# Key Environmental Performance Indicators for a simplified LCA in food supply chains

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**ABSTRACT**

The European research project SENSE will deliver an affordable and comprehensive environmental evaluation system oriented to small and medium enterprises (SMEs) in the food and drink sector. The system aims at simplifying data collection and information requirements by compiling key environmental performance indicators (KEPIs) throughout the value chain in a web-based tool. Cradle-to-gate life cycle assessments (LCA) were conducted in three selected food sectors, namely meat and dairy, fruit juice and aquaculture salmon, in order to verify, if the KEPIs that had been selected for the tool contributed to the main environmental impacts. Since the impact categories cover a wide range of environmental impacts such as acidification, climate change, eutrophication and toxicity, the KEPIs can be used to deliver a comprehensive environmental evaluation. An overview of the main results of the LCA studies and justification for the selection of KEPIs is presented. Moreover, aspects of regionalization of background database is discussed since this may affect the results and needed to be considered when designing the simplified SENSE tool.

Keywords: LCA, key environmental performance indicators, food and drink supply chains, regionalization

## 1. Introduction

Life cycle thinking and taking responsibility in environmental issues beyond the operation of the companies is gradually being implemented in large businesses along with the awareness of the concept sustainability. This trend is less pronounced in small- and medium sized enterprises (SMEs), often because of lack of understanding and limited capacities to look beyond their daily operation. Moreover, SMEs may not be familiar with environmental assessment methods. Measures to assess environmental performance need to have a positive economic impact, since data gathering is often regarded a burden and companies therefore are not willing to undertake such an assessment. However, when given opportunities to implement life cycle tools, there appears to be potential incentives in SMEs to use Life Cycle Assessment (LCA) results to create an image for the product and the organization, to use in marketing, and for product development (Witczak, 2014). The SENSE project aims at enhancing environmental awareness in SMEs in the food sector by offering a harmonized data collection system and simplified assessment of environmental impacts.

The main environmental challenges of European food and drink supply chains and their environmental impacts have been assessed in the project based on earlier LCA studies (Aronsson et al., 2014). The approach has been to select a set of harmonized input data, defined as key environmental performance indicators (KEPIs) which are essentially the required information for LCA (i.e.: water, energy, materials consumption). Full scale LCAs for three selected food and drink supply chains were conducted in the project and the result interpreted to justify the validity of the selected KEPIs to reflect the main environmental challenges. Key attributes and suitable scope of essential input data was thus prioritized according to the most important environmental impacts in order to simplify data collection in SMEs. The KEPIs are either common performance indicators such as electricity consumption, water consumption, fertilizers and pesticide use, but also key parameters such as the composition of the feed. The results from the LCA studies presented herein thus confirm the most relevant stages in the life cycle of the respective food products and the suitability of the KEPIs to be applied in the SENSE tool.

## 2. Methods

Three LCA case studies were performed on current food production and supply systems and investigated from a regional perspective:

- orange juice production in Spain (Doublet et al. 2013a)
- dairy and beef production in Romania (Doublet et al. 2013b)
- salmon aquaculture in Iceland and smokehouse in France (Ingólfsdóttir et al. 2013)

Further information on the definition of goal and scope, the life cycle stages included, definition of the system boundary, input materials/items included and excluded, justifications and assumptions made, detailed life cycle impact results and interpretation are available in the respective reports. The environmental impact assessment methods initially selected by the SENSE project team comply with the ones later recommended by ILCD (JRC, 2011). These are the same methods as later recommended by the European Commission on the Product Environmental Footprint (EC, 2013) and in the ENVIFOOD protocol except for water depletion where a revised approach to water footprinting is recommended in the ENVIFOOD protocol (ENVIFOOD, 2012).

In the LCA case studies the allocation for the aquaculture and the orange juice supply chains followed economic allocation as recommended by the ENVIFOOD protocol (ENVIFOOD, 2012). The allocation for meat and milk at the dairy farm followed the physical allocation approach suggested by the International Dairy Federation (IDF 2010). The allocation for the meat produced at the slaughterhouse followed an economical approach, while the allocation for the dairy products at the dairy plant follows a physico-chemical approach as suggested by IDF (2010).

## 3. Results

The results of the life cycle impact assessment in the three food supply chains analyzed by LCA show similarities as expected. The cultivation of biomass was the main contributor in the orange juice and beef and dairy food supply chains due to the environmental impacts of use of water, land, pesticides and fertilizers, and fuel for tractors. This is also the case for the aquaculture food supply chain including the feed from marine resources where the fuel use for vessels in fisheries is a significant contributor (Figures 1-3).

### 3.1. Life Cycle Assessment - Orange juice

The impact assessment of the Not-From-Concentrate orange juice shows that the main contribution of life cycle step depends on the impact categories assessed. About 50 % of the climate change and abiotic resource depletion are due to the bottling process.

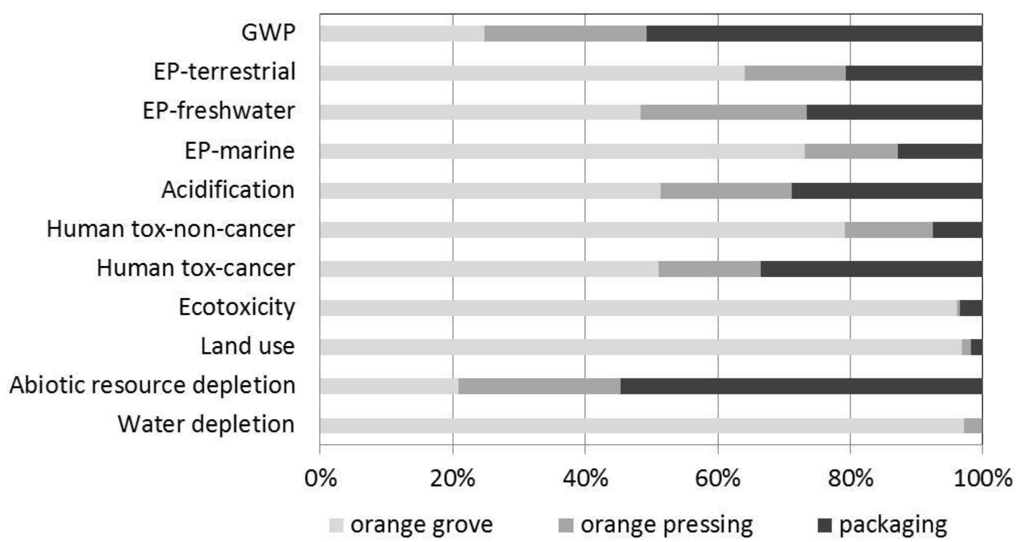


Figure 1. LCA of orange juice in Spain. Impact assessment of one litre NFC orange juice (Doublet et al., 2013a)

The impact categories land use, water depletion and freshwater ecotoxicity are dominated by the orange cultivation (more than 95 %). The orange cultivation contributes around 50 % to the acidification and freshwater eutrophication. The four main contributors to the orange cultivation are the electricity use for the irrigation, the production and use of fertilizers and the application of pesticides.

The most relevant processes for the juice pressing are the electricity use and thermal energy use. The main contributor to the bottling process is the manufacture of the PET bottle.

## 3.2. Life Cycle Assessment - Beef and dairy

The impact assessment of the beef shows that the feed cultivation at the dairy farm is the main contributor to the results (Figure 2). The slaughtering process and the packaging are negligible to most of the impact categories.

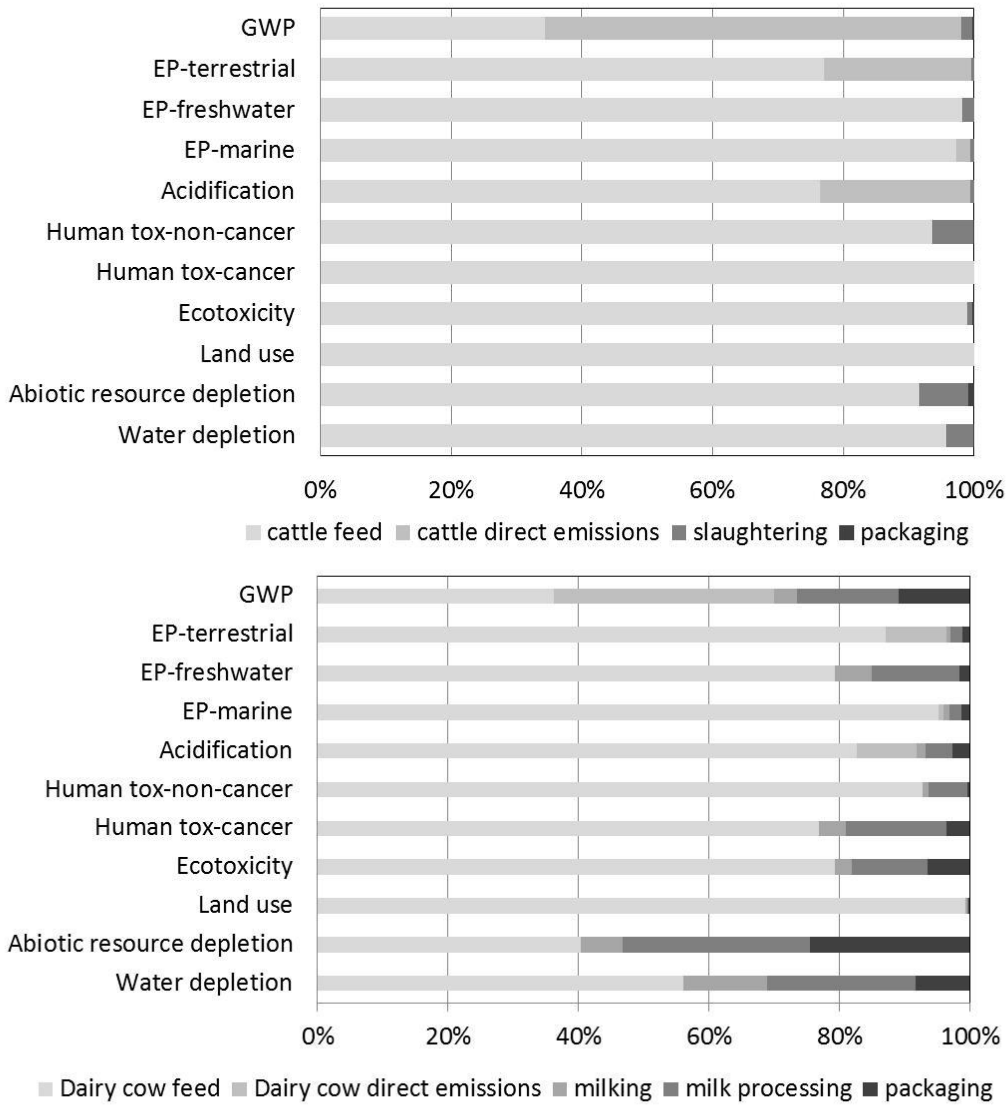


Figure 2. LCA of beef and dairy products in Romania. Impact assessment of 1 kg beef at slaughterhouse (above) and impact assessment of 1 liter milk at dairy plant (below) (Doublet et al., 2013b)

The emissions from the use of fertilizers, manure and diesel for the agricultural machinery influence the results most. The cattle emissions due to the enteric fermentation are the main source for the climate change. The animal waste disposal from slaughtering is also an important step due to its processing into animal flour before its incineration. The impact assessment of the dairy products is similar to the beef because raw milk is produced by the dairy cows. The dairy farm is also the most important step to most of the dairy products. However, the contribution of the processing step to the production of dairy products is higher than the contribution of the slaughtering process to the beef production.

### 3.3. Life Cycle Assessment of aquaculture

The impact assessment of fresh salmon (head on gutted) transported from Iceland to Europe by sea freight verified that the feed production is by far the dominant life cycle stage in all impact categories. For most of the impact categories (GWP, terrestrial eutrophication, freshwater eutrophication, acidification, human toxicity potential (cancer effects), ecotoxicity, resource deletion and water depletion) this is due to the harvesting and processing of feed ingredients (marine and crop).

For the marine eutrophication impact category it is the release of organic matter to sea (feces, uneaten feed and dead fish) which is the major cause of impact at the farm and for the human toxicity potential (non-cancer effects) the main contribution is the transportation of the feed from feed mill to the farm and long distance distribution of products.

The impact assessment of smoked salmon fillets where fresh salmon (head on gutted) is transported from Iceland to Europe by sea freight and further processed in France showed that for nine impact categories the aquaculture farm life cycle stage is the main contributor of environmental impacts, mainly due to the feed. In two impact categories the human toxicity potential (non-cancer effects) and the water depletion the operation of the smokehouse in France is the main source of impact (Figure 3).

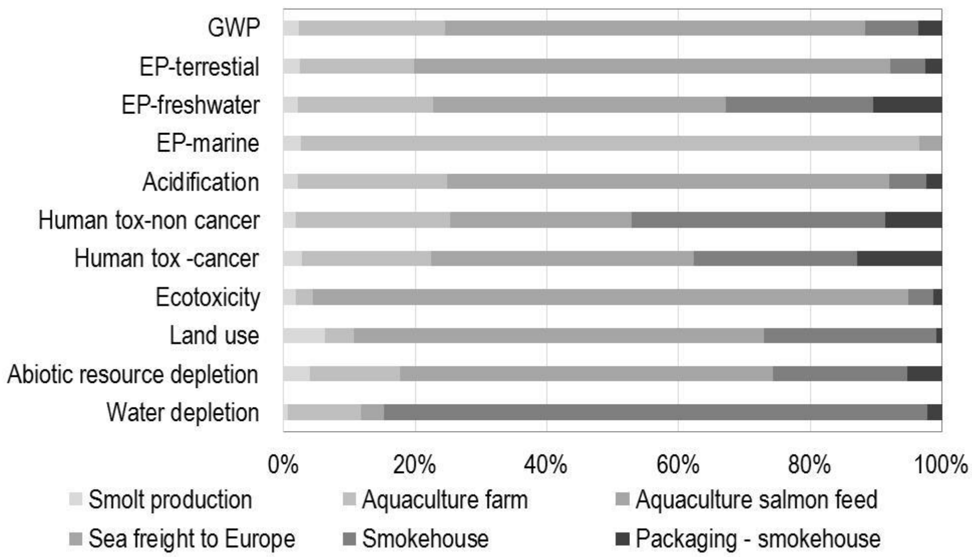


Figure 3. LCA of aquaculture Iceland and smokehouse in France. Impact assessment of 1 kg smoked salmon fillets (Ingólfsdóttir et al., 2013)

### 3.4. Key Environmental Performance Indicators (KEPIs)

The key environmental performance indicators were proposed as simple-to-measure indicators that could be used as input data in the SENSE tool to calculate the environmental impacts. The criteria for selection of input data for the SENSE tool, was the contribution to the main environmental impacts in the respective life cycle stage. The LCA results thus confirmed the validity of the selected KEPIs to be applied in the SENSE tool based on their relevance for the environmental impact, the data availability and the ease of measurement.

The KEPIs have been grouped according to the different production steps in the supply chain and are presented in a table for each production step. The following production steps were defined:

- Plant production (food and feed)
- Fisheries
- Aquaculture
- Livestock

- Food and feed processing
- Transport

| Impact category | Plant production | | | | | | | | Fisheries | Aquaculture | | | | | | Livestock - ruminants | | | | | Food and feed processing | | | | | Special | | | Main pollutants / Challenges |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | Dairy | Slaughtering | Juice processing | |
| Unit | kg N/hectare kg N/kg crop | kg-P2O5/hectare kg-P2O5/kg crop | kg N/hectare kg N/kg crop | kg/hectare kg/kg crop | l/hectare l/kg crop | ha/kg crop | ha/kg crop | m3/hectare m3/kg crop | MJ/kg product | kg feed /kg fish | MJ/kg product | kWh/l product | kg waste/kg product | m3/kg product | kg/kg product | kg raw milk/dairy cow | kg feed/kg live weight | m2/kg product | kWh/kg raw milk | m3/ kg raw milk | MJ/kg product | kWh/l product | m3/ kg product | type/kg product | kg waste/kg product | kg raw milk/kg product | kg live weight/kg meat | kg orange/l orange juice | |
| Key Environmental Performance Indicator (KEPI) | N-fertiliser use | P2O5-fertiliser use | Manure and slurry application | Pesticide and active substance content | Diesel use incl. machineries | Arable land use | Grazing land use | Water use | Energy use | Feed Efficiency (FCR)[1] | Energy use | Electricity use | Organic waste to sea | Water use | Packaging material | Raw milk production | Feed efficiency | Buildings | Electricity use milking | Water use milking | Energy use | Electricity use | Water use | Packaging material | Waste | Raw milk input | Meat production | Yield | |
| All impact categories | | | | | | | | | | x | | | | | | x | x | | | | | | | | x | x | x | x | |
| Climate change | N2O | | N2O | | CO2 | | | | CO2 | | CO2 | CO2 | | | CO2 | CH4 | | | CO2 | | CO2 | CO2 | | CO2 | | | | | CO2, CH4, N2O |
| Human toxicity | | HM | | | HM | | | | | | | | | | | | | HM | | | | | | | | | | | Heavy metals (HM) |
| Acidification | NH3 | | NH3 | | NOx | | | | | | | | | | | NH3 | | | | | | | | | | | | | NOx, NH3 |
| Eutrophication, | NOx | | NH3 | | NOx | | | | | | | | | | | | | | | | | | | | | | | | NO3, NH3 |
| Eutrophication, | | PO4 | | PPP | PO4 | PO4 | PO4 | | | | | | | | | | | | | | | | | | | | | | PO4 |
| Eutrophication, marine | NO3 | | NO3 | | NOx | | | | | | | | x | | | | | | | | | | | | | | | | NO3 (Nitrate), NOx |
| Ecotoxicity, freshwater | | HM | | PPP | HM | | | | | | | | | | | | | | | | | | | | | | | | Heavy metals (HM) |
| Land use | | | | | | x | x | | | | | | | | | | | | | | | | | | | | | | Land use ($m^2$ and type) |
| Abiotic resource | x | x | | x | x | | | | x | | x | x | | | x | | | x | x | | x | x | | x | | | | | Fossil resources |
| Water depletion | | | | | x | | | x | | | | | | x | | | | | | x | | | x | | | | | | Water use |

[1] FCR = Feed Conversion Rate: Feed used/Fish produced

Figure 4. Selection of Key Environmental Performance Indicators (KEPIs) for each production step for the three investigated supply chains in the SENSE project (Landquist et al., 2013)

The KEPIs selected for the production of all the food supply chains are shown in Figure 4. Each KEPI is given a name and a unit. When the contribution of the KEPI to an impact category is relevant, the cell is shaded and either filled with a cross or with the main pollutant emitted by the KEPI, e.g. carbon dioxide, heavy metals, ammonia, phosphate, etc. The selected KEPIs covered 95%, on average, of the environmental impacts of the respective food supply chains.

Allocation factors were computed on the basis of the shares of the different output products in the turnover, which were given by the plant. Hence, the “shares of products in turnover” is a KEPI.

It should be noted that most of the KEPIs are relevant for many more food products since most food supply chains have common characteristics and similar processing steps. For example the KEPIs for Plant production and for Food and feed processing are the same for many food chains. In all cases KEPIs were adjusted to fit general supply chains although these were not identified as a KEPI in the case studies. There are also some indicators that are specific for some production step, e.g. feed composition and feed conversion ratio (FCR) are specific to the aquaculture chain and the livestock.

### 3.4.1. Plant production

The plant production corresponds to the crop cultivation including the crop for feed (livestock and aquaculture) and orange cultivation. Plant production requires the use of fertilizer, manure, liquid manure, pesticide, agricultural machinery, land, water and storehouse. It is vital to know the composition of the feed as the impacts differ for the different ingredients.

The KEPIs N-fertilizer use and $P_2O_5$-fertiliser use refer to the production and use of these fertilizers. It is important to differentiate between the types of fertilizers applied on crops. The N-fertilizer has a higher contribution to the climate change, acidification, terrestrial and marine eutrophication whereas the $P_2O_5$-fertiliser contributes mainly to the human toxicity, freshwater ecotoxicity and the freshwater eutrophication. Therefore, it is important that the farm informs separately the amounts applied of each type of fertilizers. The production and the emissions to air, soil and water are covered in the background system and not asked to the farm.

The KEPI manure and slurry application refers to the manure and liquid manure (or slurry) applied on crops and are determinant for the climate change, acidification, terrestrial and marine eutrophication. The farm provides the application rate and the emissions to water and to air are included in the model.

The KEPI pesticide and active substance content includes the production of pesticides and the emissions from the active substances contained in the pesticides applied. It is important that the farm provides the pesticide name and the content of active substance. If the latter is not known, it can be found in literature from the pesticide name. The active substances are necessary to estimate the emissions that affect the freshwater ecotoxicity. In a similar way as for the fertilizers, the production of pesticides is included in the background system.

The KEPI diesel use incl. machineries, refers to the diesel consumption including its production and the agricultural machineries used. The diesel production and the emissions resulting from use are included in the background system. The $CO_2$ emissions due to combustion of fuels can be directly calculated with the amount of fuel burned. The agricultural machinery fleet contributes to the human toxicity and eco-toxicity impacts as well as the freshwater eutrophication. It can be difficult for a farm to estimate its agricultural machinery fleet. It was suggested to have an estimation of the agricultural machinery as a background process linked to the diesel consumption, as it was done also for the case study. Indeed, the diesel use for the agricultural processes is modelled with a dataset that includes the diesel fuel consumption, the corresponding amount of agricultural machinery needed (tractor, trailer, harvester, tillage) and its production and the shed corresponding to the machinery use.

The arable land use and the grazing land use are KEPIs for the land use impact category. The emissions of phosphorus to water due to land use affect the freshwater eutrophication impact category.

The direct water use is also a KEPI related to the water depletion impact category.

The construction of the farm buildings affects mainly the human toxicity due to the impacts of the construction material production. The farm should provide the area of the storehouse, but office buildings can be omitted based on the experience in this case study. It has to be noted that in the current case study on meat production the fodder was produced on the same farm as the animals. If animal feed is bought on the market the relevant KEPIs have to be investigated for the production of all the different type of feed bought by the farm, e.g. soy bean, maize, by-products of food and bioenergy production etc.

### 3.4.2. Fisheries

The feed used at the hatchery and aquaculture farm consists of marine and crop ingredients. The energy use at the fisheries was identified as KEPI for the aquaculture salmon supply chain since fossil fuels have a high contribution to climate change, acidification, human toxicity, terrestrial eutrophication and abiotic resource depletion.

### 3.4.3. Livestock

The farm should provide the herd size and the shares of dairy cow, bull, calf, suckler cow. This is covered in the KEPI herd size. It determines the fodder production, the manure and slurry production and the milk and animals sold to the slaughterhouse. By giving the cattle average weight in each category and the raw milk production together with its fat content and protein content, the livestock emissions of methane and ammonia can be estimated. This is the reason why these three parameters are considered as KEPIs. The feed efficiency is also an important parameter to compare different kind of feeding system. This information was however not available for the beef case study.

The KEPI animals sent to slaughtering and raw milk production together with the protein and fat content are needed for the allocation approach. The farm should also give the area of the cattle housing. The construction materials affect mainly the human toxicity and ecotoxicity.

Milking: The KEPIs electricity use and water use were identified for this process. The electricity use covers the electricity production. However, environmental impacts of electricity production vary from country to country. Consequently different impact categories might be affected by the electricity use if case studies are elaborated in another country.

Slaughtering: The KEPIs meat production and meat waste should be provided by the slaughterhouse in order to allocate the slaughtering process to the production of beef and assess the meat yield, i.e. the ratio of meat per livestock animal. The case study on meat includes the slaughtering waste treatment with background data.

### 3.4.4. Aquaculture

The aquaculture includes both the smolt production and the salmon farming. The KEPIs identified for the smolt production are feed, water use and electricity. The composition and amount of feed used are important in terms of climate change, human toxicity, acidification, eutrophication (terrestrial, freshwater) and ecotoxicity. Information on the total production at hatchery as well as at the aquaculture farm and share of products in turnover are also identified as KEPIs for allocation purposes.

For the aquaculture farm the feed composition and amount, organic waste to sea, electricity use, fossil fuels, water use and packaging materials are identified as KEPIs. The slaughtering and primary processing (gutting) are included in aquaculture. Water use and electricity use are identified as KEPIs even though these indicators are not significant in the net pen aquaculture system analyzed in this study However, these KEPIs can be very important for other aquaculture systems for example land based systems in other regions where renewable energy sources are not available and water is scarce. The other KEPIs affect climate change, human toxicity, acidification, eutrophication as well as abiotic resource depletion. The feed efficiency (FCR, feed conversion ratio), i.e. the weight of feed used (kg) compared to weight of fish produced (kg) is a key factor to assess environmental performance of the aquaculture farm. Furthermore, to assess the performance of aquaculture farms, the amount of marine resources that is consumed in the production of farmed fish, the FIFO ratio (fish in - fish out) is commonly used in the industry.

Feed intake and feed efficiency may change during the lifetime of the farmed fish. In this study the feed conversion ratio was available from the company based on the annual production. However, because the life cycle of salmon is 2-3 years, the annual data may give misleading information about the actual feed conversion ratio. In order to avoid this variation affecting the LCA results it may be more appropriate to use a three year average for the operation of aquaculture farms.

It is important to mention that the aquaculture farm in this study does not use anti fouling agents. Therefore, it is possible that in the case where anti fouling agents are used that they can be of importance. Furthermore, land based aquaculture was not analyzed in this study.

### 3.4.5. Feed and food processing

Dairy plant: The dairy plant does not only comprise the infrastructure but the whole process of transforming raw milk into dairy products. The raw milk input as well as the electricity use, thermal energy use and water use can be given on a whole of factory basis and allocate to each dairy product thank to the allocation approach applied, e.g. the IDF matrix (Doublet et al., 2013b). Furthermore the produced amount of each single dairy product has to be reported. The infrastructure of the dairy plant could be included in the background data related to the raw milk input processed at the dairy plant. It is also important to know the packaging material and its weight especially for the milk PE bottle and the yoghurt. The production of the packaging should be included in the background system.

Smokehouse: For the smokehouse the following KEPIs are identified: electricity, fossil fuel and water use as well as raw material inputs (salmon HOG), total production and share of products turnovers. The electricity and fuel have impact on climate change, human toxicity, eutrophication (terrestrial) and abiotic resource depletion. Water use has potential influence on water depletion; depending on the region the process takes place in. For land use impacts, the use of wood chips for the smoking process can also be of importance as a KEPI. The head and bones from filleting process as well as cut offs and trimmings from finished products are discarded and do therefore not carry any environmental burden in this study. This may however be of interest if sold as added value by-products.

Orange Juice processing: The juice processing plant must provide the input mass (kg) of oranges needed to produce 1 l of orange juice. The electricity use, the thermal energy use and the water use are the three main KEPIs. Both electricity and thermal energy contribute to the abiotic resource depletion and the climate change.

The water use determines the amount of wastewater that will be treated. The phosphate emissions resulting from the wastewater treatment affect the freshwater eutrophication.

There are by-products from the orange juice processing, e.g. peels, pulp, and essential oils. An allocation approach is necessary to allocate the energy and material flows to the orange juice. In our case study, the allocation factors were computed on the basis of the shares of the different output products in the turnover, which were given by the plant. Hence, the "shares of products in turnover" is a KEPI.

Bottling process: In most cases, the bottling plant does not only bottle orange juice. Therefore, the share of orange juice in the total amount of juice processed is a KEPI necessary to allocate the energy and material flows to the orange juice. The KEPIs electricity use and the thermal energy use cover the energy consumption of the bottles dryers and blowers, compressors, labelling machines, palletizers etc.

The environmental impacts of the KEPI "type of container" depend on the packaging investigated. In our case study, the packaging investigated is a PET bottle. The KEPI includes the PET material production, the PET granulates injection molding into PET preforms and the production of other materials that are included in the PET bottle e.g. secondary packaging, intermediate layer etc. It is relevant for the abiotic resource depletion, the human toxicity, the climate change, the acidification and the freshwater eutrophication. All these processes are included in the background system but the weight of the PET bottle and the other materials must be provided by the bottling plant.

#### 3.4.6. Transportation

In the case study on meat the transportation distances between farm and further processing were quite small. There are also not major transports of fodder products to the farm. Therefore impacts due to transportation were not found to be a major issue and are not considered in the definition of KEPIs for the meat and dairy chain. This conclusion is however not valid for cases with higher transportation distances involved between processing stages as is the case in the aquaculture chain.  For transportation the KEPI identified is transportation mode and distance travelled. The fuel is important factor in terms of climate change, acidification, human toxicity, eutrophication (terrestrial) and abiotic depletion.

## 4. Discussion

### 4.1 Regional characteristics and background database system

An important question of the project is the adjustment of the SENSE model to regional characteristics. The regional variation affects some of the identified KEPIs and the environmental impacts.

In the SENSE web-based tool the background information is based on the ecoinvent database and is not under the direct influence of the SME. Regionalization of background data is important when designing the simplified SENSE tool, since this may affect the results.

In many cases LCI background data are just available for a global or a European production mix. But, in practice the markets in different regions might be supplied with a different mix of products. Thus, also LCI data can be adapted to the market situation in a specific region. One example of regionalization of background LCI data is the application of a country-specific electricity mix. Publicly available country-specific electricity mix datasets have been implemented in the SENSE tool as background data.

Other important regionalized impact assessment methods were included in the SENSE tool such as water depletion, acidification and terrestrial eutrophication. For acidification regional characterization factors for many countries in Europe are available (Posch et al., 2008). Acidification characterization factors for sulfur dioxide, nitrogen oxides and ammonia are available for France and differ somewhat from the weighted average factors used in this case study.

In the context of the current LCA study on smoked salmon in France, terrestrial eutrophication, regionalized characterization factors are available for France which are higher than the weighted average applied in this study. Furthermore, for marine eutrophication it is important that datasets for emissions of organic matter to sea are available in the SENSE tool. Background LCI datasets need to be available on the nitrogen content in different aquaculture fish species to be able to assess the marine eutrophication potential from dead fish. Additionally, datasets should be available in the tool for N content from feces and feed deposition for sea based aquaculture in different regions. For other background data it was not expected that including regionalized data for diesel, natural gas, fuel oil would make major differences in the environmental impacts results.

Availability of water differs greatly between countries and regions. Regional characterization factors are available for water scarcity (Frischknecht et al., 2009). In this case study regionalization factors for water depletion were used. The smokehouse in France has considerably higher impact on water depletion than the hatchery and aquaculture farm in Iceland, although they use significantly higher amount of water. This is because water is defined as abundant in Iceland.

The feed for aquaculture is composed of both crop products (e.g. soya, rape, wheat) and marine ingredients. The use of diesel for fisheries is the main contributor to $CO_2$ emissions contributed by the use of fish ingredients in the feed and this varies depending on the type of fishery. Often the information on the feed ingredient composition is not publicly available. It was recommended that Life Cycle Inventory (LCI) background data for different types of aquaculture feed and feed ingredients would be generated and implemented in the tool.

The regionalization of emissions models was only implemented for the livestock methane emissions factors by using IPCC guidelines. Easy-to-apply models for European regions are so far not available in order to regionalize other emission models.

The regionalization of the impact assessment method (LCIA) means that different characterization factors are used for each country or for a specific region. The characterization factors of ammonia and nitrogen oxides for terrestrial eutrophication in Romania are higher than the weighted average implemented in SimaPro (Posch et al. 2008). In this assessment a regionalized approach for water depletion was applied (Flury et al. 2012). Furthermore it would be relevant to better differentiate the impacts of different types of land occupation which is not possible with the LCIA method used so far.

Several calculations for direct emissions due to the application of fertilizers and the animal rearing are based on scientific emission models and not on real measurements. One issue of the regionalization is to assess the possibility of having emission models that can be directly fed with data provided by the SME and thus better considering the local circumstances. Some of the models used in this case study are based on regional experiences e.g. in Switzerland. In principle the outcome of these calculations can be influenced by regional circumstances such as rainfall, soil quality, slope of fields, average temperatures, irradiation, etc. Therefore, it would be necessary to better adapt the models to the specific regional situation. But, such easy-to-apply models for the whole of European regions are so far not available. Therefore, only a case specific model for the methane emissions of the animals on the farm was applied according to the tier 2 approach of the IPCC. This emission model is now specific to the Romanian dairy farm (milk yield, animal mature weight, feeding situation etc.). A quite relevant question for a regionalized model would be the calculation of phosphate emissions from erosion and run-off at agriculture areas as well as different type of nitrogen emissions due to fertilizer, manure and dung use. The modelling of NOx emissions from fuel combustion, which depends e.g. on the technology standards applied in a specific region, could be another issue for a regionalized model.

Other aspect of consideration is the sensitivity of different methods for the calculation of the impact categories. For example, climate change or eutrophication is quite robust since the most influential substances are directly related to the primary data. However, other impacts like ecotoxicity or resource depletion are very dependent on the background data, therefore, the differences in the selected database could lead to great differences between LCIA. Regional background data when available should be implemented in the SENSE tool as recommended and regionalized impact assessment and regional emission models which may affect the result will need to be further developed and implemented when available in the future versions of the SENSE tool.

## 5. Conclusion

The most relevant KEPIs for food supply chains have been selected and implemented in the SENSE web-based tool. The tool is currently being validated by comparing the outcome of the SENSE tool with calculations performed by commercial software (SimaPro and GaBi). The validation is based on using as input only the selected KEPIs. Furthermore, additional case studies where the SENSE tool is tested by users are currently ongoing in the project in at least 30 companies and their supply chains. The harmonized SENSE-tool based on the selected KEPIs is designed to be flexible and adaptable to other food types and will thus be applicable to motivate an LCA based approach and support self-assessment of environmental performance in other food supply chains.

The benefit of a simplified environmental assessment as the SENSE tool can provide will be further assessed in the project by interviews and on-line surveys in companies that will test the SENSE tool.

## 6. Acknowledgements

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