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Summary

This report includes a summary of the main features of the SENSE tool and explains the risk based SAAP framework applied in the implementation. The results of functionality testing and validation carried out by LCA experts are presented:

(i) Functionality testing of the software included an iterative testing of the SENSE tool during the validation phase which was useful to implement necessary updates and further improvements to ensure the functionality of the developed tool

(ii) Verification of the results of the simplified environmental assessment in the SENSE tool was achieved by comparing with the calculations using commercial software (SimaPro and GaBi), using the same input data, methods and background database. The simplified assessment is based on using defined KEPIs (Key Environmental Performance Indicators) as input data.

(iii) Comparison was made between the SENSE-tool's simplified environmental assessment and results of LCA case studies performed earlier in the project for the three food supply chain systems (orange juice, beef and dairy, and aquaculture salmon).

Validation of the SENSE tool was focused on verifying the computation of the environmental impacts contributed by key environmental performance indicators related to a food or drink production process. Results of the validation show that the tool calculates environmental impacts which are comparable to results when using commercial software that applies the same methodologies and datasets. The validation revealed discrepancies for some impact categories between the different software used by the validators (GaBi and SimaPro) regarding methods, different versions of methods and handling of databases. This lack of compliance resulted in further explorations to reveal the reasons for the differences and provided valuable information throughout the validation process. The differences in methodological approaches regarding inclusion of long term emissions, attributional modelling and the importance of the life cycle inventory update for e.g. electricity mixes, aquaculture feed and fertilizers are discussed.

The SENSE tool was comparable to SimaPro results for all impact categories, but that was not the case for all impact categories using the GaBi software. It can be concluded that based on the performed validation studies using the SimaPro software, that the current version of SENSE tool can be used for a simplified assessment of all impact categories selected for dairy products, beef, orange juice and aquaculture salmon.

The SENSE tool could thus be applied by companies for benchmarking their products' environmental performance for the following impact categories.

- Climate change
- Human toxicity, cancer effects /Human toxicity, non-cancer effects
- Acidification
- Eutrophication, terrestrial
- Eutrophication, freshwater
- Eutrophication, marine
- Ecotoxicity, freshwater
- Land use
- Abiotic resource depletion
- Water depletion

However, it is important to note that the SENSE tool is a simplified tool, and the assessment is not an alternative for the complete LCA studies.

Comparison of the SENSE tool's results with full LCA case studies showed that the results for the following impact categories: Climate change, Human toxicity, Acidification, Eutrophication (terrestrial) and Water depletion were comparable for the orange juice supply chain. For the beef supply chain the results were comparable for Climate change, Human toxicity, Ecotoxicity (freshwater) and land use. Unfortunately, the results of the SENSE tool for dairy products and aquaculture could not be directly compared to the full scale LCA studies performed earlier, because methodologies, allocation rules or datasets were different.

The SENSE tool will be further tested by SMEs in pilot implementation in the three food supply chains to assess the functionality and obtain feedback from users on the usefulness of the tool for companies.

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Definitions and interpretations of key concepts[1]

SENSE tool	The SENSE tool is a web-based software including a protocol for data collection and a life cycle based methodology to calculate environmental impacts (i.e. GHG emission, eutrophication, acidification, toxicity etc.).
LCA: Life Cycle Assessment:	LCA according to an ISO standardized method (ISO 14040, 2006) is applied to quantify the environmental impact for a product or service from cradle to grave.
Simplified LCA:	The SENSE tool performs a simplified environmental assessment for the life cycle, since the input data is based on only selected key environmental performance indicators (KEPIs). The tool compiles through the harmonised data collection system the KEPIS (e.g. energy and resource use, water consumption, waste and wastewater generation, land occupation, fertilizer use, etc.) and performs an environmental impact assessment for the different life cycle steps of the product.
Allocation	The default allocation method in the SENSE tool is economic allocation. The tool offers the possibility for system expansion option or manual introduction of the percentage of the economic allocation of different incoming materials, such as packaging or main ingredients
KEPI: Key Environmental Performance Indicators	The KEPIs have been proposed as simple-to-measure indicators that can 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 KEPIs selected contribute on average to 90-95% of the environmental impacts of the food supply chains studied.
List of KEPIS	The KEPIs representing the input data are provided as excel tables in the SENSE tool for the respective food supply chain
Environmental impacts:	The environmental impacts are computed based on life cycle impact assessment (LCIA) methods that were defined in in the SENSE project (Landquist et al., 2013) in agreement with methods recommended by the ILCD handbook (European Commission, 2011). The ENVIFOOD protocol, which is specific for food and drink products (ENVIFOOD 2012), recommends the same methods apart from the method for the water depletion.
Product Environmental Profile	The contribution of the different inputs to the total environmental impact of the product
EID: Environmental Identification Document	The results of the tool's calculations are communicated to users by a certification scheme concept, the Environmental Identification Document (EID) giving an overview of environmental impacts in process steps.
Social impacts	The SENSE tool includes a set of social indicators to support companies´ social declaration, where users answer questions on labour conditions and human rights.
Background database	The SENSE tool uses ecoinvent and ELCD databases for the background information as well as necessary specific datasets not available in public databases
Product benchmarking	Users of the SENSE tool can benchmark their product with similar products i.e. companies can compare their sustainability performance as calculated by the SENSE tool with other similar products (orange juice vs. orange juice, etc.).
Validation	The validation procedure of the SENSE tool includes functionality testing of the user interphase and verification that the SENSE tool calculations are comparable with results from commercial software tools when using the same input data, methods and background database.

[1] Further definition of key terms used by LCA experts are available in the ILCD Handbook p.21 http://eplca.jrc.ec.europa.eu/uploads/2014/01/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf

Preface

This report is a part of the SENSE project (FP7-KBBE-GA:288974) and deals with implementation and validation as an iterative process in the development of the SENSE tool.

Important background to this work from the SENSE project is the following:

- Overview established of key environmental challenges in food and drink supply chains and the main impacts based on literature review of earlier LCA studies on orange juice (Esturo et al., 2013), meat and dairy (Aronsson 2013) and aquaculture (Ólafsdottir *et al*., 2013).
- Identification of Key Environmental Performance indicators for food and drinks supply chains to be applied as input data in the SENSE tool (Landquist *et al*., 2013)
- Selection of environmental impact assessment methods (Aronsson *et al.,* 2013)
- LCA case studies in three food supply chains represented by SENSE partners from meat and dairy production in Romania (Doublet et al. 2013a), orange juice production in Spain (Doublet et al. 2013b), and aquaculture in Iceland and secondary processing into smoked salmon in France (Ingólfsdóttir *et al*. 2013).
- User manual "Sense tool for Dummies" (Ramos *et al*., 2014a)
- Development of the SENSE tool software (Cuevas *et al*., 2013)

The report explains the protocols that were used as a framework in the pilot implementation of the SENSE tool and the working procedures applied in the functionality testing and validation of the tool. The report includes the results of functionality testing and validation carried out by LCA experts (Phase 1). Further testing of the SENSE tool by SMEs and assessment of the deployment of the tool in external companies will be reported in D4.2.

Following SENSE partners contributed to the validation process of the SENSE tool:

Guðrún Ólafsdóttir at UoI-ASCS[2] was the leader of the pilot implementation and reporting, and participated in validation of the SENSE tool for the aquaculture food supply chain.

Geneviève Doublet and Niels Jungbluth at ESU-services[3] were responsible for validation the meat and dairy and orange juice supply chains.

Gyða Mjöll Ingólfsdóttir, Eva Yngvadóttir and Alexandra Kjeld at EFLA[4] were responsible for validating the aquaculture chain.

Saioa Ramos at AZTI[5] is responsible for the SENSE tool database and compiled the SENSE tool guidelines and she partakes in the development of the software. She participated in the validation and communicated about the functionality and software requirements from validators to Ingenet[6].

Lohitzune Larrinaga and Unai Albinarrrate at Ingenet were responsible for developing and updating the software and implementing changes during the iterative validation process.

Birgit Landquist (SIK), Aintzane Esturo (AZTI), Sigurður Bogason (UoI) and Bianca Pop (TriTecc) contributed to the risk assessment, assessment of the SENSE tool (Phase 2) and reviewed the report.

[2] http://www.ascs.is/
[3] http://www.esu-services.ch
[4] http://www.efla-engineers.com/
[5] http://www.azti.es/
[6] http://www.ingenet.es/

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GLOSSARY AND ACRONYMS

AI	Active ingredient
DOW	Description of work
EID	Environmental Identification Document
KEPI	Key Environmental Performance Indicators
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
SENSE	Harmonized Environmental Sustainability in the European Food and Drink Chain
SME	Small and medium enterprises
SAAP	Step Analysis and Action Points framework
PRD	Partner Responsibility Document

Introduction

The SENSE project[7] (Harmonized Environmental Sustainability in the European Food and Drink Chain) has developed a web-based tool, the **SENSE tool**, which is designed for small and medium enterprises (SMEs) in the food and drink sector. The tool performs a simplified environmental impact assessment of food and drink products and assessment of selected social impacts of companies. The aim is to develop an easy to use tool that can be used by industrial actors without life cycle assessment (LCA) expertise. To facilitate data collection in SMEs, key environmental performance indicators (KEPIs) have been selected as input data to perform the simplified sustainability assessment. Another feature of the SENSE tool is to provide easy to interpret environmental information that is compiled in an Environmental Identification Document (EID).

The SENSE-tool development is aimed at facilitating self-assessment of sustainability in SMEs and supports the EC recommendation on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (European Commission, 2013)

Features of the SENSE tool

The web-based SENSE tool was developed using Visual Basic.Net, on Visual Studio 2010. All the application's information is stored using database engine SQL Server 2008 R2. As far as the application imaging, both design and used pictures, were done using Photoshop CS 6 and Gimp 2.8 (Cuevas *et al*., 2013; Ramos *et al*. 2014b).

Each user can access the SENSE tool with its login account and assess the environmental impacts of their products based on the input of annual data on energy use and use of resources for the production, as well as data on waste and wastewater generation from the production of the respective product. The environmental performance is assessed for the overall value chain of food or drink products including the primary agriculture and aquaculture steps that are relevant for the products that the SME sells on the market. The SME can decide if it wants to analyse one product or the whole product portfolio. The social performance of the companies is assessed by a questionnaire comprising 10 yes or no questions. Detailed guidelines "SENSE-tool for Dummies" have been developed (Ramos *et al.,* 2014a) and provided as pdf in the on-line version of the tool Furthermore, training videos for the users are available on-line.
The tool takes into consideration a legal notice and privacy policy for data protection according to the Spanish Data Protection Agency and has the necessary safety means to guarantee the total safety of the data. The responsible partner for the data is AZTI-Tecnalia[8], and the data has to fulfill the Spanish data regulation (Spanish Organic Law 15/1999, 13 December). A special clause about confidentiality is included to assure and guarantee the security and confidentiality of the data provided. The user is invited to agree with the provided text about data policy when entering the tool. AZTI-Tecnalia guarantees that the personal data collected in the forms is sent as encrypted information to avoid view by third parties.

Key Environmental Performance Indicators - KEPIs

The SENSE tool aims at simplifying data collection and information requirements. Therefore, the data to be entered in the tool are key environmental performance indicators (KEPIs) that are easy to measure and relevant for the environmental assessment. The relevance of the selected KEPIs

[7] www.senseproject.eu
[8] AZTI-Tecnalia, Txatxarramendi Ugartea s/n, 48395 Sukarrieta,

was verified by performing three LCA case studies in the beef and dairy, orange juice and aquaculture sectors (Doublet et al. 2013a, Doublet et al. 2013b; Ingólfsdóttir et al. 2013). The LCA results confirmed the validity of the selected KEPIs in terms of their relevance for the environmental impacts, the data availability and the easiness of measurement. The selected KEPIs covered 95%, on average, of the environmental impacts of the respective food supply chains

Table 1. Selection of Key Environmental Performance Indicators (KEPIs) for life cycle steps of the three investigated supply chains in the SENSE project.

Key Environmental Performance Indicator (KEPI)	**Unit for KEPIs Landquist et al. (2013)**	**Unit for SENSE tool data input (Resource use and emission profile)**
Plant production		
N-fertiliser use	kg N/hectare; kg N/kg crop	kg N/year
P_2O_5-fertiliser use	kg-P_2O_5/hectare; kg-P_2O_5/kg crop	kg/year
Manure and slurry application	kg N/hectare; kg N/kg crop	kg/year
Pesticide and active substance content	kg/hectare; kg/kg crop	e.g. kg AI/year
Diesel use incl. machineries	l/hectare; l/kg crop	energy unit (kwh, L of diesel, m^3 of natural gas, etc.) / year
Arable land use	ha/kg crop	ha/year
Grazing land use	ha/kg crop	ha/year
Water use	m^3/hectare; m^3/kg crop	Freshwater use: l or m^3/year
Fisheries		
Energy use	MJ/kg product	L of diesel / year
Aquaculture		
Feed Efficiency (FCR: Feed used/Fish produced)	kg/kg	NA
Feed use		Kg/year
Fish produced		Kg/year
Energy use	MJ/kg product	energy unit (kwh, L of diesel, m^3 of natural gas, etc.) / year
Electricity use	kWh/l product	Kwh/year
Organic waste to sea	kg waste/kg product	High / low
Water use	m3/kg product	m^3/year
Packaging material	kg/kg product	Kg/year
Livestock - ruminants		
Livestock		Type of animal /year
Raw milk production	kg raw milk/dairy cow	kg/year
Feed efficiency	kg feed/kg live weight	NA
Buildings	m^2/kg product	NA
Electricity use milking	kWh/kg raw milk	energy unit (kwh, L of diesel, m^3 of natural gas, etc.) / year
Water use milking	m^3/ kg raw milk	m^3/year
Food and feed processing		
Energy use	MJ/kg product	energy unit (kwh, L of diesel, m^3 of natural gas, etc.) / year
Electricity use	kWh/l product	
Water use	m^3/ kg product	m^3/year
Packaging material	type/kg product	Kg/year
Waste	kg waste/kg product	Kg/year
Dairy		
Raw milk input	kg raw milk/kg product	Kg /year;share in turnover (%)
Slaughtering		
Meat production	kg live weight/kg meat	Kg /year; share in turnover (%)
Juice processing		
Yield	kg orange/l orange juice	Kg /year; share in turnover (%)

The KEPIs selected for the production of all the food supply chains as defined by Landquist *et al.* (2013) are shown in Table 1. The identified KEPIs were used to define the needed input data to the SENSE tool. The annual usage of resources and amount of production is used as input data for

different life cycle steps of the food and drink product in the SENSE tool. Furthermore the annual turnover of companies is defined as KEPI. An inventory comprising the KEPIs which represent the resource use and emissions profile of material/energy resource inputs/outputs and emissions into air, water and soil for the product supply chain, is thus compiled as a basis for modelling the product environmental profile in the SENSE tool.

Table 2 Selected key environmental performance indicators (KEPIs) for the European food and drink sector as defined for the SENSE tool data input (Ramos et al. 2014b)

INPUT	UNIT	**Description**	**Data source for life cycle inventories**
Land use	ha/year	Land occupation for agricultural uses: permanent crops, arable land or grazing.	
Fertilizers	kg N/year kg P/year kg K/year	Inorganic fertilizer consisting of nitrous compounds such as ammonium nitrate or ammonium sulphate and inorganic fertilizer consisting of phosphorous or potassium compounds.	ecoinvent v.2.2
Organic fertilizers	kg/year	Fertilizers derived from animal or vegetable matter (e.g. compost, manure)	ecoinvent v.2.2
Pesticides	kg AI/year	Pesticides are plant protection products. The term "pesticides" covers insecticides, acaricides, herbicides, fungicides, plant growth regulators, rodenticides or biocides. The user has to provide the commercial name for the pesticide (i.e. RoundUp ®) in the free-text box and introduce the amount per hectare used. Once it is defined, an addition table will appear where they have to specify the percentage of active ingredient (AI) (i.e. glyphosate). If the AI is not in the list, generic pesticides could be used, such as, “fungicides” or “herbicides” or “pesticides”.	ecoinvent v.2.2
Energy	energy unit (kwh, L of diesel, m^3 of natural gas, etc.) / year	Energy consumption in agriculture systems are mainly related to fuel used during land labours (tractor), energy required for buildings maintenance and greenhouses maintenance, In the fisheries systems the use of fossil fuel is mainly related to the fishing vessels. In aquaculture, livestock and food processing systems the energy use is mainly related to the operation of machinery and building facilities.	LC-inventories 2014 (for electricity) ecoinvent v.2.2
Freshwater use	l or m^3/year	For water requirements the user has to introduce the total water usage over 1 year. Rain water is not taken into account, only tap-water	ecoinvent v.2.2
Feeds	kg/year	Data on feed can be selected from a drop down menu, offering different kind of feed ingredients (crop and marine),	ecoinvent v.2.2
Packaging	Kg/year	For the packaging the use needs to specify the type of final packaging material (glass, plastic bottle etc.) and the amount used per year. In some cases, intermediate packaging will be relevant too.	ecoinvent v.2.2
Livestock	Type of animal /year	For the livestock, the specific animal has to be selected. Specify the amount produced in one year and the share of the product in turnover (%).	IPCC 2006
OUTPUT			
Wastewater	L or m^3/year	For inland aquaculture systems the user need to specify the amount (L or m3) of wastewater discharge per year. For marine aquaculture systems an average N discharge to the marine environment due to faeces and uneaten feed per kg of fish has been taken into account (41 kg N eq/ 1 ton fish) (Heldbo et al., 2013)	ecoinvent v.2.2
Waste	kg/year	The user chooses first the waste material (organic waste, plastics, cardboard, glass or other type) and then the disposal way (incineration, recycling landfill)	ecoinvent v.2.2

The KEPIs as defined by Landquist *et al.* (2013) could be further applied as a basis for a simple quantification method for the SMEs to measure and monitor targets to trace environmental impacts and track improvements. For example the efficiency ratio i.e. kg N/kg crop or FCR (feed conversion ratio) can be calculated to be used as an “easy to compare indicator” by the company, based on e.g. the amount of feed used per year and the annual production of fish or livestock. Thus in

addition to assess the environmental impact with LCIA methodology in the SENSE tool a further improvement would be to include an option to calculate these KEPIs, e g kg N/kg product, kWh electricity/product or the feed conversion rate (FCR). Those additional KEPIs could be a further help for the SMEs to understand their environmental performance in addition to the LCIA results that are included in the EID.

The KEPIs applied in the SENSE tool for the three food supply chains are further described in Table 2. The life cycle inventory of each KEPI is either based on the ecoinvent database v2.2 or the LC-inventories, an update of the ecoinvent database v2.2 (ecoinvent Centre 2010, LC-inventories 2014). A list of the selected life cycle inventories for input data was compiled in the project by Cuevas et al. (2013) and the list will be updated during the iterative development of the tool during the implementation phases.

Environmental impact assessment methods

The environmental impacts are computed based on life cycle impact assessment (LCIA) methods that were defined in the SENSE project (Aronsson et al., 2013) and comply with those recommended by the ILCD handbook (European Commission, 2011). The ENVIFOOD protocol, which is specific for food and drink products, recommends the same methods except for the water depletion (ENVIFOOD 2012). The life cycle impact assessment methods are shown in Table 3.

Table 3 Life cycle impact assessment methods implemented in the SENSE tool (Aronson et al.,2013; Ramos et al.,2014b)

Impact category	Unit	Selected LCIA method	Reference
Climate change	kg CO2-eq	Bern Model – IPCC	Solomon, 2007
Eutrophication, Terrestrial	molc N-eq	Accumulated Exceedance	Posch et al., 2008
Eutrophication, Freshwater	kg P-eq	EUTREND Model, ReCiPe v1.05	Goedkoop et al., 2009
Eutrophication, Marine	kg N-eq	EUTREND Model, ReCiPe v1.05	Goedkoop et al., 2009
Acidification	molc H+-eq	Accumulated Exceedance	Posch et al., 2008
Human toxicity, non-cancer and cancer effects	CTUh	USEtox Model	Rosenbaum et al., 2008
Ecotoxicity, freshwater	CTUe	USEtox Model	Rosenbaum et al., 2008
Land use	kg C deficit	Soil organic matter model	Milà i Canals 2007
Abiotic resource depletion	kg Sb eq	CML 2002	Guinée et al., 2002
Water depletion	m^3 H_2O eq	Ecological scarcity model	Frischknecht et al., 2009

Allocation approach

The allocation approach selected for the SENSE tool is economic allocation, according to recommendations from ENVIFOOD protocol (2012). This means that the shares of single products in the annual turnover are used as factors to assign the inputs to the single products. However, the tool offers the possibility to choose other factors to allocate incoming ingredients and packaging to a specific product, i.e. assigning the Tetra Brick packaging only to the whole milk products.

The controversial issues regarding allocation for the selected food supply chains are discussed further in Ramos et al. (2014b). In the LCA case study on aquaculture, the economic allocation was used. It gives a higher burden on the main product than if mass allocation would have been used since the by products are given away and have no economic value (Ingolfsdottir *et al*., 2013). The allocation of environmental impacts to by-products is also an issue for the slaughtering

process in the beef chain. In the case study, the economic approach was followed and all environmental impacts are allocated to the beef (Doublet *et al*., 2013a).

SENSE tool calculations and EID

The results from the tool's calculations are presented as a Product Environmental Profile, which shows the contribution of the different inputs to the total environmental impact. The results are communicated to users by a certification scheme concept, the Environmental Identification Document (EID). In this document a summary of main environmental and social information about the product is shown. The tool also offers a benchmarking option that allows companies to compare their environmental impact contribution along the supply chain. This encourages industries to investigate the sources of variability, and promotes the identification and implementation of potential environmental improvements. Moreover, the EID allows the users to benchmark their product with similar products (Ramos *et al.,* 2014b).

Social aspects

The SENSE tool includes questions on social aspects to assess the performance of companies regarding social impacts mainly related to workers' rights and labour standards. An overall score is given and explained in the SENSE tool as follows:

- No score: 0 No evidence: SME provides no evidence.
- Scoring range 1-50 Awareness only: SME demonstrates awareness of core labour standards and/or sector code or guidelines and of the external impacts of their activities in local communities, but management of employment practices and actions taken is limited.
- Scoring range 51-60 Basic Management: SME has a named senior representative with responsibility for labour standards within the company, and has adopted policies to manage labour standards and working conditions on-site, and demonstrates evidence of actions taken to address external impacts of their production within local communities.
- Scoring range 63-84 Good practice: SME has a named senior representative with responsibility for labour standards within the company, and has policies on labour standards and working conditions in place, and has a formal management system on-site and its policies are communicated at least as far as first tier suppliers, and it demonstrates evidence of actions taken to address external impacts of their production within local communities.
- Scoring range 85-100 Best practice: SME has a named senior representative with responsibility for labour standards within the company, and has a good management systems for labour standards and working conditions in place at least as far as first-tier suppliers, and demonstrates evidence of actions taken to address external impacts of production within local communities, and makes public statements of commitment (e.g. on website/labelling).

Pilot implementation of the SENSE tool

Objectives

The main objective of the pilot implementation was to implement the SENSE tool as a web based tool to facilitate simplified environmental assessment in SMEs in food and drink chains. The implementation was executed in three phases:

- Phase 1: Validation and functionality testing of the SENSE tool by LCA experts
- Phase 2: Regional training and testing of the tool by the participating SMEs in the SENSE project representing the three selected food supply chains (orange juice, meat and dairy and aquaculture).
- Phase 3: Implementation of the web based tool in external companies. The aim is to offer companies in food supply chains from the same sectors to use the tool to assess their sustainability performance and in this way obtain their feedback on the usability of the tool. The goal is to have at least 30 companies involved and perform benchmarking.

Prior to implementing the SENSE tool in companies (Phase 3) the SENSE validation team assessed the performance of the tool by testing the functionality of the user interphase, and performed calculations with the tool using the inventory data from the participating SMEs from LCA case studies in the project (Phase 1). The aim was to verify that the outcome of the tool calculations were comparable with the results obtained when using the same input data in a commercial software (SimaPro and GaBi). Additionally, the functionality of the SENSE tool has been assessed in Phase 2 where the functionality testing was performed by the participating SMEs in all chains and the SENSE partners who are responsible as contacts for external companies testing the SENSE tool in Phase 3. Workshop, meetings and visits to the participating SMEs companies have provided valuable feedback on the functionality of the tool and the suggested improvements of the tool were communicated to the SENSE tool developers.

Furthermore, the views of the stakeholders testing the tool will be assessed by an on-line survey and results of the SENSE tool calculations will be analysed using methods to compare efficiency in environmental performance (Reported in D4.2).

Implementation protocols – Step Analysis and Control Points framework

An implementation protocol using Step Analysis and Action Points (SAAP) methodology was applied to establish a common road map for participant's involvement and procedures in the validation study and the functionality testing. The SAAP framework as detailed in Table 4 was used to identify pre-requisite developments, procedures and guidelines that were needed for the validation and implementation of the SENSE tool in SMEs.

Table 4 Step Analysis and Action Point framework for the validation process and implementation of the SENSE tool

STEP 1 ***Conduct risk analysis of the implementation phase of the SENSE tool***
⇨ List all potential failures – risk identification ⇨ Conduct a risk analysis and consider control measures ⇨ Evaluate all obstacles and possibilities to prevent or control any factors that can go wrong in the implementation of the SENSE tool ⇨ Identify conditions or events that can have an impact on the SENSE tool implementation and testing by SMEs
STEP 2 ***Determine action points*** to successfully implement the SENSE tool
⇨ Identify all action steps in the implementation where preventive measures and guidelines are needed

⇨ Preventive measures implemented by adapting the working procedures established (i.e. templates for feedback) ⇨ Description of all steps involved in the implementation (flowcharts)
STEP 3 *Establish critical limits and required actions*
Functionality criteria (Pass/Fail) Validation criteria 10% comparing with the same analysis
STEP 4 *Establish control measures and monitoring procedures*
SEE flowchart with actions and monitoring points for decision making
STEP 5 *Establish corrective actions*
⇨ Describe how deviations will be dealt with and establish contingency plans in case of failure of SENSE tool implementation ⇨ Evaluate what went wrong and implement training or support
STEP 6 *Establish record keeping procedures*
⇨ Reporting format for feedback on functionality ⇨ Assign responsibility for the flow of feedback data, information and records from the testing ⇨ All data input and output data will be stored in the SENSE tool and can be extracted from the tool in excel form for further analysis ⇨ Reporting on functionality (iterative process - performed during validation step)
STEP 7 *Establish verification procedures*
⇨ Validation of the SENSE tool output by comparing with simplified environmental impact assessment using commercial software (SimaPro/GaBi) and applying the same methods and selected inventory data (KEPIs) from the LCA case studies

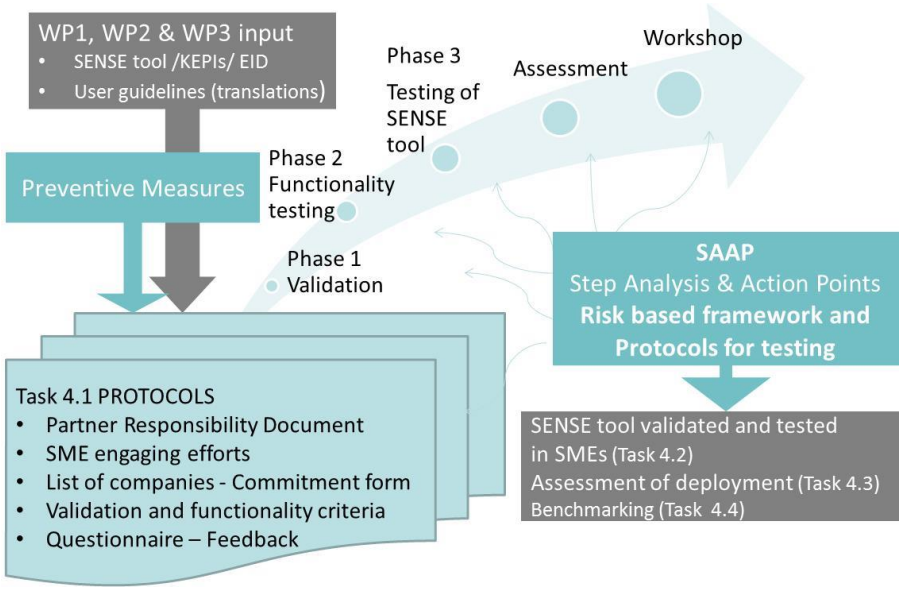

Figure 1 Step Analysis and Action Points (SAAP) methodology applied in the pilot implementation of the SENSE-tool, including validation, functionality testing and assessment of the performance.

The developments carried out in former work packages (WPs) in the SENSE project are the required input before assessment of the SENSE tool can be performed (i.e. developed software based on the selected KEPI (Key Environmental Performance Indicators and EID (Environmental Identification Document)). The SAAP framework gave an overview of activities during each step in the testing of the SENSE tool and potential risk factors were analysed. The main issue in the implementation is to adopt preventive measures and prepare clear guidelines and working

procedures. Contingency plans were established to mitigate any foreseeable risks. The outcome is a reference framework for implementing and validating the SENSE-tool (Figure 1).

Pre-requisites and preventive measures

One of the initial tasks in the pilot implementation of the SENSE tool was the establishment of the Partner Responsibility Document (PRD) to confirm the roles and responsibilities of partners as well as defining in more details what was involved in each task beyond the description of work of the project. Guidelines /protocols were developed as prerequisites and preventive measures to ensure a common approach and understanding of the participants in the overall pilot implementation. For example documents to facilitate Phase 3 implementation such as the list of companies, invitation letter, guidelines /SENSE tool for Dummies, and a questionnaire to be used to assess the deployment of the SENSE tool etc. (Table 5).

The main emphasis was put on performing the Phase 1 testing in collaboration with LCA experts prior to testing of the SENSE tool by users with limited LCA knowledge (Phase 2 and 3). This proved to be very valuable since issues and problems in the validation regarding methods, databases and functionality of the software required knowledge in LCA. During the Phase 1 validation, the risks that had been identified initially in the project were revisited and an updated risk table established with the partners. Necessary updates based on feedback from the validators were implemented during Phase 1 and new versions of the software were launched during the testing. Consequently the validation work was prolonged and the time plan was revised (Table 6). This iterative development and effective teamwork was the key to successful development of the current prototype of the SENSE tool.

Table 5 Step Analysis and Action Point *SAAP* framework to identify preventive measures

Pre-requisites and preventive measures established for SENSE tool implementation		***Task***
(1) Determine timelines for validation and readiness of the SENSE tool for implementation in SMEs	Timelines for the testing and implementation of the SENSE tool in SMEs are dependent on the delivery of the fully functional and validated SENSE tool	T4.1
(2) Define the objective of the implementation	Clarify the objective of the testing and assessment of the SENSE tool first by LCA experts and SENSE partners and thereafter by the external companies	T4.1
(3) Flow charts and description of the process for implementation of the SENSE tool	Flowcharts for all steps in the implementation and validation established including functionality testing and verification	T4.1
(4) Assign responsibility to the SENSE partners	Partner Responsibility Document (PRD) updated regularly as a working document to coordinate the role and responsibility of partners	T4.1
(5) Preparation for testing the SENSE tool by listing companies, identify responsible contact persons and establish contacts list	List of companies compiled early in the implementation phase	T4.1
(6) Assess the willingness of companies to participate in the testing	Send "Invitation letter" to potential companies who are willing to test the tool (ANNEX I)	T4.3 Phase 3
(7) Ensure the commitment of companies to participate	Explain the benefits of the SENSE tool Interviews / Commitment form / Confidentiality	T4.3 Phase 3
(8) Develop user guide/ troubleshooting document to be used by user SENSE tool for Dummies	The guidelines were developed by the SENSE-tool developers and reviewed prior to implementation in SMEs Support will be provided if companies are not able to	T 4.2 Phase1-2 T 4.3

	insert data and work with the SENSE tool - Training video developed	Phase 3
(9) Templates for feedback on functionality	Assessment of functionality carried out by LCA experts (PASS /FAIL / OBS) – the purpose is to give feedback to software developers	T4.2 Phase 1
(10) Procedures to assess the outcome of the testing and establishment of validation criteria	Assessment carried out by LCA experts. Validation criteria of < 10% compared with the same analysis in the convectional LCA software was established	T 4.2 Phase 1
(11) Assessment of the deployment after completing the testing in the companies.	Questionnaire developed as an on-line survey to be filled in by participating companies or / interviews carried out by SENSE contacts	T 4.3
(12) Describe how deviations will be dealt with in case of failure of SENSE tool implementation	Risks evaluated => corrective actions and contingency plans implemented	T 4.1
(13) Training and dissemination of success stories Workshops	Depending on the outcome of the testing SENSE partners will decide if training is necessary and for who and organize training/dissemination sessions Training /Dissemination schedule planned - timelines. Prepare Training / Success stories	T 4.3

Table 6 Revised timeplan and tasks for the Implementation of the SENSE tool (May 2014)

WP4 Validation of integrated standardised SENSE-tool for sustainability assessment in food chains

	2013								2014												2015
Actions	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Okt	Nov	Dec	Jan
Task 4.1 Establishment of protocols																					
Task 4.2 Pilot implementation																					
Phase 1 Validation and functionality testing / Validators																					
Phase 2 Functionality testing /SENSE partners																					
Task 4.3 Assessment of the deployment of the SENSE tool																					
Phase 3 Web based implementation in SMEs																					
Workshop																	Sep29				
Task 4.4. Benchmarking performance of food supply chains																					
Deliverable 4.1 Protocols, validation and functionality testing													D 4.1								
Deliverable 4.2 Assessment of deployment																		D4.2			
Reports on benchmarking /scientific publications																					

Potential risks identified

The main risks identified at the beginning of the SENSE project related to the pilot implementation of the SENSE tool were regarding the involvement of external companies (see Table 7). Working procedures were therefore established to prepare for the implementation and guidelines prepared either as part of the “SENSE tool for Dummies” or as supplementary information to ensure the successful deployment of the tool.

During the validation phase additional risks were identified which could influence the integrity of the outcome of the SENSE tool. Risks were associated with the choice of methods, characterisation factors, availability of datasets in the tool, calculation of processes and allocation factors applied. The overall risks were assessed by the partners after the corrective actions and contingency plans

were established. The probability of all of the identified risks that were rated as HIGH in the start of the project have now been rated as LOW and a few as MEDIUM (Table 7).

Table 7 Significant risks and contingency plans in the pilot implementation (updated May 2014)

Potential risks factors identified	*Corrective actions*	*Contingency plans*	H/M/L
The lack of willingness of stakeholders in the supply chain, to participate in the testing due to lack of time or lack of resources within the company.	Find out why there is reluctance to participate and if relevant promote the benefits of the SENSE tool outcome Explain what is involved in the testing	Evaluate if the timeframe for testing can be extended Offer support and training for participants. In the case if they are not willing to participate find new company	L
SMEs or other chain partners may not be willing to share data and information on resources needed for the project e.g. due to competitive reasons	Data from invited guests can be confidential	Explain the confidentiality options and how the data will be used	L
Companies not willing to participate and therefore the desired number of companies (30) was not possible within the given timeframe	Extend the list of companies already identified for testing and consider inviting also large companies	Find new company The project will benefit from having more companies involved	L
Iterative development of the SENSE- tool delays the validation phase and assessments of the SENSE tool	Protocols and questionnaires have been developed to facilitate the assessment of the deployment of the SENSE tool in an efficient way following the validation.	In the case the tool is not fully validated in due time, companies will be asked to provide data into the tool and the final outcome of the impact assessment will be delivered when software update has been completed	L
Uncertainty regarding the integrity of the SENSE tool calculations for external companies	Simplified LCA will be performed by experts using standard software tools (SimaPro or Gabi) to validate the outcome of the SENSE tool calculations. The data input would be based on the KEPIs as used in the SENSE-tool	LCA experts will collaborate to report the validity of the SENSE tool output and explain any deviations or limitations and suggest potential improvements	M
Potential failures when entering data e.g. data input not successful	Evaluate what went wrong Support will be given	If not possible to enter relevant data, document what went wrong	L
Data not available because supply chain actors of respective companies are not willing to share data even though confidentiality has been explained	Enter general data	Explain the limitation of the output and the data quality	L
Lack of compatibility could hinder an efficient assessment of the SENSE tool output	It is necessary to get an easy automatic extract from the tool with all input data in a standardized format for Excel and the output data	Update the software to make sure it will be user friendly and data can easily be accessed for further evaluation.	L
Lack of relevant datasets in the SENSE tool	Explore possibilities to obtain data from open sources	Datasets obtained from colleagues or private sources	L
The default values in the SENSE tool do not comply with what a company wants to enter (e.g. fertiliser or pesticide is missing)	Enter an alternative (which?) Support will be given	Document the discrepancies	M

The processes of the participating SME do not comply with the processes defined in the SENSE tool	Enter as much data as possible. Support will be given	Document what is missing or not complying	L
Transparency may be lacking with regard to the input data from the invited guest supplier. If there is error or unreasonable data it is a disadvantage that the data submitted into the tool cannot be assessed	The data provided by invited guests will not be confidential by default	LCA experts will provide support verify the outcome of the SENSE tool	L
Lack of transparency regarding information about the background processes applied in the tool e.g. diesel, transport, feed etc .	Provide information on all processes used in the tool This information is available in SENSE reports	Make a supplementary list to the guidelines to ensure transparency of the SENSE tool calculations	L
SENSE tool calculations not correct and environmental impacts not reasonable	Evaluate what went wrong Support will be given Correct in SENSE tool if possible within the given time frame	If not possible to correct, document what went wrong	L
Potential failures of the calculated environmental impacts in the SENSE tool when comparison is made with commercial software, i.e. there may be errors in the method / characterisation factors or the background datasets used may not be relevant	In the validation procedure the methods, characterisation factors and datasets implemented in the tool have been checked and are clearly explained. Background data from ecoinvent is often updated and can give quite different results. Therefore it is important to clearly state which processes are used in the tool. The methods implemented in the tool need to be listed, (including the version of the method)	Verification of the SENSE tool results from the additional companies by comparing with commercial software to enhance the integrity of the results	M
The aim of the SENSE tool calculations not clarified well enough and users may not have the right information to assess the usefulness of the tool	Revise documents that accompany invitation letter Provide a short description of the key concepts and give more explanations of the SENSE tool outcome	Evaluate what kind of training material needs to be developed and offer Training sessions / workshops	L

The intention is that the SMEs will themselves insert the data using the developed SENSE tool guidelines and software. Based on experience from earlier projects the engagement of SMEs can be both time consuming and costly for both the SMEs and the project partners. Qualified staff may not be available within the SMEs to perform the on-line data input, there may be lack of commitment and limited time, and therefore they will need supervision and support to perform the testing in an efficient way (Witczak, 2014). Based on experience in the project when introducing the tool to the participating SMEs for the first time there was clearly a need for support to help with data input (Romania and Iceland), both regarding how to insert data into the tool and the overall understanding of the key concepts. The translation into different language was considered necessary and has been implemented.

Considering the risk involved in engaging SMEs, SENSE partners that are involved in contacting the companies will undertake additional efforts to motivate the SMEs, explain the details of the SENSE tool using communication and training material, and help with data input on-site which otherwise could become time consuming. This will ensure that the necessary data will be collected for further data analysis and thus eliminating the risk involved if difficulties occur while using the web based SENSE tool for data collection. The stronger the database will be, the more likely it is that the SMEs would be engaged in using the tool beyond the project.

Validation of the SENSE tool - PHASE 1

Phase 1 of the Pilot implementation of the SENSE tool included validation of the performance of the SENSE tool carried out by LCA experts from ESU-services, EFLA and AZTI. The ILCD handbook (European Commission, 2010) was the general framework for the validation and further the implemented methodologies that had been recommended and selected for the SENSE tool were checked (European Commission, 2011, 2012), as well as the life cycle inventories from the ecoinvent database and other external sources. The validation included (i) functionality testing of the software and (ii) verification of the results obtained by the simplified environmental assessment in the SENSE tool by comparing with the calculations using commercial software (SimaPro and GaBi). Additionally, (iii) a comparison was made between LCA case studies and the simplified environmental assessment for the three food supply chain systems (orange juice, beef and dairy, and aquaculture salmon).

Objectives of the validation

- Functionality testing: One objective of the validation was to assess the user interphase and test the functionality of the software tool when entering data and calculating results. Different functions provided by the user profile, the process diagram, the questionnaire corresponding to the processes defined and the presentation of the results, were assessed. The SENSE tool manual "SENSE tool for Dummies" was reviewed during the testing.
- Verification: Another objective was to validate the calculation of the environmental impacts. The validation was performed based on the three food chains that had been analysed in the LCAs The approach in the validation was to apply the inventory data for the defined KEPIs in each supply chain from the case studies, on orange juice, meat and dairy and salmon aquaculture, to validate the results from the SENSE tool. EFLA[9] and AZTI[10] compared the environmental impacts of the aquaculture chain between the SENSE tool and LCA software GaBi v06 and SimaPro 8.0.2 while ESU-services[11] compared the environmental impacts of the beef and dairy supply chain and the orange juice supply chain between the SENSE tool and the LCA software SimaPro 8.0.2 (PRé Consultants 2014). The set of the key environmental performance indicators (KEPIs) identified by Landquist *et al*. (2013) were the input data to the SENSE tool. The goal of this task was to verify the results from the SENSE tool by assessing the accuracy of its results of the simplified LCA. The KEPIs were entered in the SENSE tool and in the LCA software to verify that the outcome was the same. The same background database was used for the testing. A percentage difference of <10 % between the SENSE tool and the LCA software was decided by the project group to be acceptable.
- The reference value in the validation process is the environmental impact calculated in SimaPro or GaBi. The actual difference is between the results of the SENSE tool, as shown in the tables 8,9,10 and 11, and the reference value. The actual difference is then divided by the reference value.
- Comparison of simplified LCA with complete LCA: The last objective of the validation was to compare the results of the SENSE tool with the results of the full scale LCA conducted as case studies in the participating companies from the meat and dairy, orange juice and

[9] http://www.efla-engineers.com/
[10] http://www.azti.es/
[11] www.esu-services.ch

aquaculture sectors (Doublet et al. 2013a, Doublet et al. 2013b; Ingólfsdóttir et al. 2013). The goal of this task is to check if the selected KEPIs (see Table 2) are sufficient as input data to calculate the environmental impacts in a life cycle perspective.

Validation procedure

The validation started in October 2013 and ended in June 2014. The validation work was an iterative process including the functionality testing where feedback was given to the software developers resulting in further development of the SENSE tool during this phase (Figure 2).

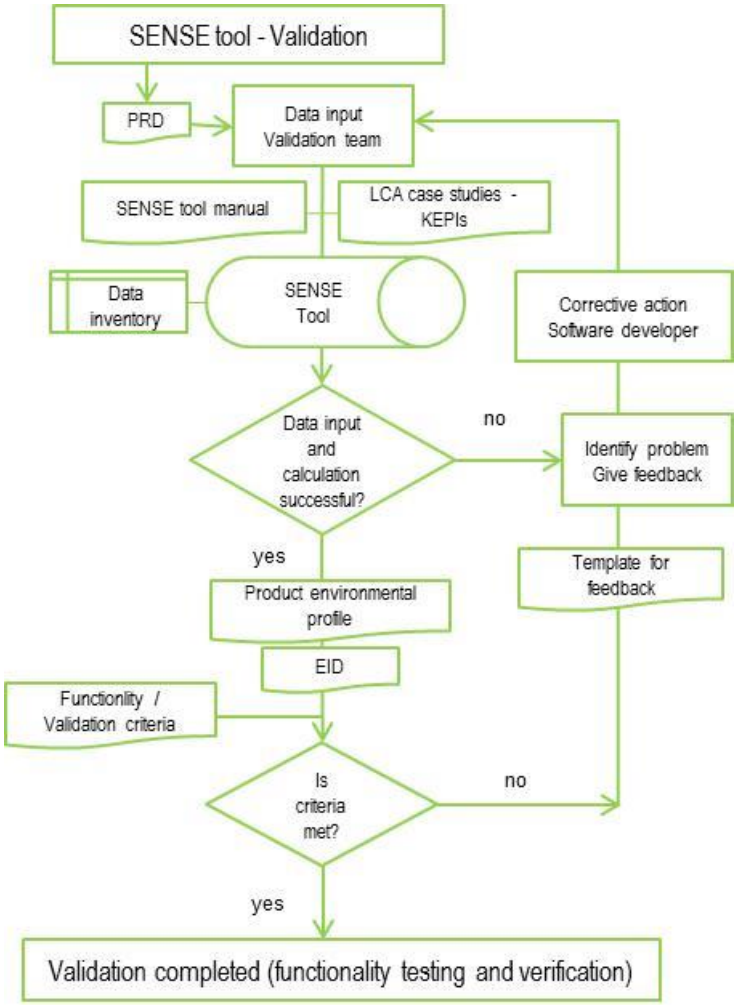

Figure 2 Flowchart for the Phase 1 validation and functionality testing of the SENSE tool by the validators, the LCA experts

The following interactions between the tool developers and the validators took place:

- Word documents with list of actions were compiled. The action corresponds to a feature of the tool, i.e. enter a product or draw a diagram. If the action does not work properly, it was given a comment “FAIL” and improvements measures suggested. If it worked properly, it was given a comment “PASS”. If it is only an observation remark, it is written “OBS”.
- Excel files were sent with the comparison of the environmental impacts. The comparison of the environmental impacts enabled to identify if they were within the +/- 10 % threshold defined by the project team. If the difference was higher than 10 %, errors were identified and improvement measures proposed. In order to identify the reason when differences

were too high, the comparison was made at each step of the chain (agriculture, fishing, livestock, aquaculture, transportation, processing). These documents were updated when the errors were corrected.

- Skype conferences were made between the validators and the tool developers.
- Further discussions were made through emails.

During the validation phase the need for further guidelines and training to be used in the testing of the tool by SMEs was assessed. The Guidelines for Dummies with translations was reviewed and a training video has been developed by AZTI to guide users when using the SENSE tool.

Results - Validation report status May – June 2014

Functionality testing of the SENSE tool

During the initial implementation phase of the web based software a close collaboration of the validators (LCA experts) with the SENSE tool developers ensured a dialogue to implement improvements while testing the functionality of the tool. This iterative process was important to ensure that the developed SENSE tool would be fully functional and validated before it was delivered for implementing and testing by SMEs.

The functionality of the SENSE tool was tested when entering data for the beef, dairy, orange juice and aquaculture supply chains. Numerous failures were encountered after the first release of the SENSE tool software system. During iterations of the functionality testing various changes were implemented The SENSE tool´s functionality thus improved vastly after the initial functionality testing took place in October 2013 and after several cycles of iterations many issues were solved and defects were removed.

A multi-product modelling approach was implemented to the SENSE tool in March 2014. This was needed since within the dairy chain, the dairy plant processes raw milk and produces seven different dairy products. A new updated version of the software including this multi-product function was launched in spring 2014. The multi-product modelling approach was validated after its implementation and further tested.

The new version of the tool additionally has the feature to export the questionnaire to Excel for companies to collect the data and fill in for convenience, prior to using the tool. The questionnaire results can also be exported from the tool for further analysis of data and error checks.

In the final testing in May - June 2014 some open issues regarding functionality, presentation and interpretation of the results were remaining. For example the EID needs to be further explained and developed. Suggestions for improvement of future version of the tool regarding the user profile and observations regarding the diagram, questionnaire and results have been communicated to the tool developers. Furthermore, the tool includes on-line information for the users that need to be further developed to facilitate for example choices for specific input selections. This will be updated during the Phase 3 implementation and errors in translations to the different languages will be checked.

Validation of the SENSE tool: General comments

Life cycle impact assessment methods

The validation of the environmental impact assessment calculated in the SENSE tool was carried out using the GaBi and SimaPro software. Although the same impact assessment methods were used by the validators, implemented in the SENSE tool (Table 3) and recommended by the JRC-

IES (European Commission, 2011), it was discovered during the validation process that in some cases different versions of identical methods were being used (European Commission, 2012), with different characterization factors for impact calculations. This led to the identification and verification of methodologies listed in Table 3.

Life cycle inventory update

In December 2013, during the second validation of the SENSE tool, it was identified that one reason for the difference between environmental impacts between softwares was a difference in the energy datasets. The database used by ESU-services includes an update of all ecoinvent life cycle inventories of electricity mixes (Itten et al. 2012; LC-inventories 2014) and of natural gas supply and hydroelectric power generation (Flury & Frischknecht 2012; Schori et al. 2012, LC-inventories 2014). These datasets are available for free online[12]. These datasets were implemented by all validators, using SimaPro and GaBi, for validation of the SENSE tool.

The database of the SENSE tool is based on the original unit processes from the ecoinvent database version 2.2 and does not include any updates from LC-inventories. During validation, suggestions were made to update life cycle inventories of electricity mixes in the SENSE tool, as some electricity mixes, e.g. Icelandic, are not available in the ecoinvent database v.2.2. These updates were carried out in January 2014, adding the ecoinvent LCI electricity mixes to the SENSE tool database but not overwriting pre-existing ones. Therefore, only the electricity mixes are updated according to the ESU dataset, but these electricity mixes are not used to calculate other background data such as e.g. fertilizer production, and processes regarding the generation of hydropower electricity or natural gas burning remain from ecoinvent 2.2. During validation, it was discovered that there were some differences in impact results for the Icelandic electricity mix between validators. For verification purposes, impacts were calculated for 1 kWh of Icelandic electricity in terms of GWP, revealing 28 g/kWh CO2-eq using SimaPro and 14 g/kWh CO2-eq using GaBi, while according to the most recent Icelandic National Inventory Report (Environmental Agency of Iceland, 2013), the weighted average GHG emissions from electricity production in Iceland in 2011 was 11.7 g/kWh CO2 eq. This average has ranged between 11 and 14 g/kWh CO2 eq in past reports. However, nearly identical impact results were obtained when comparing other electricity grid mixes between software, e.g. the Spanish electricity grid mix. The impacts from the Icelandic grid mix may therefore be slightly overestimated in the SENSE tool.

Long term emissions

It was decided in the SENSE project to exclude long term emissions in the LCIA, according to Aronsson et al. (2013). This was based on results of a recent report, where long-term emissions were found to make up between 35 and 70% of the preliminary impacts in a LCA case study on beef (Doublet et al., 2013a) for the following categories: Freshwater ecotoxicity, Freshwater eutrophication, Ionizing radiation HH, Human toxicity, cancer effects. An extensive discussion about the pros and cons of including long-term emissions in LCIA can be found in Frischknecht et al. (2007).

This was taken into account during validation, but in general, GaBi does not exclude long term emission to assess different environmental impacts. The only category where it is considered reasonable to exclude long term emission is eutrophication to fresh water (PE Int., personal communication). GaBi uses an attributional model, which does not regard long-term emission effects. The usage of ecoinvent data is therefore handled differently by SimaPro and GaBi. While SimaPro uses a plain database, GaBi has ecoinvent integrated in which the ecoinvent data have to

[12] www.lc-inventories.ch

follow the GaBi attributional model to ensure database consistency. Many long-term emissions to air have therefore been mapped onto normal emissions to air. An exception to this is for the freshwater since this highly affects freshwater eutrophication which is thus not reflected upon GaBi flows.

During validation, long-term emissions to air and to freshwater were omitted from the results obtained by GaBi, but due to its attributional model, it was impossible to exclude long-term emissions that have already been mapped to GaBi for consistency's sake. This may account for the differences observed between results of the SENSE tool and the GaBi software.

Validation of the SENSE tool: Results

Environmental impacts of the dairy supply chain

The dairy supply chain includes seven dairy products (pasteurized milk, soft cheese, yoghurt, sour cream, curd, semi-soft cheese, butter, cream cheese, fresh cheese and whey). Therefore, the percentage difference is an average of all dairy products. The relative percentage difference is smaller than 10 % in all impact categories (see Table 8). It can be concluded that all impact categories are validated successfully.

Table 8. Relative percentage difference between the environmental impacts of the SENSE tool and SimaPro. Average computed from the environmental impacts of 1 kg of each dairy product.

Impact category	Unit	Average percentage difference
Date Validation		May 21, 2014
Climate change	kg CO2 eq	1%
Human toxicity, cancer effects	CTUh	1%
Human toxicity, non-cancer effects	CTUh	-1%
Acidification	molc H+ eq	1%
Eutrophication, terrestrial	molc N eq	0%
Eutrophication, freshwater	kg P eq	6%
Eutrophication, marine	kg N eq	0%
Ecotoxicity, freshwater	CTUe	0%
Land use	kg C deficit	0%
Abiotic resource depletion	kg Sb eq	0%
Water depletion	m3 water eq	1%

Environmental impacts of the meat supply chain

The relative percentage difference between the environmental impacts computed by the SENSE tool and SimaPro is below 10 % for all impact categories (see Table 9). This is similar to the dairy supply chain. It can be concluded that all impact categories are validated successfully.

Table 9 Relative percentage difference between the environmental impacts calculated for the given KEPIs in the SENSE tool and SimaPro for 1 kg beef at slaughterhouse

Impact category	Unit	Percentage difference
Date validation		May 21, 2014
Climate change	kg CO2 eq	1%
Human toxicity, cancer effects	CTUh	1%
Human toxicity, non-cancer effects	CTUh	-1%
Acidification	molc H+ eq	1%
Eutrophication, terrestrial	molc N eq	0%
Eutrophication, freshwater	kg P eq	9%
Eutrophication, marine	kg N eq	0%
Ecotoxicity, freshwater	CTUe	0%
Land use	kg C deficit	0%
Abiotic resource depletion	kg Sb eq	-1%
Water depletion	m3 water eq	0%

Environmental impacts of the orange juice supply chain

The orange juice supply chain has been successfully validated and the percentage difference is below the 10 % deviation for all impact categories except the abiotic resource depletion (see Table 10). The reason for the difference is the update of the life cycle inventory of hydroelectric generation that is not available in the database of the SENSE tool but is included in the database used for the testing at ESU-services.

Table 10 Relative percentage difference between the environmental impacts calculated for the given KEPIs in the SENSE tool and SimaPro for 1 liter of orange juice

Impact category	Unit	Percentage difference
Date validation		May 21, 2014
Climate change	kg CO_2 eq	-1%
Human toxicity, cancer effects	CTUh	1%
Human toxicity, non-cancer effects	CTUh	1%
Acidification	molc H+ eq	1%
Eutrophication, terrestrial	molc N eq	0%
Eutrophication, freshwater	kg P eq	5%
Eutrophication, marine	kg N eq	0%
Ecotoxicity, freshwater	CTUe	0%
Land use	kg C deficit	1%
Abiotic resource depletion	kg Sb eq	19%
Water depletion	m^3 water eq	0%

Environmental impacts of the aquaculture supply chain

The aquaculture supply chain was validated for salmon products originating from an aquaculture farm in Iceland and transported to Europe where they were either sold as HOG salmon products or processed further into smoked fillets. Thus the scenarios validated in the SENSE tool, were for 1 kg head on gutted salmon (HOG) (transoceanic freight), for 1 kg HOG salmon (airfreight) and for 1 kg smoked salmon (transoceanic freight). The aquaculture chain was validated by two validators using two different LCA software; GaBi (EFLA) and SimaPro (AZTI). The results of the SENSE tool are comparable with the results from the SimaPro software for all impact categories except land use. When using the software GaBi the results are comparable (<10% difference) for climate change, human toxicity (cancer effects), acidification, terrestrial eutrophication (Table11).

Table 11 Relative percentage difference between the environmental impacts calculated for the given KEPIs in the SENSE tool, SimaPro and GaBi for 1 kg of fresh salmon (HOG), transported to Europe via transoceanic freight and airfreight, and for 1 kg of smoked salmon fillets (NC= Not comparable)

Impact category	Unit	HOG, transoceanic freight		HOG, airfreight		Smoked salmon fillets	
		Percentage difference (GaBi)	Percentage difference (SimaPro)	Percentage difference (GaBi)	Percentage difference (SimaPro)	Percentage difference (GaBi)	Percentage difference (SimaPro)
Date validation		June 3, 2014	June 3, 2014	June 3, 2014		June 3, 2014	June
Climate change	kg CO_2 eq	8%	-1%	4%	3%	7%	-2%
Human toxicity, cancer effects	CTUh	9%	-1%	10%	1%	14%	-7%
Human toxicity, non-cancer effects	CTUh	-20%	-2%	-17%	1%	-16%	-6%
Acidification	molc H+ eq	-1%	-1%	0%	1%	0%	-2%
Eutrophication, terrestrial	molc N eq	0%	-1%	0%	1%	0%	-2%
Eutrophication, freshwater	kg P eq	55%	-1%	53%	1%	54%	-2%
Eutrophication, marine	kg N eq	-29%	0%	-26%	2%	-29%	4%
Ecotoxicity, freshwater	CTUe	58%	-1%	57%	0%	58%	0%
Land use	kg C deficit	NC	0%	NC	-79%	NC	-93%
Abiotic resource depletion	kg Sb eq	-29%	-3%	-8%	1%	-4%	-7%
Water depletion	m^3 water eq	NC	-1%	NC	1%	NC	-1%

During validation of the aquaculture chain, it was discovered that although the same methods and versions were being used, the two software (GaBi and SimaPro) were in some cases incompatible, (see Table 12). The validators from EFLA and AZTI performed calculations with the different software and explored the differences observed. Furthermore, the providers of GaBi (PE International) were contacted to resolve some of the issues.

Table 12. Remarks and comments on methods used by validators for the aquaculture chain in GaBi and SimaPro, respectively

Impact category	Comments
Climate change	The exact same method was used by both validators, and the results were also within the 10% acceptability threshold. In Aronsson et al., 2013, it was stated that a characterization factor of 2 would be applied to total CO_2 emissions by aircrafts in the stratosphere based on scientific publications (Lee et al., 2009; Lee et al., 2010; Peters et al., 2011; Azar, 2012) and recommended by political institutions (Kollmuss & Crimmins, 2009; UBA, 2012). After discussions it was decided not to take this into account in the SENSE tool, and validation was therefore carried out without this characterization factor.
Eutrophication	**Terrestrial eutrophication**: The same method was used in both GaBi and SENSE/ SimaPro tool, i.e. the Accumulated Exceedance method (AE) by Seppälä et al., (2006). Slight differences between compounds accounted for in this method were discovered between software (GaBi/SimaPro), but this did not affect the results. For both validators, the results of the validation were within the 10% threshold. When calculating **freshwater and marine eutrophication**, the GaBi software uses by default a more recent version of the ReCiPe method, i.e. v.1.07, which distinguishes between marine and freshwater emissions, while according to the ILCD recommendations the 1.05 ReCiPe version should be used, referred to as "Aquatic Eutrophication" (European Commission, 2011, 2012). This was corrected during the validation process and the ReCiPe 1.05 version was used by both validators. For SimaPro, the results of the validation were within the 10% threshold, but for GaBi, that was not the case.
Acidification	The exact same method was used by all validators and the results between the SENSE tool, GaBi and SimaPro softwares were also within the 10% acceptability threshold.
Human toxicity	The same method was used by all validators (USEtox model, Rosenbaum et al., 2008), but the two software used were using a different set of flows. GaBi has implemented a "recommended" set of flows, while the SENSE tool and SimaPro use an "interim" set of flows, which includes a number of additional flows not used in most inventories, including the ecoinvent inventory, and should therefore not affect the results between softwares (PE International, personal communication). During validation, it was however discovered that the difference in values obtained between the different softwares stems from the absence of heavy metals in ecoinvent's USEtox impacts. As an example, nickel and arsenic are absent from the freshwater characterization of USEtox Human toxicity non-carcinogenic impact category of the ecoinvent center. This may partly explain the differences observed between results from GaBi and SENSE, as results of the validation in this category did not meet the 10% threshold using GaBi.
Ecotoxicity	The same method was used by both validators (USEtox), but the two softwares use a different set of flows, as with the Human toxicity impact categories, (see above). which should not affect the results between programs. However, heavy metals, e.g. nickel and arsenic, are absent from the ecoinvent database, which may explain the differences observed.
Land use	The method implemented in the SENSE tool and used by SimaPro (Soil organic matter model, Milà I Canals, 2007) was not available in GaBi and this impact category was therefore not validated using GaBi, only SimaPro.
Abiotic resource depletion	The same method was used by both validators (fossil and mineral, reserve based, CML 2002, Guinée et al., 2002) for this impact category. During validation of the SENSE tool in May 2014, the non-reserve based version of this method (CML2001), was replaced by the

	recommended ILCD method. The original CML2001 method is based on the "ultimate reserves", which is the total quantity of a material in the earth's crust, whereas the ILCD recommendations suggest using the "reserve base", which included resources that are currently economic (reserves), marginally economic (marginal reserves) and subeconomic (subeconomic resources) (PE Int., personal communication). The most important source for mining data (e.g. measures of available deposits and production rates) is the United States Geological Survey (USGS). Until a few years ago, they published yearly figures for the "reserve base" that should be used according to the ILCD recommendation. Today, however, they only publish data regarding reserves and resources with rough estimations for many materials. Although it does not perfectly match the ILCD recommendation, data on the reserves is implemented in the CML2002 method. The SENSE tool /SimaPro uses 116 conversion factors within this method, while GaBi uses 446 different conversion factors, including country specific flows for energy resources and more synonyms of minerals. In this category, the validation did not meet the 10% threshold using the GaBi software.
Water depletion	The method implemented in the SENSE tool and used by SimaPro is the Ecological scarcity model (Frischknecht et al., 2009). GaBi uses the same method, but does not implement regionalized conversion factors. The SENSE tool has implemented regionalization for at least 30 different regions/countries in Europe, which is necessary for its functionality. This impact category was therefore not validated using GaBi, only SimaPro.

The Aquaculture supply chain was last validated on June 3. When comparing results between SimaPro and the SENSE tool, the percentage difference is below the 10 % deviation for all impact categories When comparing between GaBi and the SENSE tool the three different supply chain scenarios the difference was below the 10% deviation threshold for 4 or 5 categories out of the 9 comparable categories. For all aquaculture supply chain scenarios the Climate change, Acidification, and Terrestrial Eutrophication met the 10% validation criteria.

The main reasons for the differences in results between GaBi and the SENSE tool are believed to be the following:

- GaBi uses an attributional model that handles ecoinvent long-term emissions differently than SimaPro. Not all long-term emissions could be omitted from the results due to this difference in data-handling, particularly long-term emissions to air. This could explain differences encountered in Freshwater ecotoxicity and Human toxicity (cancer effects and non-cancer effects).
- Emissions originating from the Icelandic grid mix may be overestimated in the SENSE tool, although they do not account for a major part of the emissions compared to emissions due to production of feed ingredients (marine and crop). This may affect differences observed within the Human toxicity categories, Freshwater eutrophication and Abiotic resource depletion

Comparison of SENSE tool and LCA case studies

The goal of this part of the validation is to compare the environmental impacts calculated by the SENSE tool with the results of the environmental impacts reported in the LCA case studies of beef and dairy products, orange juice and aquaculture salmon (Doublet et al., 2013a, Doublet et al., 2013b; Ingólfsdóttir et al., 2013).

This comparison is difficult to interpret because of various reasons. For example the databases used are not always the same as was explained earlier. In the case of the aquaculture chain the results of the LCA case study are not comparable to the SENSE tool calculations mainly because

different datasets were used for the marine feed ingredients. For the beef and dairy products the results from the LCA case studies were modelled with the ESU database and not the ecoinvent database v2.2. Fertilizer emissions in the SENSE tool are taken from the average data from ESU (the same data that ESU was using for the validation). The emissions from pesticides are from ecoinvent manual, which is the same as used by ESU.

The allocation approach in the dairy is not the same in the LCA case study since the SENSE tool uses economic allocation factors. However, the allocation is the same at the farm between the raw milk and the cull dairy cows to facilitate the validation procedure

Moreover, the models used to calculate the air, soil and water emissions due to the application fertilizers, uses average factors and therefore do not take into account the differences when applying different types of fertilizers. It would be recommended to calculate the input of fertilizer also as an average per nutrient, i.e. N-fertiliser, P_2O_5-fertiliser, K_2O-fertilisers in order not to give the user the impression that the emissions are specific for each type of fertiliser applied.

For poultry manure all emissions during application are not taken into account in the tool.

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Environmental impacts of the meat supply chain

The relative percentage difference between the environmental impacts of the SENSE tool and the LCA on Romanian beef and dairy products (Doublet et al. 2013a) is highly dependent on the impact category as shown in Table 13. The results are shown for 1 kg of beef at slaughterhouse. The results for climate change, human toxicity cancer and non-cancer effects, ecotoxicity, freshwater and land use have a difference smaller than 10 %. However, differences in the modelling of the emissions due to the land use and the application of, manure as well as the additional data taken into account in the complete LCA for the pesticides can explain the large deviation in the results of the acidification, eutrophication terrestrial and marine. It is not possible to compare the results of the abiotic resource depletion since the method used is not the same.

Table 13 Relative percentage difference between the environmental impacts calculated in the SENSE tool and the LCA on Romanian beef (Doublet et al. 2013a). The results are shown for 1 kg of beef at the slaughterhouse

Impact category	Unit	SENSE tool	Doublet et al. 2013a	Percentage difference
Climate change	kg CO2 eq	3.36E+01	3.30E+01	2%
Human toxicity, cancer effects	CTUh	4.92E-07	4.59E-07	7%
Human toxicity, non-cancer effects	CTUh	1.40E-05	1.41E-05	-1%
Acidification	molc H+ eq	1.25E-01	4.05E-01	-69%
Eutrophication, terrestrial	molc N eq	5.00E-01	1.84E+00	-73%
Eutrophication, freshwater	kg P eq	7.60E-04	3.10E-03	-76%
Eutrophication, marine	kg N eq	5.40E-02	1.35E-01	-60%
Ecotoxicity, freshwater	CTUe	1.50E+01	1.47E+01	2%
Land use	kg C deficit	8.01E+02	8.59E+02	-7%
Water depletion	m3 water eq	2.53E-02	1.91E-02	33%

Environmental impacts of the dairy products

The difference between the environmental impacts of the SENSE tool and the LCA on Romanian beef and dairy products (Doublet et al. 2013a) shows large deviation in all impact categories except for the land use. The results cannot be directly compared because the allocation approach

is different. In the LCA, allocation factors recommended by the International Dairy Federation are applied (IDF 2010). These factors are related to physico-chemical relationships and are not similar to price relationships. Moreover, the SENSE tool offers the possibility to allocate the raw milk and the packaging to a specific product but it is not possible to assign the electricity to a specific product. Therefore, the electricity use at the farm for the milking is allocated to all products in the SENSE tool whereas it is assigned only to the raw milk in the LCA. The packaging is also different. A brick is used in the SENSE tool whereas the LCA use a PE bottle. The results are therefore quite different for the climate change, the acidification, eutrophication terrestrial and freshwater and acidification. Moreover, it is not possible to compare the results of the abiotic resource depletion since the method used is not the same.

Table 14 Comparison between the environmental impacts of the SENSE tool and the LCA on Romanian beef and dairy products (Doublet et al. 2013a). The comparison is shown for 1 kg of pasteurized milk

Impact category	Unit	SENSE tool	Doublet et al. 2013a	Comment
Climate change	kg CO2 eq	2.47E+00	1.93E+00	Direct comparison and assessment of relative difference is not possible because the allocation approach is different
Human toxicity, cancer effects	CTUh	3.60E-08	3.65E-08	
Human toxicity, non-cancer effects	CTUh	9.82E-07	9.42E-07	
Acidification	molc H+ eq	9.14E-03	2.32E-02	
Eutrophication, terrestrial	molc N eq	3.42E-02	1.01E-01	
Eutrophication, freshwater	kg P eq	7.32E-05	2.38E-04	
Eutrophication, marine	kg N eq	3.67E-03	8.57E-03	
Ecotoxicity, freshwater	CTUe	1.10E+00	1.14E+00	
Land use	kg C deficit	5.29E+01	5.35E+01	
Abiotic resource depletion	kg Sb eq	2.45E-03	7.81E-03	
Water depletion	m3 water eq	3.07E-05	2.21E-03	

Environmental impacts of the orange juice

The relative percentage difference between the environmental impacts calculated in the SENSE tool and the LCA on orange juice is below 10 % for some impact categories such as climate change, human toxicity, acidification, eutrophication terrestrial, eutrophication marine, abiotic resource depletion and water depletion.

Table 15 Relative percentage difference between the environmental impacts of the SENSE tool and the LCA on orange juice (Doublet et al. 2013b). The results are shown for 1 l of orange juice bottled in a 1 l PET bottle

Impact category	Unit	SENSE tool	Doublet et al. 2013b	Percentage difference
Climate change	kg CO2 eq	6.57E-01	6.68E-01	-2%
Human toxicity, cancer effects	CTUh	1.16E-08	1.05E-08	10%
Human toxicity, non-cancer effects	CTUh	1.62E-07	1.69E-07	-4%
Acidification	molc H+ eq	4.03E-03	3.94E-03	2%
Eutrophication, terrestrial	molc N eq	1.08E-02	1.11E-02	-3%
Eutrophication, freshwater	kg P eq	3.69E-05	4.27E-05	-14%
Eutrophication, marine	kg N eq	1.62E-03	1.74E-03	-7%

Ecotoxicity, freshwater	CTUe	4.80E-01	1.02E+01	-95%
Land use	kg C deficit	2.42E+00	8.10E+00	-70%
Water depletion	m3 water eq	3.55E-01	3.60E-01	-1%

There are quite some differences in the modelling of the orange juice supply chain but not as many as for the beef and dairy supply chains so this explains why the percentage difference is here smaller. In the SENSE tool, it is not possible to allocate the electricity use to different products whereas a share of the electricity is assigned to a co-product of the orange in the LCA. Moreover, some differences in the type of herbicides applied and the emissions from the land use explain the large deviation in the freshwater ecotoxicity and the freshwater eutrophication impact categories. In the SENSE tool, the modelling of the land use does not include the transformation from and to permanent crop. This explains the deviation in this impact category. It is not possible to compare the results of the abiotic resource depletion since the method used is not the same.

Environmental impacts of the aquaculture supply chain

Results of the LCA case study of aquaculture (Ingólfsdóttir et al., 2013) are not comparable to the SENSE tool calculation (Table 16), due to differences in the GaBi and SENSE tool software (see Table 12). Additionally, different datasets were used for the feed ingredients and since the feed is the main contributor to most impact categories (except for marine eutrophication and human toxicity), it is not reasonable the compare directly results from the SENSE tool to the case study.

Datasets on marine feed ingredients were lacking in the ecoinvent database and when the case study was carried out (Ingólfsdóttir et al., 2013), data on the impacts for marine feed ingredients were obtained from Pelletier et al. (2009) (Ingólfsdóttir et al., 2013). During development of the SENSE tool however, datasets on fuel use in fisheries were obtained from SINTEF (Hognes, personal communication 2014). Datasets were thus further created for feed ingredients based on composition of Norwegian diet 2010 (Hognes et al., 2011) and Icelandic diet (Ingólfsdóttir et al. 2013) and implemented in the SENSE tool. Further sensitivity analysis using actual composition of feed in aquaculture companies and alternative changes to the diet would be of interest in the project to identify the impacts of different feed ingredients and thus support companies regarding choice of feed ingredients.

Furthermore, in the case study, organic emissions to sea are accounted for as BOD, nitrogen and phosphorus per whole fish (Ingólfsdóttir et al., 2013). In the SENSE tool, this has however been simplified and only the release of nitrogen is accounted for and values determined for marine and land based system based on published information (Heldbo et al., 2013). Since the guts and the blood have no value, all the nitrogen emissions have been allocated to the finished product.

In general it should be noted that LCA methodology and consequently the simplified environmental assessment provided by the SENSE tool is somewhat limited to assess of the aquaculture related environmental impacts (i.e. nutrient and organic matter releases, impacts associated with provision of feed, introduction of diseases, introduction of exotic species, escapes, changed usage of coastal areas, since they are not incorporated in appropriate impact categories in LCA (Samuel-Fitwi *et al*., 2012). The indicators and methods applied for chemical discharges and assessment of ecotoxicity are not well developed and their use for environmental impact assessment of aquaculture have been questioned (Ford *et al.,* 2012).

Table 16 Comparison between the environmental impacts of the SENSE tool and the LCA on aquaculture (Ingolfsdottir et al. 2013). The results are shown for 1 kg of fresh salmon (HOG), transported to Europe via transoceanic freight and for 1 kg of smoked salmon fillets. (NA = not available)

Impact category	Unit	HOG, transoceanic freight		Smoked salmon fillets		Comment
		SENSE tool	Ingolfsdottir et al. 2013	SENSE tool	Ingolfsdottir et al. 2013	
Climate change	kg CO2 eq	3,24E+00	2,7E-00	5,83E+00	5,0E+00	Direct comparison and assessment of percentage difference is not possible because different datasets were used and due to differences in the GaBi and SENSE tool / SimaPro software (see Table 12)
Human toxicity, cancer effects	CTUh	6,26E-08	5,5E-08	1,12E-07	5,7E-07	
Human toxicity, non-cancer effects	CTUh	2,39E-06	1,9E-07	4,10E-06	1,5E-07	
Acidification	molc H+ eq	4,19E-02	1,4E-02	7,21E-02	2,6E-02	
Eutrophication, terrestrial	molc N eq	9,07E-02	7,5E-02	1,56E-01	1,4E-01	
Eutrophication, freshwater	kg P eq	1,27E-04	2,3E-04	2,30E-04	5,8E-04	
Eutrophication, marine	kg N eq	7,41E-02	1,6E-01	1,24E-01	2,7E-01	
Ecotoxicity, freshwater	CTUe	5,50E+00	8,4E+00	9,48E+00	1,5E+01	
Land use	kg C deficit	1,78E+02	NA	2,99E+02	NA	
Abiotic resource depletion	kg Sb eq	5,99E-05	1,7E-05	1,10E-04	3,7E-05	
Water depletion	m^3 water eq	1,84E-03	NA	1,28E-02	NA	

Conclusions

The SENSE tool has been designed to be suitable for assessing environmental impacts for the food and drink SMEs. The functionality testing of the SENSE tool verified that it is an easy to use tool for simplified environmental assessment. SMEs can access the tool and perform a simplified environmental assessment of their product portfolio, using the selected KEPIs. It is important to note that the main aim is to obtain a simplified tool, but it is not an alternative for the complete LCA studies. The SENSE tool could however, be applied by companies for benchmarking their products' environmental performance.

The validation of the SENSE tool was focused on verifying the computation of the environmental impacts caused by key environmental performance indicators related to a food or drink production process. The SENSE tool was validated for the beef, dairy, orange juice and aquaculture chains. Results of the validation show that the tool calculates environmental impacts which are comparable to results when using commercial software that applies the same methodologies and datasets. The SENSE tool is comparable to SimaPro results which was the software applied as a reference in the development of the tool. The validation revealed discrepancies between the different software used by the validators (GaBi and SimaPro) regarding methods, different versions of methods and handling of databases (see Table 12). This observation and explorations to reveal the reasons for the differences provided valuable information throughout the validation process, which was useful in improving the tool.

Table 17 Results of validation of the performance of the SENSE tool to assess selected impact categories for dairy products, beef, orange juice and aquaculture products (HOG and smoked salmon) (X = validated against Simapro or GaBi (< 10% difference), "-" = >10% difference; NC= Not comparable (different methodology); C=Comparable to LCA results(< 10% difference)

Impact category	Dairy products		Beef		Orange juice		Aquaculture salmon					
							HOG			Smoked		
Validation software / LCA studies	SimaPro	LCA Doublet et al., 2013a	SimaPro	LCA Doublet et al., 2013a	SimaPro	LCA Doublet et al., 2013b	SimaPro	GaBi	Ingolfsdóttir et al., 2013	SimaPro	GaBi	Ingolfsdóttir et al., 2013
Climate change	x	NC	x	C	x	C	x	x	NC	x	x	NC
Human toxicity, cancer effects	x		x	C	x	C	x	x		x	-	
Human toxicity, non-cancer effects	x		x	C	x	C	x	-		x	-	
Acidification	x		x	-	x	C	x	x		x	x	
Eutrophication, terrestrial	x		x	-	x	C	x	x		x	x	
Eutrophication, freshwater	x		x	-	x	-	x	-		x	-	
Eutrophication, marine	x		x	-	x	C	x	-		x	-	
Ecotoxicity, freshwater	x		x	C	x	-	x	-		x	-	
Land use	x		x	C	x	-	x	NC		-	NC	
Abiotic resource depletion	-		x	NC	-	NC	x	-		x	x	
Water depletion	x		x	-	x	C	x	NC		x	NC	

Based on the performed validation studies using the SimaPro software it can be stated that the current version of SENSE tool can be used for a simplified assessment of all impact categories selected for dairy products, beef, orange juice and aquaculture salmon (Table 17). Furthermore, the results are in agreement with the GaBi software (< 10% variation) for four out of nine impact categories that are comparable. Table 16 lists the impact categories that are comparable between results from the SENSE tool and the full scale LCA studies. It can be seen that SENSE results are comparable for 5 to 7 impact categories for beef and orange juice but for dairy products and aquaculture the results are not comparable due to e.g. difference in methodologies, difference in allocation rules or difference in background datasets applied.

The SENSE tool provides a simplified, environmental assessment, since it is using only limited number of key environmental performance indicators as input data. This is the first version of the SENSE tool that will be tested further by SMEs to obtain feedback on the usability of the tool.

Following shortcomings and future improvements of the tool have been discussed during the Phase 1 validation

- Modelling of direct field emissions requires some models that are beyond the scope of this project, but would be necessary if a comprehensive environmental assessment is made covering a wide range of environmental impacts. For example, important modelling aspects like fertilizer and manure emissions and indirect emissions from NOx cannot be tackled in a simplified manner. However, by including relevant average datasets for fertilizers and including also emissions for i.e. poultry manure the shortcoming of the tool may be compensated.
- The availability of appropriate datasets for feed ingredients and fertilisers in the SENSE tool that is relevant for the aquaculture and agriculture companies has improved the assessment. If the tool will be further developed relevant background LCI datasets, including regionalised data and characterisation factors, may need to be implemented in the tool to enhance the relevance of the results for the users.
- For reliable assessment of marine eutrophication, the nitrogen content in different aquaculture fish species should be available to assess the marine eutrophication potential from dead fish
- N and P content from faeces and feed deposition for sea based aquaculture in different regions could be applied to obtain values for high and low organic load of aquaculture. These information are available e.g. for aquaculture farming in the Nordic countries (Heldbo et al., 2013).
- The SENSE tool will be further tested by SMEs to identify further issues regarding the understanding of key concepts such as allocation, environmental assessment, impact categories etc.
- Interpretation of the Environmental Information Document needs to be clarified and developed in order to serve its purpose
- The limitations of the tool need to be clearly addressed in the documentation of the tool and especially in the explanation of the EID results
- An added value of the SENSE-tool is the option to use it for training on sustainability and to enhance understanding of the concepts of environmental assessment throughout the whole lifecycle of products both in industry and for students.

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Appendix I Invitation letter

INVITATION TO PARTICIPATE IN TESTING THE SENSE TOOL

SENSE: Harmonized Environmental Sustainability in the European Food and Drink Chain

SENSE-TOOL: The SENSE project www.senseproject.eu has developed a harmonized system, the SENSE-tool, for a simplified sustainability assessment of food and drink products.
The SENSE-tool is an integration of data collection system, applying a set of key environmental performance indicators (KEPIS) and considers also selected social indicators. The system provides a calculated output of environmental indicators based on simplified life cycle environmental impact assessment methodology. This information is compiled in a certification scheme concept called EID (Environmental Identification Document).
The developed SENSE tool is a prototype that has been successfully applied and validated in case studies by the SENSE partners. The aim is to transfer the SENSE tool´s methodology to food & drink sectors and the first approach is to invite companies in the juice, meat & dairy and aquaculture chains to perform testing of the new harmonised system.

YOUR COMPANY IS INVITED TO PARTIPATE IN THE TESTING: During May - August 2014

ROLE OF COMPANIES: By participating in this testing you will have the opportunity to use the SENSE tool for assessing selected environmental and social aspects that contribute to the sustainability of your company´s production. Additionally there is an option to invite your supply chain partners to take part in the testing. This will require B2B networking and enhance the awareness of the sustainability performance of your supply chain. Companies engaged to participate in the testing of the SENSE tool will be asked to provide feedback on the use of the tool. You will be provided with on-line guidance and help from the developers of the tool.

OUTCOME AND BENEFITS

- An environmental footprint of your product: Product carbon footprint and other potential impacts such as eutrophication potential (organic pollution) or environmental and human toxicity will be reported in a standard format, the EID document
- Environmental data sorted according to KEPIs and prepared as inventory for LCA
- Training in using a simplified LCA software, the SENSE tool
- Assessment of selected aspects of social performance
- Identification of environmental improvement opportunities
- Participate in the first approach for benchmarking environmental performance between different companies producing similar products across Europe

CONFIDENTIALITY: SENSE partners will keep complete confidentiality of the data provided by the participating companies. Specifically:

- Data referring to production (energy consumption, water use, etc.) and know-how of the companies will be considered strictly confidential. Each company will have its own username and password.
- The results of this testing will be available for the responsible partners of the SENSE project to perform statistical benchmarking using Data Envelopment Analysis. Unless otherwise stated, data won't be referred to individual companies.
- The SENSE-tool database is located in a private and secure server.

In the same way, companies participating in the testing agree on preserving the confidentiality of all the aspects of the SENSE tool.

Appendix II

Identified benefits of the SENSE tool for SMEs

Life cycle thinking and taking responsibility in environmental issues beyond the operation of the companies is being implemented in large businesses along with the enhanced awareness of the concept sustainability in accordance with EC recommendations (European Commission, 2013). 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.

The SENSE project aims at enhancing environmental awareness in SMEs in the food sector by developing a web based tool including a harmonized data collection system and simplified assessment of environmental impacts. The implementation of the SENSE tool in SME´s followed a risk based protocol, SAAP (Step Analysis and Action Points), that was used as a framework in the pilot implementation. Working procedures and guidelines have been developed to ensure the successful validation of the tool prior to implementing the tool in SMEs. The ILCD handbook (European Commission, 2010) was the general framework for the validation of the SENSE tool and further the implemented methodologies that had been recommended and selected for the SENSE tool were checked (European Commission, 2011, 2012), as well as the life cycle inventories from the ecoinvent database and other external sources.

Recruitment of SMEs to test the tool will be facilitated by giving a clear message on the benefits associated with the testing:

- Enhanced awareness of stakeholders of the value of performing sustainability assessment of their supply chain and identification of opportunities to make improvements are steps towards sustainable development of the food supply chains in Europe.
- The KEPIs and impact assessment indicators provided in the SENSE tool can be used to monitor performance and will help companies in voluntary sustainability reporting
- This effort will motivate companies to establish sustainability goals and promote sustainability reporting by SMEs

The expected benefits of using the SENSE tool for SMEs

- SMEs will gain an enhanced awareness and knowledge on sustainability assessment
- An opportunity to perform sustainability assessment for free
- Environmental data sorted and prepared as inventory for Life Cycle Assessment
- Training in using the SENSE tool, a simplified Life Cycle Assessment software
- Results of a simplified life cycle assessment for the SMEs based on the selected KEPI´s and the calculated environmental impacts reported as product environmental profile and the EID
- Reporting of selected aspects of social performance of the companies
- Identification of environmental improvement opportunities
- B2B networking in the supply chain will support the awareness of sustainability performance
- Access to markets, since sustainability assessment of food production is increasingly becoming a requirement from retailers.
- Participate in the first approach for LCA based benchmarking between different companies producing similar products across Europe
- Results may be used by the SMEs to differentiate their products

- The companies will be invited to attend regional seminars /workshops organized by project partners where training and testing will be offered and results of the case studies will be presented. Other companies, national associations, regulators, academia, etc. may be invited to participate
- At the final WP4 workshop the results will be presented and the proactive vision of the participating companies will be emphasized regarding their contribution to establish benchmarking of the sustainability of the European food supply chains.
- The companies may choose to be anonymous and results will be presented without being able to trace to individual companies.

The European Commission has further identified potential fields of application of product environmental footprint and organisation environmental footprint as depicted below (European Commission, 2013). The implementation of the SENSE tool in SMEs is complementary with the recommended practices of the European Commission, supporting life cycle thinking and will motivate sustainability reporting by SMEs.

ANNEX I

POTENTIAL FIELDS OF APPLICATION OF PEF AND OEF METHODS AND RESULTS

Potential fields of application for the PEF method and PEF results:

— optimisation of processes along the life cycle of a product;

— support of product design minimising environmental impacts along the life cycle;

— communication of life cycle environmental performance information on products (e.g. through documentation accompanying the product, websites and apps) by individual companies or through voluntary schemes;

— schemes related to environmental claims, in particular ensuring sufficient robustness and completeness of claims;

— reputational schemes giving visibility to products that calculate their life cycle environmental performance;

— identification of significant environmental impacts in view of setting criteria for ecolabels;

— providing incentives based on life cycle environmental performance, as appropriate.

Potential fields of application for the OEF method and OEF results:

— optimisation of processes along the whole supply chain of an organisation's product portfolio;

— communication of life cycle environmental performance to interested parties (e.g. through Annual Reports, in sustainability reporting, as a response to investor or stakeholder questionnaires);

— reputational schemes giving visibility to organisations calculating their life cycle environmental performance, or to organisations improving their life cycle environmental performance over time (e.g. year on year);

— schemes requiring reporting on life cycle environmental performance;

— as a means to provide information on life cycle environmental performance and the reaching of objectives in the framework of an environmental management system;

— providing incentives based on improvement of life cycle environmental performance as calculated based on the OEF method, as appropriate.