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Conceptualizing Sustainability and Resilience in Value Chains in Times of Multiple Crises—Notes on Agri-Food Chains

Alexander Follmann*[1], Peter Dannenberg[2], Nina Baur[3], Boris Braun[4], Grit Walther[5], Amelie Bernzen[6], Jan Börner[7], Michael Brüntrup[8], Martin Franz[9], Linde Götz[10], Anna-Katharina Hornidge[11], Carolin Hulke[12], Tinoush Jamali Jaghdani[13], Aarti Krishnan[14], Elmar Kulke[15], Inéz Labucay[16], Gilbert Mbaka Nduru[17], Thomas Neise[18], Priya Priyadarshini[19], Javier Revilla Diez[20], Johanna Ruett[21], Christian Scheller[22], Thomas Spengler[23], Emmanuel Sulle[24]
corresponding author

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[1] University of Cologne, Institute of Geography and Global South Studies Center, Albertus-Magnus-Platz, 50923 Cologne, Germany, a.follmann@uni-koeln.de, https://orcid.org/0000-0002-4727-4346

[2] University of Cologne, Institute of Geography and Global South Studies Center, Albertus-Magnus-Platz, 50923 Cologne, Germany, p.dannenberg@uni-koeln.de, https://orcid.org/0000-0002-4159-6635

[3] Technische Universität Berlin, Department of Sociology, Fraunhoferstraße 33-36, 10587 Berlin, Germany, nina.baur@tu-berlin.de, https://orcid.org/0000-0002-6626-1997

[4] University of Cologne, Institute of Geography and Global South Studies Center, Albertus-Magnus-Platz, 50923 Cologne, Germany, boris.braun@uni-koeln.de, https://orcid.org/0000-0003-3863-2153

[5] RWTH Aachen University, School of Business and Economics, Operations Management, Kackertstraße 7, 52072 Aachen, Germany, walther@om.rwth-aachen.de, https://orcid.org/0000-0003-0022-9027

[6] University of Vechta, Economic Geography, Vechta Institute of Sustainability Transformation in Rural Areas (VISTRA), Driverstr. 22, 49377 Vechta, Germany, amelie.bernzen@uni-vechta.de, https://orcid.org/0000-0002-9494-3645

[7] University of Bonn, Institute for Food and Resource Economics and Center for Development Research, Nußallee 21, 53115 Bonn, Germany, jborner@uni-bonn.de, https://orcid.org/0000-0003-3034-5360

[8] German Institute of Development and Sustainability (IDOS), Tulpenfeld 6, 53113 Bonn, Germany, Michael.Bruentrup@idos-research.de

[9] Osnabrück University, Institute of Geography, Seminarstraße 19 a/b, 49074 Osnabrück, Germany, Martin.Franz@uni-osnabrueck.de, https://orcid.org/0000-0002-1187-5166

[10] Institute of Agricultural Development in Transition Economies (IAMO), Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany, goetz@iamo.de, https://orcid.org/0000-0001-8204-4522

[11] German Institute of Development and Sustainability (IDOS), Tulpenfeld 6, 53113 Bonn, Germany, Anna-Katharina.Hornidge@idos-research.de, https://orcid.org/0000-0002-9599-4348

[12] Economic Geography, London School of Economics and Political Science (LSE), Houghton Street, London WC2A 2AE, UK, c.hulke@lse.ac.uk, https://orcid.org/0000-0002-8365-9614

[13] Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany, jaghdani@iamo.de, https://orcid.org/0000-0003-2204-0452

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[14] The University of Manchester Alliance Manchester Business School: Manchester, GB, aarti.krishnan-2@manchester.ac.uk, https://orcid.org/0000-0002-4603-0497

[15] Humboldt-Universität zu Berlin, Geography Department, Rudower Chaussee 16, 12489 Berlin, Germany, elmar.kulke@geo.hu-berlin.de, https://orcid.org/0000-0002-8541-1030

[16] Technische Universität Dresden, Faculty of Business and Economics, Münchner Platz 3, 01187 Dresden, Germany, and United Nations University – Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES), inez.labucay@tu-dresden.de, https://orcid.org/0000-0001-9170-4406

[17] Chuka University, Faculty of Agriculture and Environmental Studies, P.O. Box 109 – 60400 Chuka, Kenya, gilnduru@gmail.com

[18] Heidelberg University, Institute of Geography, Berliner Str. 48, 69120 Heidelberg, Germany, thomas.neise@uni-heidelberg.de, https://orcid.org/0000-0001-6080-6725

[19] Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi, 221005, India, priya.p04@bhu.ac.in, https://orcid.org/0000-0002-0441-453X

[20] University of Cologne, Institute of Geography, Albertus-Magnus-Platz, 50923 Cologne, Germany, j.revilladiez@uni-koeln.de, https://orcid.org/0000-0003-2065-1380

[21] RWTH Aachen University, School of Business and Economics, Operations Management, Kackertstraße 7, 52072 Aachen, Germany, johanna.ruett@om.rwth-aachen.de, https://orcid.org/0000-0003-4732-3889

[22] Technische Universität Braunschweig, Institute of Automotive Management and Industrial Production (AIP), Mühlenpfordtstraße 23, 38106 Braunschweig, Germany, https://orcid.org/0000-0003-3514-2167

[23] Technische Universität Braunschweig, Institute of Automotive Management and Industrial Production (AIP), Mühlenpfordtstraße 23, 38106 Braunschweig, Germany, t.spengler@tu-braunschweig.de, https://orcid.org/0000-0002-0212-1899

[24] The Aga Khan University, Arusha Climate and Environmental Research Center, Off TPRI Road, 23201 Ilkiushin, Arusha, Tanzania, emmanuel.sulle@aku.edu, https://orcid.org/0000-0002-7816-9848

Abstract

Global and regional agri-food value chains feed societies and are an income source for hundreds of millions of farmers around the world. They are also target areas for action to achieve a global sustainability transformation. Agri-food chains are highly vulnerable in the context of multiple crises, including the global environmental crisis, geopolitical fragmentation, armed conflicts and wars, and the aftermath of the COVID-19 pandemic. Measures to increase chain resilience are widely discussed; however, some such measures contradict sustainability measures. While there has been considerable research on the sustainability and resilience of agri-food chains, few studies have integrated both perspectives or outlined potential synergies and trade-offs. Therefore, this interdisciplinary literature review sketches possible contours for a synthesized research agenda on sustainability and resilience for agri-food chains during multiple crises. We argue that such an agenda should include, amongst others,

- *a more differentiated and critical perspective on the importance of value chain characteristics and developments (e.g., power structures, capabilities, up- and downgrading, and the borders of chain internalities and externalities)*
- *a more comprehensive perspective that includes global and regional contexts and relations (e.g., whole-chain perspectives that integrate agro-input supply)*
- *an actor-oriented approach that interrogates aspects of inequality, cost-sharing, and the potential benefits of sustainability and resilience for different actors along a value chain (i.e., sustainability and resilience for whom?)*

Keywords agriculture, global value chains, global production networks, supply chains, sustainability, resilience

1. Introduction

Interlinked global and regional crises—environmental crises, including climate change and biodiversity loss, geopolitical tensions, conflicts and wars, and the lasting impacts of the Covid-19 pandemic—have caused significant disruptions that increase the vulnerability of international and regional agri-food chains (Clapp & Moseley, 2020; Elobeid et al., 2021; Stead & Hinkson, 2022). Each of these crises differently affects agri-food systems on a global scale, including international value chains and their corresponding regions at various levels (e.g., Global North and South; producers and consumers). The direct effects of these crises (e.g., high inflation, food supply shortages) and crisis-related public and private responses (including growing protectionism and nationalism [Oldekop et al., 2020]) have reconfigured production systems and global trade and affected agri-food value chains' sustainability and resilience (see, e.g., the debate on reshoring and regionalization of production [Gong & Hassink, 2019]).

For example, the war in Ukraine has disrupted global agri-food value chains. As a response, and despite negative effects on sustainability, different policy measures have put the resilience of national food security at the center-stage: The former Brazilian president Jair Bolsonaro publicly endorsed further deforestation in the Amazon to mine potassium to compensate for increased risk in the global fertilizer and food supply chains. Similarly, the EU postponed its *nature conservation package* (that aimed to halve the use of chemical pesticides by 2030 and re-naturalize agricultural land) due to the threat of food shortages caused by the war (Dannenberg et al., 2024). These examples highlight the frictions between the goal of creating simultaneously resilient *and* sustainable agri-food value chains.

Sustainability and resilience are both analytical and normative concepts. Both concepts are not self-contained theories, but rather scientific paradigms. They are defined and used empirically in a variety of ways—within and beyond (agri-food) value chain research (for a detailed discussion, see e.g., Ponomarov & Holcomb, 2009). Due to multiple understandings and the normative assumptions associated with both concepts, it is important to be explicit about our understanding of the two concepts, especially when analyzing frictions between them (see Johnson et al., 2018).

In the context of this paper, we understand

- *value chain sustainability* as the long-term economic, social and environmental viability of the structures, practices and processes that make up a value chain (see Grumiller et al., 2022, p. 12); and
- *value chain resilience* as the adaptive capacity of value chains and their different actors to deal with change (e.g., shocks and disruptions) and recover from them (see Ponomarov & Holcomb, 2009, p. 131; Stockholm Resilience Centre, 2015).

Within the broader literature on human-environment interactions, the two concepts are fundamental paradigms and the synergies and tensions between them are widely discussed (Redman, 2014; Turner, 2010). In short, this debate often pictures resilience and sustainability as complementary concepts (Tendall et al., 2015), whereby resilience is often conceptualized to contribute to sustainability and resilient systems are sometimes equated with sustainable systems (Maleksaeidi & Karami, 2013). For example, Johnson et al. (2018, p. 18) summarize that "resilient systems may not necessarily be sustainable, but social-ecological systems must be resilient in order to achieve sustainability." Less discussed is how sustainability contributes to resilience.

There has been considerable research on both the sustainability and resilience aspects of value chains (and agri-food value chains in particular), but few studies comprehensively conceptualize both perspectives and their relations (Grumiller et al., 2022; Negri et al., 2021). Additionally, the effects of current multiple crises on the sustainability and resilience of agri-food value chains as a whole and on specific chain actors are poorly understood. In particular, we argue that while sustainability and resilience are conceptually related, the multiple crises reveal existing frictions that arise from trade-offs and externalities between the two normative goals. In turn, policy measures often face the dilemma of prioritizing resilience over sustainability or vice versa.

In order to contribute to these conceptual debates and address emerging policy dilemmas, this paper develops an integrative conceptual approach that draws on concepts and theories from different disciplines for a joint analysis of sustainability and resilience in agri-food value chains. To do this, this article brings together different strands of literature, including works on supply chains (SC), global value chains

(GVC) and global production networks (GPN). We use the term *value chain* here as an umbrella term for the object of research and then distinguish between different conceptual approaches, including SC, GVC and GPN.

Based on the above briefly outlined urgency to address sustainability and resilience in agri-food value chains in times of the multiple crises, we use agri-food chains both as the research object and specific lens to study sustainability-resilience relations. A specific challenge of agri-food chains—especially global, from Global South to Global North—are the different capabilities of the involved chain actors from smallholders (primary producers) to big multinational companies (food industry, supermarkets; see Krauss & Krishnan, 2022). Therefore, we argue (following Béné et al., 2016) that frictions arise from the fact that, for example, resilience costs (anticipation costs arising from safeguarding against a shock, e. g., by means of a safety stock in grains, costs of destruction after the shock such as from damaged farm assets, costs of recovery/adaptation/transformation such as rebuilding of water infrastructure) tend to be unequally distributed along the chain and these frictions translate into very different resilience and sustainability levels which can be maintained by these different actors.

Finally, we outline the importance of a *whole-chain approach* that goes beyond buying lead firms and agricultural producers and includes different agro-input suppliers.

This conceptual framework allows us to develop:

- a more differentiated and critical perspective on the importance of value chain characteristics and developments for sustainability-resilience relations and frictions (e.g., power structures, capabilities, up- and downgrading and delimiting chain internalities and externalities)
- a more comprehensive and differentiated perspective that includes global and regional contexts and relations (whole-chain perspective integrating agro-input suppliers and their role in governing the chain)
- an actor-oriented approach that interrogates inequality, cost-sharing, and the benefits of sustainability and resilience for different actors along a value chain (i.e., *sustainability and resilience for whom?*)

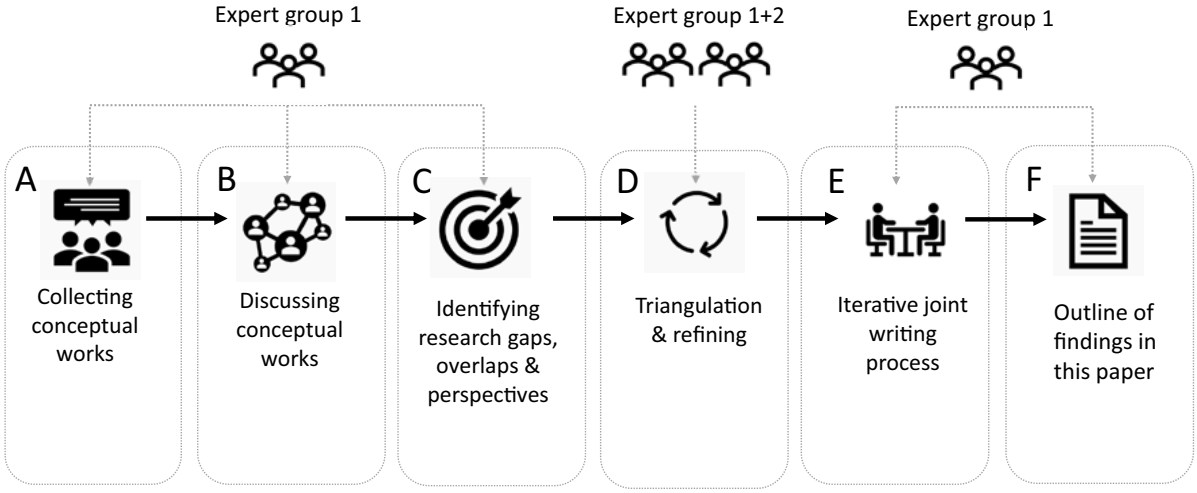
The article is structured as follows. The next section outlines the methodology. Section 3 covers the state of the art and sets the scene for section 4, which discusses synergies, frictions, and conceptual overlap between current empirical and normative sustainability and resilience approaches (see Table 1) in times of multiple crises. Section 5 finishes with concrete avenues for future research. A short conclusion summarizes the main arguments.

2. Methodology

This paper draws on shared thinking developed from a three-day workshop "Sustainability and Resilience of Agri-Food Chains in Times of Crises" organized by the authors Follmann and Dannenberg on 15 to 17 June 2023 (for a similar approach see Pratzer et al., 2024). The overall 17 participants (all authors of this paper) were purposively selected by the workshop organizers to represent a range of perspectives on sustainability, resilience and agricultural value chains from different disciplines (human geography, sociology, [agricultural] economics, development studies, sustainability studies, environmental studies, land and agrarian studies, political ecology, and business administration) and countries (Germany, United Kingdom, India, Tanzania, and Kenya). Our intention was to collect and discuss current perspectives on sustainability and resilience in agricultural value chains, identify potential research gaps, conceptual overlaps and perspectives for synergies of future research. To do this, during this workshop we presented overviews on works from our disciplines, discussed in different formats (plenaries, world café etc.). The workshop provided a starting platform for building the framework of the present manuscript. These findings were presented to a larger group of in total 32 experts (this time including additional experts in the fields of logistics, food economics, economic education, environmental humanities, environmental history, environmental anthropology, industrial production, political science) in a second one-day workshop on 30 October 2023 (organized by authors Dannenberg, Follmann and Braun) and again discussed (world café) and further refined (plenary discussion; see Figure 1).

A subsequent literature review was undertaken for further substantiating the major outcomes and framework resulting from the workshop and providing scientific documentation for the examples, case studies and approaches mentioned in the manuscript henceforth.

Figure 1 Workflow for the Interdisciplinary Expert Discussions and Triangulation of Different Perspectives



Note. Source: own figure.

3. State of the Art: Sustainability and Resilience in Value Chains

In this section we outline partly overlapping analytical frameworks (SC, GVC and GPN) which are used in interdisciplinary research to study sustainability and resilience in value chains and agri-food chains more specifically. As the GVC perspective and the GPN perspective are closely related and used in similar research fields (e.g., economic geography), we partly discuss them together (see 3.2.2 and 3.3.3). In contrast, the SC and GPN/GVC literatures hardly speak to each other. In order to provide an overview of the different perspectives, we outline here the main debates in a large body of literature and do not claim to be exhaustive on the subject of resilience and sustainability but with a specific focus on the interface between the two with respect to agri-food value chains.

3.1 Different Chain Perspectives: SC, GVC and GPNs

The study of SCs is an established interdisciplinary field of research with insights for politics, business and civil society (World Bank, 2020). Older, more business-oriented SC concepts (Cavinato, 1992) mainly focus on input-output-relations, structures, competitiveness, innovation and cost, and the challenges of differentiating between internal and external costs within chains. They examine influences on SC performance, including chain actors' capabilities and management practices. Newer conceptualizations also consider governance aspects and unequal power relations (Negri et al., 2021; Ponomarov & Holcomb, 2009). With these different analytical dimensions SC perspectives give a first analytical frame for the following analyses.

GVCs (see Gereffi et al., 2005) and GPNs (see Coe et al., 2004; Coe & Yeung, 2015) go beyond SC perspectives to integrate a specific governance perspective that analyzes power relations and dependencies within the chain (e.g., due to capabilities, capacities, and market access; see especially work on GVC such as Gereffi et al., 2005). While GVC and GPN approaches have different conceptual origins and varied foci, we generally discuss them together in this paper (for a detailed differentiation see Neilson et al., 2014).

Moreover, both GVC and GPN understand chain dynamics as embedded into specific global, national and regional settings (e.g., regional assets, political and institutional frameworks; see in particular GPN literature like Coe et al., 2004). These spatial and locational dimensions help explain why, how, and where certain value chain segments developed, who participated in the value capture process, who was excluded, and what kind of dependencies and inequalities developed (e.g., in the Global South).

3.2 Sustainability in Value Chains

Sustainability has long been an important keyword in value chain research. However, it is often defined using three rather generic pillars—environmental, economic and social. Of course, there is no *one* concept of sustainability; the idea contains multiple

conceptualizations, interpretations and measures (Fearne et al., 2012) on the spectrum between "weak" and "strong" sustainability. Sustainability approaches are therefore criticized for being vague or too flexible. They further often fail to consider the conflicts and tensions between these different sustainability dimensions (Fearne et al., 2012). Finally, sustainability is often defined from the Global North, omitting characteristics emerging from the Global South (Abe Chatterjee & Bernzen, 2022). Such asymmetric power relations, capabilities, and capacities both orchestrate value chains and enforce a normative discursive agenda about pathways to global development.

Despite these weaknesses, sustainability has become a key paradigm of multiscalar policy debates and normative agendas (see e.g., the UN's sustainable development goals) and has therefore also been intensively discussed in the applied and scientific literature on value chains. Literatures on SCs, GVCs and GPNs have addressed questions of sustainability and sustainability measures from different (partly overlapping) perspectives (Negri et al., 2021).

3.2.1 SC Perspectives: Costs, Efficiencies, Firm Perspectives, and Closed Loops

Most SC work from economics and business administration combines economic and environmental objectives. For instance, studies may integrate life cycle assessment data into strategic investment decisions (Hugo & Pistikopoulos, 2005) or analyze the Pareto-frontier for bi- or tri-objective eco-efficiency in SC design models (Quariguasi Frota Neto et al., 2009). Other models integrate social acceptance and cost (Becker et al., 2023) and sustainable SCs (Thies et al., 2021), sometimes with applications for the food sector (Oglethorpe, 2010). Nearly all of these approaches are written from the perspective of a centralized system or focal company. Furthermore, most studies analyze and center the potential of closed-loop SCs and circular economies for efficient resource use for a sustainable transition (Quariguasi Frota Neto et al., 2009). There are further attempts to measure the agri-food chains performance towards sustainability through total factor productivity analysis (Gaitán-Cremaschi et al., 2017).

3.2.2 GVC/GPN Perspectives: Sustainability Principles as Upgrading and Downgrading in Unequal Chains

GVC, and to a lesser degree GPN, studies often consider whether chains promote or hinder sustainability (Krauss & Krishnan, 2022). Some scholars argue that integrating producers into international chains will lead to more efficient and sustainable production that leverages comparative advantages and transfers technologies (Vanpoucke et al., 2014; Achabou et al., 2017). However, more critical work contends that international chain integration often encourages a race to the bottom that forces suppliers to compete using socially and environmentally unsustainable practices (e.g., Barrientos et al., 2011; De Marchi et al., 2019; Humphrey & Schmitz, 2002; Krishnan et al., 2022).

GVC and GPN work intensively discusses these issues in the context of economic (e.g., increased revenues), social (e.g., improved work safety), and environmental (e.g., reduced pollution, reduced CO2 emissions) upgrading, but also reflected conflicts and downgrading. According to Humphrey and Schmitz (2002), upgrading in a chain is usually conceptualized using four categories: product, process, functional, and inter-sectoral upgrading. Upgrading the different categories can create more sustainable products and processes; it may also allow firms and regions to move into more sustainable business sectors or take over more sustainable functions (e.g., through capacity building). However, other studies have questioned these straightforward path conceptualizations, arguing that upgrading processes co-exist alongside downgrading, higher risks, and limited rewards for certain chain actors (Ponte, 2022). This is especially important since value chains often involve significant power imbalances, with lead firms exerting control over the entire chain. These power imbalances distribute sustainability costs and benefits unequally along the chain and affect, for example, how/whether farmers adopt sustainable practices.

3.2.3 GVC Perspectives: Sustainability Standards as Value Chain Governance

A related debate surrounds the role of standards and certifications in value chain sustainability governance (Bernzen, 2013; Dannenberg & Nduru, 2013; Ouma, 2010; Ponte et al., 2023). In agricultural value chains, the implementation, success, and failure

of sustainability standards depend on governance and power asymmetries within the chain, producer capabilities, and the local and regional context (Ouma, 2010). Powerful buyers (like Northern supermarket chains) exert their will over producers like economically dependent, small-scale farmers in the Global South with limited capacities to upgrade (Krishnan, 2018; Vicol et al., 2018). Sustainability standards are widely discussed to result in the exclusion of small-scale farmers especially in the Global South as they are often not able to fulfil standard requirements and are therefore excluded from the chains (Dannenberg & Nduru, 2013; Ponte et al., 2023; Swinnen, 2016).

Crucially, sustainability governance in value chains is multi-scalar—it must include the whole value chain, the different actors within the value chain, and the affected actors beyond the chain itself. According to Bush et al. (2015, p. 9), sustainability must be analyzed "in chains, of chains and through chains." Sustainability governance in chains may be derived from an external standard (e.g., ISO 14001), a lead firm's business-to-business standard, or multi-stakeholder initiatives beyond the chain like the Roundtable on Sustainable Palm Oil (Bush et al., 2015). While standards and certification schemes can drive positive change and set clear sustainability criteria, they also create compliance costs (Johannessen & Wilhite, 2010).

Sustainability compliance costs are often pushed upstream to relatively weak producers like small-scale farmers in the Global South (Hulke & Revilla Diez, 2022) who stand to lose significant income in what Ponte (2019) calls the "sustainability supplier squeeze." These are often "hidden costs of sustainability compliance and related risks" (Ponte, 2022, p. 1).

Producers may even find themselves entirely excluded from the chain to implement sustainability standards and related measures (in case of lacking capabilities or capacities, see González & Nigh, 2005). However, farmers may also bypass standards or otherwise subvert sustainability measures when implementation is impossible (e.g., by mixing produce of certified farms with products from non-certified farmers; see Dannenberg and Nduru [2013]). Similar problems are discussed for the implementation of the German SC due diligence law ("Lieferkettengesetz", Bierbrauer, 2022) as well as in third-party, voluntary sustainability certification schemes, for example, for global cocoa value chains (Parra-Paitan et al., 2023).

When measuring sustainability, it is crucial to delineate whether actions are limited to parts of the value chain, the whole chain, or go beyond the chain (Bush et al., 2015). This raises conceptual and methodological questions about system boundaries—what to include and exclude—when assessing the effects of sustainability measures (Horton et al., 2017). It is also important to consider whether some sustainability measures simply obscure problems to the direct disadvantage of others and the long-term disadvantage of society as a whole (see Rodríguez-Pose & Bartalucci, 2023). Put differently, it is important to ask, *sustainability for whom* (e.g., small-scale farmers vs. lead firms) and where (center vs. periphery; Global North vs. Global South).

3.3 Resilience in Value Chains

According to the Stockholm Resilience Centre (2015, p. 25), the interdisciplinary concept of resilience describes "the capacity of a system to deal with change and continue to develop." Such systems include regions, businesses, households or, in this case, value chains. Studies on resilience typically identify the risks and vulnerabilities different actors or systems face (see, e.g., Cannon & Müller-Mahn, 2010; Miller et al., 2010).

Many contemporary studies favor a dynamic perspective—a resilient system does not necessarily stay the same, but constantly changes due to strategic measures and flexible responses to shocks and crises (see Ponomarov & Holcomb, 2009). Thus, resilient systems are learning systems. Response strategies can be divided into coping (overcoming adversities), adaptation (learning from past experiences and adjusting to future challenges) and even transformation (crafting sets of institutions that foster individual, organizational and societal robustness towards future crises; see Keck and Sakdapolrak [2013]—Wisner et al. [2004] even argue that this might require a modification of underlying *root causes* such as societal power relations or ideologies) depending on the capacities and degree of actual change and adjustment.

The literature on (socio-ecological) resilience has identified principles underpinning such strategies: maintaining diversity and redundancy, managing connectivity and feedback, fostering complex adaptive systems thinking, encouraging learning and ex-

perimentation, broadening participation, and promoting polycentric governance systems (Biggs et al., 2012, pp. 441–442). These strategies usually entail challenges and trade-offs (e.g., maintaining diversity and redundancy can be costly; Biggs et al., 2012, p. 427). Understanding why certain systems are (or can become) resilient requires analyzing underlying risks, vulnerability to crises, shocks and stressors, and the potential and weaknesses of related responses in their respective contexts.

3.3.1 SC Perspectives: Individual Risks and Whole SC Risks

Much existing work on SC resilience aims to better understand and manage risk. Therefore, these studies distinguish between risks at the firm level and risks to the whole SC (see Harwood et al., 1999; Leat & Revoredo-Giha, 2013). Harwood et al. (1999) list *individual-level* risks, including production risk, price or market risk, institutional risk, human or personal risk and financial risk (see also Leat & Revoredo-Giha, 2013). Such risks concern individual firms or smallholders and are unevenly distributed along the chain and within the different chain segments (i.e., producers or retailers).

For a SC perspective, it is necessary to go beyond the individual actor. Therefore, the distinction between process and control risks is critical as it helps to understand where and which activities or segments of a SC are vulnerable. Process risks are associated with interruptions in the value creation and managerial activities of businesses, while control risks stem from the breakdown or misapplication of systems and standards (Leat & Revoredo-Giha, 2013, p. 221). Risks affecting the whole SC are categorized into supply and demand risk: Supply risk refers to interruptions between a producer and its supplier, for instance, disrupted material, service, or monetary flows. In contrast, demand risks focus on the disruption between the firm and its customers (e.g., products, revenues or information; Leat & Revoredo-Giha, 2013, p. 221). SC risk concerns interruptions from outside the SC, which are referred to as environmental risks. Environment refers to political, social, technological or natural events that influence the setting of a SC (Leat & Revoredo-Giha, 2013, p. 221).

3.3.2 SC Perspectives: Capabilities and Practices to Manage Risks

Other SC studies (see e.g., Ponomarov & Holcomb, 2009; Negri et al., 2021) reveal that companies are aware of risks and that SC disruptions have high financial costs. SC management perspectives argue that resilience can be achieved if SCs incorporate event *readiness*, enact efficient and effective responses, and recover to their original state (or better) after a disruptive event (Ponomarov & Holcomb, 2009). For Ponomarov and Holcomb (2009, p. 131) SC resilience entails the "adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function." Other studies examine certain *risk management practices* to achieve resilience, including supply-side (i.e., long-term supplier relationships, green purchasing, multiple-sourcing strategies, flexible and redundant supply), demand-side (i.e., customer relationship management, demand postponement), product-related (i.e., product interchangeability), and information-related (i.e., training, education) practices (Negri et al. 2021, p. 286).

3.3.3 GVC and GPN Perspectives: Risks and the Impact of Governance, Structure and Organization

While GVC scholars, as partly discussed already above, have engaged with sustainability and resilience issues (see for details De Marchi et al., 2019; Krishnan et al., 2022), GPN work has more focused on resilience and risks (Völlers et al., 2023). For example, GPN research has engaged with risk, both calculable and incalculable risk (uncertainty) affecting different chain actors (Yeung, 2023, p. 3). Coe and Yeung (2015, p. 111) distinguish five types of risk: economic, product, regulatory, labor, and environmental. The risk categorization by Coe and Yeung (2015) resembles the above-mentioned understanding of environmental risks. They refer to uncertain or unpredictable events that affect the entire GPN, rather than which processes in a value chain are affected. However, much of this research has used a *governance perspective* that considers how lead firms organize and control chains in the context of risk (see Franz et al., 2018; Gibson & Warren, 2016; Lanari et al., 2021). Nevertheless, adopting a decentralized view of all network actors—beyond the lead firm—is critical for under-

standing resilience and adaptation strategies (e.g., in sourcing, production) in the chain as a whole (Lanari et al., 2021; Völlers et al., 2023). In this context, insights from political ecology research on agricultural products using a GVC/GPN perspective is a valuable contribution (see, e.g., Pye, 2017).

Research linking GPN/GVC with political ecology has highlighted inequalities in distribution of resources and environmental risks in value chains from multiscalar perspectives (Campling et al., 2019; Dorn & Huber, 2020; Werner, 2022). Drawing on long-standing research on the commodification of nature as well as on the power relations between place-based and non-place-based actors, research has focused on extractive industries (see, e.g., Bridge, 2008), but also on agri-food chains like soybeans, palm oil, coffee, cocoa, etc. (see Pye, 2017; Dorn & Huber, 2020). These works highlight the interlinkages between unsustainability and inequality in especially global production systems.

Uncertainties stemming from crises are troubling for all chain actors since it is impossible to calculate management and control measures (Bryson & Vanchan, 2020; Neise et al., 2023). Value chains may even become *transmitters for various crises* depending on their *structure and organization*. A crisis in one segment, sector, or region can quickly engulf the entire global chain. There are three primary sources of crises-induced risks: the trading of risk-laden products, a high concentration in value-added creation, and a high trade frequency (Mariasingham et al., 2023).

For example, the Covid-19 pandemic and related interruptions between producers (in particular in China) and end markets (in Europe and elsewhere) revealed the specific vulnerability of linear chains compared to other more network-organized societal and economic systems. When production networks have multiple actors for each stage, individual actors can be more easily replaced and interruptions circumvented. In linear value chains, a breakdown or temporary malfunction of a single actor or segment (e.g., a turnkey supplier or a central logistic hub) can lead to a complete chain failure (Sydow et al., 2021; Yang & Chan, 2023). There is a current endeavor to integrate *regional resilience*, a concept that analyzes how regions generate adaptability and transform towards being more resilient towards shocks and prepared for risks, into GPN studies (see Hulke et al., 2022; Martin & Sunley, 2014). Here, the focus lies on the region, not the chain or production system. Therefore, Yeung (2023, p. 4) calls for more risk analysis that would incorporate geopolitical, social and environmental risks—from pandemics to climate change.

Recent crisis-driven volatility of energy and resource prices has spotlighted vulnerabilities in high-energy and resource-intensive agricultural input supply. Studies predict significant, long-lasting consequences for global agri-food chains embroiled in multiple crises (Clapp & Moseley, 2020; Priyadarshini & Abhilash, 2021; Tups et al., 2024). This includes the larger restructuring away from smaller farms to larger agricultural production systems. Current debates also consider relocating agricultural production closer to Global North markets to bolster the food security resilience of local and regional chains (despite a majority focus on commercial, often international, chains; Hulke & Revilla Diez, 2022; Molitor et al., 2017). Notably, the industrial fertilizer SC—which is dominated by a few powerful global companies which partly act as lead firms from the supply end—has been largely left out of the GVC and GPN debate thus far (for an exception, see Tups & Dannenberg, 2021).

4. Linking Sustainability and Resilience in (Agri-Food) Value Chain Research

Our interdisciplinary review and conceptual debates reveal conceptual overlaps and theoretical synergies but also practical frictions and tradeoffs among sustainability and resilience in value chain research. In the following sections, we outline the most relevant conceptual overlaps, synergies, and frictions between sustainability and resilience principles in the existing literature on (agri-food) value chains. As an interdisciplinary group of scholars focusing on our debates on the sustainability and resilience in (agri-food) value chains, we intentionally limit our analysis here to sustainability and resilience within and from a chain perspective (see Johnson et al., 2018 for a broader discussion of the synergies and frictions of the two concepts, which would go beyond the scope of this paper).

4.1 Overlaps—Similar Dimensions, Variables and Categories

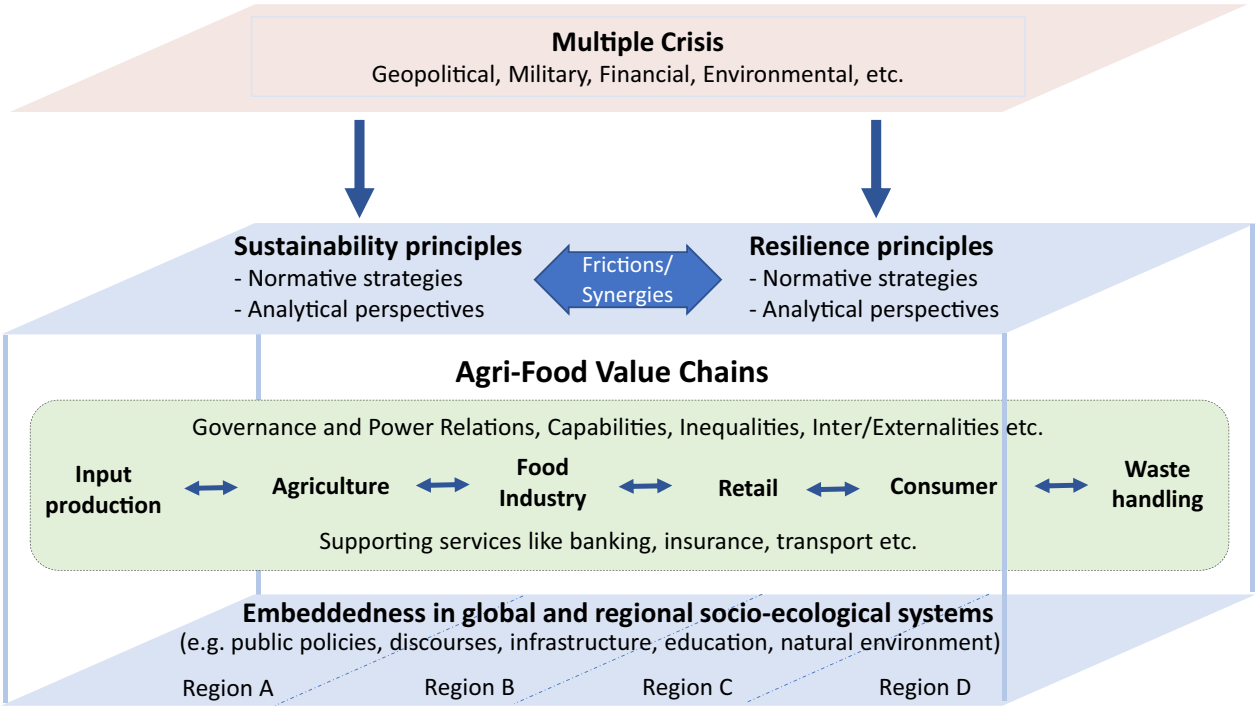
Sustainability and resilience can be, at least partly, analyzed using similar analytical variables and categories. Therefore, we argue that different analytical dimensions within the value chain approaches are relevant and useful for a comprehensive understanding of sustainability and resilience along chains.

Using our focus of agri-food chains, Figure 2 summarizes our conceptual approach, highlighting how sustainability and resilience share key analytical dimensions despite drawing on different key principles (e.g., resource efficiency versus redundancy). These dimensions include governance, chain actor capabilities and capacities, inequalities in resource distribution, and the question of internalities and externalities. This allows an interlinked analysis of resilience and sustainability from a value chain perspective.

4.1.2 The Role of Governance Structures, Resource Distribution, and Capabilities and Capacities

The degree of sustainability and resilience (and the success or failure of such measures) depends on the governance structures, resource distribution, and capabilities and capacities of the involved actors. These dimensions are also key to understanding practical frictions between resilience and sustainability. Agri-food chain sustainability and resilience measures are both heavily influenced by changing regional environmental conditions like extreme weather events and general climate change. In many regions of the Global South, these challenges collide with the limited financial resources and infrastructures (physical, institutional, and personal) of involved chain actors and/or the whole chain (Kiesel et al., 2022). Achieving resilience or sustainability does not only depend on high or low capacities and capabilities; it also requires the *appropriate* capacities and capabilities for specific challenges, strategies, and spatial and temporal situations.

Figure 2 Workflow for the Interdisciplinary Expert Discussions and Triangulation of Different Perspectives



Note. Source: own figure.

4.1.3 The Unequal Effects of Resilience and Sustainability Measures

In addition to questions of sustainability for whom (Krishnan et al., 2022), we can also consider *resilience for whom*? Resilience-oriented strategies like near-shoring, friend-shoring or reshoring seek to relocate the supply (i.e., relocating agricultural production closer to Northern markets), thereby fully or partially excluding former suppliers. This is particularly problematic for interchangeable actors with limited opportunities (e.g.,small-scale farmers in the Global South), who may turn to less socially and environmentally sustainable markets and production methods. Less existential costs of sustainability and resilience measures are also shared along the chain. These can include for example jointly developed standards and certifications along the chain (Meemken et al., 2021; Oya et al., 2018) or the joint financing and implementation of warning systems for agricultural production to be more adaptive in managing unfolding climate challenges (Agyekumhene et al., 2023). Here it depends, for example, on the sharing of costs and efforts in how far such measures lead to unequal effects or "fair" sharing.

4.1.4 Analytical and Practical Demarcation Problems—the Question of Internalities and Externalities

One challenge for both resilience and sustainability perspectives is the demarcation of internal and external elements within a value chain or (regional) production system. This question is crucial from both scientific and policy/practitioner perspectives (e.g., for the development of sustainability standards [see Meemken et al., 2021]) since resilience and sustainability measures sometimes externalize their costs to the detriment of other regions and actors. Determining whether specific value chain measures positively contribute to overall sustainability and resilience requires establishing system boundaries and externalities. Even though some practices, measures, and achievements might increase the sustainability or resilience of individual chain actors, (un/intended) external effects on other actors within or beyond the chain might hinder overall sustainability or resilience.

4.2 Synergies and Frictions Between Sustainability and Resilience Measures

Existing research indicates that installing and maintaining resilience can actually endanger and counteract sustainability efforts (Grumiller et al., 2022). For example, ceteris paribus, transforming a value chain towards more redundancy can increase resource use through the creation of double structures and backups, which often works against economic and environmental sustainability goals (Grumiller et al., 2022). Conversely, establishing and maintaining sustainability and resilience measures increases system complexity and inefficiencies. In such cases, one objective is often prioritized over the other (see Biggs et al., 2012). Examples include the above discussed near-shoring strategies and more rigid supply chain standards.

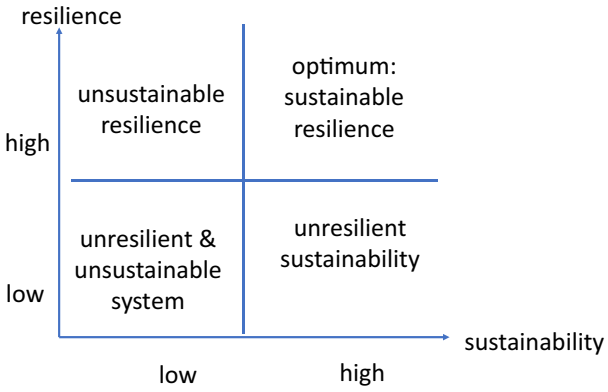
On the other side, crisis situations may encourage (or even necessitate) sustainability transformations in value chains (Sarkis, 2021). The threat of rising resource prices can drive sustainability efforts, particularly the reduction of resource dependencies. Thus, sustainable resource use can foster SC resilience—reducing resource use and circular economy reuse create win-win situations for sustainability and resilience (Negri et al., 2021). Negri et al. (2021) argue that resilience and risk reduction must be goals of sustainable management in order to achieve long-term sustainability.

These synergies and frictions can be conceptually simplified using a matrix to illustrate potential relations between resilience and sustainability (see Figure 3). Conceptually, while *sustainability-resilience synergies* allow different chain actors to increase sustainability and resilience within value chains, *sustainability-resilience frictions* undermine different chain actors' initiatives to do so. Normatively, the desired optimum is a value chain which is both sustainable and resilient. We can term such a stadium as *sustainable resilience* or *resilient sustainability*—always depending on what to prioritize (Grumiller et al., 2022). For example, the aforementioned example of the "sustainability supplier squeeze" (Ponte, 2019), where sustainability compliance costs are often pushed upstream to small-scale farmers (Hulke & Revilla Diez, 2022; Ponte, 2022) might considerably affect the farmers resilience to other external shocks. With regard to different adaptation and de-risking strategies associated with climate risk, Agyekumhene et al. (2023) outline resilience-sustainability synergies, such as intercrop-

ping and other climate robust management practices, water management and digital warning systems, which could be used for more sustainable agri-food production (see Kiesel et al., 2022).

In sum, comparing and contrasting perspectives on sustainability and resilience in value chains, Table 1 summarizes the main general, (agri-food) value chain perspective specific findings. It highlights frictions between sustainability and resilience measures in practice and outlines conceptual overlaps and potential synergies for a comprehensive analytical perspective.

Figure 3 Idealized Relational Matrix of Resilience and Sustainability Measures



Note. Source: own figure.

Table 1 Conceptual Overlaps, Synergies and Frictions on Sustainability and Resilience Perspectives on Value Chains

Sustainability principles and categories	
General perspective	· Ecological, social, economic sustainability · Normative and analytical perspectives · Strong vs. weak sustainability · Output vs. process-oriented measures and analyses
Chain perspective	· Potentials of sustainable and closed-loop SCs · Sustainable SC management · Implementation often focuses on cost reduction but also on trade-offs between economic, environmental and social criteria · Economic, social and environmental up/downgrading of products, processes; functional and intersectoral upgrading in one area can lead to downgrading in another · Global SCs as promoter or barrier of sustainability · Power imbalances and inequalities in chains as sustainability challenges (e.g. externalization of costs) · Sustainability in chains, of chains and through chains
Agri-food perspective	· Characterized by particular risks and vulnerabilities to crises (e.g., limited storage options, perishability, inelastic demand)
Resilience principles and categories	
General perspective	· Different definitions e.g., capacity of a system to deal with change and continue to develop · Linked to vulnerability and risk · Normative strategies and analytical perspectives · Coping, adaptation, transformation · Different principles on: diversity and redundancy, connectivity, variables and feedbacks, adaptive systems thinking, learning and experimentation, participation, polycentric governance
Chain perspective	· Capability of firms to manage risks · Focus on increase in flexibility and redundancy (results in costs) · Different risk management practices include supply-side, demand-side, product-related, and information-related practices · Resilience as readiness and ability to respond and recover · Resilience as the adaptive capability of the SC to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function · Distinction between resilience against risk at firm or SC level · Resilience as not downgrading (social, environmental and economically)
Agri-food perspective	· Establishing new agri-food chains for risk diversification: geographical diversification strategies and partial de-globalization, reshoring, establishing new global or regional supply chains, adapting supply chains to the new situation. · Few works on critical input suppliers which have been identified as crucial at latest during recent multiple crises

Synergies and Frictions between measures	
General perspective	· Installing and maintaining resilience and sustainability measures is costly in terms of increasing system complexity and inefficiency which can lead to prioritizing one over another
Chain perspective	· Sustainable use of resources relates to building supply chain resilience— e.g., through less resource use or reuse in circular economies (win-win opportunities) · Resilience becomes a short- and long-term goal of sustainable management and risk reduction · Disruption risk and environmental practices can have a negative relationship · Upgrading via social and environment standards can be in conflict with maintaining diversity and redundancy · Friend-shoring can lead to exclusion of actors from the chain (socially and environmentally unsustainable) · Responsive actions to crises can endanger sustainability efforts · Crises can offer opportunities for sustainability transformations · Conceptually: windows of opportunities & firms' risk mitigation strategies · Firms' risk mitigation strategies & public/political pressure to reconfigure GVCs
Conceptual overlaps and perspective for synergies	
General perspective	· General perspective on costs, complexity, inefficiencies and differentiation of long-term strategies and short-term measures (in particular in times of multiple crises) and related outcomes (temporality)
Chain perspective	· Risk and knowledge are integrated as additional dimensions into sustainability concepts · Risk or resilience are drivers for sustainability effort in particular for reducing resource dependencies · Differentiation of different structures and actors (e.g., individual actors vs. whole chain) · Analyses of internalization or externalization of costs for sustainability and resilience measures (e.g., through standards) · Governance structures and power relations as a key for the manifestation and shape of sustainability and resilience measures along the chain · Understanding resilience and sustainability as different forms of up/downgrading which can be in sync or conflict with one another · Global Chains as transmitters of sustainability, resilience or crises · Understanding of "externalizing" costs of resilience and sustainability measures
Agri-food-perspective	· The outlined problem of *sustainability for whom* can be transferred also to *resilience for whom*, e.g., concerning re-allocation of supply which includes the full or partial exclusion of existing suppliers

Note. Source: own compilation; based on sections 3 and 4.

5. Potential Future Research Foci and Perspectives

This section considers opportunities for socially relevant interdisciplinary research and sketches out scopes for future research. Firstly, we suggest that interdisciplinary research should address sustainability-resilience frictions and synergies and the question of sustainability and resilience for whom. We then outline four conceptual perspectives that could reveal different aspects of sustainability-resilience relations within agri-food value chains: new perceptions on risks and uncertainties, crises-related upgrading and downgrading, integrating externalities using interdisciplinary whole-chain perspectives, and de-centering perspectives on resilience and sustainability in value chains.

5.1 Sustainability-Resilience Frictions and Synergies

We suggest focusing on sustainability-resilience frictions and synergies (see Table 1) to better understand the effects of certain measures and restructuring of agri-food chains in times of crisis. Future research might address the relations between resilience and sustainability (see Figure 3) and whether/to what extent sustainability-resilience frictions undermine different chain actors' initiatives to increase sustainability and resilience within value chains. From a normative perspective, achieving optimally sustainable and resilient value chains is desirable. Therefore, future research should identify (potential) frictions and synergies to harmonize measures, avoid frictions, and create synergies between different chain actors' sustainability and resilience measures. This work can build upon a more differentiated and critical perspective on the importance of value chain characteristics (i.e., power structures, capabilities, up- and down-

grading, and conceptualizing internalities and externalities).

5.2 Sustainability and Resilience for Whom?

Future approaches should interrogate how different chain actors experience inequality, cost-sharing, and the benefits of sustainability and resilience in crisis-related restructuring. In short, research can ask sustainability and resilience for whom? For instance, crisis-related strategies like near-shoring, friend-shoring, and reshoring can result in the (potentially socially unsustainable) detriment of replaceable and powerless producers and workers at the very end of the chain, often in the Global South. Using the case of the South African wine industry, Ponte et al. (2023, pp. 11–12) recently argue that "sustainability governance is playing a role in the worsening inequalities" within the chains and "that sustainability per se does not pay for upstream wine value chain operators, and for wine grape farmers in particular."

Beyond the problems for individual actors and the general problem of injustice, this approach can hinder the acceptance and, therefore, the efficacy of potential measures (see, e.g., the aforementioned example of standard bypassing). There is little chance of achieving truly sustainable and resilient developments if the burdens and costs of sustainability are simply passed to the suppliers or externalized. Therefore, interdisciplinary research can also focus on analyzing (potential) unsustainable and non-resilient developments and practices along the chains and anticipate future unequal distributions of benefits and burdens emerging from redress measures.

The literature on value chains (especially GVC) has always dealt with questions of unequal power distributions, capabilities, etc. and the negative implications for weaker links in the chain. Other work on structural inequalities and injustice (e.g., from a Global South perspective) can be used to analyze this context. These and other critical perspectives can enhance perspectives on resilience and sustainability in value chains and promote more plural and social value systems.

5.3 New Ideas on Risks and Uncertainties in Agri-Food Chains

Multiple simultaneous crises have produced new forms of risk and uncertainties that are translated into material practices that remake the global economy (Yeung, 2023, p. 3). Incalculable uncertainties are met with subjective and dynamic risk perceptions among different chain actors and policymakers (Völlers et al., 2023). Lead firms and other actors aim to change the chain's organizational and institutional setups to make them more resilient and better prepared for new uncertainties. However, it is unclear how these transformations towards increased resilience affect the sustainability of the chains.

We advocate for future research on dynamic new crisis-related forms of risks and uncertainties within agri-food chains and how to address them with sustainability initiatives. The different value chain frameworks (SC, GVC, GPN) and existing knowledge on governance structures, distribution of resources, and capabilities and capacities among the different chain actors can guide future analysis. However, we suggest that new conceptual approaches should also better understand the particularities of crisis-related uncertainties and how they affect sustainability and resilience.

Existing conceptualizations in the GVCs/GPNs literature offer vantage points from which to analyze governance and institutional setups when the riskscapes that chains are embedded in change (Müller-Mahn et al., 2018). The concept of riskscapes underscores that risk is socially produced and conceived through perceptions, communications, and collective action at the societal level (Müller-Mahn et al., 2018). Therefore, ongoing and multiple crises can be conceived and handled very differently in different societal environments (Völlers et al., 2023). This leads to different pathways of (un-)resilient development along a value chain stretching through different regions (e.g., from Global South to Global North). Future research on global agri-food value chains should pay special attention to the distribution and sharing of risks and uncertainties as well as the production of certain riskscapes among the different actors. A solution-oriented shift is needed for questions around the sustainability-resilience nexus.

5.4 Crises-Related Upgrading and Downgrading in Agri-Food Value Chains

Different forms of upgrading and downgrading—whether synced or in conflict—may offer conceptual starting points to better understand the relations between resilience and sustainability in agri-food value chains. These concepts offer promising conceptual starting points to engage with the dynamic shifts in agri-food value chains during multiple crises. The up-and-downgrading perspective considers potential trade-offs and conflicts between resilience and sustainability measures (e.g., at the expense of certain actors and regions along the chain) to inform the debate on de-risking strategies and their possible effects on sustainability and resilience. The "sustainability supplier squeeze" (Ponte, 2019) can be conceptually extended to the *resilience supplier squeeze* to help chain actors and policymakers more fully understand current crises and related responses.

5.5 Integrating Externalities Into Interdisciplinary Whole-Chain Perspectives

Public and private actors' responses to multiple crises have produced new externalities. Crises-related resilience and sustainability measures exist within evolving unequal governance structures and capabilities; therefore, they produce unequal and unjust outcomes, for example, the internalization of benefits and externalization of costs or the exclusion of actors. Responses to multiple crises often shift problems out of sight, that is, beyond the chain with negative societal consequences. This can lead to unsustainable resilience (i.e., an alleged sustainability or resilience) in which the real environmental, social, and economic costs/risks are hidden.

The problem of system boundaries and externalities demands drawing from an interdisciplinary whole-chain perspective—from the raw material extraction and pre-production to trade, consumption, and waste handling in agri-food chains. Both ends of agri-food value chains (input production and waste handling, see Figure 2) remain under-researched (see recent debates on the use of agrichemical inputs; Kulke et al., 2020; Tups & Dannenberg, 2021; Werner, 2022). This becomes even more important as some input suppliers (e.g., large fertilizer companies) are powerful key actors for the functioning and un/sustainable development of agri-food chains. Existing studies, especially from the field of agricultural economics, have studied certain agri-inputs with special attention on concentration processes and resulting market power in agri-food chains (Crespi & MacDonald, 2022; Sheldon, 2017) as well as the diffusion of technologies and adoption of innovation in upstream segments of the chains (Reardon et al., 2019; Zilberman et al., 2019). Therefore, we argue that the common field-to-fork focus of GVC/GPN work needs to be extended into a whole-chain perspective integrating these aspects.

Moreover, we also argue for a spatial, multi-scalar perspective that considers the regions encompassing the chain as well as developments and risks on other spatial scales (see Figure 1). The lead firm may exclude or disarticulate locations to pursue more cost-effective, compliant, sustainable, and resilient chains. An interdisciplinary whole-chain approach could also draw on existing approaches—for example, Life Cycle Sustainability Assessment (Vidergar et al., 2021), hotspots analysis (Anastasiadis & Tsolakis, 2021), Multi-Criteria Decision Analysis (Ortiz-Barrios et al., 2020)—that offer conceptual starting points and inform and enrich research from GVC and GPN perspectives (which rarely address such whole-chain perspectives).

5.6 De-Centering Perspectives on Resilience and Sustainability in Value Chains

It is generally useful to ask who defines sustainability and resilience in the value chain and beyond. Global SCs are not isolated from socio-ecological systems and socio-economic foundations. Their embedding in and impact on social systems (culture, institutions, practices, etc.) at different scales (global, national, local, etc.) is central to their constitution (Coe & Yeung, 2015; Kulke et al., 2020). In this context, "epistemic inequalities between knowledge systems" (Hornidge et al., 2023, p. 36) are widespread in agri-food supply chains and may also be part of the foundation of inequalities in terms of resilience and sustainability within the chains. In this context, Din et al. (2017), among others, show that if sustainability measures are misaligned with regional cultural practices (e.g., disregarding pastoral ways of life) they can have counterproductive effects.

A deeper (interdisciplinary), more integrative understanding of these complex interrelationships is helpful to make global agri-food chains more sustainable

and resilient in the long term. Therefore, future research should also address who actually defines (has the power to define) what is considered to be sustainable and resilient and in what context. Assessing sustainability and resilience in agri-food value chains can be improved by debating participatory, multi-stakeholder assessment frameworks and asking who is affected and whose reality counts.

6. Conclusion

Our review of existing work on sustainability and resilience in (agri-food) value chains stressed the importance of integrating sustainability and resilience perspectives in times of multiple crises. It identified synergies and frictions between sustainability and resilience as well as the conceptual overlaps that are important starting points for future research. We outlined a future research agenda to continue investigating sustainability and resilience in (agri-food) value chains in times of multiple crises. In sum, we identified six interrelated future research fields: 1) the analysis of the conceptual and normative frictions and synergies between sustainability and resilience; 2) more research on the question of sustainability and resilience for whom; 3) the conceptual integration of new ideas on risks and uncertainties, 4) the conceptualization of crises-related upgrading and downgrading; 5) research on externalities from interdisciplinary whole-chain perspectives; and 6) a de-centering of the perspectives on resilience and sustainability on a global scale.

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