Methodological challenges for combining qualitative future scenarios and LCA in the food and agricultural sector

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Abstract

The scenario method is an established instrument in foresight and strategy development that supports the user with handling uncertainties. Scenarios explore the future and identify different future perspectives, thus provide a background for decision-making. Moreover, by unfolding scenarios, decision makers win awareness of the variety of future possibilities, uncertainties in surrounding environment and indicators of discontinuities. Since they are based on assumptions about future developments scenarios mostly include a wide range of qualitative descriptions and are presented as story lines about alternative futures.

A life cycle assessment, however, is based on quantitative data as well as values and numbers related to the present, e.g. alternative options of products (studies unit versus reference unit). In this study a concept to combine future scenarios with a life cycle assessment will be developed. Scenarios of the future European food sector serve as a basis to test the conceptual framework of quantifying the qualitative descriptions and their subsequent combination with LCA. In other words, this approach serves to extend LCA and incorporate future competence in the evaluation of products or production systems.

Introduction

In the European research project Food processing in a box (FOX) that is a part of the Horizon 2020 Research and Innovation programme, scenarios for the European food sector are developed.

The framework conditions for food systems are subject to constant change. Despite many uncertainties, we still know a lot about future developments from environmental analysis and horizon scanning. There are demographic trends that will shape the future in the long term. Trends that describe political, economic, societal and technological developments can be included in the discussion on possible futures. Nevertheless, we must be conscious of the complexity of these developments and therefore create robust solutions. At this point scenarios serve as a tool to handle uncertainties.

The focus was on alternative developments for the food sector along its entire value chain, from production and processing to packaging and logistics as far as sales and consumption. The scenario method enables a structured examination of conceivable alternative development paths. This helps to raise awareness of the fact that complex topics do not allow a simple distinction between a best-case and a worst-case. Scenarios make the future tangible today and enable their users to act in a future-oriented manner. Therefore, this future framework conditions are used to assess innovative technologies, that are developed by other partners in this project.

The project concentrates on mildly processed fruits and vegetables through innovative, small-scale technologies in flexible and mobile processing units to be used in regional food systems. This study will develop a concept of how to integrate the findings from the scenarios for the European food sector into LCA in order to future-proof the analysis of the lifecycle of products. This enables the technology developers to design their processes in a more robust, sustainable and market oriented way.

Methodology

The development of the qualitative scenarios followed five steps. In the beginning a identification of key factors helps to describe the most relevant developments in the European food sector. Both, the framework conditions that are already relevant today and those that could have an influence on the food value chains in the future were considered.

In the next steps experts discussed how the key factors compiled can unfold in future. This was amended by additional research on future studies i.e. from agriculture, land use, food value chains or biodiversity. Among these factors the drivers of change were then identified. An analysis of interconnections between the key factors was conducted in order to uncover critical factors that are dynamic and strongly interconnected. Due to their strong influence on and through the other factors, they play an important role in the scenarios.

In the penultimate step conflicts and synergies between the future assumptions of different key factors were analyzed. From the multitude of possible consistent combinations of assumptions, three plausible scenario drafts were selected, which differ significantly from each other. These core scenarios were subsequently enriched with additional factors and corresponding assumptions in an expert online consultation. In the last step possible development of the relevant areas in 2035, including the prevailing conditions in each scenario, were outlined.

Scenario method and LCA are in focus of the analysis. Qualitative information from scenarios will be transferred into quantitative data in the course of this study. That means that qualitatively described scenarios or aspects of these scenarios will be converted into variables in order to be incorporated into a LCA model.

LCA is normally carried out in four steps and is limited to observations of the present. The Life Cycle approach can be applied to compare different products or to identify the stages within production with the highest environmental impact. The combination with the scenarios takes place during the inventory analysis, using the qualitative descriptions to be translated into quantitative values.

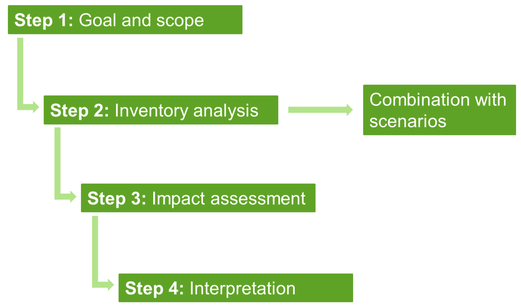

Chart 1: *Steps within Life Cycle Assessment and the point of interaction with qualitative scenarios.*

Results

Scenario 1: Policy secures sustainability

This scenario drafts a future world where the states own agricultural land, produce food according to local conditions and care for the well-being of all their citizens. It also has data sovereignty and access to data along the whole food value chain. Consumers do not understand the complexity of food production nor do they care about how it influences the environment around them. They trust their government in providing nutritious food and ensuring accessibility for all citizens. The awareness for the necessity of sustainable food production is present and promoted by science. Politicians have recognized that sustainable agriculture is vital to national food security.

Scenario 2: Society drives sustainability

In this future, people are driving developments forward through their search for a healthy lifestyle in harmony with nature. Sustainable behaviour is in the heart of society and economic growth is no longer the main paradigm to follow. Agricultural land is in the hand of many, especially local biodiversity is of high value. Food is produced sustainable and local, which also has an effect on the availability of certain products. "Food as a Service" evolves as a distinctive concept combining technological innovation with decentralisation and resource savings. The role of national governments is limited, but there are well-organized governments at the local level.

Scenario 3: A CO_2-currency and retailers dominate trade and consumption

Dynamic technological progress, a competitive surrounding and unlimited growth characterise this future scenario best. Retail and sales have huge market power and data sovereignty, e-commerce is mainly in the hands of the big box retailers and the shift towards online consumption of food is completed. Agricultural production has to be efficient and economically successful and the effects on land and biodiversity are of minor importance. The role of global trade on the variety and prices of food as well as on its security is as central in this future as CO_2-prices, the large-scale industrial processing of food and the use of side streams.

LCA in different future scenarios

In the initial phase of the life cycle assessment, the objective and scope of the study are determined and defined. Next, quantitative statements on material and energy consumption as well as emissions are to be made. These input and output flows of the entire product life cycle are described in the life cycle inventory. The results form the basis of the impact assessment. Data collection shall cover all relevant inputs and outputs of the process by measurement or calculation.
A big challenge in this context will be to fill the databases in the inventory step by step for future developments of indicators. This means transferring the qualitative considerations of alternative pathways to the inventory. Although these are only estimates, they do provide a basis for evaluating products in terms of their future environmental performance. This allows the right strategic decisions to be made today. Especially in the food processing sector, investment cycles are long and a long-term foresight approach is required. For the periods considered in the qualitative scenarios, quantitative statements from pure extrapolations or simulations are hardly valid. The assessment of expert surveys and interviews can meet this methodological challenge.

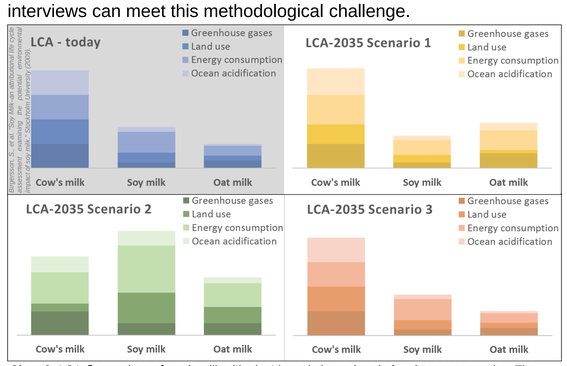

Chart 2: *LCA-Comparison of cow's milk with plant-based alternatives in four impact categories. The LCAs of 2035 are examples how the indicators could change by considering alternative futures.*

To illustrate the approach and the effects, chart 2 shows a comparative LCA of cow's milk with plant-based alternatives. The chart shows the calculated impacts on greenhouse gas emissions, land use, energy consumption and ocean acidification for the LCA of today. It also shows how these values could change in the future if different scenarios are used as a basis. Examples are short transport distances and thus significantly lower CO_2 emissions in a scenario that assumes locale food circles. On the other hand, in a very technologically oriented scenario, the in vitro production of cow's milk in the laboratory could be established, thus contributing to a significant reduction in land use.

Conclusion

The world is facing major global challenges with a high impact on food systems and food security. Climate change and digitalisation are examples for mega trends that have great impact on various stages of the food value chain. Consumer behaviour as well as the attitude towards sustainability in society are driving factors for the demand for diversified food. These aspects are discussed in scenarios within the project FOX. In this project scenario development as well as LCA is conducted for specific products and technologies. The consideration of qualitative aspects and alternative future developments in the LCA would set this quantitative method in a bigger context.

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