Participation Statement – A Digital Approach to Making Food Sustainability Holistically Measurable from Farm-to-Fork

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Summary

Achieving greater sustainability in every aspect of our lives is an urgent goal for our society. This also applies to the food system, where modern farming methods, the increasing need for higher production rates, better yields, and maximum efficiency are essential to feed a growing population and secure producers' incomes. Although various initiatives exist to track and reduce the impacts of food production and post-production, a holistic approach to measuring and comparing sustainability along the entire farm-to-fork value chain is still missing. This paper describes a dissertation project that aims to develop a digital platform solution that: (1) meets the business needs of the users involved while promoting equality for all actors in the value chain, (2) enables reliable and consistent traceability of food sustainability metrics from farm to fork, and (3) considers sustainability as an essential and integral component of the platform design itself.

Keywords

Sustainable Food Supply Chain, Value Network, Environmentally Reflected System Modeling, Sustainable Platform Design, Digital Food System

1. Author Situation

The European organic action plan sets a development target, defining that 25% of the EU's agricultural land shall be cultivated organically by 2030 [1]. The German national target is even higher: 30% of the land is to be farmed organically by 2030, a goal that was reinforced by the new government in 2021 [2]. Participating in achieving this goal, the federal state of Baden-Wuerttemberg is aiming for a 30-40% share of organic agriculture [3]. To assist the processes of reaching these goals, the state of Baden-Wuerttemberg initiated the research program "Organic Farming" in 2019. In 2020, four research projects received a grant as part of the program: AgroBioDiv, WertKalb, OEKO-Valuation, and the research project on which the author works, OekoTrans [4, 5]. The OekoTrans project is a joint effort by the informatics department of the University of Reutlingen and by the agricultural sciences department of the University of Rottenburg. Whereas the University of Rottenburg concentrates on identifying organic conversion barriers and drivers for farmers and addressing their most prominent issues, the University of Reutlingen focuses on enabling a more regional and organic value chain from food processing to canteens, by exploiting the potential of digitalization.

2. Context and Motivation

On the one hand, increasing the share of organic farming is an approach of the EU to achieve a sustainable and climate-neutral food system and hence, a centerpiece of the European Green Deal [6]. The benefits of organic farming methods are the reduced impact of agriculture on the ground- and

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surface water, on biodiversity, especially of insects and pollinators, and on the climate. Organic agriculture also promotes animal welfare and increased produce resilience [1]. On the other hand, the demand for regionally produced and sourced products increases on the customer side. The advantages seen by the consumers in regional products can be attributed to territorial identity, superior quality, and greater environmental friendliness [7].

Although organic farming methods are not the only way of producing food products more sustainably, environmentally friendly, and with more respect to nature and its inhabitants, one big task of the organic movement is to be a flagship initiative and to "lead by example" [1]. The criteria of organic agriculture build a foundation of farming methods that are currently known and proven to be better for achieving the objectives of more ecosystem-friendly farming. Hence, organic certifications provide a way of measuring a certification-specific collection of (sustainability) metrics. It strongly depends on the organic association though, which criteria are obligatory and to what extent, as long as they fulfill the minimum requirements defined by the EU. Hence, an organic certification makes a statement regarding the sustainability of the underlying farming methods, but it cannot be considered a comprehensive sustainability label, especially since it primarily evaluates the farming procedures and only minimally affects preceding or subsequent processes.

Regionality also addresses fundamental issues of sustainability: shortening transportation routes and reducing the associated CO_2-equivalents of a product as well as strengthening regional value chains and local economies. Although the EU regulation on organic production specifically mentions local production and short distribution channels as objectives for those reasons [8], the regionality of food items is commonly regarded as a separate product property since this is not an obligatory criterion for actually getting an organic certification. Both objectives have their raison d'être by working to achieve climate neutrality for greater sustainability. But both are also just one side of the dice[2] of sustainability.

This paper describes a doctoral research project that aims to propose a solution by designing a digital platform to evaluate and better represent holistic food product sustainability along the entire farm-to-fork value chain. First, the research objective of the dissertation project is explained, including a cursory look at related key work. The research methodology is outlined thereafter, with a graphical representation of the expected steps. Presenting the existing results and highlighting the next steps will provide a more detailed insight into the research intention. Conclusively, the expected benefits of participating in the doctoral symposium will be stated.

3. Research Objective and Background

The goal of the doctoral research project is to develop a digital platform solution that allows the tracking and measuring of multiple meaningful sustainability scores or metrics along the farm-to-fork value chain. The particular focus of this work lies on the farm-to-fork value chain of out-of-home catering (oohc) as this market is significant [9][3]. To achieve the best possible sustainability along the value chain, the two following objectives define the scope.

3.1. Sustainable Products

To make the level of sustainability of products transparent, it is essential to define measurable criteria that apply to all food items and are comparable. This will provide all actors along the value chain grounded foundation to argue in favor of sustainable products since the price will not be the only comparable product property anymore. Existing initiatives to make sustainability metrics more transparent will be evaluated and the most feasible methods analyzed in depth. For the context of this work, the predominant evaluation criteria will be if and how well a metric is (digitally) measurable along the processing steps. For example, it is easier to track the places a product passes through and add up the distances between them to get a measure for environmental impact than it is to collect information on the wages and working conditions of the people involved to assess social sustainability.

[2] Referring to the saying "there two sides of the coin", by implying the undefined multiplicity of sides a die can have.
[3] Own calculations presented in a GitHub wiki, exemplary for the German state of Baden-Wuerttemberg

Regarding the definition of sustainability and appropriate metrics for measuring such, the work will analyze and build on other research and initiatives. Based on theoretical, foundation-providing work a general evaluation matrix will be derived for comparing different metrics and scores, like for example the environmental label *Planet Score* [10]. Additionally, it is important to define organizational and technical implementation methods to measure the sustainability metrics digitally and along the entire value chain, such as blockchain technology [11].

3.2. Sustainable Platform

To further promote a holistic and more natural implementation of sustainability efforts, the platform design itself will adhere to the sustainable software engineering principles of the Karlskrona Manifesto [12] and related research and studies [13–15]. On the one hand, the platform architecture will base on the requirements of all users while providing a digital way to measure and visualize the food item's sustainability reliably. While iteratively designing the solution, the five dimensions of sustainable software design will frequently be evaluated and discussed:

- Environmental dimension: to evaluate the platform's effects on our natural system, including resource usage, greenhouse gas emissions, water usage and pollution, food production, and more
- Social dimension: to evaluate the platform's effects on social (in)equality, employment rates, political systems, food security, and more
- Economic dimension: to evaluate the platform's effects on wealth creation, business process efficiency, profitability, and more
- Technical dimension: to evaluate the platform's time resilience by analyzing aspects like platform maintainability, compatibility, application of standards and usage of standard data formats, and more
- Individual dimension: the evaluate the platform's effects on humans as individuals, including their physical and mental well-being, education, autonomy, and more

3.3. Digital Transformation Path

Bringing together multiple actors to represent and support the entire farm-to-fork value chain means interacting with and aiming to have an impact on multiple

3.4. Research Methodology

This dissertation project follows the Design Science Research Methodology (DSR) [16]. Applying the specific approach by Johannesson and Perjons [17], it is crucial to commence the work by creating a profound understanding of the underlying problem. Once the problem is explicated, requirements for a solution are identified, and an artifact is designed following. The artifact design is then demonstrated to the target audience and subsequently evaluated. Figure 1 shows the DSR methodological approach and the respective research objectives of this doctoral research project. If columns are separated by a horizontal line, it indicates a clear distinction between the steps of the first and second iteration cycles.

4. Existing results and next steps

The underlying research project OekoTrans concentrates on enhancing organic transformation and strengthening or establishing regional organic value chains in the German state of Baden-Wuerttemberg. The project's focus lies on the first three DSR steps as shown in Figure 1.

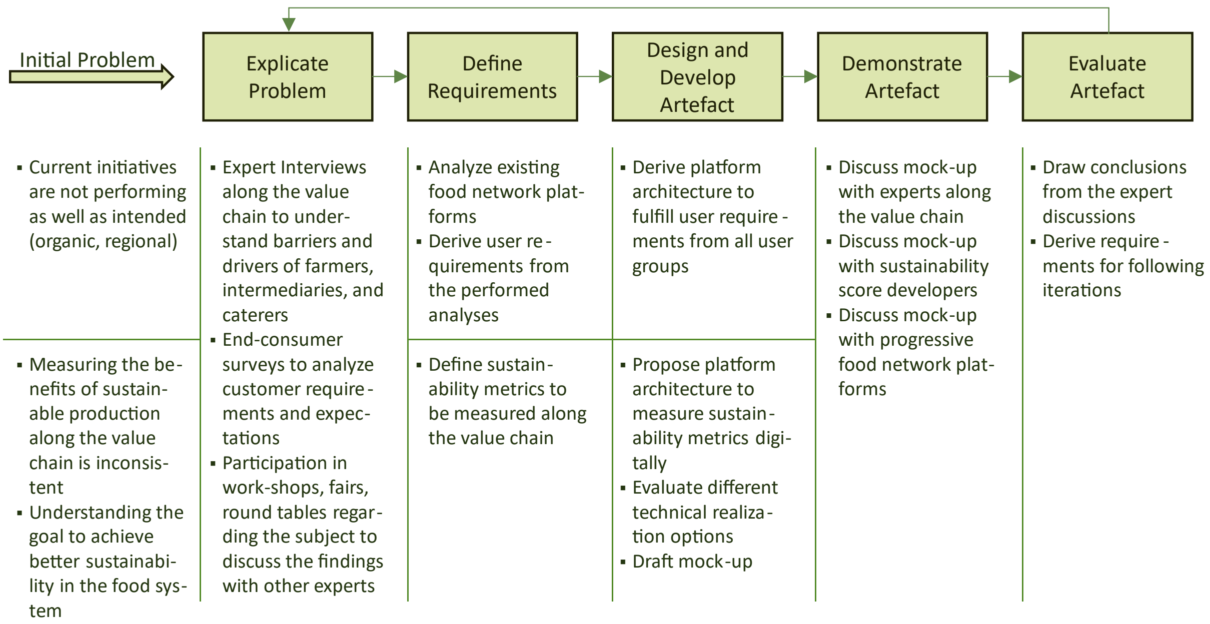

Figure 1 Research approach following the Design Science Research Methodology

4.1. Problem Refinement

Against the background of the aforementioned goals by the EU, Germany, and the state of Baden-Wurttemberg, it was a primary research objective to identify the barriers and drivers of organic conversion. Hence, we performed expert interviews with actors along the farm-to-fork value chain (caterers, food procurement specialists, intermediaries, processors, farmers), participated in round tables and workshops on this topic, and conducted an end-consumer survey in a project partner's canteen. The value chain actors can be divided into three subsystems that are hierarchically dependent within the value chain but largely act independently from one another: (1) farmers, (2) intermediaries (including processing plants, retailers, wholesalers, and more), and (3) canteen-systems (combining caterers, end-consumers, and the hosting company). All three get supported by logistics, which cannot be allocated to one subsystem alone. Figure 2 shows an abstracted as-is value chain model including the three subsystems based on Porter's [18] modeling concept. A key outcome of the research was that breaking open the current linear value chain (farmers > intermediaries > canteens) into a value network holds great potential and that a well-designed platform can be an optimal solution to achieve this change. Additionally, further dominant barriers were identified in line with the drivers to organic conversion, focusing on those that can be resolved or implemented with a respective digital solution.

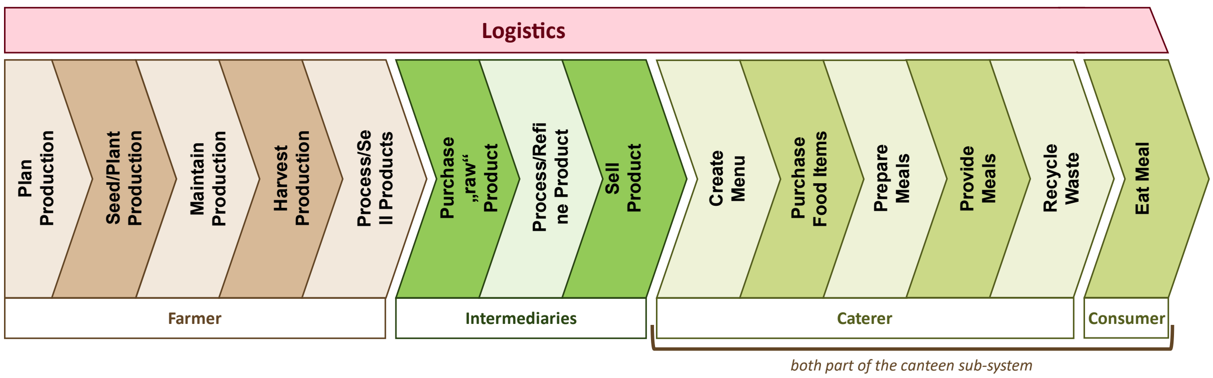

Figure 2 Abstracted farm-to-fork value chain

4.2. Requirements Definition and Artefact Design

The insights gained from working on a comparable problem with a specific focus (organic food as a sustainability label for only Baden-Wuerttemberg) raised two questions that need to be answered:

1. How can sustainability be reliably measured in the food value network?
2. How can existing barriers to sustainable and digital transformation be reduced along the food value network?

The findings on digital improvement and barrier removal were used to create a first outline of the platform. The requirements for the said platform were defined specifically centralizing the usability and practicability for the users. This is particularly important as the goal is to equally integrate, enable and empower all value-network participants. The results were then summarized in a use-case-based platform design.

4.3. Next steps

Although the scope of this solution is limited to organic-regional food with particular attention to the German state, a result of the research to date is that taking overall sustainability into account and ensuring a scalable digital solution is essential. Hence, the previous research and its' results form the basis for the dissertation project presented here.

Following the general approach shown in Figure 1, the next steps begin with DSR step four, demonstrating the current platform design to experts in the scientific community and to all actors along the food value chain. The feedback gained from the discussions will be aligned with the results of analyzing existing food-network platforms to evaluate the artifact. An important aspect of this work will include a detailed conceptual analysis of whether and why a platform poses an ideal solution. This is where the first DSR iteration cycle will be concluded and a second cycle will be initiated. To put the focus specifically on overall sustainability, the problem explication will be refined by conducting further desk and field research. The outcome will focus on defining food product sustainability metrics and scores and how to effectively track them digitally along the value chain to further specify the requirements for the solution. Having a broad understanding of the platform's overall target functionalities, the platform design itself will be analyzed and continuously monitored for sustainability. The resulting platform design will then again be discussed with experts and be the centerpiece of the dissertation.

5. Expected benefits from participating in the symposium

Participating in the symposium promises to be very beneficial for several reasons. Firstly, the interviews and expert communication so far always included professionals from the analyzed value chain sections, but never digital pioneers or IT specialists. Therefore, it seems utmost promising to discuss the drawn conclusions and implementation ideas with the technical community from a different point of view, but keeping sustainability as a goal in mind. Regarding the dissertation project as a whole, it is always helpful to receive feedback from peers outside of the project to validate its content, scope, and approach. Gaining insight into other doctoral research projects additionally broadens the horizon, potentially highlighting aspects relevant to the own project, or offering ideas to further refine, improve or even change the own strategy. Lastly, it can also be very motivating to receive validation for your work.

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