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RESEARCH ARTICLE

Understanding the role of value chain formation in the scaling of crop diversification

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Abstract

Significant detrimental effects of agricultural intensification and specialization are becoming increasingly evident. Reliance on monocultures, few varieties, and intensive use of agrochemicals is a major factor in climate change, biodiversity decline, soil health deterioration, and pollution, putting our food system at risk. This requires sustainable agricultural processes, such as crop diversification, to be more rapidly and effectively tested, adopted, and scaled. While these processes are typically introduced at niche level, they often struggle to scale and to induce broader sustainability transitions. In this study, we investigate how scaling may occur, focusing on institutional logics, their changes, and realignment over time. In particular, we applied an abductive research strategy to collect empirical evidence from two in-depth, longitudinal case studies of innovation niches related to crop diversification. Doing so, we show for the first time that, despite their many differences, scaling processes of crop diversification in both niches converge, presenting similar progressions in terms of institutional dimensions, and facing similar obstacles when it comes to value chain formation. While initial experimentation could still be implemented using organizational forms familiar to the lead actors, we discover that a systemic lack of adequate value chain arrangements obstructed the scaling process of crop diversification in both cases. These findings have been used to reflect on the role of value chain relations in scaling processes in sustainability transitions in agriculture.

Keywords Crop diversification · Value chains · Sustainability transitions · Innovation niche · Institutional logics

1 Introduction

Increasing diversity in agricultural systems is now considered a starting point to mitigate the negative effects of agricultural intensification and specialization on climate change, biodiversity decline, soil health deterioration, and pollution (Meynard et al. 2018; Lanz et al. 2018; Rockström et al. 2020). Crop diversification, for example through crop rotation and/or intercropping, is increasingly seen as a process to support transitions towards more sustainable food systems (Bonke and Musshoff 2020; Gurr et al. 2016; Rodriguez et al. 2021; Struik and Kuyper 2017; Wezel et al. 2020), playing a significant role in many approaches targeting more sustainable agriculture, such as organic agriculture, ecological intensification, and agroecology (Duru et al. 2015; Garibaldi et al. 2019; Migliorini and Wezel 2017; Therond et al. 2017). Crop diversification targets the increase of the number of different crop species in the same plot of land in a given timeframe. As such, it provides several potential benefits, including increasing agro-biodiversity, decreasing the incidence of pests and diseases, enhancing carbon and water sequestration, and improving soil health and structure (Bedoussac et al. 2015; Ditzler et al. 2021; Magrini et al. 2016; Watson et al. 2017). In particular, when crop diversification is associated with the (re-)introduction of legumes in a farming system, their nitrogen fixation properties reduce the need of chemical fertilization, and thus reduce pollution and eutrophication (Bedoussac et al. 2015).

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Source: The authors

Fig. 1 Targeted rotation in BSF case: clockwise: tomato, peas, and wheat straw after harvest (left) and diverse crops in EDL case; clockwise: lupines, potatoes with flower strips, flax (right). The crops shown here are examples of the wide variety of crops from which the EDL farm builds its rotations.

These benefits are recognized by recent EU strategies on climate and biodiversity vocally supporting both crop diversification generally, and increased production of legumes in particular (European Commission 2018, 2021). Despite the recognition of its benefits, and the political support, in the European context, crop diversification remains a process confined to so-called niches, where innovations are developed and tested at a small scale (Duru et al. 2015; Geels 2019; Ingram 2015). In recent years, the investigations of enablers and barriers for scaling these niches, for example at a territorial or value chain level, have provided novel insights, but the scaling process is still far from being fully understood (Ingram 2015; Magrini et al. 2016; Meynard et al. 2018; Morel et al. 2020). In fact, scaling niches in agricultural and food systems is considered a relatively complex endeavor (Boulestreau et al. 2021; Wigboldus et al. 2016; Wojtynia et al. 2021), and in the case of crop diversification touches upon many dimensions, including policies, markets, value chains, and farm management (Magrini et al. 2016; Meynard et al. 2018; Voisin et al. 2014). Accordingly, farmers cannot be considered to be in full control of the crop diversification process beyond the innovation niche level (Bonke and Musshoff 2020; Boulestreau et al. 2021), particularly when value chain formation, i.e., the creation of novel market outlets and relationships for their products, is needed. Hence, the interplay between scaling and value chain formation is an essential aspect to understand in order to stimulate wider sustainability transitions in agricultural and food systems (Meynard et al. 2018). This remains a key theme to investigate, and constitutes a still relatively less explored field of inquiry.

Given this background, this study focuses on scaling of innovation niches engaging with processes of crop diversification. More specifically, in our analysis, we look at *how* innovation niches develop *over time*, paying special attention to the barriers and enablers of scaling crop diversification related to value chain formation dynamics (Meynard et al. 2018; Weituschat et al. 2022). Drawing on extant literature, and in order to further enrich it, we have gathered empirical evidence from two longitudinal case studies: on one hand, we collected data related to a project of crop diversification implemented within the wider *Barilla Sustainable Farming* (BSF) initiative. In this project, crop diversification has been introduced by farmers in the north of Italy (see Fig. 1, left), supporting a socio-ecological innovation process in an existing industrial value chain where the Barilla Food Company is involved as a main buyer, and representing a case of a company-led diversification process. On the other hand, we collected data from the *Ekoboerderij de Lingehof* (EDL) initiative in the Netherlands, a bio-dynamic farm and community-led approach where the process of crop diversification has originated at farm level (see Fig. 1, right), but quickly stimulated the need for formation of new value chains. Despite their differences in terms of socio-ecological and institutional conditions, in both cases, we observed actors engaged in the attempt to scale crop diversification through value chain formation dynamics.

In the next section, we present and discuss this methodological strategy in further details. We introduce the conceptual and analytical approach first, particularly focusing on the role of institutional logics in sustainability transitions (Fuenfschilling and Truffer 2014). Then, we present and discuss the findings and develop the discussion section, where results are conceptualized in relation to scaling of crop diversification and sustainability transitions. Finally, in the last section, we present the main concluding remarks of our study.

2 Materials and methods

In this section, we present our abductive research strategy. Usually, an abductive strategy is motivated by the need to explain a surprising set of evidence, given extant knowledge, or the initial theorization of researcher(s) (Schurz 2008; Philipsen 2018). In our case, the starting point was the realization that the crop diversification processes in the selected case studies were expected to be rather different. To our surprise, they presented evidence of several similarities, for instance in terms of value chain formation dynamics in their scaling attempts. Given the different objectives and contexts of the two projects, this was genuinely a puzzling outcome. The literature on sustainability transitions, in this case, offered a conceptual framework to begin with, but it did not offer an effective and clear pathway to understand the convergence of and similarities between these cases. Therefore, the need to expand extant knowledge became evident during the analytical process, a condition typical for abductive research (Schurz 2008; Philipsen 2018). Since the initial conceptualization failed to explain our empirical observations[1], the research team embraced the abductive approach, and moved into exploring a more suitable conceptualization, digging more decisively in the literature on scaling and innovation niches, and mobilizing the notion of institutional logics, using the latter as the theoretical lens for its conceptual framework (as presented in section 2.1). The research team then moved into a new analytical stage, re-engaged with the empirical evidence, and went back and forth, interactively, with this conceptual framework to suggest a new conceptualization of the process of scaling in relation to value chain formation dynamics (see Sections 3.1 and 3.2). In what follows, we further present and discuss the stages of our abductive research approach.

2.1 Conceptual framework

In line with an abductive strategy, the conceptual framework we present in this section has emerged in stages and through iteration between conceptualization and data analysis. Initially, our investigation engaged with extant literature on innovation niches and sustainability transitions in agriculture, while subsequently we have focused particularly on institutional theories. In fact, our starting point was to identify projects facilitating adoption and scaling of crop diversification processes as innovation niches in sustainability transitions. In literature, sustainability transitions refer to fundamental, purposive changes to fulfil societal functions more sustainably (Geels et al. 2016; Vermunt et al. 2020). Niches are defined as protected spaces in which actors (e.g., farmers) experiment and test novel practices, in response to pressures and opportunities in their wider societal and ecological context (Hermans et al. 2016; Ingram 2015). While in some cases actors operating in the niche do not intend to scale their innovative practices (Belmin et al. 2018), in other cases there is the expressed aim for the actors to scale beyond the niche, and trigger a broader shift in practices and technologies (Geels et al. 2016; Ingram 2015; Meynard et al. 2017). Scaling is here understood as increasing the number of actors (willing to) engage with a socio-ecological change. While scaling can initiate a sustainability transition, there is debate about the conditions that enable this process to happen (Pigford et al. 2018; Wigboldus et al. 2016), particularly around institutional factors (Berthet and Hickey 2018; Hermans et al. 2016; Meynard et al. 2017). Scaling is a non-linear process, entailing tensions and negotiations between the involved actors (Fuenfschilling and Truffer 2014; Geels 2011). When tensions and negotiations are too severe or complex, or actors are misaligned, scaling does not occur, nor are transitions triggered (Wojtynia et al. 2021).

Extant scholarship suggests that these tensions and negotiations are guided by the (changing) institutional logics under which actors in an innovation niche operate (Fuenfschilling and Truffer 2014; Thornton and Ocasio 1999). Institutional logics are defined as "the socially constructed, historical patterns of (material) practices, assumptions, values, beliefs, and rules," both formal and informal, which "guide and constrain decision makers in accomplishing the organization's tasks and in obtaining social status, credits, penalties, and rewards in the process" (Thornton and Ocasio 1999, p. 804). Therefore, focusing on institutional logics mobilized by the different actors involved in the specific innovation niche can help scholars investigate scaling processes, particularly in contexts of sustainability transitions. In our conceptualization, the scaling process is expected to be influenced by the institutional logics guiding actors to introduce rotation practices. Fuenfschilling and Truffer (2014) suggest to explore *values*, *mission*, *technology*, *actors*, *expertise*, *funding*, and *organizational form* as key dimensions of institutional logics (see Fig. 2). In our study, we found this suggestion particularly useful in order to operationalize institutional logics and facilitate their empirical analysis. In this approach, farmers engaged in an innovation niche can be driven by different sets of *values and mission* which motivate why they are interested to implement and scale diversification processes. These values and missions may be focused on protecting the environment, increasing biodiversity, improving soil health, maintaining productivity, and/or increasing profitability. Based on their values and missions, they will identify which *technologies and practices* to use and mobilize, such as adopting new crop rotations, new machinery, or IT systems. In this approach,

[1] We, for example, tested a framework of system design based on Buchanan (2019), which failed to sufficiently explain our observations.

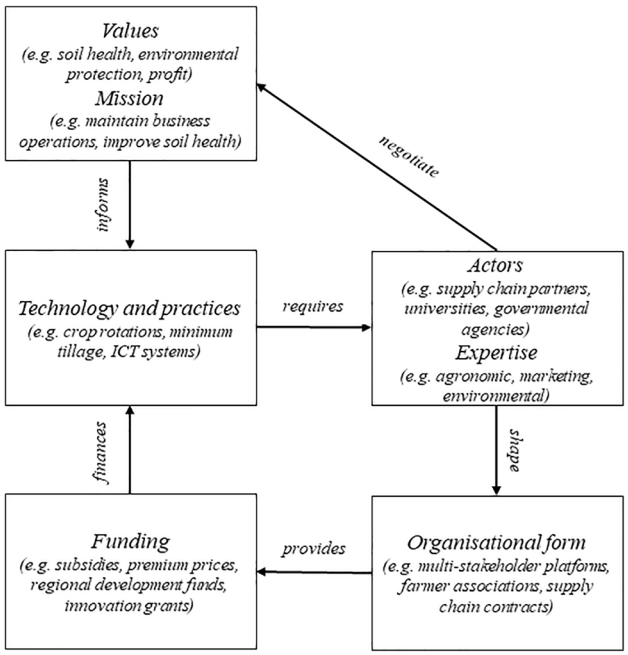

Fig. 2 Proposed relations between key dimensions of institutional logics. Source: Adapted from Fuenfschilling and Truffer (2014).

technologies and practices include (farming) techniques, such as crop rotations, intercropping, or precision fertilization. To identify and experiment with these technologies and practices, additional *expertise* may be needed. This expertise might be in terms of agronomic knowledge, understanding of environmental effects, or financial considerations. In order to acquire or develop this expertise, farmers may network, collaborate, and/or engage with other *actors*, such as research institutes, policy makers, and value chain partners. Crucial to the experimentation with novel technologies and practices is the *funding* mechanism that may be internal or come from external parties, such as subsidies or innovation grants from governmental agencies or investors. Yet, in order for both long-term viability and scaling of the experimented technologies and practices, funding mechanisms will need to be internalized through forms of commercialization, which will require new *organizational forms at value chain level*, such as new contractual arrangements, professional associations, or partnerships, providing the long-term funding mechanisms needed for scaling.

The suggested conceptual framework (Fig. 2) offers an opportunity to identify the key relations emerging from the investigated innovation niches, namely the BSF and EDL projects, and to support the abductive analytical strategy accordingly. More specifically, we used this lens of institutional logics, and related dimensions, as it offered the research team key analytical categories that could be observed over time, and highlighted the missing pieces of scaling processes. The following section describes the methodology that informed this conceptual approach in further details.

2.2 Research strategy and context

In line with our analytical strategy, initial data collection was targeting actors (e.g., farmers) experimenting with crop rotation practices in two cases resembling the typical features of innovation niches. In particular, the aim was to observe and reconstruct the temporal process of scaling, and to identify the role of value chain relations in this process. The team followed an in-depth case study methodology (Eisenhardt et al. 2016; Eisenhardt and Graebner 2007), and designed the research to seek a long-term engagement and commitment from and to these case studies. We had the opportunity to select two case studies, as part of an EU-H2020 funded project, Diverfarming, in which the research team had been involved since its initiation (Diverfarming 2017). Specifically, we selected a project supported by the *Barilla Sustainable Farming* (BSF) initiative, in the north of Italy, and a project initiated by the farm *Ekoboerderij de Lingehof* (EDL), in the Netherlands. Both cases described the establishment of crop diversification processes, including the introduction of legumes in crop rotation as the key innovative practice. However, the contexts of the two projects were quite different.

On one hand, the diversification project related to the BSF initiative was initiated in the 2000s by the Barilla Group, a family-owned, multinational food processing company with its headquarters and majority of operations in Italy (Barilla 2021c). It involved farmers already engaged in commercial activities in the Barilla value chain. The BSF initiative's aim was to promote the company's brands, while simultaneously securing high-quality raw materials, and improving resilience and productivity of the farming systems contributing to its supply. While the company's main focus was to improve the sustainability of their own supply chains, the BSF initiative revealed that to do so, often the entirety of farmers' cropping systems needed to be considered, and diversified. Since the beginning of the BSF initiative, Barilla aimed to work with their supply chain partners, e.g., aggregators, storage centers, and producer organizations, to identify small groups of farmers, in different areas, keen to experiment with novel practices. For the purpose of this research, the team focused on one specific project within BSF in which farmers located in the north of Italy (i.e., Emilia-Romagna, Lombardy, Piedmont, and Veneto) were attempting to rotate soft and durum wheat with tomatoes and peas (illustrated in pictures in Fig. 1). For many of these farmers, this was the first time to test crop rotations with legumes, given the existing industrial value chain in which cereal and wheat production is dominant. While such crop rotations have

been more widely adopted since, it initially started with niches of small groups of farmers, (Barilla 2020, 2021a, 2021b). Thus, while the company Barilla itself, given its size and global reach, is unlikely to be considered a niche, this specific project within the BSF initiative is an innovation niche. In line with the definition of a niche innovation, practices were initially tested at small scale and those evidencing positive results were selected, and scaled to other areas and supply chains, e.g., through adoption of codes of conduct (e.g., the Barilla Sustainable Farming Handbook), decision-support systems, and contractual agreements (Barilla 2020, 2021a, 2021b). Barilla is not alone in this type of approach but in fact represents a wider trend in agribusiness, where large multinational companies have committed to experiment with sustainable practices and processes through multi-actor and value chain-based strategies (e.g., Ellen MacArthur Foundation 2022a, b; Sustainable Agriculture Initiative Platform 2022), and thus face the need to coordinate multiple sourcing streams, raw material buyers, and other food companies, which poses a novel and unique challenge to scaling processes.

EDL, on the other hand, represents a case of a niche farm, encompassing approximately 100 ha, in the region of Gelderland, Netherlands (Ekoboerderij de Lingehof 2020). The farm currently carries biodynamic[2] and organic certification and delivers their crops to regional, national, and European buyers. Since its establishment, EDL farm managers considered agroecological principles and particularly the enhancement of soil health as a defining factor in crop rotations and in diversification processes, which eventually extended to approximately 10–15 different crops each year. Rotations are now 6 to 7 years long and include 2 consecutive years of clover for soil restoration, grains, and vegetable crops like pumpkins and cabbage. However, root crops like potatoes and onions, which are heavier on the soil, still played an important role in rotations. To further balance pressure on the soil, EDL farm managers aimed to give legumes, such as lupines, a more regular role in rotations. Driven by their own ambitions, and with the interest of other farmers, who were also involved in the biodynamic and/or organic movements, EDL engaged with supply chain partners, such as buyers and large retailers, interested in expanding their sourcing from organic producers. In particular, the commercialization of legumes, such as lupines, triggered an interest for scaling crop rotations to other farming systems, and to work together with other farmers to achieve critical mass of production[3].

[2] Biodynamic agriculture assumes the farm, soil, and ecosystem to be a living organism, and diversity in rotations with a focus on soil health is a key factor in biodynamic farming. Sources: Biodynamic Association (2022); Demeter (2021).

[3] Further information on the case studies is presented in the Appendix.

2.3 Data collection

In line with the abductive strategy, an iterative and longitudinal process of data collection and analysis was undertaken (Philipsen 2018). Data was primarily collected using in-depth, semi-structured interviews with farmers (EDL) and company managers (BSF), who were asked to describe the origin of the innovation process, its key features and activities, and how these changed over time. The structure and key elements of the interviews were adjusted, as necessary, to each interviewee and context[4]. Moreover, to enrich our primary data, interviews with actors related to the activities in the innovation niche, e.g., value chain partners (farmers and aggregators for BSF and buyers for EDL), and observational data were collected. All interviews lasted between 1 and 2 h and were conducted within the timeframe of 2016–2020. The two EDL managers were interviewed during periodic farm visits (approximately once a year) and project meetings (approximately twice a year). Three of the Barilla managers involved in the project (Global purchasing manager, Agronomy R&D manager, Sustainable Farming specialist) have also been engaged in regular meetings, on average one every 3 months, and interviewed in the early stage of the project, during the mid-term review (2018) and towards the end of the data collection (2020). Singular interviews were conducted with additional company managers (see Table 1). These engagements and interviews were conducted in English since the interviewees were proficient in this language. However, there was always at least one researcher present who spoke the native language of the interviewee (Dutch or Italian), in order to clarify or translate terms if needed. For the BSF case study, we also conducted two focus groups with farmers and suppliers in Italian. Finally, we integrated and triangulated information from the cases with secondary data according to the specific needs suggested by evidence from the field (Eisenhardt and Graebner 2007). Both cases had an inventory of documents and information related to their key activities, as well as a website. Table 1 reports an overview of all consulted data sources.

2.4 Data analysis

We manually coded the contents of interview and meeting transcripts and notes, and triangulated with a comprehensive collection of documentary data (see Table 1 above). In line with the abductive strategy, and consolidated practice in qualitative case study analysis (Eisenhardt and Graebner 2007), the conceptual framework presented in Fig. 2 provided the final thematic codes for both primary and secondary data (see Fig. 3). As common and often

[4] An example of an interview guide is presented in the Appendix.

Table 1 Overview of data sources.

Category	Barilla Sustainable Farming	Ekoboerderij de Lingehof
Interviews	Global purchasing manager (GPM) Agronomy R&D manager (ARD) Purchasing director for raw materials (PDM) Sustainable Farming specialist (SFS) Marketing manager (MM) Brand equity manager (BEM) Purchasing soft wheat manager (PSW)	Farm manager (1) (FM1) Farm manager (2) (FM2) Value chain partner 1 (SCP1) Value chain partner 2 (SCP2)
Observations	Internal strategic meetings (ISM)	Farm visit 1 (FV1) Farm visit 2 (FV2)
Focus groups	Famers focus group Parma (FGP) Suppliers focus group Parma (SFG) Jeffersonian dinner Parma (JDP)	Jeffersonian dinner Wageningen (JDW)
Documents	Barilla Sustainability reporting inventory (BSI) Reports and presentations on sustainable raw material initiatives related to crop diversification (SRMI) Barilla strategic reporting (BSR)	Report – Lupine project (LPR) Presentation – Crop rotation design Diverfarming Wageningen (CRDW)
Secondary data sources	MSc thesis reports Academic papers Barilla corporate website	Farm website repository

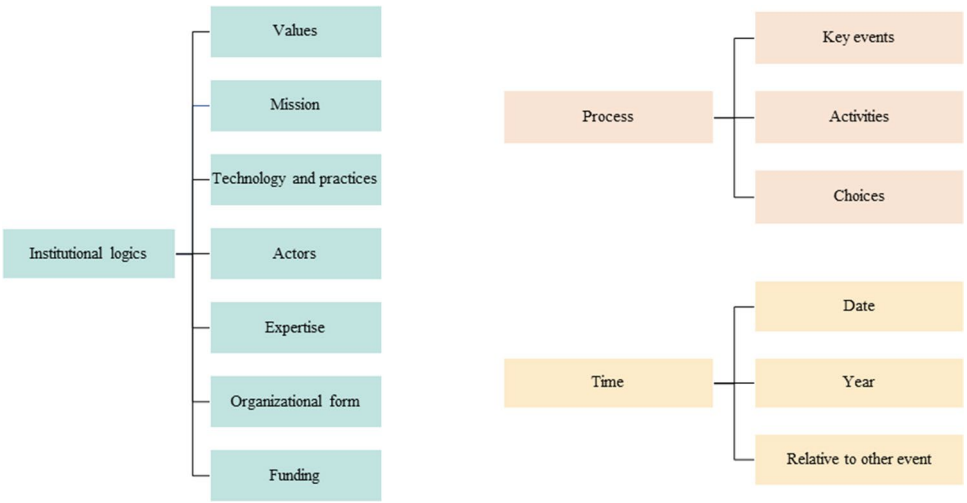

Fig. 3 Coding trees based on final conceptual framework. Legend: left to right: in blue, codes referring to the seven dimensions of institutional logics adapted from *Fuenfschilling and Truffer* (2014); in light red, codes referring to the process-related dimension of our analysis, namely key events, activities and choices made by farmers and institutional actors. In light yellow, the time-related codes of our analysis, answering the analytical question of 'when events happened'. Three set of codes have been identified: a point-time event related to a specific date, a timespan related to a given year, and any other point-time relative to a specific event.

needed in abductive research, the conceptual framework was not finalized until after data collection, and interview guides were thus not specifically aimed towards the given dimensions. Instead, once the pattern was recognized, we purposefully analyzed and categorized all data sources for indications of and relations between the different dimensions of institutional logics indicated in our conceptual framework, namely values, mission, technologies and practices, actors, expertise, funding, and organizational form. At the same time, we organized these codes and their respective extracts in chronological order, using a process analysis approach, thus creating a timeline of key events, activities, and choices (Langley 1999), accounting for coherence, tensions, and changes of the identified institutional dimensions and relations in the two cases. Based on this process reconstruction, we identified temporal stages characterizing the scaling process in the two niches. We describe the identified institutional logics at play in each of the case studies and discuss how the order of key events creates specific institutional dynamics. Results

Table 2 Overview of changes in dimensions informing each innovation niche.

	Institutional dimensions	Barilla Sustainable Farming	Ekoboerderij de Lingehof
Stage 1	Values	"Good for you, good for the planet": While the collection of values remained the same, there was a shift towards more emphasis on environmental sustainability and productivity of its supply base.	"Artisan of the soil": Shift from organic farming and maintaining soil health to focus on restoring and improving soil as a living organism (biodynamic).
	Mission	Maintaining or improving business operations remains central, yet there was a shift in recognizing that improving soil fertility and farm productivity is necessary for that mission in the long run.	Shift towards improving on-farm soil health and ecosystem, while maintaining the financial viability of the farming business, recognizing the trade-off when it comes to cash crops.
Stage 2	Technology and practices	Introducing e.g. **legumes or oil seeds in an at least 3 to 5-year crop rotation with cereals**, supported by decision support system.	Combining **cash crops** (e.g. potatoes and onions) **with rest crops** (e.g. legumes) **in a long, 6 to 7-year crop rotation,** supported by new weeding machinery.
	Actors	Shift to closer engagement with and consultation of stakeholders, incl. farmers, associations, storage centers and brokers, other food companies trading complementary crops, enabling actors (e.g. NGOs, universities, extension services).	Shift to closer engagement with other farmers, suppliers, brokers, associations, certification bodies, consumers.
Stage 3	Expertise	Agronomic expertise: shift from internal R&D to cooperation with universities, and expertise of the value chain: based on purchasing department and value chain partners → shift from internal to joint expertise	Agronomic and financial expertise: own experimentation and mutual advice with farmer group, cooperation with university, shift from internal to joint towards sharing of expertise, e.g. on legume production with others
	Funding	Initially internal funds are complemented with external funding from e.g. EU research projects, but for scaling funds need to be rooted in the value chain	Experimentation supported by research projects and regional development funds, but for scaling needs premium prices for biodynamic crops
	Organizational form	Multi-stakeholder partnerships for consultation and experimentation but for scaling needs value chain formation through contract farming	Long term verbal contracts work for most crops but for scaling needs value chain formation incl. associational/collective contracts

were validated by respondents from each case study. The quotes used are marginally adjusted for conciseness and readability.

3 Results and discussion

3.1 Findings

In this section, we present a detailed account of the institutional logics and their chronology as emerging from our data analysis. We have identified common stages characterizing the temporal development of both niches, and identified the key "turning points" of their scaling pathways, from project to value chain level. First, Table 2 summarizes the changes in the institutional dimensions as they occurred across the different stages of the scaling process. Then we discuss each stage of the scaling process in more detail, relating them to the different dimensions of institutional logics, according to the conceptual background presented in section 2.

3.1.1 Stage 1—Commitment to values and mission leads to changes in technologies and practices

We now present each stage in Table 2 in more detail, relating it directly to our primary data. In stage 1, in both innovation niches, the process of engaging with crop diversification started through the need of reconsidering the set of values of the involved organizations. BSF was launched in the early 2000s with the aim of learning about the environmental footprint of the Barilla Group's sourcing, production, and value chains (Blasi et al. 2015). Initially, the company focused on life cycle assessments of its products, which highlighted the need to engage with the supply chains' agricultural production (Blasi et al. 2015). Subsequently, the company engaged in the design of a systemic initiative:

> We looked at our values – good for you and good for the planet [the company's mission statement] – and we thought we were not always consistent. We needed a long-term view, and to mobilize ideas and create conversations from the retailing shelves to the farmer's gate, and beyond [ISM]

BSF was soon defined as a strategy to re-shape the wider sourcing of the company, connecting it more closely to its core values, and re-embedded in a place and locality, and working more closely with farmers and local suppliers.

> Reference to the Mediterranean diet has been always very important in our business values. We recognized that this starts by looking carefully at the sourcing of your raw materials [PDM]

The BSF initiative had started with a shift in the strategic focus of Barilla, as captured in their corporate motto "good for you, good for the planet." When confronted with the need to operationalize this vision, the company needed to re-think its value chain organization more profoundly. The company was already confronted with issues of reduced productivity, coupled with increased uncertainty for sourcing raw materials, like cereals, both nationally (from Italian farmers) and globally. The (re-)commitment to the company's stated values and mission led to these institutional dimensions being more firmly implemented as guiding principles. Since these principles were previously not fully aligned with current practices, this re-commitment led not only to the re-shaping of the marketing of the company's products, but also to the introduction of a more "place-based" sourcing strategy, increasing the sourcing from local/national (Italian) farmers through the BSF initiative. This is evidenced in one of the statements of the supply chain strategist:

> Until the mid-90s we have been operating through a portfolio of sourcing options, from spot markets to international brokers, to support our global brand in the pasta segment. We then realized we needed more diversity in our sourcing, and a more careful, regionalized approach. We had moved into a 'good for you, good for the planet' approach, and what was good for the planet we needed to figure out and control more carefully [PDM].

Among many pressures, the need to enhance soil health had taken a pivotal role in the introduction of the Barilla Sustainable Farming initiative as a framework to experiment with farmers' sustainable practices. The need to improve soil fertility also triggered the idea to engage with a wider set of stakeholders, and to create partnerships, for sharing practices and knowledge, beyond managing value chain relations.

> We needed to design and implement guidelines and procedures, rapidly learning from farmers and practitioners, but trying to still govern a complex and dispersed supply chain [ARD]
> I remember the agronomist from Barilla mentioning a new decision system and guidelines to be used in our farm. I thought, here we go again; they're coming to squeeze us. But instead, we started discussing best practices, reducing fertilization, crop rotation. I felt engaged to be honest, perhaps for the first time [SFG]

This led to the establishment of specific projects with groups of experimental farmers and supply chain partners, particularly cooperatives and farmers associations operating in the north of Italy. Therefore, while maintaining business operations remained first priority for Barilla, the commitment to environmental values and the associated mission

supported by the BSF initiative and its related projects changed *how* that aim was to be achieved.

In the other case, our findings indicate a similar shift, although from a different perspective. Arable farming is the core activity for EDL, a farm located in the Gelderland region, in the Netherlands. When taking over the farm in 2005, the founder of the Ekoboerderij de Lingehof immediately initiated the transition to organic farming. In subsequent years, however, the farm managers wanted to move beyond organic and embraced biodynamic farming.

> I was looking for a way of making the soil come back to life, to experiment with new crops, to embrace nature in my daily farming decisions [FM1]
> Learning how to manage multiple crops was my initial challenge, but there was no alternative, we needed to go back to the basics and see this as a new project [FM2].

Becoming an active member of the biodynamic movement, EDL started its innovation journey by recognizing the need to engage with crop rotation as part of a shared ecological worldview and value system. Becoming an "artisan of the soil" meant focusing on restoring and improving the soil and thus further diversifying the crop rotation. However, the mission to remain a functional farm meant aligning rotations with financial and marketing considerations. Which crop to introduce in the rotation, its duration, and adaptation to the agro-ecological conditions of the farm had to be combined with the need to ensure the presence of a few cash crops, for example potatoes and onions:

> We were following a strict biodynamic calendar and planning for our rotations. You have to treat tuber crops that are heavy for the soil very carefully, but we needed some more to make the long rotation [economically] viable [CRDW]

Both innovation processes started with a (re-)commitment to the core actor's values and mission. Yet, the specific values and mission stated in the two cases were clearly distinct, with BSF focusing on profit and business operations while including environmental concerns, and EDL starting from an ecological focus that needed a business perspective to be maintained. Still, in stage 1 in both cases, the tension of values and mission being inconsistent with current practices led to the identification of new technologies and practices, including the adoption of diversified crop rotations, that more closely adhere to these values and missions.

3.1.2 Stage 2—New, diversified technologies and practices require changes in partners and expertise

In the BSF initiative, the need to combine soil fertility with productivity triggered the mobilization of a wider network of actors including value chain partners, such as aggregators and millers operating in the durum and soft wheat markets, other suppliers, food companies interested in sourcing tomatoes and peas, farmer associations, research centers, universities, public institutions, and NGOs.

> We had considered several agronomic practices, but we needed a wider understanding of how these practices could be introduced and implemented, which incentives to use and where to apply them. We needed to start collecting data and partners who knew how to do it. That's when we opened to collaboration with universities and [farmer] associations [SFS]

In 2008–2009, BSF took the shape of a multi-stakeholder platform based on formal rules and procedures to improve the sustainability of the durum wheat supply chain. This move was due to the need of scaling extended crop rotations and sustainable practices among Barilla's supply base, and to identify drivers for their adoption. As part of this platform and related interactions, actors negotiated the interpretation and operationalization of the values and mission put forward by Barilla. As an outcome of these consultations, the Barilla Sustainable Farming Handbook was officially launched. The Handbook represented the first moment where Barilla and its value chain partners codified practices, including crop rotation, into a form that could be shared more easily (Blasi et al. 2015). The final BSF Handbook organized rules and best practices to support farmers in making the production of durum wheat more sustainable:

> Durum wheat has always been a very strategic crop for our company. [To set-up and develop the Handbook] We focused on small scale and territorial clusters where quality programs to improve the protein content in durum were already in place. We needed an infrastructure and methodology to emerge, to be tested and used. We needed data, not only stories. [GPM]

To facilitate the implementation of the Handbook, a decision support system was developed and farmers were encouraged to use it free of charge. The Barilla Group had already developed a network of extension services and strong value chain contract relations in various regions in Italy.

> Before crop-rotation and contracts were considered, we had experimented with various partners we could trust. We started in Emilia-Romagna and Lombardy, where associations could help us to unpack the complexity of what we wanted to achieve. Then we looked for universities, labs and NGOs who could support a regionally-based multi-actor platform… that's were all this started [JDP]

Thus, in order to identify the necessary changes in practices, agronomic expertise was needed first, collected from internal R&D, as well as consulting university resources. For implementation among the supply base, extensive knowledge on farmers and operations from different value chain partners was needed.

In the same period, EDL had re-organized its management by introducing a shared farm management strategy and entrepreneurial ideas, mostly by focusing on new crops with the intention of having long and diverse rotations. After few trials, crops were selected that could be harvested in one go, then stored on-farm or delivered directly to the customer, often with a short value chain approach. The company moved more decisively towards biodynamic practices.

> Experimenting with new crops, looking for new marketing channels and going to work with my machines has been challenging and exciting at the same time [FM1]
> Consumers are interested in where their food comes from, but it also needs to work for the farmers and it has to be part of a supply chain approach. That's what we do at [EDL] [JDW]

Additionally, the farm began to design and experiment with new machinery for manual and mechanical weeding to reduce the increased labor cost associated with their soil health approach. On-farm experimentation and agronomic expertise was complemented by mutual advice with a group of farmers, as stipulated in the biodynamic approach. Alongside that, the farm entered research projects with a local university and research center for mutual learning. These collaborations included, for example, on-farm experimentation to support variety development for legumes, and the development of financial expertise connected to the profitability of different rotations. This was necessary so that the soil health–focused rotations would still maintain farm operations. Thus, EDL simultaneously engaged these new actors and new expertise. It then moved to share this expertise with other farmers, enabling the attempt to reshape marketing conditions. For example, sweet lupines were introduced due to their benefits for soil health. Yet, in order to improve the viability and profitability of this crop, engagement with other farmers and the sharing of agronomic knowledge on production were needed to create critical mass of local lupine production, with the aim to sell under better (bargaining) conditions.

Thus, while both cases included the element of extending rotations and introducing new crops, the specificities of the rotation to be introduced differed widely. EDL's approach was more ambitious in terms of crop diversity, while the BSF approach kept the rotation simpler in order to reach a large number of farmers. For the scaling process, this implied that EDL wanted to increase their own level of crop diversity as well as motivating other actors to do the same. BSF on the other hand, focused on reaching as many farmers as possible and thus had to be careful to not ask for too big a change while still increasing diversity in farmers' fields. Furthermore, the types of actors both niches involved were rather similar as both engaged with farmers and actors in the respective value chains, as well as research institutions. However, as BSF's activities were overall bigger endeavors with more resources and actors involved, they managed to also engage public institutions and NGOs and were thus able to draw on a wider range of expertise. Still, for both cases, the engagement and consultation with their partners led to a continuous re-design of rotations to balance the co-existence of profitable cash crops with soil health enhancing crops. In summary, in stage 2, the companies moved to experimenting with the identified technologies and practices, and in this experimentation phase realized the need for new partnerships and expertise for their intended activities.

3.1.3 Stage 3—Changing institutional logics require new organizational forms and funding

From 2013 onwards, the BSF approach was extended and further scaled up. To scale up and reach more farmers in the supply base, the company's sourcing strategy had to be adapted. In order to extend support to farmers, more intensive coordination along the value chain was needed, and BSF aimed for implementing (at times multi-year) contractual arrangements with farmers and value chain partners. Since 2015, BSF had become one of the flagship initiatives for introducing sustainable practices in the Barilla sourcing strategy, involving value chain stakeholders in different countries (Pancino et al. 2019; United Nations Global Compact Network Italy 2015).

> We realized we also needed a strategy for mobilizing different departments, but without jeopardizing our core operations – we needed to reach a different scale too, without scaring anyone. [JDP]
> We work with farmers to improve decision-making. Partners are engaged to support the change process too, since farmers struggle to change crop practices and engage with supply chain contracts [ARD].

However, with the scaling of operations and guidelines across the value chain also came tensions related to the governance of this process, as BSF met resistance from its partners with regard to the contractual arrangements.

> Farmers aren't sure on how to go about these practices, and the data monitoring… it's tricky, they want stability but they seem to avoid long-term commitments […] they dislike multi-year contracts [SFG]

The scaling process of BSF stimulated a period of intense organizational experimentation, as the changes in the other institutional dimensions were no longer aligned with the organizational forms in use at the time. From the early 2010s, the BSF initiative moved from experimenting with groups of associated farmers and dispersed regional projects, into a more ambitious approach to redesign contracts at value chain level, and across crops and commodities.

> We wanted crop rotation introduced across borders, as a way of increasing our brand value and reduce costs, stabilizing sourcing, and making a strategic alignment possible between marketing and supply chain governance [PDM]

In the end, contractual arrangements that prescribe agronomic practices were needed in order to reap marketing benefits from sustainability activities and thus integrate consistent flows of funding into the value chain. Thus, while limited internal and external funds, e.g., for research projects, were sufficient for experimentation, in order to scale up, finding adequate agreements on organizational form obstructed the continuous flow of funds along the value chain.

A surprisingly similar process was observed in the scaling of the EDL case. Starting in 2013, farm management at EDL became particularly concerned with ensuring financial viability for the farm business operation while keeping a focus on soil health and fertility, combining biodynamic practices with the use of technology and precision agriculture for balanced plant growth and efficient business operations (Ekoboerderij de Lingehof 2020). While initial experimentation was externally funded through regional development funds, research projects, and innovation grants, in order to continuously keep rotations focused on soil health, funding needed to be integrated into the value chain. Therefore, EDL relied on an extended network of collaborations. EDL experimented with value chain partners and consumers for many of their crops, for example by shortening the value chain and opening the farm gates to consumers and partnerships with other farm managers and buyers.

> When you operate in a niche you either need to create margins by getting closer to the consumers or by protecting your bargaining power with buyers [JDW].

Next to building partnerships with local farmers for managing organic manure, and with various value chain partners, including a local mill for grains, EDL also continuously engaged with the biodynamic certification scheme Demeter (Demeter 2021; Ekoboerderij de Lingehof 2020). The farm also created collective marketing agreements for crops such as potatoes and red beets, and contracts with processors or retailers for others, such as red cabbage or pumpkins. In particular, to enable other farmers to follow in their footsteps and diversify with legumes such as lupines, a completely new initiative was needed to not only enable joint marketing, but also create demand in the market place. Thus, similarly to BSF, EDL has been commercializing crops increasingly using value chain agreements and creating alliances with certification bodies and retailers.

> The demand for eco-friendly food products is booming, they [retailers] have to look into projects like our farm more often than before [JDW]

However, the increased complexity of the value chain relations had put some pressure on the farm managers too:

> We should invest in an inventory and data collection, as well as partnership contracts […] but we do not have the resources to do that. Also, quality standards from retailers are tricky, we do not know if they're paying premiums or not. We need to invest in storage facilities and improve our bargaining power… this is sometimes nerve-wracking [FM2]

Despite the increasing evidence that crop rotations could create the conditions to combine ecological benefits with economic gains, both the BSF and EDL initiatives quickly faced a set of challenges, interfering with, if not blocking, any scaling process. The Barilla Group was interested in defining contract templates which could be used in various contexts and with different types of farmers (Blasi et al 2015), while questions remained on how one governs this approach in the absence of clear legal and institutional frameworks.

> If you make a statement that the farmer will be able to sell all the crops in a rotation, then you need to offer them a contract and some forms of guarantee… but how you go about it if you are not the buyer of the crop but another company? [MM]

This was the central reason for Barilla to engage with such a variety of value chain partners, and it is an issue specific to crop diversification processes, as Barilla cannot oblige other companies to buy the other crops in the rotation that they themselves do not need. To give farmers such a guarantee, new types of "platform contracts" would be needed that include not only Barilla and their suppliers but also other companies using other crops from the rotation which is rather uncommon, as well as legally complex and costly to negotiate.

EDL needed to maintain some flexibility to continue to experiment with crops and a long-term rotation while experiencing the pressure of using more formalized partnerships and contracts. Thus, both cases created new arrangements within their value chains to accommodate the new practices. Still, the *type* of value chain arrangements differed. Due to its much larger business operations, BSF focused on more uniform, replicable contracts that could be applied to

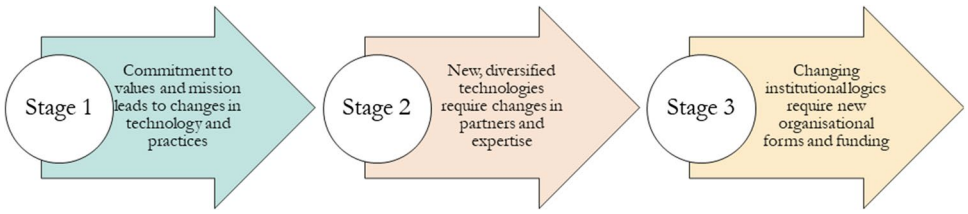

Fig. 4 Three stages of niche scaling observed in the case studies. Source: The authors.

a variety of suppliers. EDL, on the other hand, used a wider variety of arrangements, from direct consumer engagement to collective marketing, to tailor their value chains to their own specific needs. Still, in both cases, lack of standards and labels for diversified farming systems, and lack of policy support for value chain formation also created concerns on how scalable both innovation trajectories could be. In short, both organizations were confronted with the absence of organizational mechanisms to facilitate their practices.

In summation, as the required agricultural practices crystallized following the commitment to values and mission, the required expertise and the interactions between value chain partners and other actors changed, becoming more complex and in need of novel organizational solutions. These pathways can be analytically distinguished into three phases illustrated in Fig. 4, as used to present our results. Our findings indicate a convergence of both innovation pathways towards tensions related to organizational forms, where the innovation practices and processes seem to be obstructed. Despite different institutional settings otherwise, these tensions currently seem to converge towards organizational solutions such as novel value chain arrangements. However, developing these solutions requires substantial efforts by the lead actors involved. We further reflect on these processes in the discussion.

3.2 Discussion

Based on our findings, we are able to further discuss the scaling of innovation niches through an institutional lens, by looking at the dimensions of institutional logics and their internal coherence throughout changes over time. Our findings add to extant scholarship emphasizing the role of alignment of logics between the niche and the wider institutional context (Fuenfschilling and Truffer 2014; Smink et al. 2015; Turner et al. 2017). What our study highlights in addition is the relevant role of how these logics are formed, negotiated, and defined through processes involving actors in the niche. In particular, we looked at how the internal coherence of these logics affects the scaling of innovation niches, when crop diversification is concerned. For instance, the importance of coherence for niche stability has been previously emphasized (Belmin et al. 2018), indicating that the more internally coherent the dimensions of institutional logics are, the more stable the niche. Nonetheless, stability of a niche does not necessarily mean scaling (Geels et al. 2016), and rigidity itself can be a barrier to the scaling of a niche and associated transition processes (Smink et al. 2015). Our results show that changes and re-alignment in the dimensions of institutional logics may be necessary in order to enable scaling of a niche. Specifically, in our cases, changes in the lead actors (priorities of) values and mission lead to the quest for new technologies and practices. For experimentation and initial implementation, the lead actors engaged with researchers and value chain partners to gain the needed expertise, while relying on innovation funding and grants. Yet, when it came to further expanding the niche, and scaling up, these funding sources were no longer sufficient. In order to support the scaling, long-term, continuous funding sources were needed. Therefore, the focus of the lead actors shifted to their value chains. In negotiation with their partners, new value chain agreements needed to be formed to internalize funding for new practices. Figure 5 shows this process over time.

Our findings also indicate that niches focused on similar practices, like extended crop rotations, may follow a rather similar process of scaling, and face similar issues of value chain formation. For our cases, this was true, despite their many differences. One niche was embedded in a multinational company's wider innovation strategy, the other an agroecological farming system. The niches had rather different values and missions as starting points. The specific crop rotations they targeted were different, as well as some of the actors they involved in the process. Finally, the types of value chain arrangements they looked to as solutions were also distinct. Still, both niches went through a process of realignment of the dimensions of institutional logics under which they operate. We observed, for instance, that when these dimensions are not aligned, the scaling process is stalled (see Fig. 6). When logics start to be reframed around a novel set of values and mission, then a continuous need for reconfiguration becomes conducive for a wider redesign of niche technologies and practices, involving novel actors and expertise, and the need for new sources of funding. This process results in emerging organizational tension which creates the space for discussing and negotiating solutions between actors in the niche (Berthet et al. 2016, 2018). Therefore, in order to overcome these tensions, actors in both niches are aiming to form new value chain arrangements, showing that such organizational innovations are essential in the scaling

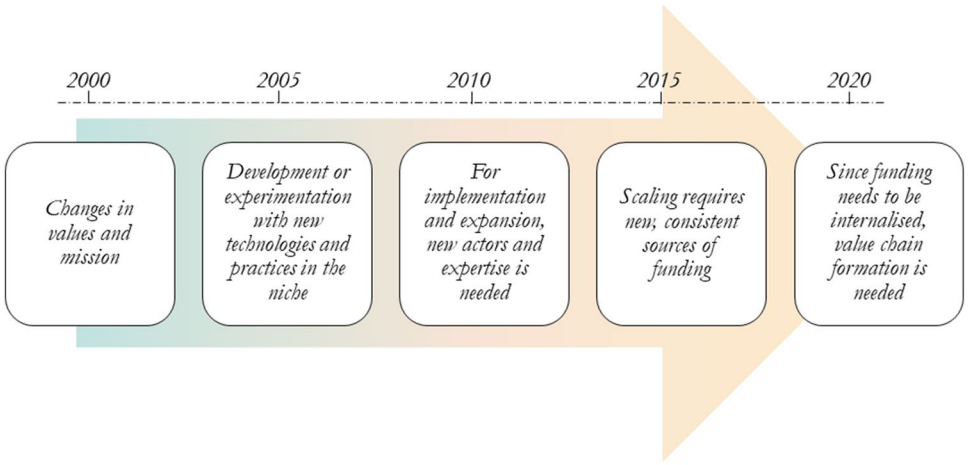

Fig. 5 Adjustment process of dimensions of institutional logics over time. Source: The authors.

process (Meynard et al. 2017). Looking specifically at our cases, it is *value chain formation* that is creating the conditions for bringing crop rotation to scale. This finding is of particular interest as it adds to extant literature in which farmers' agronomic knowledge is considered the key factor in the adoption of crop diversification (Morel et al. 2020; Zimmer et al. 2016). Our analysis confirms that agronomic knowledge and technological innovation, while necessary, is not a sufficient condition for scaling, but also attempts to explain why and how this occurs. In both our niches, the lead actors aiming to implement crop diversification managed to get sufficient agronomic expertise by experimenting and collaborating with other actors. However, building value chain relationships that can sustain and scale crop diversification may be even more challenging. While a lack of funding is also often cited as an obstacle of scaling (Bonke & Musshoff 2020; Rosa-Schleich et al. 2019), our approach allowed us to identify that the absence of clear and effective organizational forms to manage relations in the niche, and to maintain funding over time, is also a significant barrier. We find that value chain formation is necessary to finance a scaling process from experimentation with crop diversification at niche level, to diversification occurring at a wider value chain level. Current organizational forms seem to be supporting innovation pathways for productivity and agricultural intensification (Dicecca et al. 2016; Duncan and Pascucci 2017; Seifu et al. 2020; Virginia et al. 2018), rather than diversification.

Hence, our research indicates that tensions in relation to organizational forms are crucial to understanding pathways to transitions. Without adequate organizational forms, the innovation niche may struggle to operate, to scale, or even to survive. This echoes Meynard et al. (2017) who also highlight the necessity of organizational forms changing alongside the engagement in crop diversification processes. These results show that during the scaling process institutional logics change and realign, and that this flexibility is likely necessary for niches to adapt to changing conditions during the scaling process.

In practical terms, however, this implies that actors may need support to find and create suitable organizational solutions. This may be in the form of legal frameworks and/or subsidies that allow for experimentation with new arrangements, as well as creating template solutions that cover the more complex approaches potentially needed for diversified cropping systems, such as platform contracts that involve buyers for other crops. Extant literature has investigated scaling processes through diverse socio-technological and organizational perspectives (Meynard et al. 2017, 2018; Seifu et al. 2020), often looking at how actors operating in innovation niches are engaged in developing logics and their dimensions, aligned with actors operating outside the niche, in order to mobilize key institutional, technological, and financial resources, and to facilitate the scaling process (Hounkonnou et al. 2018; Seifu et al. 2020). The assumption is made that organizational forms emerge separately or because of the "success" of the innovation niche. Our findings suggest that identifying organizational solutions at value chain level is part of development of innovation niches, and, as pointed out by Pigford and colleagues (Pigford et al. 2018) and Meynard et al. (2017), they should be considered more organically and systemically part of the niche scaling process. Value chain partnerships and networks emerge as a response to tensions among institutional dimensions in the innovation niche, and they are necessary to push practices such as extended crop rotations beyond the niche. To the best of our knowledge, this study is the first to show how these tensions unfold similarly in fundamentally different niches aiming to scale crop rotations, implying that these processes may not depend on niche characteristics. Understanding the "temporality" of this process, in relation to key dimensions in institutional logics, is a key factor in explaining (a lack of) scaling processes, and therefore sustainability transitions (Fuenfschilling and Truffer 2014; Pigford et al. 2018).

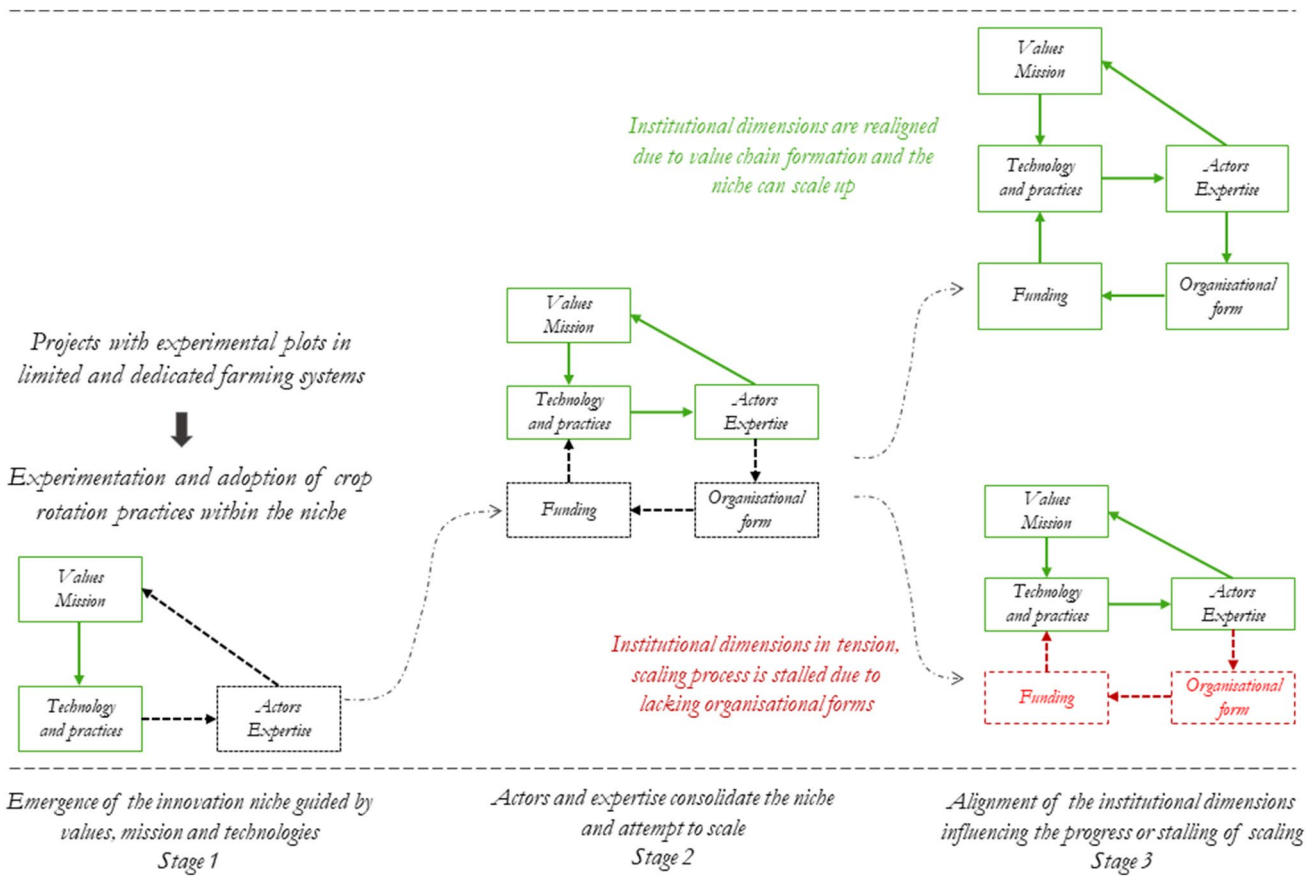

Fig. 6 Institutional dimensions and scaling processes. Legend: from left to right the different stages of scaling. Stage 1: crop rotations are experimented at small scale, involving experimental plots or farms. Actors seek alignment between values, mission, and technologies and practices. Stage 2: Actors attempt scaling, changing organizational forms, to provide funding for the innovation process. Stage 3: If the organizational change fails to identify suitable organizational forms for the value chain, scaling is stalled (bottom). When organizational change is conducive to value chain formation, funding is provided and the scaling is supported (top). Source: Authors' adaptation inspired by Fuenfschilling and Truffer (2014).

4 Conclusions

The contributions of this study to the extant literature are twofold. Firstly, our study demonstrates how the lens of institutional logics can enhance our understanding of scaling of innovation niches. Our approach has relevance in terms of expanding existing conceptualization of institutional logics and their role in stimulating or impeding sustainability transitions from innovation niches. By analyzing the niches' values, missions, technologies and practices, actors and expertise, organizational forms, and funding sources, we gain insight into the niches' institutional logics. When observing these dimensions and their development over time, we can detect how tensions between the dimensions can lead to changes and realignment, which facilitates the scaling process, and how the absence of this realignment stalls it. Secondly, we contribute to the literature on crop diversification by analyzing the scaling process of diversification niches. For the first time, it has been shown that scaling processes of crop diversification can progress similarly in different niches, whether the lead actor is a multinational company, or an individual farm. We indicate that struggles to find organizational solutions at value chain level are connected to scaling mechanisms, but originate from *tensions* internal to the innovation niche. These tensions are indeed part of the innovation process, and, to be better understood, can be investigated through an institutional lens (Fuenfschilling and Truffer 2014).

From a practitioner perspective, this analysis has shown that there is currently a lack of adequate organizational mechanisms that allow actors to compensate the higher cost

of diversified practices that they are currently experiencing, from within the value chain. This lack of organizational forms blocks the scaling of crop rotation, as it prohibits the trade-off between environmental benefits and economic costs to balance out long-term and at scale (Meynard et al. 2017; Rosa-Schleich et al. 2019). Based on our findings, we can conclude that supporting only the experimentation phase of the scaling process, e.g., with innovation grants and subsidies, may not be sufficient to induce a sustainability transition at scale. Scaling likely requires the internalization of funding into the value chain. Support for value chain formation could take the form of creating legal frameworks and templates for new arrangements, as well as financial support to compensate for efforts and experimentation in value chain formation. Niche actors currently planning to scale practices related to crop diversification should be aware that value chain formation can become a significant obstacle.

This study is limited to two case studies, and while their similarities in process despite differences in characteristics give us confidence, our results remain exploratory. Similar longitudinal studies should be conducted to draw conclusions from a wider variety of case studies. Furthermore, our findings are limited to the European context and may not hold in different institutional settings where other limitations may outweigh value chain formation as a crucial barrier curtailing the scaling process. We therefore suggest that future research should further investigate the role of institutional logics, exploring multiple settings and indeed integrating evidence from other cases. Moreover, we suggest to further exploring what measures are effective to support actors finding suitable, locally adapted organizational forms that allow for the adequate compensation of diversified agricultural and food systems.

Appendix

Case study descriptions

Barilla Sustainable Farming (BSF)—Barilla Group

Barilla is a family-owned company founded in Italy in 1877, and nowadays owns 18 different brands of food products, from pasta to baked goods and sauces (Barilla 2021b). Barilla currently purchases and processes raw materials in 30 production districts, owns 15 factories in different countries other than Italy, and sells their products in 100 countries across the world (Barilla 2021b).

In 2009, Barilla established the Barilla Centre for Food and Nutrition Foundation (BCFN), whose objective is to understand the complexity of agri-food systems and promote dialogue between scientists, institutions, private sector, and civil society (Barilla 2020). The theoretical approaches developed by the BCFN also contributed to the company's new vision around the sustainability of food, looking at both the consumption side, in terms of sustainable diets and the production side. Considering specifically sustainable agricultural production, Barilla launched different sustainability initiatives for selected supply chains and raw materials.

For example, in 2009, for durum wheat, one of Barilla's key raw materials, Barilla introduced a sustainable durum wheat project in collaboration with academic partners, specialized in agronomy and innovation in cropping systems. Two tools were introduced to support the development of more sustainable agronomic practices: The Handbook for the sustainable farming of durum wheat and a decision support software (granoduro.net®,) which provides support to farmers in making technical decisions on e.g. field fertilization and crop disease treatments, taking into account previous crops and rotations. These tools also offer specific advice on beneficial crop rotations that improve both soil structure and wheat quality, focusing on the inclusion of crops for oil production, such as sunflowers and rapeseed, and legumes. Multi-year agreements with suppliers, which require compliance with specific guidelines concerning product quality and (sustainable) farming practices, have been launched at limited scale (Barilla 2021b). For its soft wheat supply chain for the brand Mulino Bianco, Barilla launched a similar project, in collaboration with universities, an NGO, and value chain partners (Barilla 2020). This focusses on product quality, crop diversity, controlled use of chemicals, and protection for pollinating insects. In this project, diversity in the field is increased through the introduction of at least one legume and/or oil seed within a 3- to 5-year rotation, as well as the use of flower strips. It further aims to ensure the traceability of soft wheat during all stages of the supply chain, in combination with third-party certification and a price premium for wheat flour produced according to the given rules (Barilla 2021a).

Using the same approach, the company also initiated sustainability programs for the procurement of other raw materials and for other brands, for value chains in Italy and abroad, largely based on crop diversification, carbon neutral, and regenerative practices. These include the Harris Paper, for French grains in bakery products, a protocol for the wheat-pasta supply chain in Greece, Turkey, and the USA. Furthermore, there is an initiative related to rye production for the Wasa brand in northern Europe, and a project focused on cocoa procurement in Ivory Coast for the Pan di Stelle brand (Barilla 2021b).

Ekoboerderij de Lingenhof (EDL)

This arable farm of about 100 ha with organic and biodynamic certification is located in the central Dutch region of Gelderland. This farm illustrates some of the consequences to value chains when soil health is the guiding premise of crop rotation design. Promoting soil health sets the limits of crop choice for each plot. Rotations are 6 to 7 years long with a total of about ten to fifteen different crops on the farm each year, including onions, potatoes, grain, and lupines. Such diversity in crops requires creativity in value chain relationships. This is illustrated by the variety of marketing arrangements in just 1 year:

For some crops, rather straightforward contract farming arrangements, using both written and verbal contracts, are used. In these cases, the aim is to build, and build on long-lasting relationships with buyers both nationally and at a European scale. For other crops, the Ekoboerderij farm uses more complex arrangements cooperating with other farmers. In these, the farmers group pools their production and sells the crop jointly and thus reaching different markets than they would have been able to as a single producer. For example, companies processing red beets, a crop regularly grown on the farm, often need a particular range in size of beets. By pooling production, beets can be sorted by size and yet each category will reach a quantity sufficient for the farmer group to be an attractive trading partner for these processors.

The Ekoboerderij farm also uses more "experimental" approaches to value chain organization in order to maintain or increase crop diversity on the farm. They entered an agreement with a local art college to grow flax for sustainable fibers for the college's fashion program. Furthermore, the farm experiments with hemp production for a newly established CBD factory, as well as using apple tree adoption by consumers for producing apples and apple juice.

In order to establish a crop that is good for the soil but not established in the local market, namely lupines, a more extensive approach was chosen. It includes the establishment of a company for marketing and communication to consumers in cooperation with other farmers in order to breed suitable varieties and increase production capacities, and building relationships with the processing industry. This case study illustrates the entrepreneurial skills farmers may need in order to diversify their crops with a focus on soil health .

Example of interview guide

Table 3 below shows an example of an interview guide as used for data collection in this study.

Table 3 Interview guide BSF sustainable farming specialist.

Questions	Notes
What exactly is your position and your responsibilities within Barilla?	
Based on your knowledge and your expertise, what is your understanding of sustainability and sustainable agriculture?	
What are Barilla's goals in terms of sustainable agriculture? How do you attempt to achieve them?	What role does diversification play among those goals? What is your personal role in achieving them?
Are you directly involved in one or more projects concerning sustainable agriculture?	What role does diversification play in any of these projects?
How does Barilla engage with its suppliers in relation to the adoption of sustainable agricultural practices?	To be more specific, how did and does Barilla engage with suppliers in the Barilla Sustainable Farming initiative?
Has diversification played a role in the BSF programme so far?	
What lessons were you able to learn from the Barilla Sustainable Farming Initiative?	
What challenges do you face when engaging farmers with regard to sustainable practices, within and outside the BSF?	Are there particular challenges in engaging farmers with regard to diversification? Do you have any solution to face this challenge?
In the future do you see diversification as a fundamental strategy used by Barilla regarding its productions?	
We are basically finished with the interview. As a last question, in your personal opinion, what changes would need to be made to allow farmers in Italy to implement crop diversification practices? How do you think crop diversification practices could be facilitated?	What challenges are you expecting in relation to that? What role could Barilla play to facilitate the process? What consequences would it have for Barilla's supply chains? Are you expecting differences between northern and southern Italy?
Is there anything you would like to add? Anything relevant to this issue that we missed?	

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Data availability For privacy reasons, qualitative raw data will not be shared.

Code availability Not applicable

Declarations

Conflict of interest The authors declare no competing interests.

Ethics approval Not applicable

Consent to participate Consent was given by all participants, following the guidelines of the H2020 project Diverfarming.

Consent for publication Consent was given by all participants, following the guidelines of the H2020 project Diverfarming.

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