10.20378/irb-92403

Sustainability in Vegetable Supply Chains – Case Study on Agriculture Systems and their Growth Dependency

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Abstract:

In 2015, the United Nations agreed to work together to achieve sustainable development in the world described by the Sustainable Development Goals (SDGs). Since then, the issue of sustainability has become increasingly important at the global, national, regional, and local levels. The transformation to a sustainable economy also plays an important role in the fight against the climate crisis, as the latest IPCC report once again confirmed. It also states that a transformation of all economic sectors is necessary to mitigate the climate crisis to a significant extent. Therefore, it is also important to make food production and supply sustainable and create sustainable food supply chains.

This paper looks into this aspect with a focus on vegetable supply chains. It especially looks at the length of vegetable supply chains and how sustainability is affected by the geographical extension of production and distribution systems. As we live in a globalized world the global mobility of goods also affects vegetables. E. g. vegetables consumed in Germany may come from all over the world. In terms of sustainability, however, this global mobility may be counterproductive. Therefore, this paper examines the influence of the geographical length of supply chains on their sustainability. For this purpose, local and regional as well as trans-regional and global vegetable supply chains are considered.

The study is based on expert interviews with representatives of organizations from different vegetable supply chains. The participants represent food retailers and intermediaries as well as farmers and community-supported agriculture initiatives. The analysis of the data shows that other factors than the length of supply chains have a high influence on its sustainability. It also shows that most of today's vegetable supply chains are growth-dependent. However, there are business models that allow vegetable production and distribution in a sufficient oriented approach.

JEL Classification: M14 (Social Responsibility), O13 (Environment), Q19 (Agriculture), Q56 (Sustainability)

Keywords: Vegetable Supply Chain, Sustainability, Supply Chain Expansion, Expert Interviews, Growth Dependency.

1 Introduction

The design of globally sustainable economies, which allows humanity to develop within an ecologically safe and socially just space, remains a great challenge (Hickel and Hallegatte, 2021). Despite global crises such as a pandemic, disturbed supply chains, and a war in Ukraine, there must therefore be no delay in the pursuit of sustainability. This is also shown by the latest IPPC report (IPCC, 2022). Outside of scientific publications, this can be seen in Germany in the political discussion about social relief programs, the correct design of the energy transition, and the drought in the summer of 2022 (Moller, 2022; FAZ, 2022; Grimm, 2022; Handelsblatt, 2022; Kammleiter, 2022; BMBF, 2022).

In addition to the energy turnaround, a food turnaround is also necessary for a sustainable society (Bilali et al., 2018; Schneidewind, 2019; IPCC, 2022). Overall, global meat consumption and the consumption of products dependent on factory farming must be drastically reduced (Broekema et al., 2020). These and the associated global flows of goods have a significant share in global CO2 emissions, deforestation of rainforests, and human health (IPCC, 2022). This also applies to food supply chains in Germany. Against this background, it is important to make the production and supply chains of vegetable production more sustainable (Fresán and Sabaté, 2019; Lonnie and Johnstone, 2020; Molnár and Pal, 2022).

Therefore, this article provides insights into the design of vegetable supply chains in the context of sustainability with the help of a qualitative study. We want to identify further fields of research on the way to a nutritional turnaround. However, the focus is on two research questions from different areas of sustainable vegetable supply chains. These are:

- *RQ1: Does the sustainability of vegetable supply chains depend on their geographical expansion?*
- *RQ2: Are there business models in vegetable supply chains that are growth-independent?*

RQ1 looks at the current state of vegetable supply chains. The aim is to investigate to what extent the geographic extent of real existing vegetable supply chains has an impact on their sustainability and whether a connection can be identified here.

RQ2, on the other hand, is dedicated to the future design of sustainable vegetable supply chains. Thereby, the thesis is taken up that the economic systems of western industrialized countries have to be transformed into a post-growth economy to achieve sustainability on a global level. Therefore, RQ2 analyzes which existing business models in vegetable supply chains are compatible with a post-growth economy. Nesterova (2020) identifies a research gap here.

To obtain answers to the two research questions, Section 2 first discusses the theoretical background of sustainable vegetable supply chains. Section 3 then explains the methodological approach to the case study before Section 4 presents the organizations studied and the results. Section 5 then concludes by summarizing the most important findings.

2 Theoretical Background

2.1 Sustainability

Sustainable development *"[...] meets the needs of the present without compromising the ability of future generations to meet their own needs [...]*" (WCED, 1987, p. 8). This formulation of the Brundtland Report is often the starting point of today's global sustainability discussion. Furthermore, the report specifies that primarily the fundamental needs of the world's poor must be met and that this must be done within the limits of technology, societies, and the environment (WCED, 1987). Thus, sustainability includes an ecological dimension as well as a socio-economic one (Waas et al., 2011). However, it is also noted that sustainability will have different manifestations in different countries and systems. Today, sustainability is often described with the concept of the three pillars/dimensions of ecology, economy, and social aspects (e.g. Moldan et al., 2012; Schoolmann et al., 2012; UN, 2015; Purvis et al., 2019). In their analysis, Pervus et al. (2019) show that there is no coherent theoretical and historical basis for this approach. This also is another hurdle to a general operationalization of sustainability which therefore is always context-dependent and requires an appropriate explanation in each case.

In this paper, we take a qualitative approach. In addition, the use of sustainable management systems and the use of labels within vegetable supply chains will be considered. These are explained in section 2.3. The understanding of sustainability on which this paper is based builds on the findings of Rockström et al. (2009), Steffen et al. (2015), and Raworth (2012). The first two authors identified several planetary boundaries for the global ecosystem. They show that it is necessary to change human behavior so that the impact of humanity on the Earth's ecosystem remains within these planetary boundaries. Here the ecological perspective of the three pillars can be found. With her concept of the doughnut economy, Raworth then extended the idea of planetary boundaries and established the socio-economic foundation for a good and just life for humanity. Also, she introduced indicators for the measurement of the foundation there are different approaches here. For example, the Sustainable Development Goals (SDGs) can also be used for operationalization.

Regardless of the actual measurement in individual cases, these findings set the framework for understanding sustainability. It is about organizing human activities in societies in such a way that their ecological impact remains within planetary

boundaries and, at the same time, the basic socio-economic needs of all people are met.

This concept also takes up the basic ideas from the Brundtland Report. However, it should be noted that a distinction is necessary between sustainable development and sustainability (Purvis et al., 2019; Sneddon, 2000). Since the term development is usually associated with a growth-oriented change in economic activities in the direction of Western industrialized countries (Redclift, 2005; Johnston et al., 2007; Brand, 2012). Such an understanding is not in the sense of sustainability as it has just been defined. Therefore, the SDGs, in particular the growth-oriented goal 8, must also be viewed critically.

2.2 Sustainable Food Supply Chains

Several reviews have been published on sustainable food supply in resent years (2018-2022). The findings of previous studies will not be repeated here. Rather, the present paper is to be placed in the identified research gaps and connections to existing studies are to be pointed out.

Zhu et al. (2018) have identified twelve areas of great potential for future research in quantitative modeling of sustainable food supply chains. These include problems in global as well as regional and local sustainable supply chains. In particular, Zhu et al. believe that the latter should receive greater attention from the research community. This study addresses that to a certain degree. Even more recently Kumar et al. (2022) identified nine emerging and relevant research themes in sustainable food supply chains. These include the areas of *supply chain sustainability and impact assessment* and *sustainable business models*. Our article is at the interface of both areas. The focus, however, is more on sustainable business models in vegetable supply chains than on assessment. (An integrated literature review on sustainable food supply chains) Quantitative research was considered in the content analysis of Nematollahi and Tajbakhsh (2020). The authors found that the environmental dimension of sustainability in agricultural supply chains has so far received more attention than the social dimension. This is probably because sustainability is intuitively mostly associated with ecological aspects. The social foundations of a good life on earth are often only an additional aspect of studies in the context of sustainability but not the focus. The understanding of sustainability introduced in section 2.1 is intended to provide a holistic understanding of sustainability for this study. With regard to the geographical extension of supply chains and the focus on France Chiffaleau and Dourian (2020) give the first hint that shorter supply chains tend to be beneficial in the social aspects of sustainability in food supply chains. Parajuli et al. (2019) are looking specifically at fruit and vegetable supply chains. They consider the impact of different climate change scenarios on these systems. The focus here is environmental sustainability and how food production can be secured for the future.

2.3 Measuring Sustainability

Also, we established the understanding of sustainability for this paper in section 2.1 sustainability has still to be operationalized for each context as Purvis et al. (2019) conclude. In this qualitative study, we aim to gain insight into the business activities of individual players in vegetable supply chains. In order to guarantee as open an approach as possible, sustainability should therefore not be further narrowed down to key figures and indicators. However, in the context of vegetable supply chains, there are several certification procedures and labels that are used in practice and are mentioned in the interviews. These should therefore not be ignored. Table 1 therefore lists and describes the standards and labels used by at least one organization.

Standard/Label	Description
IFS/ISO 14000	The international food standard (IFS) ISO 14000 sets standards for the environmental management of processes and makes it possible to certify individual sub-areas and product life cycles.
GAP+GRASP	Good agricultural practice (GAP) and global risk assessment and social practice (GRASP) define minimum environmental and social standards in the business-to-business sector.
EU/Organic label	The label guarantees an environmentally friendly and resource-conserving form of farming without the use of genetic engineering and synthetic pesticides and fertilizers.
Demeter	Demeter certification guarantees strict limits on the use of fertilizers, the creation of biodiversity areas, the use of biodynamic preparations as well as humus build-up, and the natural improvement of soil structure.
Bioland	Bioland also means tight limits on the use of fertilizers and additional biodiversity additives. Certain social standards must also be complied with.
Regionality label	Regionality indicates that products come from the region of the place of sale. However, regions can also cover several hundred kilometers.

Table 1: Standards and labels used in the considered supply chains

The description in Table 1 shows that the indicator systems and labels focus on agricultural and ecological aspects. Social aspects, both concerning the employees and the communities, are not taken into account. Exceptions are only GRASP and Bioland.

2.4 Sufficiency and post-growth

To achieve sustainability, the focus is usually on increasing efficiency. In the end, the goal here is the absolute decoupling of output from input to allow growth without using non-renewable resources and stay within the planetary boundaries. Additionally, the efficiency strategy aims at a constant increase in prosperity and wealth, which thus fulfills the social aspects of sustainability.

It should be noted, however, that the efficiency strategy alone does not lead to sustainability (Vadén et al., 2020). This is also due to the fact that an absolute decoupling, as would be necessary to comply with the planetary boundaries, is not realistic (Ward et al., 2016; Sanyé-Mengual et al., 2019; Hickel, 2019). Also, the rebound effect often prevents a relief for the planetary boundaries (Druckman et al., 2011; Kurz, 2019). Against this background, sufficiency must be considered as a strategy for sustainability (Young and Tilley, 2006; Kurz, 2019). Sufficiency is based on the idea of living well with less consumption and resources used (Niessen and Bocken, 2021). If a sufficiency economy is considered, it is described as a de-growth or a post-growth economy (Nesterova, 2020).

In this paper, the term post-growth economy will be used. It describes an economic system whose *"(1) material throughput is in line with ecological limits, (2) GDP does not inform major policy decisions, (3) resource and energy productivity gains are translated into decreasing material throughput, labor productivity gains into more leisure until condition (1) is satisfied*" (Strunz and Schindler, 2018, p.70). It forms the background for answering the second research question. Here we look at the business models of the interviewed organizations and whether these can be an approach for shaping companies in a post-growth economy and support sufficiency. We, therefore, analyze the statements of the interviewees with regard to the growth dependency of the business models. Additionally we use the framework of Khmara and Kronenberg (2018) to evaluate if a company follows the sufficiency strategy.

3 Methodology

3.1 Study design and scope

As the previous chapter has shown, sustainability is a concept for which no uniform quantifying approach exists. Additionally, companies are reluctant to publish data related to their processes and supplier relationships and there is no consistent reporting on supply chain sustainability and its relationship to the geographic expansion of vegetable supply chains to determine its connection. Thus, it is not possible to answer the research questions by analyzing publicly available data.

We have therefore chosen a case study approach to gain qualitative information about individual actors in vegetable supply chains with the help of semi-structured expert interviews. As research methodology expert interviews are particularly suitable when the information sought is so specific that it cannot be researched in the literature, or when current practical information and knowledge about practical implementation is sought, which is the case here. Also, data collection with the help of interviews allows us to use the holistic understanding of sustainability introduced in the previous chapter. Furthermore, in addition to testing the hypothesis, expert interviews allow us to pick up on other aspects mentioned by the experts.

3.2 Expert interviews

The expert interviews were conducted using semi-structured interview guides and analyzed with the MAXQDA software. The aim was to obtain information about the role of the actors in vegetable supply chains, the extent to which sustainability is taken into account in the processes and products, and the success model pursued by the company under consideration. The interviews, therefore, covered the three areas of (1) structure and processes of the supply chain, (2) measurement of success and pursued goals of the company, and (3) consideration and measurement of sustainability. The interviews were conducted in the form of conversations with general questions. Detailed inquiries were only made on individual points.

To ensure the confidentiality of company data and encourage honest responses, the information presented is anonymized. The data collected came from a total of nine interviews. All interviews were conducted in the year 2021 in Germany. Table 2 shows the different types of companies and the position of the experts interviewed.

Company	Code	Position
Community-supported agriculture initiative	CSAI	Member of board
Organic Farm 1	OF 1	Executive management
Organic Farm 2	OF 2	Executive management
Conventional Farm 1	CF 1	Assistant to executive management
Conventional Farm 2	CF 2	Executive management
Intermediary 1	IM 1	Executive management
Intermediary 2	IM 2	Organic value chain management
Distribution center for retailers	DC	Purchase management fruit, vegetables, flowers
National retailer	NR	Executive management

Table 2: Position of interviewed experts in the companies

As the companies shown in Table 2 are quite different and are located in different places along the vegetable supply chain, their views on sustainability differs. This is important in regard to the relationship between supply chain expansion and sustainability. Therefore, the different types of companies and their roles in the vegetable supply chain are briefly presented at the beginning of capture 4.

4 Findings

4.1 Results

4.1.1 Interviewed organizations and supply chain structure

The different organizations considered in the interviews and their role in the supply chains were described by the interviewees as follows:

Community-supported agriculture initiative (CSAI):

A community-supported agriculture initiative (CSAI) is a special form of vegetable production. CSAIs are non-profit organisations. The protection of the environment, local cultivation and distribution of vegetables, and the preservation of social justice have top priorities. Members commit to monthly payments for one year, in exchange for receiving fruits and vegetables on a weekly basis. The special feature compared to similar profit-oriented concepts is the distribution of the products: The amount of harvested products each week is allocated on a pro-rata basis. The respective delivery thus depends on the harvest and varies.

The payments of the members are used exclusively for the wages of the gardeners, the careful treatment of soil, humus build-up, CO2 storage, and grounding. Thus, there is no outflow of monetary profits. In CSAI, seeds and some young plants are purchased from external suppliers, while all work is done by employed gardeners and the members themselves.

Farm (OF or CF):

On the side of the producers, both organic farms (OF) and conventional farms (CF) were considered. Two interview partners were available for each of the two forms, so four farms were considered. In all of the farm's seeds, young plants, and in some cases fertilizers are purchased. The process of plant raising, harvesting, and in some cases storage are carried out by the farms themselves. Some farms even handle the marketing to end customers by themselves. Farms are at the beginning of the vegetable supply chain and are significantly involved in ensuring product availability.

Intermediary (IM):

Intermediaries bundle the vegetable products on the side of production. The logistical effort is taken over by the intermediary and thus considerably reduced. The intermediary buys the products of many producers and passes them on to numerous buyers. At the same time, the large number of producers minimizes the risk of out-of-stock situations for food retailers. Food retailers are the main customers of intermediaries. In addition, they supply major customers in the hotel and catering industry, the German Armed Forces, and end consumers with the help of online retailing.

It should be noted that intermediary 1 (IM 1) is involved in regional, trans-regional and global SCs, while intermediary 2 (IM 2) is exclusively involved in regional SCs.

Distribution Centre for Retailers (DC):

Distribution Centres (DCs) are widely used in food supply chains to exploit economies of scale. Due to the high purchase volumes, low purchase prices can be negotiated, which in turn are partly passed on to the customers. The aim is to achieve cost leadership in the market. In addition, DCs have a mitigation effect on supply risks for the food retailer, similar to intermediate or wholesale. The food retailer cannot rely on the ability of individual producers to supply vegetables at all times. Therefore DCs are used to ensure that products are always available.

National Retailer (NR):

Also, there are independent stores, food retailing in Germany as well as globally is dominated by large national retailers (NR) (Pérez-Mesa et al., 2021). The retailer interviewed in the study is part of them and operates mainly in trans-regional and global supply chains. However, independent stores as well as NRs are active in local and regional vegetable supply chains. According to a POSpulse survey, the majority of Germans use grocery stores to buy fresh food (Ahrens, 2021). This is the main point of sale for fruit and vegetables to the end consumer.

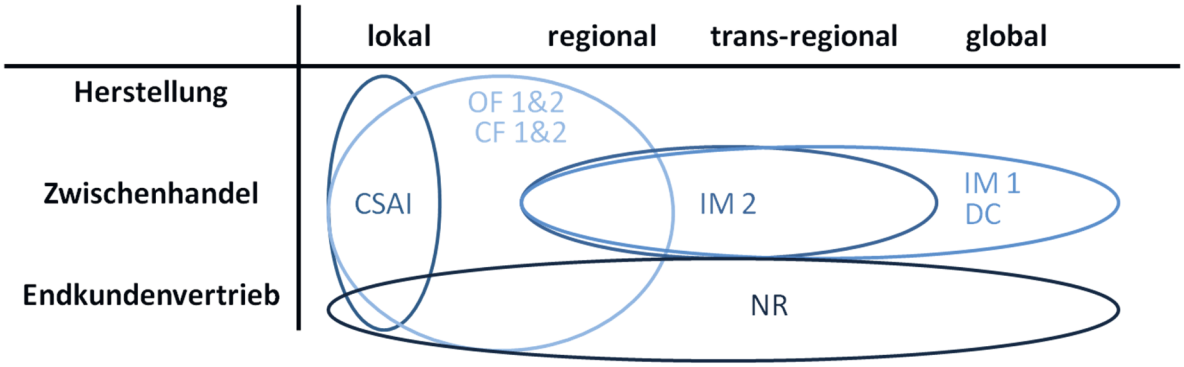

Figure 1: Supply chain activities of interviewed organizations

The paper aims to investigate whether conclusions can be drawn about the sustainability of vegetable supply chains due to their expansion. Since a supply chain usually consists of many actors, only the individual actors can be questioned and conclusions drawn about the entire supply chain based on the information obtained. To allocate the information on the individual actors to the respective supply chains, figure 1 shows in which supply chains they are active.

Description of supply chains consider in the interviews
In local supply chains, consumers either buy directly from the producer in farm stores or at weekly markets, are part of CSAI or the producer delivers directly to retailers. The distance between them is no more than 25 kilometers. Local supply chains thus consist of organic or conventional farmers, food retailers, and CSAI. The turnover through direct marketing is 100% for CSAI. For organic farms, the share varies (5% for OF 1; 50% for OF 2) (interviews OF 1 and OF 2). In conventional cultivation, only CF 2 has 10% direct marketing (interview CF 2).
Regional supply chains cover distances from at least 25, up to a maximum of 200 kilometers (interviews OF 2, CF 2, IM 1, and IM 2). Within these distances, there is no direct marketing between producers and consumers. Sale via (national) retailer is the main distribution method in regional supply chains (interviews IM 2 and CF 1). Also, intermediates and/or distribution centers are often involved in regional supply chains to bundle products and ensure constant availability (interviews OF 1, OF 2, and CF 1). Intermediates also deliver to large consumers like hospitals, gastronomy, hotels or company canteens.
Trans-regional supply chains are intra-European networks. Here the vegetables are imported from European countries (interviews IM 1 and IM 2). Farms in other European countries are the starting point of trans-regional supply chains. IM 2 distinguishes between trans-regional and global supply chains because the degree of complexity of the supply chain increases due to the imports from non-European countries (interview IM 1).
Global supply chains are based on third-country procurement (outside the European Union) and overseas imports (interview DC). Because of the complexity of the international logistics network, IM 1 outsources the freight business in global supply chains to sales agents (interview IM 1). This reduces risks due to currency fluctuations and delays in scheduling. Sales agents also implement country-specific procurement regulations.

Table 3: Supply chains considered in the interviews

NRs are the only type of business that is active in all supply chains and thus obtains and sell vegetables in all supply chain types. The interviewed CSAI, on the other hand, stays exclusively within local SC boundaries. The organic and conventional farmers (OF 1, OF 2, CF 1, CF 2) interviewed in this study distribute their products locally and regionally. However, it is clear that in trans-regional and global vegetable supply chains farmers have to be at the beginning of the supply chain and are therefore also involved in all supply chain expansions, even if this is not the case with the participants of this study. Both IM are not involved in local SCs and thus are only involved in regional and trans-regional supply chains in the case of IM 2 and are regional, trans-regional as well as globally active in the case of IM 1. DC is also active in all forms of supply chain expansion except for regional supply chains. The structures of the supply chains in which the organizations from the interviews are active are described in Table 3.

4.1.2 Supply chain sustainability

Even if the environmental impact of transportation is presumably lower in local supply chains due to lower boarding distances, this assumption alone does not yet allow a statement about the sustainability of the different supply chain expansions (Coley

et al., 2011). The interview partners were therefore asked about sustainability management within the supply chains in which they are active.

Organization	IFS/ISO	GAP	EU organic label	Demeter label	Bioland label
CSAI					
OF 1				X	
OF 2				X	X
CF 1	X		X		
CF 2	X				
IM 1			(X)	(X)	(X)
IM 2	X	X	x	X	X
DC	X	X	X		
NR	X		X	X	X

Table 4: Performance measurement systems and certificates used by the interviewed organizations

With regard to the **indicator systems** for the implementation of sustainability, it must be noted that these systems are barely used in the organizations surveyed. Neither GRI, NKS, lifecycle assessment, nor EMAS was mentioned by one of the interviewees. The IFS/ISO standard is used by five and GAP by three companies as can be seen in Table 4. The table indicates that such systems are more important for actors in trans-regional and global supply chains. However, this does not apply to all actors in the study. IM 1, for example, does not use any of the systems or **certificates** mentioned in chapter 2 for his conventional products. Only a new organic product line introduced in 2021 is certificated with three organic labels. Organic labels are also used in organic farming. In particular, the Demeter seal is of great importance for the two organic farmers. It enjoys a high level of trust among consumers who value organic food. It, therefore, serves to prove the business model of organic farms. Other certificates or labels do not play a role for any of the interviewees from the production organizations. Crucial for them is, whether the customer demands a corresponding certificate or not. If this is not the case, then no corresponding label is sought. The reason for this is the high cost of the certification process. No intrinsic motivation is expressed to use the corresponding processes with the goal of sustainability. No added value is seen in the procedures/standards which must be fulfilled to receive the label. If sustainability is the goal, then it is independent of the certificates and performance measurement systems.

For the IM 2, the DC as well as the NR labels play a much more important role. Even if this mostly concerns product lines for organic vegetables and the higher price segment. Nevertheless, DC emphasizes that the ISO standard is a basic requirement for

all products to be included in the assortment. So certain (sustainability) standards must be met here.

The interviews conducted aimed to gain insights into the sustainability orientation of the organizations beyond the certificates. Concerning the research questions, three aspects came up. These are (1) the perception of corporate success and how this is measured, (2) the wants and purchasing criteria attributed to consumers, and (3) the necessity or goal of corporate growth.

One point where differences depending on the expansion of supply chains can be identified from the interviews is the **measurement** of success. The NR and IM 1 which are both active in trans-regional and global supply chains stated that success is primarily determined based on classic quantitative KPIs. These are, for example, sales and growth as well as the number of customers in the store (interviews IM 1, NR and DC). Quantitative criteria also play an important role in regional supply chains. Organic as well as conventional farms and the regionally operating IM 2 stated that an increase in sales, as well as an expansion of the cultivated land, are relevant. Also, the price of the products is important. However, regional organic farms (OF 1 and OF 2) also mention qualitative targets such as employee satisfaction, the creation and maintenance of near-natural areas (hedgerows, biotopes, bee meadows), or maintaining soil health as important goals. The CSAI, as representative of local SCs, measures its success solely through member surveys on the quality as well as the quantity distribution of the harvested products (interview CSAI).

Differences are also apparent in the **wants assigned to the consumer** and the criteria that are decisive for the purchase decision. Retailers and other players in trans-regional and global supply chains report that pricing, the quality of products, and the range of the assortment are decisive factors. Consumers also demand constant availability of products (interviews NR and DC). Therefore, cost-effective processes to achieve a defined product quality are the focus of the management behavior within geographically extended supply chains. The wants of end consumers in regional supply chains are based on the criteria of price, regionality, and quality (interviews CF 1 and CF 2). During the interviews, it was found that consumers of vegetables from organic regional supply chains have a higher tolerance for more expensive products than is the case in conventional regional supply chains. However, for both types of vegetable production, the challenge of regionality arises at certain times of the year. Due to the seasonality of vegetable production, products from global supply chains are partly used here. Consumer requirements in local SCs are primarily described as seasonality, sustainability, quality, and locality (interview CSAI). Transparency is also important to consumers. Price is not a primary decision criterion here.

As already listed in the section on success criteria, growth plays a role for all players in trans-regional and global as well as regional supply chains (interviews IM 1, IM 2,

DC, and NR). Growth in sales, the number of customers, and cultivated land are explicit goals here. However, regional supply chains are increasingly constrained in their pursuit of growth by workforce shortages. The necessary expansion of infrastructure, for example in the form of cold storage facilities, is a challenge. Unlike other organizations, the CSAI does not strive for growth. On the contrary, it was emphasized during the interview that the current size of the initiative is not to be extended (interview CSAI).

4.2 Discussion

4.2.1 Vegetable supply chain expansion and sustainability

One objective of this paper is to investigate whether the sustainability of a vegetable supply chain is dependent on its geographical expansion. As indicators for this investigation, indicator systems for sustainability and (organic) certificates were considered, and whether these are used in the respective supply chains.

In summary, it can be said that **sustainable indicator** systems play no important role for the interviewed organizations. **Certificates**, however, are relevant. They have greater importance for actors in supply chains with a wider expansion than for actors who are more active in local and regional supply chains. However, this does not apply to all product lines. Mostly the organic sector or products in a higher price segment are concerned. Nevertheless, DC emphasizes that the ISO standard is a basic requirement for including products in the assortment. A certain minimum standard of sustainability is thus maintained here. The primary reason for the use of the certificates in more expanded supply chains is the associated standards, which facilitate quality assurance for large volumes. For organic farmers, this also applies due to the Demeter label. It serves in particular as a signal and proof of quality to consumers who value organic vegetables. The focus in terms of the content of the certificates, however, allows at most a positive contribution related to ecological aspects of sustainability. Since the players do not have all products certified, only supply chains for organic products, can be considered ecological (more) sustainable than vegetables without certificates. Within the scope of the interviews, this is more common in the more extended supply chains.

With regard to the **success measurement** of the actors in the different supply chains, it becomes apparent that only in regional and local supply chains are aspects of sustainability relevant as a goal. This is especially true for the CSAI, but also to some extent for regional organic farmers. For actors who are primarily active in trans-regional and global supply chains, however, sustainability aspects do not represent explicit success criteria. In this respect, supply chains with a smaller scope are therefore to be assessed as more sustainable.

In terms of **consumer demands**, it can be seen that a certain product quality is required in all supply chains. Here, differences can only be found concerning the requirements for organic cultivation, but not with regard to the supply chain extension.

This is different from the price of the vegetables. In local supply chains, this criteria is not as important as in more expanded supply chains. In local vegetable supply chains, locality and the sustainability of production play an important role in the purchase decision. If the supply chain actors are oriented towards the customers' wishes, it can be assumed that supply chains with a smaller extension, especially local systems, are more sustainable than trans-regional or global supply chains. In addition, the smaller geographical distance also promotes lower emissions due to shorter transport distances (Coley et al., 2011). However, this cannot always be realized in regional supply chains due to seasonal growing conditions. In local supply chains, however, it can, as consumers are aware of seasonality and accept it.

If we summarise the information on certificates, success measurement, and customer preferences in the different supply chains, we can conclude that local supply chains tend to be more sustainable than supply chains with a larger expansion. The primary indicators that lead to this conclusion are the seasonality of production and the key performance indicators for the respective supply chains. Even if the consideration of the certificates used initially suggests a contrary assessment. It should be noted that these only have a very small influence on the sustainability of the supply chains. The function of the certificates is primarily quality assurance. The fact that producers in local supply chains do not use certificates is due to the high (financial) costs associated with certification. However, the production processes described in the interviews do not suggest that sustainability is lower here. The decisive factor for sustainability is whether the vegetables are produced according to the seasonal growing conditions. If this is the case, as with the CSAI, these local supply chains are more sustainable than regional, trans-regional or global systems. This is also true because of the organization's objectives which is recognized and supported by consumers. Here, the promotion of sustainability, both in the environmental and social spheres, is an explicit factor. This is not the case with the supply chains with a larger extension.

4.2.2 Business models for post-growth vegetable supply chains

The second research question in this paper concerns the identification of growth-independent business models in vegetable supply chains. From the discussion on performance measurement and growth in section 2.2.1, it is clear that the activities of most actors in vegetable supply chains are based on classic, growth-oriented, and growth-dependent business models. This is especially true for retailers, intermediaries, and farmers in trans-regional and global supply chains. In regional supply chains, approaches can be identified among organic farmers that at least do not pursue growth. Ultimately, however, only the CSAI approach can be identified as functional in a post-growth economy among the business models of the interviewed organizations.

The concept of the CSAI interviewed is neither based on entrepreneurial actions nor does it intend to grow beyond the current capacity. Members build up competence in self-sufficiency by helping with fieldwork. This leads to a greater appreciation not

only for the products grown but for the environment and nature as a whole. Also, further growth would lead to a size that would make decision-making processes and solidarity among the members more difficult and is therefore rejected.

Additional to this assessment seven criteria introduced by Khamara and Kronenberg (2018) can be used to assess whether a company follows the post-growth paradigm. They are listed in Table 5. The assessment of the interviewed CSAI can also be found in the table. Even though this is only a brief assessment, it can be concluded that a CSAI supports sufficiency and can exist as an organizational form in a post-growth economy.

Post-growth criteria	**CSAI**
Alternative understanding of business	Yes
From business activity to activism and social movement	Yes
Collaborative value creation	Yes
Democratic governance	Yes
Corporate leaders commitment to company values in personal life	Cannot be evaluated for sure.
Reduction of environmental impacts at all stages of product/service life-cycle	yes
Making products that last and are repairable	Does not apply to vegetable production.

Table 5: Assessment criteria for post-growth business models

5 Conclusion

This paper has considered two research questions on vegetable supply chains and their sustainability. In RQ1, relationship between the geographic expansion and sustainability of supply chains was analyzed. Sufficiency-based business models in vegetable supply chains were the focus of RQ2. The foundation of the analysis was a qualitative case study approach for which data collection was carried out through expert interviews.

Considering RQ1, it can be stated that a connection between the geographical expansion of vegetable supply chains and their sustainability can be assumed. Especially in the case of local production and distribution of vegetables, it can be seen that ecological and socio-economic sustainability aspects are taken into account. However, it should be noted that only a limited range of vegetables is available in these supply chains. Suppliers of vegetables who want to ensure the constant availability of goods resorts to more extensive supply chains. Here, less consideration of sustainability factors can be observed.

The organizations covered by the study operate on different business models. This applies in particular to CSAI. It is a special case in terms of its objectives, internal organization, and range of services. However, it is also the only organization for which it can be assumed that its business model will continue to be successful regardless of the organization's growth. This, therefore, represents the answer to RQ2.

The expert interviews also show that the sustainability of vegetable supply chains in Germany depends strongly on the respective assortment and this in turn depends on the seasonality of vegetable cultivation. Only if consumers are willing to buy vegetables based on the seasonal availability at local producers can sustainable vegetable supply chains be designed. This aspect shows that a sustainable transformation is only possible through the efforts of all stakeholders. Change is needed among producers and suppliers as well as among consumers and the framework conditions of society.

The findings presented here are subject to the limitation that they were obtained as part of a qualitative study based on nine expert interviews. The conclusions drawn can therefore not be applied to all vegetable supply chains. However, they do provide indications as to which aspects are important for the design of sustainable supply chains. In particular, the findings on the sustainability of CSAI represent an aspect that needs to be further investigated. Thus, it should be investigated whether the statements of the interview partners apply to all organizations with such structures. In addition, it should be examined whether this business model can also be transferred to other activities outside of vegetable supply chains.

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