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# Forever Niche:
# Why do organic vegetable varieties not diffuse?

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# Abstract

While organic food has increased its market share in conventional food retail, virtually all organic vegetables are still conventionally bred. For decades, organically bred vegetable varieties remained a market niche, despite their socio-ecological benefits. This paper conceptualizes actors and activities around organic breeding as a Technological Innovation System (TIS) and analyzes what prevents these varieties from widely diffusing into conventional supermarkets. The investigated barriers relate to knowledge, market formation, investments, and legitimacy. The study is based on interviews with breeding initiatives and food retailers in Germany. Theoretically, the paper adds an innovation systems-perspective on the diffusion of organic varieties, a blind spot in the emerging debate so far. Furthermore, it contributes to the literature on sustainability transitions by introducing a novel empirical topic to the debate and reframing the TIS framework to analyzing fresh produce. Identifying existing barriers provides suggestions for practitioners seeking to successfully diffuse organic vegetable varieties.



**Key words:** agri-food transitions; Commons; organic breeding; diffusion; technological innovation systems; food retail

**JEL-Codes**: O30, O31, O33, Q13

# 1. Introduction

Across the world, socio-technical systems involve practices and technologies which lead to ecological crises and social injustices. Transition scholars investigate why and how socio-technical systems shift to more sustainable configurations (Markard et al., 2012). Literature has traditionally focused on low carbon transitions in electricity, heating, or transport systems. Only recently, transition research on agri-food systems has gained traction (El Bilali, 2019; Hebinck et al., 2021), as their current and dominant modes of production and consumption contribute to climate change, biodiversity loss, resource depletion, soil degradation, malnutrition, and economic disparities (Eakin et al., 2017; Weber et al., 2020). Previous studies on agri-food transitions mostly emphasize grassroot movements and the development of socio-technical niches around innovations such as alternative agricultural production methods or regionalized marketing of local produce (Seyfang and Smith, 2007; Randelli and Rocchi, 2017; Rosin et al., 2017; Rossi, 2017; van Oers et al., 2018). However, there is little knowledge on how novel and sustainable food alternatives leave these niches, enter conventional grocery stores, and become widely accepted and sought after – or why they fail to do so. Only very few alternatives have increased their market share and shelf-space in European food retail over the last decade, such as plant-based meat and dairy substitutes (Mylan et al., 2019; Tziva et al., 2020).

The agri-food systems around vegetables, potatoes, or fruits are often characterized by lock-ins that impede the commercialization of innovative breeds. However, studies on these impeding conditions mostly focus on development activities for breeding and cultivating plant varieties (Vanloqueren and Baret, 2008; Nuijten et al., 2018; Orsini et al., 2020a). In this paper, we extend the analysis to diffusion activities across the entire value chain and ask which socio-technical barriers prevent alternative and sustainable food products to gain market shares in conventional supermarkets. We specifically investigate novel vegetable varieties that are bred and raised organically (IFOAM, 2014; Sievers-Glotzbach et al., 2020). We base our analysis on empirical insights from a case study on breeding initiatives from Germany and interviews with representatives from conventional grocery stores. Opposed to the predominant vegetable varieties, organic varieties include a wide array of breeds that are specifically bred for organic farming conditions. However, despite their socio-ecological benefits, organically bred vegetable varieties have very small market shares.

To identify the relevant barriers for wide-scale diffusion, we conceptualize actors and activities around breeding, propagating, cultivating, marketing, and selling organic vegetable varieties as part of a Technological Innovation System (TIS). As this particular TIS is characterized by few actors, low market shares, and little growth, it is still in its formative life-cycle phase (Markard, 2020). It thus shares many characteristics with a socio-technical niche, where non-competitive innovations exist in small and delineated protective spaces, such as dedicated research programs, communities of users, or regional settings. In transition studies, TIS is viewed as a viable framework for analyzing conditions that nurture socio-technical niches (Smith and Raven, 2012) from an interactive and dynamic perspective (Bergek et al., 2008; Markard and Truffer, 2008). It particularly draws attention to "the [distinct] problem of adoption and utilization of technology [or products]" (Carlsson and Stankiewicz, 1991, p. 112). We draw on recent applications and adaptations of the framework regarding agri-food innovations (Long et al., 2016; Randelli and Rocchi, 2017; Tziva et al., 2020). Furthermore, we draw on the notion of 'TIS context' (Bergek et al., 2015), with a particular emphasis on conventional food retail, as this is the most important environment for the wide diffusion of alternative and sustainable food products (Willer and Lernoud, 2018). Food retail is part of further contexts – such as policy environments or customer preferences – which might go along with further diffusion barriers.

Overall, our paper offers a comprehensive account of diffusion barriers for organic vegetable varieties, which are related to knowledge flows, market formation, financial investments, and their legitimacy. We show how these barriers result from the interplay of actors, networks, institutions, and product characteristics within the TIS and with its context. While our empirical analysis focuses on barriers and challenges, such a stocktaking might provide starting points for practitioners who aim to strategically facilitate the diffusion of these ecologically valuable vegetable varieties. Theoretically, our paper provides a twofold contribution. On the one hand, we add a diffusion-based perspective on marketing and selling organic seeds and vegetable varieties, as this emerging debate so far mostly focuses on conditions for product development and breeding. On the other hand, we contribute to the literature on sustainability transitions by introducing a novel empirical topic to the debate and applying and refining TIS analysis in the context of vegetables.

The paper is structured as follows: First, we provide the theoretical background on TIS and diffusion (section 2). We then introduce organic breeding of vegetable seeds as our empirical topic (section 3), before modelling it into an analytical TIS framework (section 4) and explaining our methods (section 5). Finally, barriers for the diffusion of organically bred vegetable varieties are presented (section 6) and discussed (section 7).

# 2. TIS and their diffusion in the agri-food sector

In the following section (2.1), we briefly introduce the TIS framework, which draws attention to a wide range of product-related and external factors that influence not only the development, but also the market rollout of alternative products. In section 2.2, we review previous TIS applications in the context of agri-food transitions and summarize key insights relating to our research.

## 2.1 TIS and the diffusion of alternative products

The TIS framework covers the systemic and interactive process of introducing and utilizing socio-technical innovations. All actors, networks, and institutions that advance and influence the development and diffusion of the investigated product belong to the TIS (Bergek et al., 2008). The notion of actors usually refers to organizations such as companies from along the value chain, research institutes, or political lobby groups; but also individuals who actively contribute to innovating and applying the product, such as pioneering entrepreneurs or dedicated end-users (Hekkert et al., 2007; Hekkert and Negro, 2009). Actors coordinate and exchange ideas or resources within informal network structures or formal networking organizations (Musiolik and Markard, 2011; Rohe and Chlebna, 2021b). Institutions are usually defined as the 'rules of the game' (North, 1990; Markard and Truffer, 2008): laws, standards, norms, or expectations that control, enable, or constrain TIS actors.

The interplay of these structural components – actors, networks, institutions – might create positive externalities such as knowledge, financial investments, market access, or technological legitimacy. These externalities are framed as system functions or – as we do in this paper – system resources. The latter conceptualization emphasizes the relational character of the resources (Binz et al., 2016; Musiolik et al., 2020). While they are often understood as 'collective goods' at the level of the innovation system, they are nevertheless unevenly distributed and not all actors have equal access to them at any place and to any time. This potentially allows for an analysis of power – asking which actors control the formation of and access to system resources – although this issue is often neglected in TIS analyses (Binz and Truffer, 2017; Rohe, 2021). Ultimately, the TIS framework allows researchers to identify system level factors that enable, accelerate, or block the development and diffusion of novel products (Weber and Rohracher, 2012; Wieczorek and Hekkert, 2012).

The speed and success of a product's rollout is not only influenced by the TIS itself, but also by sectoral, political, and geographical contexts (Smith and Raven, 2012; Bergek et al., 2015). The sectoral context represents companies, infrastructures, and (im)material assets that can be leveraged in the formation of a new TIS. At the same time, misalignments between the TIS and its sectoral context – such as land-use conflicts between food and energy production – can impede the further rollout of the technology (Wirth et al., 2013; Markard et al., 2016). The political context of a TIS is shaped by the regulatory environment, the availability of public funding, targets laid out in governmental plans, or political actions from civil society stakeholders (Rohe and Chlebna, 2021a; van der Loos et al., 2021). This is closely tied to the geographical context of a TIS, that also includes place-specific industrial specifications, local demand, or physical infrastructures and resources (Hansen and Coenen, 2015; Losacker and Liefner, 2020). A TIS is embedded into multiple and diverse sectoral, political, and geographical contexts, which affects the specific functional dynamics across its value chain (Stephan et al., 2017; Rohe, 2020).

While the creation of new knowledge and the invention and improvement of new products is important in TIS studies, the framework also allows for the analysis of market dynamics, the role of demand, and the diffusion of alternatives (Carlsson and Stankiewicz, 1991; Martin, 2016; Rohe and Mattes, 2022). Binz and Truffer (2017) refer to this as product valuation and hold that the characteristics of the product itself shape the complexity and spatiality of the valuation process and which actors are involved in it. While the authors do not specifically analyze unprocessed vegetables, they note that food retail is characterized by standardized valuation: Market formation is driven by economies of scale and price-based competition and legitimation shaped by relatively coherent user preferences across institutional contexts (cf. also to Allaire and Wolf, 2004). Opposed to that is customized valuation for complex products, which need to be adapted to local contexts and niche markets and for which consumer expectations or product standards do not (yet) exist. Besides complexity and institutional compatibility, other product-related variables that impact diffusion rates include the product's relative advantage, its perceptibility, and trialability (Fichter and Clausen, 2021).

## 2.2 TIS and previous research on agri-food transitions

Research addressing sustainability transitions in agriculture and food is rapidly emerging (El Bilali, 2019; Hebinck et al., 2021). Although the application of systems approaches (Vanloqueren and Baret, 2008) and the TIS framework have been limited (El Bilali, 2019), some contributions make valuable additions to TIS in research on agri-food transitions.

First, the interplay between the supply and demand side is emphasized. Randelli and Rocchi (2017) for example draw attention to this in the case of alternative food networks between suppliers and customers. Feedback mechanisms from the demand side, in the form of consumers sharing their experiences, recommendations, and warnings about a product among their networks, may influence the formation and diffusion of knowledge about a product or innovation. Similarly, Long et al. (2016) stress the interaction between supply and demand in their analysis of socio-economic barriers to the adoption and diffusion of climate-smart technological innovations in European agriculture. Barriers faced by providers of innovations in agriculture may differ from those experienced by their users.

Second, an active role of consumers is considered crucial in agri-food transitions. Randelli and Rocchi (2017) see consumers as active agents in the different TIS functions and analyze their co-evolving interplay with producers. Tziva et al. (2020) stress the role of consumers in their analysis of the Dutch plant-based meat substitutes industry, exploring the relation between consumers' support for an innovation and their willingness to pay more for an alternative product.

Third, the (emergence of) norms that are connected to a certain product, such as ethical considerations concerning meat consumption connected to meat substitutes (Tziva et al., 2020), is closely related to the role of legitimacy in diffusion processes. So-called norm entrepreneurs, for example vegetarians or environmental NGOs challenging the appropriateness of meat consumption, may contribute to knowledge diffusion among consumers in their attempt to convince others of the norms surrounding a product (Tziva et al., 2020). This can contribute to strengthening its legitimacy. Particularly, when consumer groups hold very dissimilar norms, making it difficult to establish far-reaching support for a product, such norm-establishment can be relevant.

Fourth, considering the 'length' of the value chain, it is important to not just analyze processes surrounding production and consumption, but also processing, distribution, retail, storage, and waste disposal, as well as the interaction between these processes (Ericksen, 2008; Horton et al., 2017). The type of value chain as well as the coordination among its actors can influence support for a food-innovation (Morel et al., 2020). Despite TIS studies typically drawing much attention to manufacturing-processes, as the core of a high-tech value chain, the TIS approach also provides a perspective on the complex and interlinked parts of the value chain. This is also important considering the dynamic, continuously evolving nature of products (Randelli and Rocchi, 2017).

Our paper aims to underpin the potential of using the TIS approach in the analysis of agri-food systems with a particular focus on organic vegetable varieties as alternative products transcending their niche contexts and entering supermarkets. The research described above demonstrates the applicability of the TIS framework to less-technology focused sectors such as agriculture and food[1], as well as the importance of considering interactions between production and consumption sides.

[1] Food processing, packaging, and conventional agricultural practices have been described as low and medium technology industries. They are characterized by low investments in Research & Development (R&D) and incremental changes in processes, organizational set-ups, and marketing. However, the breeding of new plant varieties itself is a knowledge-intensive process with similarities to bio-chemical or life-science industries, which are often described as high-tech and based on science and technology driven innovations (Randelli and Rocchi (2017); Trott and Simms (2017)).

# 3. Organic breeding and the seed sector

Seeds are the basic ingredients of agricultural systems. However, current developments in the seed industry pose several sustainability-related environmental, social, and economic challenges (Clapp, 2021). In the context of ongoing privatization and commercialization of seeds through the extensive use of intellectual property rights such as patents, the global market is largely controlled by three companies with a market share of over 60 % (Bonny, 2017; Clapp, 2021). Their primary business model is one of economic optimization: selling a narrow set of genetically uniform varieties which promise high yields. However, resistances against pests and weeds are often not sufficiently developed in these varieties, thus they strongly depend on optimal growing conditions and on mineral fertilizers (Messmer, 2014; Horneburg, 2016). High yields can only be achieved with the combined application of agro-chemical plant protection products and fertilizers. This creates economic dependencies for farmers, leading to social injustices and power imbalances (Bonny, 2017). Furthermore, supply chains are less resilient in the face of external shocks, as can be observed in the food crisis caused in part by extreme peaks in fertilizer prices as a result of the invasion in Ukraine (New York Times, 2022).

The conventional varieties are usually cultivated from hybrid seeds. Thus, they cannot be reproduced with the same characteristics, and farmers hence cannot harvest new seeds. This business model also leads to negative environmental outcomes (Rasmussen et al., 2018) and genetic erosion (van de Wouw et al., 2010) of plant varieties, continuously reducing the level of agrobiodiversity.

## 3.1 Tackling the sustainability challenges in vegetable farming

While organic agriculture provides an alternative to the highly input dependent industrialized agriculture, it is estimated that about 95% of organic agriculture is still based on varieties bred for conventional farming (Lammerts van Bueren et al., 2011)[2]. From a legal perspective, seeds are considered as organic and can therefore be used in organic agriculture if they have been propagated under organic conditions for at least one generation, or, for perennial crops, for two growing seasons (Art. 12 lit. i, European Organic Regulation 834/2007). However, since these varieties have been developed under the conditions and according to the needs of conventional and industrialized agriculture, they are often not well suited to the low input conditions of organic farming (Lammerts

[2] Comprehensive and up to date numbers on market shares in this segment are not available. For specific crops, there are some more recent estimates that confirm continuous low diffusion rates of organic vegetable varieties. For instance, Orsini et al. (2019, p. 38) report for organic carrots in Europe that about "90% of the seed is from conventionally bred and conventionally multiplied cultivars, 9% of organically multiplied and only 1% of organically bred cultivars".

van Bueren et al., 2011).[3] Contrarily, all steps in the organic breeding process (cultivation, selection, and propagation) take place under organic conditions and are adapted to the specific requirements in organic farming. The developed vegetables are then called organic varieties or organically bred varieties – we use both terms interchangeably. In organic breeding, methods or biotechnological means that limit the natural reproductive ability of plant varieties (e.g. terminator technologies) or interfere with the genome and cell as impartible entities are refused (Lammerts van Bueren, 2010).

Additionally, organic breeding applies social principles of organic farming such as participation and transparency, thereby adding a process-oriented dimension that reaches beyond material product-characteristics. In this context, the breeding and production of organic vegetable varieties is usually associated with commons-based approaches, so-called Seed Commons (IFOAM, 2014; Sievers-Glotzbach et al., 2020).[4] They explicitly challenge the dominant (conventional) property regime described above. Those initiatives and their approaches are quite diverse and reach from seed sharing networks or communal seed banks to organic or participatory breeding initiatives. Seed Commons have been comprehensively reviewed and conceptualized by Sievers-Glotzbach et al. (2020) and provide a particularly interesting case in light of innovation processes. Such initiatives take collective responsibility for preserving plant genetic diversity and developing new plant varieties, recognizing the historic and present contribution of farmers to developing the cultivated plants. They refrain from the use of private property rights such as patents or variety protection on seeds or biotechnological means that could limit the natural reproducibility of plant materials. Seed Commons thus reject the usage of those instruments for protecting and commercializing innovations and rather adopt alternative measures such as forms of collective ownership. Moreover, breeding is organized in an open innovation process, where resources are managed collectively in polycentric structures. These structures embody multiple, independent centers of autonomous decision-making that take collective decisions on central values or goals. Additionally, participants share both formal and informal knowledge on their seeds and breeding processes freely within and beyond the initiatives.

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[3] Low input farming systems such as organic agriculture aim to minimize or totally restrict the usage of external inputs (e.g., pesticides, chemical-synthetic fertilizers) by optimizing the usage of internal natural resources and concurrent management practices (e.g., cover crops, crop rotations) (Migliorini and Wezel (2017)).

[4] In Germany, organically bred vegetable varieties are almost always bred and produced by commons-based initiatives. Empirically, both approaches are inseparable (in this country), but they pose two distinct theoretical levels. We are mostly interested in organically bred vegetable varieties because this theoretical level is more tangible in empirical praxis. However, we also address commons-based principles in the empirical analysis if they directly relate to diffusion barriers of organically bred vegetable varieties.

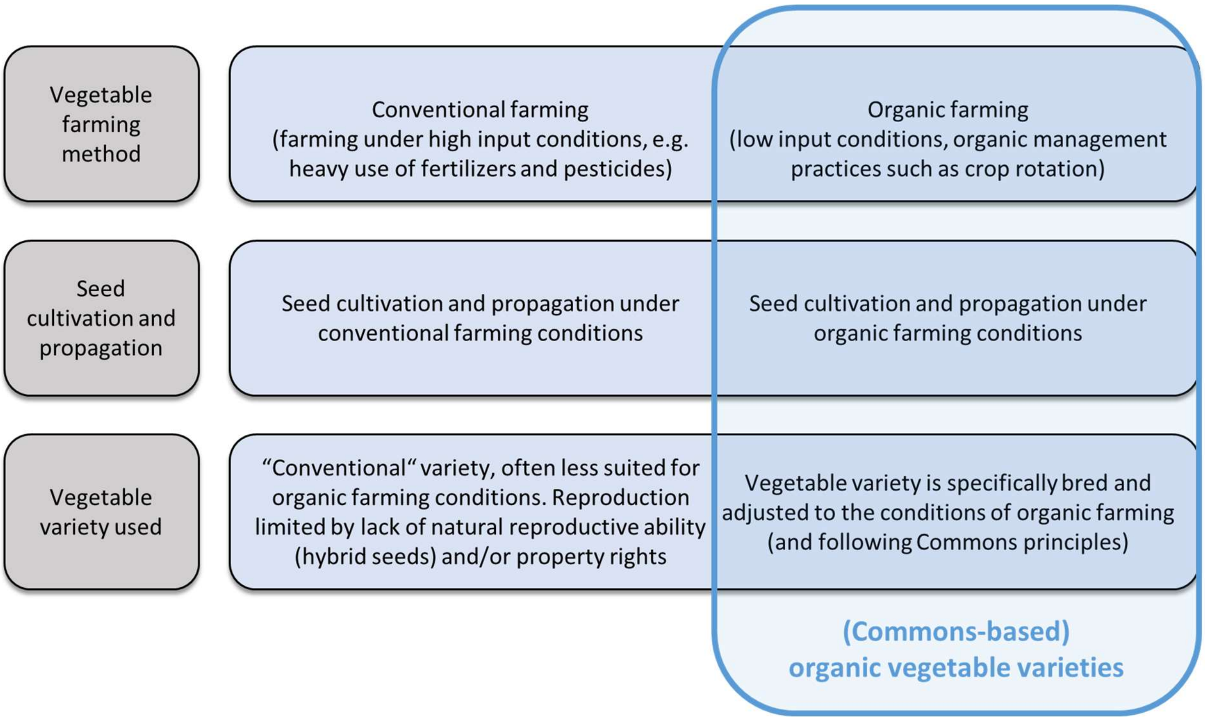


*Figure 1: Conceptualization of (commons-based) and organic vegetable varieties (own figure).*

Figure 1 summarizes the distinct characteristics of the vegetable varieties we investigate in this paper. Their crops are cultivated under organic farming conditions, their seeds have been propagated under organic farming conditions, and the varieties have been bred for the conditions of organic farming, often following Commons principles.

## 3.2 Research focus: Zooming into the German seed value chain

In this paper, we focus on Germany. With its geographical and institutional context, it provides a suitable and interesting empirical case for three reasons. First, it is an industrialized country with a highly regulated and formalized seed sector (Tschersich, 2021) and thus representative of similar countries in the Global North. Second, a range of organic breeding initiatives have emerged that challenge the current regulative system (ibid.). Third, the food market in Germany is a highly developed demand market where retailer as well as consumer awareness is a key factor (Nuijten et al., 2018). We further limit our research to fresh produce and neglect processed food as the evolving value chain would prove too complex for a contingent analysis. Furthermore, previous studies find that the longer the value chains are, the less likely it is for farmers to use organic seeds (Orsini et al., 2020b; Winter et al., 2021). This suggest that organically bred varieties would face even more difficulties in long value chains for processed food.

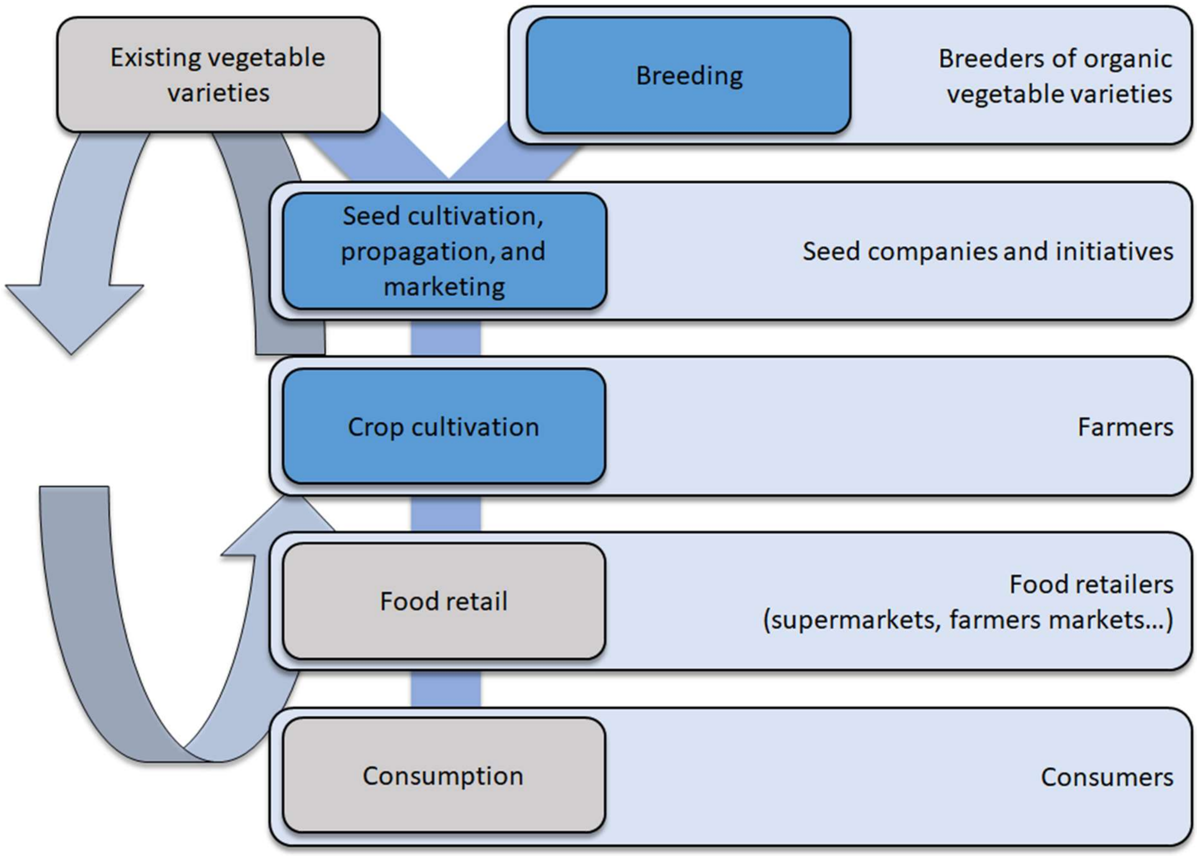


*Figure 2: The simplified value chain for organic and commons-based vegetable varieties (own figure).*

The seed system as we understand it does not stop at farmers as buyers of seeds. Instead, our perspective reaches from breeding to consumption (and back), including key actors and institutions. A simplified value chain (Figure 2) shows the relevant actors and value creation stages in the vegetable seed system, the commodity value chain of vegetables, and how they interact. Breeding, seed propagation, and crop cultivation (colored in blue) represent the activities of the TIS (as will be discussed in section 4). The curved arrows in figure 2 represent the 'non-linearity' of the value chain. Hence, we recognize that actors and activities are influenced by developments up- or downstream segments. We briefly introduce each segment in the following.

To breed new varieties, parental varieties are retrieved from conservation sources like (inter-)national and corporate gene banks or (in-)formal sharing among farms and conservation initiatives. After a novel variety is bred, it must be registered according to the criteria of distinctiveness, uniformity, and stability (the so-called DUS criteria) at the German Plant Variety Office (*Bundessortenamt*). At this point, it is also possible to apply for variety protection to ensure intellectual property rights. Actors in Seed Commons waive that option as described above. The initial, small stock of seeds for this new variety is then given to contractors (often farmers) for multiplication, which is also described as seed production. This procedure is regulated by legal standards and regularly controlled by governmental bodies. Retailers buy or lease new varieties from breeders and organize seed multiplication and sales to farmers. Activities at this stage include marketing, customer service, packaging, transport, and logistics. Farmers choose seeds that fit their (local) requirements and farming approach and cultivate vegetables from them. They then sell their produce through one or several retail channels. We focus on conventional food retailers. [5]

Food retailers buy vegetables from farmers directly or from wholesalers. They then market them to end consumers. German conventional food retailers are in a strong bargaining position because of their market concentration and farmers' time constraints to sell their perishable produce. In 2019, German food retail had a turnover of 252.7 billion € including non-food. Five corporate groups (Edeka, Rewe, Schwarz, Aldi, Metro) combine about 75 % of market shares, of which the Edeka group has the highest share with about 25 % (DBV, 2021).

Finally, consumers buy vegetables for their everyday consumption at food retail such as grocery stores or supermarkets. Consumers mostly pick vegetables according to appearance and visual traits (Revoredo-Giha and Renwick, 2012). In general, consumers are unaware of which variety they buy, with the exceptions of apples and potatoes (Nuijten et al., 2018).

# 4. Towards an analytical framework

In the following, we adapt and operationalize the TIS framework as to analyze the systemic process of product diffusion (cf. section 2) regarding the value chain of organically bred vegetable varieties as the empirical context of our study (cf. section 3). We apply the framework to capture the barriers for the wide-scale diffusion of organic vegetable varieties.

As described in section 2.1, actors, networks, and institutions are the foundational structural elements of any TIS. The relevant actors in the system for raising organic vegetables are depicted in the value chain (Figure 2). The interactions and relations between these organizations and individuals build the network structure of the TIS. Regulations, standards, norms, and values are institutions structuring the TIS. This includes variety registrations requirements (Desclaux and Nolot, 2014), but also the shared goals in the community of breeders and farmers. Finally, as the characteristics of a product also influence its development and diffusion, we add this structural feature to our TIS.

[5] We differentiate between conventional and organic food retail. Whereas conventional food retail may offer organic products as part of a larger product portfolio, organic food retail encompasses all retailers that solely sell organic products. Supermarkets (large shops with a large product portfolio) and grocery stores (generally smaller portfolio) are subtypes of conventional food retailers (Han et al. (2012)) that we focus on in our paper.

Mylan et al. (2019) describe four environments that are especially influential in the diffusion of new products in the agri-food sector: business, policy, users, and wider publics and culture. We focus on the business environment of conventional food retailers and the barriers for the large-scale diffusion of organically bred vegetable varieties that persist in this context. The TIS is also directly embedded into other business environments, such as farmers markets or businesses that sell vegetable boxes directly to consumers. But since these distribution channels have a relatively low market share (DBV, 2021), we neglect them in our further analysis. Instead, we explicitly analyze the actions and perceptions of conventional food retail towards the TIS, as they are central and powerful actors with immense buying power. We view the other environments as the wider context that both the TIS and conventional food retailers are embedded in (Deuten et al., 1997; Mylan et al., 2019)[6]:

- Customer preferences and culture: As cultural norms and customer expectations are deeply intertwined in the food sector (cf. section 2), we combine these two product environments. This analytical category includes broader market and customer demand trends that supermarkets need to cater to. Examples include general price expectations, overarching trends like growing health concerns, or strategic campaigns from activists that seek to delegitimize established products such as processed meat through shocking graphic images or other, less controversial tactics (Enthoven and Thelken, 2022).
- Policy environment in the agri-food sector: Governmental regulations and public subsidies influence the production, marketing, and consumption of food. Examples include subsidies for farming, requirements for registering plant varieties, or public labels like the EU organic logo. Such labels can help bridge information asymmetries and guarantee sustainability-related attributes of products which are otherwise not verifiable for consumers during purchase or consumption (Kliem and Wolter, 2022).

[6] We recognize that the ecological context might also be a relevant environment that influences the diffusion (and availability) of new vegetable varieties indirectly (Nuijten et al. 2018). This includes issues such as regional soil conditions, regularly occurring crop diseases, or climate change impacts on agriculture. Since we focus especially on the diffusion of fresh produce, we largely neglect the ecological context in our analysis.

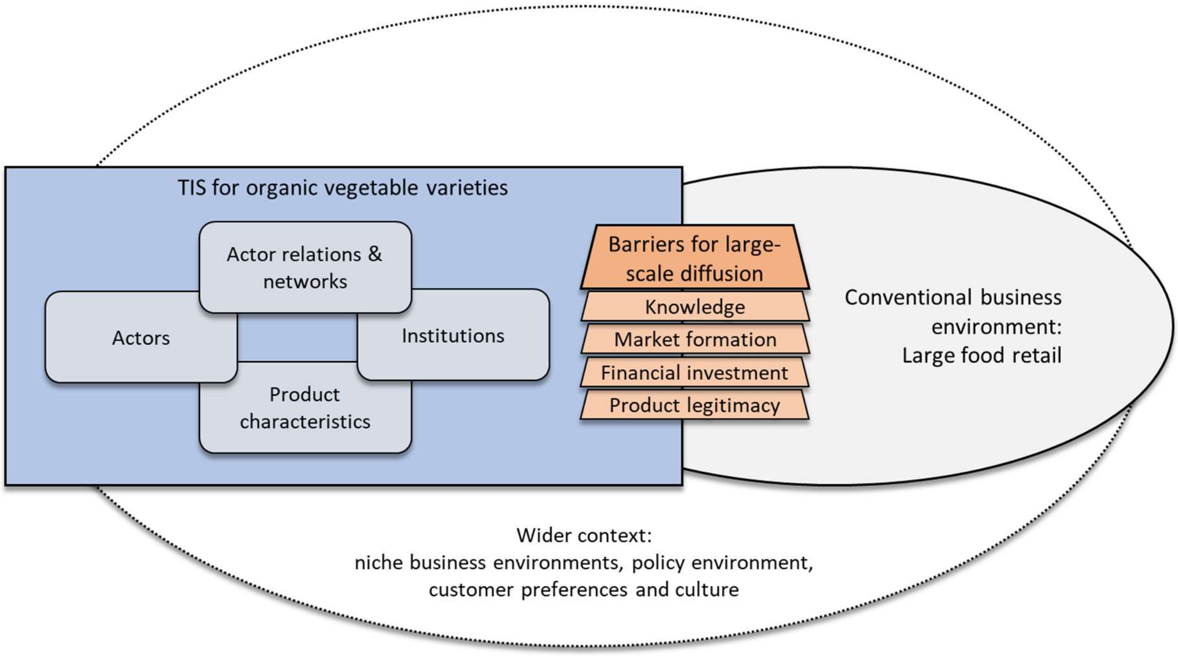


*Figure 3: Framework for analyzing barriers for the wide-scale diffusion of organic vegetable varieties (own figure).*

Figure 3 shows the resulting framework for our subsequent analysis. We hold that barriers for the wide-scale diffusion of organic vegetables can be located within the value chain of the TIS itself, within the business environment of large-scale food retailers and their wider context, and/or in the systemic relation and interplay between these elements. We use the TIS resources knowledge, market formation, financial investment, and product legitimacy as analytical categories to systematize the kind of barriers that exist. Persisting barriers in any resource dimension, or existing misalignments across multiple ones, might impede the uptake of the entire TIS (Hacker and Binz, 2021).

# 5. Empirical methods

To empirically identify diffusion barriers, we provide a qualitative case study of the TIS for organic vegetable varieties in Germany. This case study approach is commonly used in transition studies (Hansmeier et al., 2021), as it is well suited for understanding the complex and systemic processes driving or impeding socio-technical change (Sovacool et al., 2018). Since little research has so far been conducted concerning the diffusion of organic vegetable varieties, theory building and hence answering 'why' questions is required (Yin, 2018), for instance why organically bred vegetable varieties remain a niche phenomenon.

A total of 22 semi-structured expert interviews are our central source of evidence. In 2018 and 2019, interviews were carried out with representatives of a leading German organic breeding initiative and some of their associated breeders. The initiative has been active as a working group since the mid-1980s and became a registered association in the mid-1990s. Under this umbrella, the efforts of breeders and cultivators from around 30 farms are coordinated. Around 130 new varieties have already been developed and they are registered by the non-profit breeding initiative to protect them from enclosure. In 2022, we carried out additional interviews with intermediary distributors and buying agents from large food retailers to include the perspective of these crucial stakeholders from the conventional business environment into the analysis (cf. to Annex 1 for a detailed interview list).

To analyze the interviews, we conducted a qualitative content analysis of the transcribed material with the use of the MAXQDA software. Specifically, we followed a categorical deductive application proposed by Mayring (2014): We started by deducting a system of categories and subcategories based on our theoretical framework and research question. On a set of sample interviews, we then tested the category system and set up and refined definitions, anchor examples, and coding rules for each category. Each interview was analyzed and discussed by multiple researchers from our group to increase inter-coder reliability. The final category system, which was then applied to code all interviews, can be found in Annex 2 of this paper. In a workshop, we then clustered the results on diffusion barriers according to the structural components and the TIS resources. The interviews were carried out in German and mostly face-to-face. Subsequent quotes from the interviews were translated by the authors.

# 6. Results: Barriers for the diffusion of organic vegetable varieties

We now present the results of our empirical study. The barriers for large-scale diffusion of organic vegetable varieties in conventional food retail are analyzed around the TIS resource which they are most related to. The empirically identified barriers are summarized according to our framework in table 1. In each of the four subsections, we analyze in detail how structural TIS elements and contextual factors contribute to diffusion barriers related to knowledge, market formation, financial investments, and product legitimacy.

| | Knowledge | Markets | Investments | Legitimacy |
|---|---|---|---|---|
| **Actors** | • Organic breeders draw on diverse types of knowledge; not all adhering to (established) scientific methods and standards, but some based on intangible experiences. Modern (bio-technical, genome-based) breeding methods are rejected for ethical reasons<br>• Relevant stakeholders do not know or understand the concept of organic varieties | • Cultivators and farmers of organically bred varieties do not usually aim to market their produce to conventional food retailers, but rather to organic supermarkets | • Companies and initiatives in the organically bred seed TIS generally have few and limited financial and human resources | • Conventional supermarkets have other sustainability issues on their problem agenda (e.g. packaging) |
| **Networks** | • Little knowledge exchange and coordinated interaction between breeding community, vegetable producers, and buying experts from supermarkets | • Difficult to establish long-term and reliable cooperation between farmers and large buyers to remunerate breeding efforts | • Networking with financiers difficult, as organic breeding is not a known sustainability topic and complex to explain<br>• Established companies are reluctant to finance additional costs for organic varieties | • Additional value of organic varieties is lost and/or difficult to communicate across the value chain |
| **Institutions** | • Widespread norms and values in the breeding community (e.g. anthroposophy) result in use of rather subjective breeding methods which are not (always) backed scientifically<br>• Esoteric world view within breeding community inhibits a formulation of values compatible to a wider range of (sustainability) actors | • Breeding goals focus rather on ecological resilience, nutritional and (subjective) taste quality, and sustainability than on economic potential (divergent market logics)<br>• Economization and growth of organic vegetable sector decreases margins; less room for price mark-up on organic varieties<br>• Guidelines and regulations for variety approval and marketing are too strict and do not match the needs of organic breeders | • As the commons-based breeding community rejects variety protection, they cannot generate income from this revenue stream<br>• Economic survival in organic breeding community depends on scarce donations and public funding (e.g. for R&D) | • Lack of public labels that guarantee 'organically bred variety' as a product characteristic<br>• Entire sector views product characteristics of hybrid varieties as standard/norm<br>• Generally low appreciation for the value of (organic) food from customers; price as the de facto most important buying criteria |
| **Product Character-istics** | • Diminishing genetic variety (availability of old breeds) limits input for selection process<br>• Established knowledge on characteristics of potential input varieties for breeding is difficult to access | • Low agricultural yields from organically bred varieties<br>• High heterogeneity within organically bred varieties | • Using novel and more heterogeneous organically bred varieties is associated with increased (short-term) financial and economic risks for cultivators and farmers | • (Selection) characteristics of the organically bred varieties (e.g. resilience towards pest) do not match customer expectations (e.g. taste, appearance) |

*Table 1: Empirically identified barriers summarized along TIS resources and structural components (own table).*

## 6.1. Knowledge-related barriers

The most fundamental knowledge-related barrier to the diffusion of organically bred varieties is that relevant actors in the vegetable value chain have never heard of or do not understand the concept of organically bred vegetable varieties.

> *"I tried to do research on the subject [before the interview] and found very little... This is incredible because you usually find anything on the internet! [...] You don't hear much about these organic vegetables and if you know so little about it, the farmers are just not interested in it." (I_retail buyer01)*

This lack of knowledge applies not only to farmers and procurement managers, but also to customers. For most vegetables (with few exceptions, for instance potatoes or tomatoes), customers do not realize the existence of different varieties at all.

> *"As a procurement manager, I am not really aware of this subject. I would argue other competitors are neither. [...] I think many customers are indeed looking to buy organic vegetables, but not in the sense of organically bred. There might be few people who shop in the health food store, who really deal with this issue." (I_retail buyer02)*

Knowledge gaps are not surprising, as media coverage and research on this topic are scarce. TIS actors also lack a coherent and coordinated communication concept.[7] Interaction between the organic breeding community and conventional food retailers is also rare and arduous (I_breeder08). Because knowledge and collective awareness is limited as a system resource, farmers must constantly (re)establish contacts to and attention of food retailers to market their produce, which demands much energy (I_breeder03). This in turn restricts knowledge flows about organically bred varieties and growing conditions across the value chain (I_retail buyer01). This especially applies to imported vegetables from places like Spain or Italy, where wholesalers function as additional intermediaries (I_retail buyer03).

Breeding initiatives themselves also face knowledge-related challenges. This primarily concerns the development of novel organically bred varieties: The physical and legal availability of vegetable varieties for organic breeding is diminishing, for instance because powerful conventional breeding companies hold property rights on potentially suited input varieties. Knowledge on the characteristics

[7] Efforts are made regularly by organic breeding associations to raise awareness with their core customers, for example with the *'Kernkraft – ja bitte!'* campaign in collaboration with two German organic supermarket chains. However, coverage on these issues has not reached a wider consumer range.

of non-conventional vegetable varieties is also often limited and/or not easily or digitally accessible (I_breeder09).

The organic breeding process is not always entirely systematic and scientific (I_breeder03, I_breeder07). In part, this is caused by the lack of personal and financial resources (cf. section 6.3) and "*deficits [in scientific] knowledge and skills*" (I_breeder05). However, it is also caused by the norms, values, and goals shared among much of the breeding community. Many breeders follow an anthroposophical philosophy[8] which makes their approach and method of selecting plants for the breeding process less objective (I_breeder02).

> *"And so I select plants not only from the point of view of 'which has the most grains', but also whether I respond positively to them or not." (I_breeder02)*

Indirectly, this knowledge base influences the (economic) diffusion potential of the organic varieties. Breeding methods do not aim to optimize yields, making organically bred varieties less appealing to most farmers and food retailers and posing a competitive disadvantage vis-à-vis hybrid vegetables.

> *"Variety development is a creative activity, promoted by exchange and [...] hindered by overly strict specifications of profitability. If, [...] - as I learned in my former conventional company - every decision between two plots or two breeding lines must be based on what will maintain the profit [...], then this restrictive thinking hinders creativity. [...] Surprisingly, however, these companies are still creative and very successful." (I_breeder16)*

Yield potentials are directly related to the market potential of organically bred varieties in conventional food retail, as is discussed in the following section.

## 6.2. Market-related barriers

For the interviewed breeders, the main goal is the creation of varieties with ecological resilience and high (subjective) quality. Whether and to which extent these varieties cater to the market-logic demands of (conventional) farmers and customers is usually a secondary breeding target (I_breeder16) as "*profit expectations play a smaller role*" (I_breeder07).

> *"Take the example of cucumbers or outdoor tomatoes [...]. I don't just look at the suitability for commercial gardening. For instance, if I have extremely resistant lines, I continue them also. Even if I have to say, there are perhaps still too many with a bitter taste in it. Or no one*

[8] Anthroposophy is a spiritual and esoteric world view adopted by part of the stricter organic movement. It is especially popular in German-speaking parts of Europe. Anthroposophic concepts and methods in the agricultural sector can be subsumed as 'biodynamic agriculture'. The organic association *Demeter* is the largest certification organization in this sector.

*grows outdoor tomatoes in our climate anyway. But if I have something that [is so resistant], then I have to maintain it. So that I stay as diverse as possible."* (I_breeder04)

This approach to breeding is mirrored in the characteristics of the organic varieties. As mentioned above, they generally have smaller yields – 80 to 90 percent of what to expect from conventional hybrid breeds (I_breeder01, I_breeder03, I_breeder08). Furthermore, individual plants and their vegetables of the same organic variety show a greater heterogeneity – in their taste or growth rate, for instance (I_breeder09). This also makes these breeds less attractive to conventional supermarkets, which demand stable and reliable delivery volumes (I_retail buyer02) and seed cultivators, who then carry greater risks (I_breeder05).

Paradoxically, a growing market share of organically farmed vegetables in conventional stores (which are largely bred conventionally) is making it more difficult for the TIS around organic vegetable varieties to diffuse. This results from "*extreme price pressures*" (I_breeder16) on the organic segment in general, which more and more competes directly with conventional vegetables to be bought by consumers. In this institutional context of economization, procurement managers feel that organically bred varieties with further mark-ups on prices would not be appealing to customers (I_retail buyer02).

*"Rewe, Edeka and Penny now all want to play in the organic sector. At the same time, last year [the segment] no longer recorded double-digit growth for the first time [...]. Some buyers suddenly say, "We just have to concentrate on our day-to-day business now, let's not talk so much about non-hybrid seeds and stuff like that." [...] If economic circumstances are difficult, I have to secure my own livelihood before I go out on a limb and take new breeds of mine into production on my own farm, where there are more risks concerning harvest rates." (I_breeder03)*

Considering this business environment, many actors from the TIS do not even think of marketing (parts of) their produce to conventional food retailers and instead focus on direct distribution channels or target the premium segment of organic food retailers and health food stores (I_breeder03). On the demand side, conventional retail stores themselves could actively build-up awareness for these organic varieties. However, introducing new products is a resource-intensive and long-term process.

*"The important thing is the price, the taste, the quality, and the consistency of the item. If you have a vegetable that works well all year round, tastes good, and is relatively stable in price, we have won over the customer. Then, of course, the customer must learn to buy the item, which takes a lot of effort, usually money, and consistency." (I_retail buyer02)*

Therefore, introducing new organically bred products does not appear attractive to these powerful conventional food retailers and food processing companies in the current market environment (I_breeder03, I_breeder10). Proactive market formation via the demand side is thus limited.

Finally, guidelines and regulations for required variety recognition on EU level (DUS criteria) and marketing limit diffusion potentials (I_breeder03). Fulfilling the requirement of high uniformity of individual plants within a variety is particularly challenging for organically bred varieties, and can hence present an important barrier for distributing these seeds on the market (Tschersich, 2021). Registration and in particular needed field growing trials also require significant time and financial resources. Alternatively, varieties can be registered in a simplified procedure as amateur varieties. Yet these may only be sold in small packaging and along with the denomination of amateur varieties, this can significantly impair their marketing to commercial farmers (Tschersich, 2021).

## 6.3. Investment-related barriers

The market-related barriers show that the business model of most actors in the TIS for organic varieties is not economically viable in the dominant market environment and hence companies and initiatives have little financial resources. Restraints in terms of staff are associated with people – who are motivated by non-economic values – often working overtime for a small pay (I_breeder07, I_breeder17). These shortages in human resources, in turn, limit the ability of actors to strategically drive forward diffusion (I_breeder01) or attract public funding.

> *"On our farm, there is actually a half-time employer writing applications to foundations so that the farm can continue to run. This is simply a huge problem because this work cannot be used for breeding." (I_breeder06)*

Such funding from the public sector, non-profit foundations, or private donors is the most relevant source of income for organic breeding initiatives. From the perspective of these initiatives, the amount of this funding is not at an appropriate level (I_breeder14), compared to the public goods character, ecological value, and long-term assurance of organic agriculture. Particularly, financial resources for public research on breeding methods for new varieties are scarce, which presents a challenge also due to the long-term character of breeding (I_breeder01). Creating income from variety protection is not an option either, as such protection regulations stand against the commons-based norms of the breeding community. Organic breeders therefore join calls for a sort of basic income from the state as one solution to dissolve such financial dependencies (I_breeder09, I_breeder17). However, it does not appear that this option will be politically enforced in Germany in the (near) future (I_breeder04).

Established companies from conventional breeding possess far more financial resources, which could significantly drive forward progress in the development and diffusion of organic varieties. However, these companies currently *"don't jump at growing anything extra for organic agriculture"* (I_breeder03) and many TIS actors even fear such a scenario because of their fundamentally different values and necessary resources for competition (I_breeder07). As already alluded to in section 6.2, even food processors and buyers that already use organic varieties are reluctant to proactively finance additional costs and thus contribute resources to the long-term growth of the TIS (I_breeder03). Moreover, due to the complexity of organic breeding and its invisibility as a sustainability topic, the communication and interaction with potential financiers proves difficult. Also, cultivators and farmers are exposed to financial risks when using novel and heterogenous organically bred varieties.

> *"And the question is whether you get paid for the work you invest. And particularly cultivators bear this risk. Threshold values exist of the vitality in terms of quality, which is defined for each variety. And if you are one, two percent below, it's possible that the whole work was for nothing, that it's not usable. And this does not happen infrequently." (I_breeder05)*

Customers, retailers, or farmers co-financing breeding efforts by buying produce with dedicated labels could be an option, which would redistribute a share of the generated income to the breeding community (I_breeder09, I_breeder10). These models are framed as *Züchter-Cent* (Breeder-Cent) or *Saatgutfonds* (Seed-Fund). Whether such models work also depends on the evaluation, acceptance, and willingness-to-pay of customers and is analyzed in more detail in the following subsection.

## 6.4. Legitimacy-related barriers

To receive a positive evaluation from key stakeholders, especially consumers, organically bred vegetable varieties must be recognizable as such. Currently, they lack visibility in comparison to organic, fair-trade, or regional produce which all are marked by widely recognized labels and rank higher in customer's sustainability concerns (Kliem and Wolter, 2022). A label for organically bred and cultivated (vegetable) varieties does currently not exist. Hence, information about the added-value and ecologically and socially beneficial product characteristics are lost throughout the value chain (cf. to section 6.1). This de-legitimizes increased consumer prices for these vegetables.

On a broader scale, TIS actors lament that there is generally too little appreciation of the value of vegetables and food in general, and that customers are often unwilling to pay the appropriate price for food. Most consumers still rank price above all other attributes.

*"This is not a question of breeding, but a societal question. There needs to be a paradigm change. As long as German consumers only invest less than 10% [of their income] into food products, more appreciation of food cannot evolve. This is solely a matter of price. [...]" (I_breeder09)*

Different, partly divergent preferences and values along the value chain are a recurring topic. Product characteristics such as diversity or resilience, which are vital in the breeding community, are not compatible with the preferences of most customers, who look for tasteful vegetables with a flawless appearance (I_breeder09). Most consumers seem insusceptible to other added values and characteristics of organic varieties.

The additional value of organic varieties is difficult to communicate across the value chain and identified as one of the biggest challenges (I_breeder09, I_breeder10). The importance of breeding tends to fade into the background (I_breeder09). If comprehensive communication was successful and all actors understood and were aware of the challenges (e.g. lower yields, heterogeneity) and value (e.g. contribution to a healthy ecosystem) of organic breeding, this could legitimize higher prices. However, this necessary paradigm change (see above) is difficult to induce.

In contrast to organic varieties, product characteristics of hybrid varieties are seen as standard by the entire sector and taken for granted. This especially concerns farmers: "*You don't say that open-pollinating varieties are the standard. [...] No, hybrid varieties are 100% and everything else is below that*" (I_breeder10). Economic performance is of major importance, and this is, in the existing food system, only possible with high-yielding and uniform varieties. Besides, for conventional food retail it is crucial that farmers can deliver a specified, constant, and high quantity of vegetables because retail wants to sell as many product units as possible: "*Because of this, conventional fruit and vegetable varieties are popular among us. They are always available, fast to reorder, and processes and guidelines are not as complicated as for organic products*" (I_retail buyer01). This value-clash along the value chain makes it difficult for organic vegetable varieties to diffuse on the market.

Nevertheless, a clear tendency of rising awareness towards ecological challenges can be observed at the side of consumers and actors throughout the value chain. In the long term, this cultural shift might contribute to legitimizing the TIS for organic vegetable varieties in the conventional business environment. However, while conventional food retailers increasingly introduce sustainability units in their organizations, they are currently tackling other issues first (e.g. food packaging or animal welfare) and do not yet have organic breeding on their agenda (I_retail buyer02). This corresponds to environmental activist groups in Germany, who have not yet focused their strategic efforts and communication campaigns on the specific issue of organically bred vegetable varieties.

# 7. Discussion and conclusion

Vegetable varieties specifically bred for organic farming offer several social and ecological benefits, but their diffusion remains limited and their market share in conventional food retail is extremely low. In this paper, we conceptualized the supportive structures around organic vegetable varieties as a Technological Innovation System (TIS) and analyzed barriers for large-scale diffusion based on expert interviews with actors along the value chain in Germany. Our results show that important stakeholders – including buying agents at food retail stores and customers – lack knowledge and fundamental understanding of the benefits or even existence of organic vegetable varieties. At the same time, these varieties are currently not price-competitive compared to varieties grown from conventional hybrid seeds. Their additional value is difficult to communicate to consumers and retailers. This makes it challenging to legitimize higher prices, especially because a universally accepted label for organic varieties does not exist. Proactive market formation through retailers or investors is limited. Furthermore, organic breeding initiatives lack resources to solicit for shelf space in conventional food retail or investments from private donors. They often deliberately specialize in catering to the niche demand of highly environmentally conscious customers, thus reinforcing the stagnating growth of the TIS for organic vegetable varieties.

This empirical study adds an exceptional case to the literature on sustainability transitions, where most of the commonly investigated technologies experienced a rather quick diffusion over the last decades (Bento and Wilson, 2016). Contrarily, the wide-spread diffusion of organic vegetable varieties has not yet taken up and this sustainability innovation remains a relatively stable niche within the transitioning agri-food sector. Overall, our qualitative analysis of these barriers thus respond to recent calls for "more research on the less successful diffusion processes in the agriculture [and] food […] sector" (Fichter and Clausen, 2021, p. 47). Furthermore, the study contributes an innovation system perspective with an explicit focus on market diffusion to the emerging debate on organic breeding and Seed Commons (Sievers-Glotzbach et al., 2021; Tschersich, 2021).

Most of the interviewed representatives from organic breeding initiatives do not actively seek to market their products to conventional food retailers. This raises the question whether large-scale diffusion is even a goal desired by breeders and farmers; especially because diffusion in conventional retail would likely require fundamental changes in TIS institutions (profit-oriented thinking) and product characteristics (breeding focused on yield increases) – hence leading to a "fit-and-conform" dynamic, aligning the TIS to dominant contextual structures (Smith and Raven, 2012) and the standardized valuation in the food retail sector. This opens a dilemma: Because of the deep value-orientation within the commons-based breeding community, large-scale diffusion seems an unlikely scenario. Moreover, adhering to the dominant institutional logics of growth and materialism could limit the transformation potential. However, the TIS needs some growth and diffusion, as actors consistently lament shortages in (financial and human) resources and investments. Furthermore, organically bred varieties aspire to address and solve multiple sustainability-related challenges in agriculture, such as resilience towards climate change or pests, better yields under extensive and low-input organic farming, or an increase in agrobiodiversity. As to unfold, these benefits need organic vegetable varieties to be cultivated at a wider scale. For this to happen, a “stretch-and-transform” dynamic would be more impactful (Smith and Raven, 2012). In this scenario, contextual institutions are adjusted to suit the new varieties. Overcoming lock-ins, routines, and resistance from powerful incumbents in food retail requires mobilization from sustainability-oriented action groups and policy makers as well as a cultural shift in the preferences and willingness to pay of customers shopping at conventional retail stores.

Our analysis suggests that a growing organic market in general might even constrain the diffusion success of organic vegetable varieties in the short term, because customers, activists, and other stakeholders currently focus on other sustainability-related challenges, such as reducing meat consumption or consuming organically grown vegetables. Selling, marketing, and consuming organically bred varieties is less of a focus. We hypothesize that certain baseline sustainability innovations must become clearly established and reach wide market shares first before innovations that are more complex and are of a ‘higher-order sustainability’ have a chance to pick up diffusion. Analogous examples from the (widely analyzed) electricity sector could be technologies and business models like prosuming, contracts for certified ‘regional electricity’, or sector coupling technologies such as hydrogen. These have existed for decades but might only pick up growth once the transition has progressed enough so that core technologies (PV-modules, wind power) have diffused sufficiently and companies, regulators, and customers turn their attention to other, more complex TIS in the sector. Similar discussions took place in the past concerning organic food in general (Latacz-Lohmann and Foster, 1997), which remained a stable niche for a long time. Future studies could compile more empirical examples of such phenomena. A systematic comparison of these stable niches across sectors and countries would unveil the potential existence of common patterns that prevent long existing sustainability innovations to widely diffuse into conventional market environments.

Our focus on barriers for diffusion should not leave readers with an impression that is too bleak or pessimistic regarding the prospects of organic vegetable varieties. On the contrary: Studying existing diffusion barriers makes it possible to identify concrete and realistic leverage points for breeding initiatives and policy makers that wish to facilitate the diffusion of organic vegetable varieties. Apart from targeting diffusion in conventional food retail, actors in the organic vegetable variety TIS should continue to individually market their product in niche business environments, e.g. farmers markets or marketing seeds to amateur gardeners. But collectively, TIS actors should be encouraged to further develop a coherent and forceful marketing campaign to communicate the existence, benefits, and characteristics of organic vegetable varieties to farmers, wholesalers, food retailers, and policy makers. Creating this knowledge is the first step of raising awareness among powerful decision makers in the downstream value chain. Breeding initiatives should also aim to draw activists to their cause, as these two groups could jointly increase market awareness through complementary and mutually strengthening tactics (Enthoven and Thelken, 2022). It might be an option to build communication campaigns around one or two flagship varieties, where customers already expect a certain diversity (e.g. tomatoes). Ultimately, a clearly recognized label (set up by the state or by collective food retail) would need to be established that helps legitimize higher costs. This could also be linked to profit sharing agreements with breeders, who lack income from variety protection licensing. Such supply chain partnerships are already discussed and tested in the food sector (Schäfer and Messmer, 2018). Considering these potentials, organic vegetable varieties do not necessarily have to stay forever niche – their ecological benefits prove an important puzzle piece in the transition towards sustainable food and agricultural systems.

# Annex

## Annex 1 – List of interviews

| Interview code | Representative of | Date of interview |
|---|---|---|
| **I_breeder01** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder02** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder03** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder04** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder05** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder06** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder07** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder08** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder09** | TIS for organic vegetable varieties | Jan 18 |
| **I_breeder10** | TIS for organic vegetable varieties | Sep 19 |
| **I_breeder11** | TIS for organic vegetable varieties | Sep 19 |
| **I_breeder12** | TIS for organic vegetable varieties | Sep 19 |
| **I_breeder13** | TIS for organic vegetable varieties | Jul 19 |
| **I_breeder14** | TIS for organic vegetable varieties | Jul 19 |
| **I_breeder15** | TIS for organic vegetable varieties | Jul 19 |
| **I_breeder16** | TIS for organic vegetable varieties | Jul 19 |
| **I_breeder17** | TIS for organic vegetable varieties | Jul 19 |
| **I_breeder18** | TIS for organic vegetable varieties | Sep 19 |
| **I_breeder19** | TIS for organic vegetable varieties | Sep 19 |
| **I_retail buyer01** | Conventional food retail | Feb 22 |
| **I_retail buyer02** | Conventional food retail | Feb 22 |
| **I_retail buyer03** | Conventional food retail | Feb 22 |

# Annex 2 - Codesystem

| **Code** | **Subcode** |
|---|---|
| TIS | Actors |
| | Networks |
| | Institutions |
| | Product characteristics |
| Value chain | Breeding of (novel) vegetable varieties |
| | Seed production and marketing |
| | Cultivation |
| | Intermediation |
| Context | Conventional food retail |
| | Customer preferences and culture |
| | Policy environment |
| | Niche business environment |
| | Power |
| Resources | Knowledge (creation and diffusion) |
| | Market (formation) |
| | (Financial) investments |
| | Legitimacy (product legitimation) |
| Dynamics | Drivers for development (of organic varieties) |
| | Barriers for development (of organic varieties) |
| | Drivers for diffusion (of organic varieties) |
| | Barriers for diffusion (of organic varieties) |

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