, mostly the quantity of diesel for boat operation, the amount of cooling agent used to refrigerate the fish in the boat and the quantity electricity use for depuration and farm operation (in particular sea water pumps). More details are provided in Bellassen et al. (2016).

Extended food miles

Two indicators will be computed for each FQS and its standard reference. Several products may be considered throughout the value chain (eg. wheat upstream, flour downstream). For both indicators, the upstream – from cradle to the processing plant – and downstream – from the processing plant to the end-consumer – parts will be estimated separately as they rely on different data sources and different stakeholders. Case study conductors should prioritize their data collection effort towards the upstream part (collection stage, from production to processing), and also towards the dowstream part when it applies to a product which is mainly exported.

Distance traveled, in ton.km per ton of product

This indicator is the most intuitive and striking for dissemination to the general public and it sticks to the basic idea of the concept of "food miles". It is estimated by combining the distances between each value chain level and the concentration of the product from upstream to downstream (eg. if 10 kg of milk are needed for 1 kg of cheese, the distance between breeder and cheese factory is multiplied by 10). However, this indicator is to be interpreted cautiously and need to be complemented by the estimation of the related carbon emissions. A longer distance traveled does not necessarily mean larger carbon emissions. Considering the logistics (transportation modes, volumes carried, and spatial repartition of the different stages) is crucial to assess the environmental impact of transportation.

Carbon emissions related to the transportation stage, in kgCO2e per ton of product

This indicator is more relevant for assessing the environmental impact of products, since not only the distance but also the logistics of the collection stage of raw materials and of the distribution stage of the final product is considered. Moreover, it allows for a more comprehensive and precise estimate of the carbon footprint indicator. This indicator will be computed using the Cool Farm Tool, Transport tab (Hillier et al., 2011).

Water footprint

The water footprint of a product or a process is the amount of water that is consumed and polluted during all stages of its production. Water footprint, as composed of three metrics, is at the same time an indicator of water consumption and of water pollution. The water footprint of a product is the sum of the water footprints of the processes/steps taken to produce the product during the whole production and within the value chain.

Three indicators compose the water footprint. They require that the main steps in any value chain are taken into account to measure the impact of the whole value chain. If different intermediate products (e.g., milk for cheese) serve the same value chain, calculation should be carefully planned considering the amount of the intermediate product(s) that is employed to obtain the final product. This aspect needs to be specified by the case study conductor.

Blue water footprint, in water volume per product unit (i.e. m3/kg)

This metric is the most intuitive one as it accounts for the consumptive use of fresh surface or groundwater, the so called blue water, along the whole production chain. It quantifies the water that is withdrawn from surface or groundwater to assist production in all phases, from crop growth to product selling.

Green water footprint, in water volume per product unit (i.e. m3/kg)

This metric quantifies the volume of water consumed by the crops during their growth through evapotranspiration. It is computed as a balance between the plant evapotranspiration and the volume of effective precipitation and is particularly relevant where rainwater is scarce.

Grey water footprint, in water volume per product unit (i.e. m3/kg)

This metric indicates the water volume needed to assimilate a pollutant load that reaches a water body. It is an indicator of water resources appropriation through pollution that can be associated to production in the whole value chain. . It is computed as the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards. Here, the only pollutant considered is nitrates.

Method to compute the indicators and sources of data

The green water footprint and the blue water footprint quantify respectively the evapotranspiration of rainfall and the evapotranspiration of irigation water. Their calculation relies on the knowledge of the crop water requirement (CWR) which is the product of the reference crop evapotranspiration (ET_0) by the crop coefficient (Kc): $CWR = Kc \times ETo$. The reference crop evapotranspiration ETo is the evapotranspiration rate from a reference surface, not short of water. The reference crop is a hypothetical surface with extensive green grass cover with specific standard characteristics and therefore the only factors affecting ETo are climatic parameters. The effects of characteristics that distinguish field crops from grass (reference crop) are integrated into the crop coefficient (Kc). The product $Kc \times ETo$ under the condition that the crop water requirements are fully met quantifies the actual crop evapotranspiration (ET_C).

Green water evapotranspiration ($ETgreen$), evapotranspiration of rainfall, can be equated with the minimum of total crop evapotranspiration (ETc) and effective rainfall $\left(P_{eff}\right)$.

$ETgreen = min\,(ETc\,, Peff\,)$

In fact when precipitation exceedes the crop evapotransipration the excess rainfall is not used. On the oher hand when precipitation are limited all the rainfall is used by the crop.

When the effective rainfall is less than the total crop evapotranspiration what needed to satisfy plant evapotranspiration must come through irrigation ("irrigation required"). This is the theoretical water needed by the crop and its value is then compared with the amount of water provided to the crop through irrigation. If no irrigation is applied, the blue water footprint is equal to zero, no matter if the crop needs water to balance the lack of rain and compensate for the evapotranspiration. When crops are irrigated the blue water evapotranspiration is assumed equal to the minimum between irrigation required and amount provided through irrigation.

Measuring evapo-transpiration is costly and unusual. Generally, one estimates evapotranspiration indirectly by means of a model that uses data about climate, soil properties and crop characteristics as input. Here we use CROPWAT, developed by the FAO (FAO, 2010). The climate database CLIMWAT 2.0 provides the climatic data needed in the appropriate format required by the CROPWAT 8.0 model.

The grey component of the water footprint of growing a crop or tree (m^3/ton) is calculated as the chemical application rate to the field per hectare (App, kg/ha) times the leaching-runoff fraction (α) divided by the maximum acceptable concentration (kg/m^3) minus the natural concentration for the pollutant considered (kg/m^3)

$$WF_{grey} = \frac{\alpha \times App}{C_{max} - C_{nat}}\ (volume/time)$$

This value is then and then divided by the crop yield (ton/ha). For the leaching-runoff fraction coefficient (α) no databases are available. We assume 10 per cent for nitrogen fertilizers. As for the maximum acceptable concentration we rely upon ambient quality standards that are available in European directives (50 mg of nitrates per liter). Cnat is considered equal to 0, which underestimates the actual waterfootprint.

For food processing, the amount of water that evaporates during storage, transport, processing and disposal is generally not measured directly, but can be inferred from the difference between abstraction and final disposal volumes. The best sources for blue water consumption in manufacturing processes are the manufacturers themselves or regional or global branch organizations. The Ecoinvent (Ecoinvent, 2012) database dedicated to LCA methods provides further information instrumental to calculating water consumption in production processes, with particular attention to the processing, packaging and distribution of the final products phases.

Social Indicators

Employment

Labour-to-production ratio, AWU per ton of product

Number of annual work unit per ton of product. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope, 2001).

Turnover-to-labour ratio, € per AWU

The labour productivity is measured as turnover-to-labour ratio. It is expressed as the turnover per annual work unit.

Method to compute the indicators

Labour inputs are estimated using the calculation of labour units based on standardised figures, e.g., one Annual Work Unit, abbreviated AWU, for each person between 18 and 65 years who works full-time on the farm(s)/business unit(s). All form of farm labour (farmers, hired employees and unpaid family workers) are included in the calculation. One annual work unit corresponds to the work performed by one person who is occupied on a full-time basis. Full-time means the minimum hours required by the relevant national provisions governing contracts of employment. If the national provisions do not indicate the number of hours, then 1 800 hours are taken to be the minimum annual working hours: equivalent to 225 working days of eight hours each. As the volume of labour is calculated on the basis of fulltime equivalent jobs, nobody can represent more than one AWU, even if someone works for more than the maximum number of hours defining full-time work in that Member State.

Turnover (turnover) is computed from total sales (see above).

Bargaining power distribution

As bargaining power determines the capacity of individual stakeholders to capture value created throughout value chains (Coff 1999, 2010), our indicator is concerned with the repartition of bargaining power among individual actors. Bargaining power is therefore closely linked to several indicators proposed in the SAFA typology, such as those pertaining to fair trading practices (FAO 2013). It is defined as an actor's capacity to influence in its favour the definition of terms and conditions of a contract (Argyres and Liebeskind 1999). If standard microeconomics has essentially conflated bargaining power with market power, such an approach can hardly be applied to the analysis of value chains and for the purpose of Strenght2Food research, bargaining power is not only rooted on market-based factors, but also has to consider transactional and institutional dimensions.

By taking a wider lense than only that of market mechanisms, we adopt a more global conception of bargaining power that is multifactoral and collective because we ascertain the capacity of supply chains actors of different supply chain levels to weigh in on bargaining processes. We thus better ascertain whether FQS supply chains can be considered as socially more sustainable by appraising how they generate and manage possible sources of bargaining power and how it is vertically distributed along supply chains.

Although incomplete and imperfect, the distribution of bargaining power nonetheless gives an indication over the economic and social sustainability of supply chains. (see Touboulic, Chicksand, and Walker 2014). One may therefore expect that supply chains for which bargaining power is evenly distributed between levels shall be more socially and economically sustainable (Filippi and Muller 2013).

Method for computing the bargaining power distribution indicator

The method proceeds into two main steps :

In a first step, a bargaining power index value BP_l is computed for each level l of the supply chain. It is computed as the average of the following variables, all normalized to be bounded by 0 and 1. Following our argument, variables account for one of the three aforementionned dimensions of bargaining power (market-based, transactional, institutional).

Market-based variables:

- ✓ the level of concentration at level l (market share of the two largest firms);
- ✓ the number of entities producing similar/substituable products compared with other supply chain levels;

Transactional variables:

- ✓ the proportion of transacted volumes that are subject to long-term contracts between value chain level l and its clients (level l+1);

- ✓ whether the level l of the value chain contributes to the differentiation of the product with potential substitutes;
- ✓ whether level l of the value chain requires the possession of specific resources (natural, physical, knowledge/skills…) not accounted for in the specifications.

Institutional variables:

- ✓ whether firms at level l are involved in a product management consortium;
- ✓ whether firms at level l are involved in other professional unions linked to the product;

We then compute a normalized Herfindhal-Hirschmann index on the basis of obtained bargaining power value at each level:

$$HHI = \frac{\sum_{j=1}^{L}\left(\frac{BP_j}{\sum_{i=1}^{L} BP_i}\right)^2 - \frac{1}{L}}{1 - \frac{1}{L}}$$

Where : BP_j is the bargaining power value of level j; L is the total number of levels in the supply chain. By construction, HHI is bounded within a [0,1] interval where the level of inequality increases with the value of the normalized Herfindhal-Hirschmann index.

Educational attainment

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. Education could be considered as an important cause of many forms of political and social engagement (Putnam, 1999). For these authors, a rise of educational attainment has a beneficial effect on trust and social engagement which are themselves key components of social capital. It is specifically the case for empirical political behaviour research which consistently observed a robust and positive relationship between education and political engagement (Hillygus, 2005). Educational attainment is also a predictor of political trust and liberal social attitudes (Schoon and al., 2010). The measurement of educational level allows us to indirectly measure some components of social capital. The systematic indicator is the educational level of people who work in the supply chain. A secondary indicator based on average wages is also proposed. It allows to take account indirectly of the vocational education and the skills which is needed for workers. In this sense it will complete the educational attainment and replace it for processing level if the difficulties for collecting data are too strong.

Method to compute the indicator

We use The International Standard Classification of Education (ISCED) 2011 to classify educational attainment into five categories:

- ✓ Primary education or less / middle school degree or less (level 1 and 2 of ISCED)
- ✓ Secondary education or equivalent / high school degree or equivalent (level 3 of ISCED)
- ✓ Short cycle tertiary education, post-secondary non tertiary education or equivalent (one or two years after high school, level 4 and 5 of ISCED)
- ✓ Bachelors/license or equivalent level, three or four years after high school (level 6 of ISCED)
- ✓ Higher education or equivalent level, at least five years after high school (e. g., master degree, PhD, …, level 7 and 8 of ISCED)

If it is not possible we can accept to regroup the last three categories (short cycle tertiary and post secondary non tertiary education, Bachelor/license level and higher education level) into one categorie : tertiary education level or equivalent.

The indicator is then normalized as follows:

[(prop_primary x 0) + (prop_secondary) + (prop_short_tertiary + prop_license + prop_master) x 2]/2

For the secondary indicator (average wages), we include the net results at farm level, to account for the non-salaried employees:

At farm level: wage = Turnover * (%net result + %wages) / annual work unit

At other levels: wage = Turnover * %wages / annual work unit

Generational change

Generational change performance at each j^{th} stage of the supply chain is captured the percentage ratio between the number of employees in the 15-35 age bracket and the number of employees in the 45-65 age range:

$$GC_j(\%) = \frac{EMP_{15\div35;j}}{EMP_{45\div65;j}} \cdot 100$$

where $EMP_{x\text{-}y,j}$ is the share of employees aged between x and y at level j of the value chain.

Gender Equality

This indicator corresponds to SAFA indicator S 4.2.1. and draws on the methodology and – to some extent – data for the calculation of the UNDP Human Development Index (HDI), and its component gender inequality indicator (GII) (UNDP, 2018). Because it relies on geometric means, the indicator cannot be calculated whenever 0% occurs for one of the primary variables. Following the indications in UNDP (2018), a minimum value of 0.1% (or 0.001) is employed instead. This composite indicator relies on the following primary variables: gender-based share of employees with an upper secondary education (if available), gender-based share of employees, and gender-based share of entrepreneurship.

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