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Strengthening the resilience of city region food systems: A literature review following the COVID-19 pandemic

Strengthening the resilience of city region food systems: A literature review following the COVID-19 pandemic

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Abbreviations and acronyms

CRFS	city region food system
CSA	community-supported agriculture
CSOs	civil society organizations
FAO	Food and Agriculture Organization of the United Nations
HLPE	High Level Panel of Experts
ICLEI	International Council for Local Environmental Initiatives
IFAD	International Fund for Agricultural Development
NGOs	non-governmental organizations
RUAF	Resource Centres on Urban Agriculture and Food Security
SERS	Subjectively self-evaluated resilience score
SMEs	small and medium enterprises
UNICEF	United Nations Children's Emergency Fund
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization

1. Introduction

Evidence continues to mount regarding the unsustainability of both global and local food systems (Campbell *et al.*, 2017; HLPE, 2017; Willett *et al.*, 2019). The need for a transformative food system agenda is urgent (Webb *et al.*, 2020), one that goes beyond the currently dominating focus on efficiency gains and instead reimagines food systems (McGreevy *et al.*, 2022). The current unsustainability of food systems manifests in numerous ways, including the many risks that threaten to disrupt food systems and exacerbate food insecurity and malnutrition (Dury *et al.*, 2019). Building food systems resilience is becoming a critical dimension of the transformation agenda, especially as food security, malnutrition, child undernutrition, and mortality rates are worsening globally (FAO *et al.* 2022; Osendarp *et al.*, 2021). The recurrence of shocks and stresses has undone decades of progress within just a few years.

In response to these challenges, the 2021 United Nations Food Systems Summit identified "building resilience to vulnerabilities, shocks, and stresses" as one of five key action areas to help governments transform food systems (Hertel *et al.*, 2021). In July 2022, the Chairperson of the High-Level Panel of Experts on Food Security and Nutrition declared at the High-Level Political Forum in New York, "We live in a permanent food crisis; efforts must be made to massively strengthen the resilience of local food systems" (FAO, 2022).

The COVID-19 pandemic added an additional shock to already failing food systems. The subsequent economic downturns were clear signs of the lack of resilience of food systems. Swinnen and Vos (2021, p. 366) state that "both income shocks and supply disruptions have affected food security and livelihoods the most where supply chains were more poorly integrated, and poverty and market informality had a greater presence before COVID-19. As such, the pandemic has reinforced existing inequalities". Household' coping strategies and social safety nets have not been enough for many to remain food secure during the first few months of the pandemic, especially in low- and middle-income countries with large informal sectors and subsistence agriculture (Egger *et al.*, 2021).

In addition to the COVID-19 pandemic, food systems have frequently experienced other shocks and stresses that magnified the impacts of the pandemic, raising concerns about their resilience to a wider range of shocks and stresses. The Russia-Ukraine crisis is the latest event to expose further vulnerabilities in food systems. While trade and long value chains can support the resilience of local food systems, they can also become major propagators of shocks. The Russia-Ukraine crisis has affected already tense global food commodity markets, inflating food import costs and threatening food supplies in many developing and emerging countries (Lang and McKee, 2022). Beyond food, many farming systems have been affected by the rising cost of energy and agro-chemical inputs on which they depend (WFP, 2022). Social protection measures have been key in mitigating food insecurity and malnutrition following the pandemic, though these efforts tend to address the symptoms rather than the root causes of vulnerability. However, narrowing fiscal space in many countries and the lower capacity to borrow (higher cost of debt) following the Russia-Ukraine crisis, are raising additional concerns about the sustainability of social protection schemes in low- and middle-income countries, and about the concomitance of a food and debt crisis (Estevão, 2022).

Strengthening food systems resilience requires a deeper understanding of the long-term impacts of recent shocks and stresses, and the lessons that can be drawn from them. Looking at long-run transmission channels such as nutrition education and health, Egger *et al.* (2021, p. 2) suggest that "the substantial and widespread economic distress caused by the current pandemic may induce fallout that persists for decades into the future". Similarly, changes in consumption patterns, and purchasing power are prompting gradual adaptations and transformations of the food systems, which are difficult to grasp due to their extended timeline.

It is therefore critical to understand how different actors react to these shocks and stresses, and the implications for the resilience and sustainability of food systems. Rather than offering a comprehensive review of the extensive literature on the impacts of COVID-19 or food system resilience, this review provides a focused perspective on how the pandemic is shaping resilience thinking in food systems.

The following section seeks to clarify what city region food system (CRFS) resilience means in this study. Section 2 highlights principles that could help strengthen the resilience of CRFS. Section 3 examines the resilience capacities of CRFS, while section 4 explores the food system attributes needed to develop these resilience capacities. Section 5 uses the COVID-19 pandemic to review impacts, individual responses and collective actions to decipher the complexity of a CRFS. Section 6 concentrates on the myriads of recommendations to improve food system resilience found in literature. The last section draws conclusions from the literature review and charts a path forward.

2. Clarifying city region food system resilience

Following the 2008 food crisis, the concept of resilience in food systems became a central focus for many development actors, despite its frequent use as a buzzword (Walker, 2020). However, the practical value of resilience as a concrete, operational concept in relation to food security and nutrition remains unclear (Béné *et al.*, 2016). Today, resilience has resurfaced as a priority on the food agenda, but key challenges persist.

2.1 Defining resilience

Resilience remains an ambiguous concept. In an extensive literature review, Stone and Rahimifard (2018) identified 48 different definitions of resilience across various academic disciplines—some specific to agri-food supply chains, others much broader. The United Nations defines resilience as the "ability of individuals, households, communities, cities, institutions, systems and societies to prevent, resist, absorb, adapt, respond and recover positively, efficiently and effectively when faced with a wide range of risks while maintaining an acceptable level of functioning without compromising long-term prospects for sustainable development, peace and security, human rights and well-being for all" (United Nations, 2020). When considering systems, which are complex in nature, and interrelated with other systems, resilience can be defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker *et al.*, 2004, p. 2). This view contrasts with the narrower understanding of resilience as stability or returning to a prior equilibrium. Instead, it places adaptation and transformation at the centre (Folke *et al.*, 2010).

In the following section, the resilience framework applied to farming systems by Meuwissen *et al.* (2019) raises key questions for city region food systems: resilience of what? Resilience to what? And resilience for what purpose? Meerow and Newell (2019) extend this framework to 'five Ws': resilience for whom, what, when, where and why. The application of such a framework "brings the politics of resilience to the forefront by encouraging the explicit recognition of politicized decisions, scalar dimensions, and trade-offs inherent to applying resilience empirically" (Meerow and Newell, 2019, p. 316). The application of this resilience framework to CRFS offers insights into the questions of 'whom,' 'when,' and 'where.'

Resilience is still a fuzzy concept. Based on an extensive literature review, Stone and Rahimifard (2018) identified 48 definitions of resilience, from different academic disciplines, some being specific to agrifood supply chains, others much broader. The United Nations defines resilience as the "ability of individuals, households, communities, cities, institutions, systems and societies to prevent, resist, absorb, adapt, respond and recover positively, efficiently and effectively when faced with a wide-range of risks while maintaining an acceptable level of functioning without compromising long-term prospects for sustainable development, peace and security, human rights and well-being for all" (United Nations, 2020). When dealing with systems, which are complex in nature, and interrelated with other systems, resilience can be defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker *et al.*, 2004, p. 2). This definition differs from the narrow sense of resilience as stability or the return to the initial equilibrium. Adaptation and transformation are placed at the centre (Folke *et al.*, 2010).

In the following section, we use the resilience framework applied by Meuwissen *et al. (2019)* to farming systems and raise the following question regarding city region food systems: resilience of what? Resilience to what? And resilience for what purpose? Meerow and Newell (2019) extend this framework to "five Ws": resilience for whom, what, when, where and why: the application of such a framework "brings the politics of resilience to the forefront by encouraging the explicit recognition of politicized decisions, scalar dimensions, and trade-offs inherent to applying resilience empirically" (Meerow and Newell, 2019, p. 316). As we will see later, the application of this resilience framework to CRFS provides some answers to the "whom", "when" and "where".

2.2 Resilience of what: city region food systems

While various approaches have shaped food security thinking over the past decades (Fanzo, 2023), food system approaches have increasingly gained prominence on the food security agenda "as it incites us to broaden our conventional thinking and to acknowledge the systemic and interactive nature of the different processes and actors involved" (Béné and Devereux, 2023, p. 2). Food systems are commonly defined as encompassing "all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes" (HLPE, 2014, p. 29). To apply the food system approach to specific locations, including cities, several models have emerged. One of them is the city region food system (CRFS) approach, offering a valuable "conceptual and practical framing for policy through wide engagement across sectors that enables the co-construction of a relevant policy frame that can be enacted through sufficiently integrated policies and programs that achieve increasingly sustainable food systems" (Blay-Palmer *et al.*, 2018, p. 2).

CRFS refers to "the complex relation of actors, relations and processes related to food production, processing,

marketing, and consumption in a given geographical region that includes one main or smaller urban centres and surrounding peri-urban and rural areas that exchange people, goods and services across the urban rural continuum" (Dubbeling *et al.*, 2017, p. 3). More recently, FAO and RUAF (2023, p. 6-7) provide an updated definition where "[the] CRFS encompasses the complex network of actors, processes and relationships that are involved in food production, processing and manufacturing, distribution, markets, consumption, and food loss and waste, in a given city region. It includes the economic, societal, and environmental components that configure actors, processes and relationships."

It is based on the wider city region concept that gained visibility in the 2000s, which was reaffirmed in the New Urban Agenda (UN, 2016). City regions correspond to territories where "nodes of human activity tend to coincide with relatively large cities or with systems of medium-sized cities in close geographical proximity, that articulate the economic and social developments of suburban, peri-urban, and rural hinterlands" (Rodríguez-Pose, 2008, p. 1025). The city region concept has been heavily criticized because of the overemphasis put on cities (city-first approach) at the expense of rural areas when operationalized, in contradiction to apparent discourses (Copus, Kahila and Fritsch, 2022; Harrison and Heley, 2015).

The CRFS seeks to overcome these criticisms. It first appeared in the Bonn Declaration of Mayors during the ICLEI Annual Global Forum on urban resilience and adaptation in 2013 (Cabannes and Marocchino, 2018). Its territorial focus is key for several reasons. First, food system nodes are often spread across different locations but are highly interdependent, requiring the use of local resources and potential. Second, when considering resilience, shocks and stresses can impact any of these locations, potentially affecting multiple or all food system nodes. Geographic connectedness is thus critical, as "rural-urban linkages can be both a shock absorber and a shock extender" (Maredia *et al.*, 2022). The CRFS concept also allows to consider the most fragile and vulnerable locations or nodes as pivotal in building resilience (Queiroz *et al.*, 2021). Lastly, the geographical dimension delimits the boundaries of the CRFS, which in turn determines the actors involved. In other words, these boundaries define both the "resilience for where" and "resilience for whom." Identifying the CRFS actors whose "vision of a desirable resilient future prevails and who benefits or loses as a result of this particular construct" (Meerow and Newell, 2019, p. 317) highlights the central importance of inclusive governance in shaping the CRFS.

Beyond its geographic dimension, the CRFS concept has other theoretical benefits, some generic to the city region concept, others specific to food systems:

- A change from sectoral to territorial development, with a focus on economic, environmental social, cultural and institutional dimensions;
- The flexibility to develop, innovate and experiment with strategies and policies adapted to the local context and needs through bottom-up participatory approaches;
- The coordination of different actors and institutions, as CRFS boundaries rarely overlap with administrative boundaries.

However, these benefits might be challenging to harness if the CRFS concept does not translate into a CRFS approach which includes the following features:

- The definition of CRFS boundaries, a social construct that tends to evolve over the evolution of the food system, and that is built on rural-urban linkages and capacities;
- The availability of data across the rural urban continuum to address research boundaries, and monitor, evaluate and learn from public policies and collective initiatives;
- An adequate degree of decentralization and devolved governance endowed with the necessary powers and capacities, be they human, technical, or financial, able to operationalize research findings. Financing CRFS is particularly difficult due to the misalignment between administrative and CRFS boundaries.
- The governance of spaces that have cross-jurisdictional boundaries through a greater horizontal and vertical coordination of actors to create synergies, improve efficiency, and prevent increasing competition and inequalities within and between CRFSs;
- A transfer of power and adequate agency for all actors – public and private, large and small, wealthy and poor – to participate in the governance system, and fulfil their roles and responsibilities.

To achieve these features, FAO and RUAF have designed tools to help cities implement the CRFS approach, including CRFS assessment, planning, and policy tools (Blay-Palmer, Renting and Dubbeling, 2015; FAO and RUAF, 2023; Santini, Dubbeling and Blay-Palmer, 2019).

The effectiveness of city region approaches is too often assessed solely against local economic development without any consideration of social equity and environmental sustainability. It, therefore, depends very much on the size of the city region, its local assets and its natural endowments for growth, everything else being equal. As Rodríguez-Pose (2008, p. 1040) states, "the weaker the initial economic and institutional conditions are, the much less likely it is that a city-region approach will be successful". In addition, Copus *et al.* (2022) highlight the gap between city region thinking and implementation in practice:

when the city region concept is mobilized to justify local development policies, the characteristics of the city region approach are often neglected - or worse ignored - when developing these policies. As a result, policies tend to prioritize supporting economic growth in cities, while the rural dimension is increasingly overlooked, based on the assumption that urban economic growth will eventually benefit rural areas as well. Recent academic developments aim to shift the focus of city region strategies from solely economic growth to include environmental, social, and cultural aspects, thereby enhancing overall quality of life. This shift moves away from merely minimizing the negative environmental and social impacts of growth towards achieving more positive outcomes (Axinte *et al.*, 2019). Interestingly, Yanarella and Levine (2020) use the challenge food poses to restrictive city region approaches when centred on cities and growth to explain how city region approaches should go beyond this liberal view.

The effectiveness of CRFS approaches must be assessed against their impact on the food security and nutrition of local populations all along the rural-urban continuum, considering all six dimensions of food security: availability, access, utilization, stability, agency and sustainability (Clapp *et al.*, 2022; HLPE, 2020). The relationship between growth and food security and nutrition is not straightforward since income inequality more than economic growth determines food security and nutrition. This highlights the need to avoid focusing exclusively on urban economic growth. Furthermore, local food production is an integral part of the CRFS, helping to prevent a city-centred focus. Thus, the factors that undermine the relevance of city region approaches previously mentioned might be less pronounced with the CRFS approach. However, the gap between CRFS theory and practice may still be a matter of concern. Blay-Palmer *et al.* (2021, p. 14) suggest that while more research and projects are needed, there is increasing evidence that the CRFS approach enhances resilience and flexibility, enabling food systems to better respond to various shocks, including pandemics and climate change.

2.3 Resilience to what: shocks and stresses

The COVID-19 pandemic and the Ukraine crisis have renewed attention to the resilience of CRFS in the face of shocks and stresses. This heightened focus can be attributed to at least two factors. First, both events were largely unexpected, catching food system actors off guard. Second, the magnitude of these crises has had direct and indirect impacts on food systems in nearly every country, regardless of wealth.

Shocks are defined as "external short-term deviations from long-term trends, deviations that have substantial negative effects on people's current state of well-being, level of assets, livelihoods, or safety, or their ability to withstand future shocks" (Zseleczky and Yosef, 2014, p. 1). Stresses, adapted from Choularton, Frankenberger, and Nelson (2015), are here referred to external long-term pressures that undermine a system's stability and heighten its vulnerability. Unlike some definitions like Choularton *et al.* (2015) and Sagara (2018), the emphasis here is on the 'external' nature of these stresses impacting food systems. The COVID-19 and the Ukraine war are not the only shocks or stresses that have affected food systems over the past years. Many others, whether economic, social, environmental, technological, or political, have also impacted food systems. These stresses existed before and during these crises, yet they did not spark such widespread debate about resilience. In some cases, multiple shocks occurred simultaneously. For example, in certain countries or regions, the pandemic coincided with severe weather events, natural disasters, or pest and disease outbreaks. These compounded shocks disrupted food availability, physical and economic access, and utilization (Teng, Caballero-Anthony and Montesclaros, 2021).

Most importantly, "[an] accumulation of stresses and (potential) shocks is likely to increase farming system vulnerability in nonlinear ways, leading to tipping points when critical thresholds are crossed" (Meuwissen *et al.*, 2019). This might apply not only to farming but to all nodes within food systems.

Below is a compiled list of shocks and stresses that can impact food systems (**Table 1**). Since this analysis focuses on system-wide resilience, only covariate shocks—those affecting large areas or populations—are considered, rather than idiosyncratic shocks, which affect individual households or small areas. These shocks are grouped into five categories: climate events, geological events, economic events, political and social events, biological events, and technological events. They are also classified as either temporary shocks or prolonged stresses. While analysts often categorize these events as 'risks' (which can be estimated), many are more accurately described as 'uncertainties,' making them difficult to predict or quantify.

2.4 Resilience for what: food security and nutrition

When looking at the resilience of food systems, the key question becomes: "resilience for what purpose?" (Meuwissen *et al.*, 2019). The most widely used definition of food system resilience refers to "a built-in, continuously developing capacity that enables a food system to minimize food insecurity in a changing environment with recurring disturbances" (Tendall *et al.*, 2015, p. 19). This focus on food security implies that resilience must apply to all people, at all times, which raises the question of whether resilience should be considered a dimension of food system sustainability. A bibliometric analysis of Scopus-indexed papers from 1991 to 2022 by Kalachevska, Koblianska and Holzner (2022) concluded that sustainable food systems first

Table 1 List of shocks and stresses potentially affecting food systems

Climate events	
1.	Droughts
2.	Flooding / extreme precipitation
3.	Extreme heat waves
4.	Extreme cold wave / frost
5.	Typhoons / hurricanes / cyclones
6.	Tornadoes
7.	Wildfires (naturally occurring)
8.	**Sea-level rise**
9.	**Desertification / Deforestation**
Geological events	
10.	Earthquakes
11.	Tsunamis
12.	Volcanic eruptions
13.	Landslides (relates to floods)
Economic events	
14.	Financial crisis / Market disruptions / Asset bubbles burst in large economies
15.	Collapse of a systemically important industry
16.	(Hyper) inflation
17.	Debt crisis
18.	Illicit economic activities
19.	**Prolonged stagnation**
20.	Severe commodity price shocks
21.	Exchange rate deterioration
22.	Rise in interest rates
23.	Proliferation of illicit economic activity
24.	(Agricultural) export commodity prices collapse
25.	(Agricultural) import commodity prices increase
26.	Increase of the price of inputs (fertilizer, energy, seeds)

Political and social events:	
27.	Terrorism
28.	Interstate conflict
29.	Gender-based violence
30.	Civil unrest / erosion of social cohesion
31.	Coups
32.	Crime / violence
33.	Human rights violations
34.	Social exclusion / discrimination
35.	Population pressure
36.	Growing (extreme) poverty / lack of social security systems
37.	Growing inequality
38.	(Irregular) migration
39.	Employment and livelihood crises
40.	Failure of public infrastructure
Biological events	
41.	**Biodiversity loss and ecosystem collapse**
42.	Plant pests and diseases (e.g. locust, FAW, rusts)
43.	Terrestrial and aquatic animal disease (e.g. African swine fever, foot-and-mouse disease)
44.	Food safety events (food containing harmful microorganisms or harmful combinations of substances)
45.	Human epidemics and pandemics (e.g. COVID-19, HIV, malaria, zika, etc.)
46.	Pollution-driven harms to human health / animals / plants
Technological events	
47.	Cybersecurity events
48.	Chemical hazards / toxic spills / industrial accidents
49.	Dam failure
50.	Electrical grid failure
51.	Nuclear disaster
52.	Other major infrastructure disruption or collapse
53.	Digital inequality

Grey cells are stresses, white cells are shocks. Please note that many shocks could be classified as stresses when they persist over a long period.

Sources:

Sagara, B. 2018. *Resilience Measurement Practical Guidance Note Series 2: Measuring Shocks and Stresses.* Washington, D.C. Retrieved from: https://www.fsnnetwork.org/sites/default/files/GN02_ShocksandStressesMsmt_Final4-11508_0.pdf

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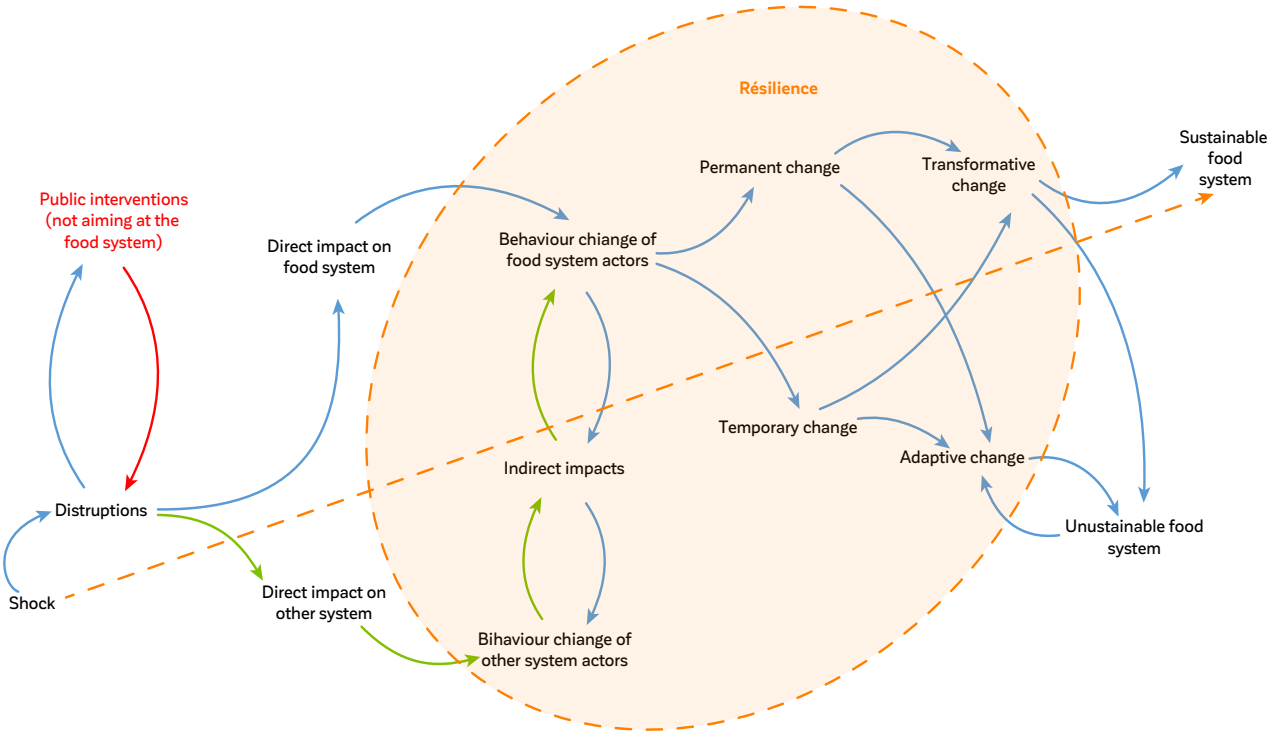
Figure 1 From shocks to food system resilience and sustainability of food security and nutrition



Source: Authors' own elaboration

emerged as a research topic in the 1990s and has only recently been integrated into system thinking. The HLPE (2014, p. 12) defines a sustainable food system as one "that delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to ensure food security and nutrition for future generations are not compromised." This definition was later adopted by FAO (2018) and is commonly referenced in studies on food system sustainability.

Through a literature review, Béné *et al.* (2019) confirmed these four dimensions of food system sustainability: ecological, economic, social, and food security and nutrition as universally acknowledged. However, they question whether resilience should be considered a dimension of sustainability, as it is difficult to measure. Jacobi *et al.* (2018) point out that a seemingly resilient food system may not be sustainable, especially over short time horizons. Tendall *et al.* (2015, p. 19) offer a useful distinction: "Resilience and sustainability are complementary concepts. [...] Sustainability is the measure of system performance, whereas resilience can be seen as a means to achieve sustainability during times of disturbance." **Figure 1** illustrates the relationships between a shock, its impacts on a CRFS and surrounding systems (such as transport, energy, water, etc.), the responses of actors (i.e. changes in behaviour), and the implications for the resilience and sustainability of a food system. Immediate policy interventions in response to the disruptions are included. Policy interventions targeting the food systems are not specifically shown but are included in behavioural change of food system actors since local or national governments are actors of the CRFS. Resilience plans and strategies should therefore align with food system sustainability, implying a central role of transformative measures.

3. Key principles for strengthening CRFS resilience

The previous section addressed the characterization of resilience (resilience of what, to what, and for what purpose), but it did not cover how resilience can be achieved. In this section, four principles are emphasized that, while still debated, are highly relevant for CRFS: transforming food systems, differentiating individual and food system resilience, fostering collective actions and public policies, and moving from specific to general resilience.

3.1 From recovery to transformation

Soubry and Sherren (2022) highlight that actors within the same CRFS may have very different definitions of resilience, rooted in a divide between understanding resilience as preserving a status quo or as prompting transformation. This dichotomy can be seen as an extension of the debate on resilience and sustainability over different time horizons: immediate resilience may preserve the status quo, while long-term resilience as a dimension of sustainability necessitates transformation. This dichotomy is also the reflection of what has attracted public and media attention: the immediate disruption of value chains and the rise of food insecurity (Campbell, 2021). While resolving this debate is beyond the scope of this work, it is critical to understand the underlying rationale between resilience through stability versus resilience through transformation, as it shapes the range of actions food system actors should undertake. On the one hand, some argue that food systems are already resilient because they remain stable. For instance, Hobbs (2021) notes that during the COVID-19 crisis, food supply chains in Canada and the United States of Americaperformed well after the initial disruptions, suggesting that these disruptions were inevitable and not due to weaknesses in the food system itself. In Hobbs' (2021, p. 191) view, "[the] heavy reliance of vulnerable portions of society on food banks and subsidized meals highlights troubling gaps in social safety net policies, along with social inequalities, but does not necessarily signal a problem with food supply chains or the food system per se". However, this may not hold true for those whose livelihoods depend directly on the food system (such as farmers, petty street vendors, etc.). In rural Ethiopia, for example, Haile, Seyoum, and Azmeraw (2022, p. 7) argue that safety nets cannot "improve resilience of rural households in the long run unless complemented with sustainable livelihood activities and greater investment in health and education". Moreover, framing resilience as short-term stability overlooks the fact that food system vulnerabilities (such as poverty), which prevent actors from coping with shocks (lack of resilience capacities), represent a failure of the food system itself. Consequently, equating resilience to short-term stability conflicts with the long-term objective of sustainability as it impedes any deep transformation of food systems.

On the other hand, the proponents of the lack of food system resilience argue that the COVID-19 crisis has exacerbated already existing and well-known structural weaknesses within food systems, and unveiled new vulnerabilities that were there but never perceived or envisioned (Agyemang and Kwofie, 2021). FAO *et al.* (2021, p. xxiii) state that "[the] COVID-19 pandemic is just the tip of the iceberg, more alarmingly, the pandemic has exposed the vulnerabilities forming in our food systems over recent years as a result of major drivers such as conflict, climate variability and extremes, and economic slowdowns and downturns". This highlights the need for a greater understanding of the internal weaknesses of food systems and for deep transformation to achieve resilience and sustainability. Food system transformation is an ambitious strategy, aiming to achieve a range of development objectives, such as health, inclusiveness, safety, sustainability, efficiency and resilience (Leeuwis, Boogaard and Atta-Krah, 2021, p. 761). In this study, resilience is considered as a need for change: food systems are socio-ecological systems that have reduced the resilience to the biosphere (Line *et al.*, 2017). They are now subject to great shocks and stresses operating along thresholds and tipping points, which make any return to previous states unlikely. Recovery and stability, therefore, represent the antithesis of resilience, as they reinforce existing food system dynamics and trap them in rigidity (Hodbod and Eakin, 2015) or resilience traps (Kythreotis and Bristow, 2017; Rachunok and Nateghi, 2021), which should be avoided.

Consequently, transformation has a strong normative sense, aimed at breaking free from the resilience trap of the old system and building the resilience of a new one (Folke *et al.*, 2010). Transformation becomes a deliberate, purposive process (Béné, 2022, p. 3) able to circumvent traps, prevent unwanted transformations, and promote desirable ones (Walker, 2020), ultimately delivering food security and nutrition for all. In this respect, Blay-Palmer *et al.* (2018, p. 19) emphasize that the "CRFS approach provides both a conceptual framing and operational approach to support transformational change".

3.2 From individual food security and nutrition to food system resilience

Resilience can be understood at different levels. At the individual, household, or community level, resilience is primarily concerned with ensuring food security. For households whose livelihoods are not tied to food-related activities, resilience is viewed from the perspective of consumers, with the primary goal of securing food security and nutrition. This is reflected in the majority of the scholarly work around resilience and food security (Béné *et al.*, 2016; Constas *et al.*, 2021; d'Errico, Romano and Pietrelli, 2018). In some cases, food security is seen as integral to a household's overall resilience to shocks (Upton, Cissé and Barrett,

2016). However, even if households possess the capacity to respond to shocks, severe disruptions in food systems can render this capacity useless. For example, a household may have sufficient wealth to purchase food, but if severe food supply disruptions leave no food available for purchase, their resilience is compromised. This is why scaling up resilience analysis is critical when addressing shocks that affect food security and nutrition (Devereux and Béné, 2023). For those whose livelihoods depend on food-related activities (farmers, processors, retailers, street vendors, etc.), resilience depends on the capacities and attributes they possess and the strategies they develop to continue their businesses, earn a living, and secure their own food security. Ensuring the continuity of CRFS actors' activities is essential for maintaining the value chains they contribute to.Consequently, the food supply chain has become a critical level of resilience analysis (Kumar and Singh, 2021). However, the resilience of supply chains does not guarantee the resilience or sustainability of the broader food system. Indeed, supply chains within and outside food systems often compete for limited resources (water, energy, land, labour, ecosystem services, human capacities, finance, etc.). Simply ensuring that individual supply chains are resilient or sustainable will not necessarily lead to a resilient or sustainable food system overall, because resources are limited. Hobbs (2021, p. 193) stresses this point: "Much of the literature on supply chain resilience focuses on resilience from an individual firm's perspective, while in an agrifood context it is also important to recognize that we are often dealing with a series of interrelated, interconnected supply chains within the broader food system."

The CRFS approach is particularly relevant because it takes into account three critical dimensions, as illustrated in **Figure 2**:

- The state of individual food system actors. Short-term behavioral changes may improve an actor's immediate situation after a shock, but they are not necessarily beneficial in the long run and could even undermine long-term well-being.
- The impact of each actor on others within the same or different segments of the food system. Individual actions may benefit one actor but harm others, particularly if coordination within the system is lacking.
- The broader impact on the economy, society, and environment.

3.3 From individual responses to collective actions and public policies

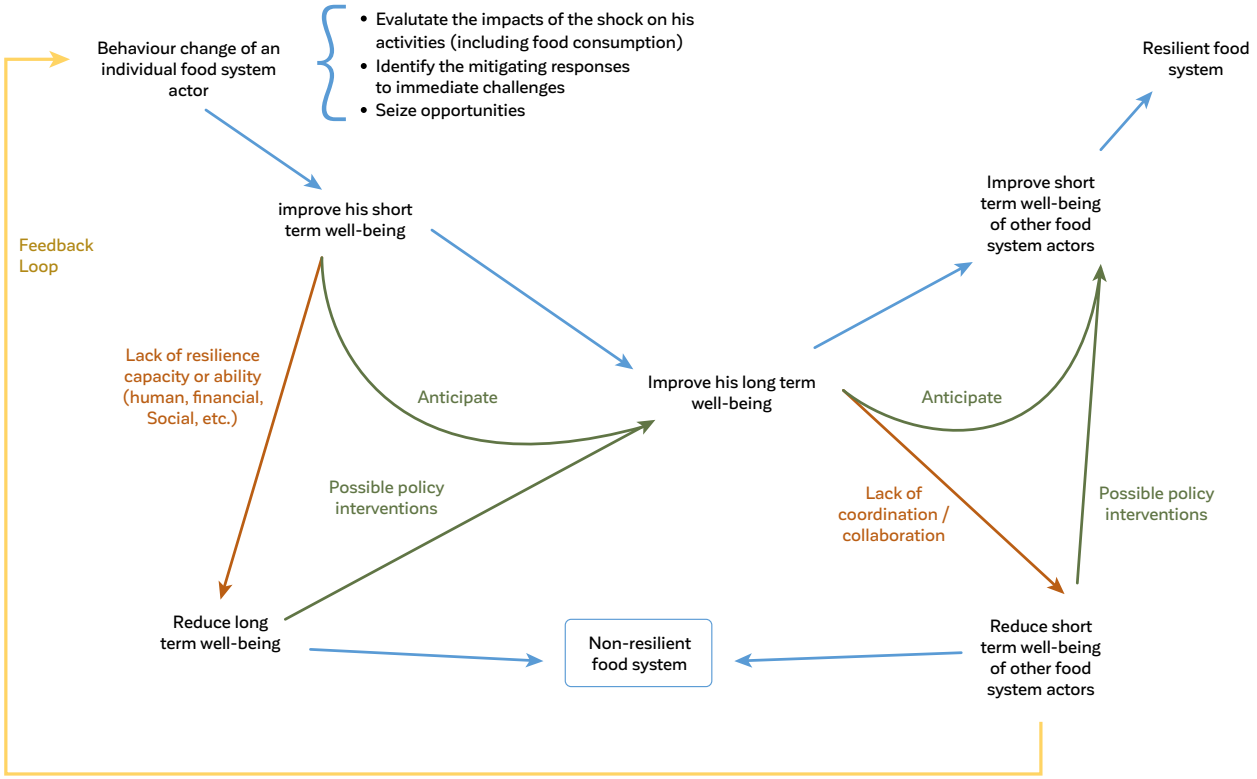
Collective actions are here considered a crucial response to shocks and stresses within food systems. Social capital plays a pivotal role in initiating these actions. It can either contribute positively to resilience building by unlocking a community's innovation potential or hinder progress by preventing necessary changes. Additional research is required to better understand "the nature and role of different forms of social capital and the conditions under which these can contribute effectively/positively to building people's resilience at different levels" (Béné *et al.*, 2016).

Positive collective actions can play a crucial role in building resilience in city region food systems by addressing systemic issues that contribute to food insecurity, environmental degradation, and social inequality. Firstly, when individual or household resilience capacities are exhausted or insufficient, CRFS actors often rely on collective initiatives to overcome the impacts of shocks and stresses on their livelihoods, particularly in terms of daily food security and nutrition. In this way, part of an individual's resilience depends on their ability to participate in collective efforts. Shocks and stresses create "new opportunities for local communities to work differently, to increase collaboration, and to improve outcomes for those most in need" (Zerbian, Adams and Wilson, 2022, p. 2). Local collective food initiatives supporting the most vulnerable serve as most striking examples, although collective actions can develop across all parts of the food system. For instance, Benedek *et al.* (2022) consider a farmer's ability to act collectively with others as a key attribute of individual resilience.

Secondly, as discussed in the previous section, resilience thinking stresses the importance of collaboration to avoid the negative consequences of individual resilience strategies on other CRFS actors, which could ultimately undermine the resilience of the entire food system. This scenario closely parallels collective action initiatives designed to manage common pool resources, as outlined in Ostrom's (2012) seminal work. City region actors need to foster synergies, which can emerge from their creative encounters, negotiations, and cooperation (Yanarella and Levine, 2020), a concept equally applicable to CRFS. A substantial body of literature exists on the conditions necessary for collective actions to emerge, develop, and become institutionalized, although this falls beyond the scope of this work.

Finally, as previously explained (see section 3.2), the CRFS approach emphasizes the role of food system actors in experimenting and innovating in response to shocks and stresses while considering local contingencies, challenges, and opportunities to transform CRFS. More broadly, "[systems] transformation is a process of societal and environmental change where different actors work in concert to change collectively a system towards greater sustainability" (Hellin *et al.*, 2022, p. 1). An example of this is provided by Prosser, Thomas Lane, and Jones (2021), who describe how producer-led collective actions were established in response to the

Figure 2 From individual to food system resilience



Source: Authors' own elaboration.

COVID-19 pandemic to address gaps in the marketing structure of local food products, and why these innovations are likely to endure due to the social capital developed during the crisis. Thus, collective action is essential for advancing sustainability. "[Collective] action, or individuals working together toward a common good, is essential for achieving the scope and scale of solutions to current sustainability challenges" (Ardoin, Bowers and Wheaton, 2023, p. 30). Collective actions often emerge as grassroots or local food initiatives—such as farmers' markets, community-supported agriculture, community gardens, food banks, and growers' cooperatives—led by economic, social, or cultural associations (e.g., CSOs, NGOs, farmer associations, cooperatives). These initiatives can sometimes form bridges that support the development of more innovative and creative solutions. Local authorities could play a key role, as they can manage collaborative spaces (Zerbian *et al.*, 2022). Moreover, local food initiatives may unite within social movements to increase their transformative power (Schiff and Levkoe, 2014), through "engagement in collective action with an aim to transform modes of production and consumption, as well as social organization, values, and individual well-being" (Andrée *et al.*, 2019, p. 8).

This discussion on collective action and resilience points out the difficulty in establishing clear causality links between the two. Queiroz *et al.* (2021, p. 550) suggest that "the collaborative and participatory process of building resilient food systems can strengthen collective action, and align the interests of broad coalitions of relevant actors in the food system". Conversely, the lack of collective action could then be seen as a clear sign of a weak resilience-building process.

Public policies can consolidate collective actions through dedicated laws, rules and regulations, or specific budget support, thereby supporting the innovation process. When collective actions do not emerge, public policies can also be used to promote the emergence of such collective actions, especially when public authorities lack technical and/or human resources.

Public policies can strengthen collective actions through dedicated laws, regulations, and budgetary support, thereby fostering the innovation process. Additionally, when collective actions do not emerge organically, public policies can be used to promote and facilitate such initiatives, particularly in cases where public authorities may lack the technical or human resources to address challenges on their own.

3.4 From specific to general resilience?

In theory, a wide array of shocks and stresses can potentially affect CRFS as listed in section 3.3. In practice, depending on their location and local contingencies, CRFS are usually sensitive to a more limited number of shocks. As a result, there are tendencies to build specific resilience to the particular shocks that CRFS are 'familiar' with. Some shocks, however, may be overlooked because they are a) less frequent and therefore forgotten, b) new and consequently unexpected, or c) expected but record-breaking due to their magnitude, intensity, or duration. Examples such as the COVID-19 pandemic, which spread globally and had an unknown character (unlike Ebola for instance), the Ukraine war, and unprecedented extreme climate, seismic, or financial events, raise the question of whether resilience should be developed to a wider range of shocks and stresses. Several authors have emphasized the difference between specific (or specified) and general resilience: "Specified resilience, as its name suggests, is the resilience of some specified part of the system to a specified shock – a particular kind of disturbance. General resilience is the capacity of a system that allows it to absorb disturbances of all kinds, including novel, unforeseen ones, so that all parts of the system keep functioning as they have in the past" (Walker and Salt, 2012, p. 18).

Two key questions arise from this distinction. First, do measures or initiatives undertaken to build a specific resilience contribute or impede resilience to other shocks, including less familiar ones? Second, is it then possible to build general resilience, i.e. "the capacity of social-ecological systems to adapt or transform in response to unfamiliar or unknown shocks" (Carpenter *et al.*, 2012, p. 3251)?

Building general resilience presents several challenges. First, general resilience aims to account for shocks whose occurrence is difficult or impossible to predict—shocks that are known to be possible but uncertain in timing or probability. These are referred to as "known unknowns." Additionally, there are shocks that seemingly come out of nowhere—"unknown unknowns"—which have never been envisaged. These types of shocks present both a challenge and a justification for building general resilience (Carpenter *et al.*, 2012). "Building general resilience, given its focus on preparing the system for unknown disturbances, can therefore be useful at any scale, since outcomes can be unknown at all levels, but it is particularly useful when there is high randomness or high complexity in the system" (Wassénius and Crona, 2022).

Second, while the specific shocks themselves may not always be known, all shocks result in disruptions to some aspect or node of a food system. Building general resilience requires identifying potential disruptions or failures in any node of a CRFS, rather than attempting to anticipate every possible shock. For example, the focus should not necessarily be on whether a shock will affect staple food production, but rather on the types of disruptions staple food production could experience. General resilience is thus defined in terms of the potential disruptions or failures across the entire CRFS, not the specific shocks or their combinations. It must consider the implications these disruptions have on the overall functioning of the system and their consequences for local food security and nutrition. While it may be feasible to inventory potential disruptions for specific infrastructures (Sweetapple, Fu, Farmani and Butler, 2022), applying this approach to an entire CRFS is considerably more challenging. This raises the question of whether pursuing general resilience is the right goal—whether a partial representation of general resilience might be sufficient to improve preparedness—and how trade-offs between specific and general resilience could be managed (Yumagulova and Vertinsky, 2021).

Finally, Thorén (2019) points out that defining and describing a system, including its boundaries, depends on the perspectives and values of the person describing it, whether that individual is a CRFS actor or an external observer. As a result, there are no fixed or definite descriptions of a system—only multiple perspectives shaped by the values of the observers or actors involved. The resilience of a system, therefore, depends on how the system is described, making general resilience more complex as it requires a shift away from this plurality of perspectives and values, and demands a simplified, monistic view of the system. While Thorén (2019) argues that this approach makes general resilience unhelpful or even obstructive, it can also be viewed as rather reinforcing the importance of collective action in developing a shared description of the system, a common vision for its future, and a mutual understanding of what general resilience should look like.

4. Capacities to strengthen CRFS resilience

As previously mentioned, clarifying what resilience means when it comes to food security and nutrition is challenging. While acknowledging this difficulty, Béné and Devereux (2023, p. 8) propose that "resilience is simply and broadly about the capacities of individuals, households and communities to deal with adverse events (shocks, stressors) in a way that does not affect negatively their long-term well-being, and in particular their food security." 'Capacities' are at the centre of resilience. Depending on the level of analysis, resilience capacities vary depending on whether an actor, a value chain or a system is considered. Furthermore, these capacities are often mixed up with attributes that activate these capacities. The difference might be subtle, but as stated by Bene (2020, p. 7), resilience is a latent variable, difficult to quantify, leading to some sort of confusion: "researchers or practitioners are often tempted to claim that they are measuring resilience, whereas what they measure are in fact indicators of resilience capacity". This creates many challenges on how measuring resilience at whatever level (Constas, d'Errico and Pietrelli, 2022). The following sections focus on resilience capacities, while section 5 deals with their attributes.

4.1 Individual resilience capacities

At the individual or household level, resilience is conceptualized as the result of the interaction between three key capacities: absorptive, adaptive, and transformative (Béné *et al.*, 2016; d'Errico *et al.*, 2018). The mobilization of these capacities depends on the intensity and duration of the shock encountered (d'Errico *et al.*, 2018). In response to shocks of increasing intensity, individuals or households typically activate these capacities sequentially, with absorptive capacities being mobilized first, followed by adaptive, and finally transformative capacities when the shock surpasses a certain threshold (Béné *et al.*, 2012). Once these individual capacities are exhausted, people become increasingly vulnerable to shocks, requiring external interventions, either through collective actions or public policies. Numerous approaches have been developed to assess and categorize individual or household resilience capacities, and various comparative analyses have been conducted to define typologies (Bekee and Valdivia, 2023). A more in-depth discussion of these approaches will follow in section 6.1.

4.2 Supply chain resilience capacities

Resilience capacities at the supply chain level have primarily been studied in the context of supply disruptions or fluctuations in demand at an organizational level. However, several challenges remain in fully conceptualizing supply chain resilience. First, recent shocks have demonstrated that disruptions can affect supply chains in multiple ways simultaneously. Blessley and Mudambi (2022) highlight this by distinguishing between the scale (volume of supply or demand) and the *scope* (nature or breadth of supply and demand) of disruptions. Second, the absence of a comprehensive conceptualization and measurement framework has led to confusion between resilience capacities and the drivers or attributes that activate them. Third, the prevalent focus on a single organization or node within a value chain often masks the broader disruptions affecting upstream or downstream nodes, ultimately threatening the resilience of the entire value chain (Blessley and Mudambi, 2022). Finally, the sustainability dimension is often absent in these supply chain resilience studies, leading to the mobilisation of capacities that look for a quick and efficient return to the original state of the value chain.

As a result, much of the focus lies on preventing the operational and financial consequences of a shock. These limitations have led to various, sometimes conflicting, ways of naming and characterizing resilience capacities. Two key approaches in the literature stand out. The first, commonly cited in studies of supply chain resilience (Hosseini and Barker, 2016; Hosseini, Ivanov and Dolgui, 2019), distinguishes between three resilience capacities:

- **Absorptive capacities**: The ability to absorb or withstand the impact of disruptive events and minimize their consequences. Examples include supplier diversification, multiple sourcing strategies, inventory control measures, and the use of multiple transportation channels.
- **Adaptive capacities**: The ability to adapt and overcome disruptions without initiating recovery activities, often through temporary changes. This may include flexible backup supplier strategies, redundancy within transportation networks, enhanced communication and cooperation, and temporary input substitutions.
- **Restorative capacities**: The ability to repair and restore normal operations following a disruption, achieved through technology diversification or budget restoration.

A second approach, developed through a review of the literature on supply chain resilience (Ali, Mahfouz and Arisha, 2017), expands these capacities to five and offers a more comprehensive framework by distinguishing between proactive (pre-shock), concurrent (during the shock), and reactive (post-shock) capacities:

- **Anticipative capacity (proactive)**: The ability to identify and monitor potential events, changing environments and performance, before they affect the supply chain's functionality.
- **Adaptive capacity (concurrent)**: The ability to continuously manage and adjust critical supply chain resources during both disruptions and normal business activities.
- **Responsive capacity (concurrent)**: The ability to react timely and efficiently to supply chain events to reduce the impact of disruptions and ensure desirable outcomes.
- **Recovering capacity (reactive)**: The ability to restore or return to normal operations after a disruption.
- **Learning capacity (reactive)**: The ability to understand past disruptions and improve future performance based on lessons learned.

Both approaches draw on the concept of engineering resilience, which emphasizes stability as the main objective of resilience strategies. Notably, the resilience of households (as end consumers) or the broader food system in which supply chains operate is often excluded from these frameworks. This raises the question of whether these are overlooked «blind spots» or if they are implicitly assumed to be resilient by default. In the latter case, the lack of resilience at the household or food system level only becomes included in these approaches when they evolve into critical shocks that directly threaten the functioning of the supply chain.

4.3 Delimiting resilience capacities

Contrary to supply chain resilience, the consequence of a shock on a food system cannot be narrowed down to operational and financial costs. A system is much more complex. There is no clear reference as to which capacities should be considered. For instance, Ouoba and Sawadogo (2022) refer to three dimensions of resilience of food systems: absorptive capacity, adaptive capacity, transformative capacity following Smith and Frankenberger (2018). Štreimikienė *et al.* (2021) distinguish absorptive (automatic absorption of negative impacts), adaptive (internal changes within the food system) and restorative (external support) measures. These capacities are narrow in scope compared to the broader resilience framework proposed by the United Nations to make societies resilient. FAO (2021) adapts the United nations' definition of resilience capacities (UN, 2020, p. 35) to food systems and provide examples that illustrate concrete implications:

- **Preventive capacities**: "The ability to implement activities and take measures to reduce existing risks and avoid the creation of new risks". For example, diversifying sources of food supply to limit risks of shortages in the event of a disruption affecting a specific source.
- **Anticipative capacities**: "The ability to take early action in anticipation of a potential threat to reduce its potential negative impacts; including through early warning, early action and forecast-based financing". This includes the existence of and access to effective early warning systems for food system disruptions, and being able to act upon them.
- **Absorptive capacities**: "The ability to take protective action and "bounce back" after a shock by utilizing predetermined responses that preserve and restore essential basic structures and functions". Examples include social protection for vulnerable populations and mutual support networks among businesses and communities.
- **Adaptive capacities**: "The ability to make incremental adjustments, modifications or changes to the characteristics of systems and actions to moderate potential changes, in order to continue functioning without major qualitative changes in function or structural identity". For instance, temporarily shifting marketing channels to ensure continued food distribution during a disruption. These changes may inform longer term transformation.
- **Transformative capacities**: "The ability to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable". This might involve overhauling the structural features of the food system.

FAO (2021) places particular emphasis on absorptive capacities as being critical. However, such a focus on one capacity, absorption, might suggest that recovery and a return to stability are the primary goals of resilience strategies.

5. Attributes of food systems to support resilience capacities

As capacities are difficult to measure, it seems theoretically easier to focus on attributes which can support or activate these capacities. While resilience capacities have different meanings depending on what is considered (individual value chain or system), so do attributes of resilience capacities.

5.1 Attributes for individual resilience

There is no universally accepted framework for defining which attributes should be considered when assessing resilience. Most studies move from discussing attributes to focusing on indicators, in an effort to address the challenges of measuring resilience capacity. As a result, the list of significant attributes tends to vary from study to study. Upton, Constenla-Villoslada, and Barrett (2022) show how different methods lead to different outcomes, raising questions about what these measures actually capture. Focusing on identifying attributes rather than measuring them, this review briefly looks at different methods to determine the resilience capacities they include. Many studies aimed at moving beyond the traditional view of resilience as individual absorptive capacities based on asset categories – financial, human, natural, physical and social capitals. One of the most widely used is the Resilience Indicators for Measurement and Analysis (RIMA-II) includes absorptive capacity indicators (access to basic services, assets) and resilience capacity indicators: income diversification, education, and income earners' share (Cissé and Barrett, 2018; FAO, 2016). Similarly, USAID offers a framework for measuring capacities and consider assets, savings and credit as both absorptive and adaptive capacity indicators (Vaughan and Frankenberger, 2018). Smith and Frankenberger (2018) propose what seems to be the most comprehensive set of indicators to measure resilience capacities at the household level, as they consider absorptive, adaptive and transformative capacities (**Table 2**). In this framework, an indicator can support two different resilience capacities, reflecting the difficulty to clearly allocate attributes to specific capacities, or draw a clear line between different capacities.

A key aspect is the role of social capital as an indicator for fostering individual resilience capacity, with a central role of the community, which underpins broader community resilience and supports the potential for collective action (McDaniel, Mas and Sussman, 2021). However, the poorer the community, the smaller seems to be the role of social capital in supporting food security and nutrition (O'Meara *et al., 2022)*.

Table 2 Indicators to measure different resilience capacities at the household level

Absorptive capacities	Adaptive capacities	Transformative capacities
Bonding social capital within a community: bonds between community members. It involves principles and norms such as trust, reciprocity, and cooperation, and is often drawn on in the disaster context, where survivors help each other to cope and recover.	Bridging social capital between communities: connecting members of one community or group to other communities/ groups.	Bridging social capital
Asset ownership	Linking social capital: trusted social networks between individuals and groups interacting across explicit, institutionalized, and formal boundaries in society.	Linking social capital
Cash savings	Aspiration and confidence to adapt: beliefs, preferences, and capacities relevant to the future and future-oriented behaviour.	Access to markets
Access to formal/informal safety nets	Diversity of livelihoods	Access to services
Availability of disaster preparedness and mitigation: improved physical infrastructure, early warning and response systems, emergency services, etc.	Asset ownership	Women's empowerment
	Human capital	Local governance: representative, responsive, transparent, and accountable governance
	Access to information: access to a cell phone, regular communication with people outside of one's village, etc.	

Source: Adapted from Smith, L.C. & Frankenberger, T.R. 2018. Does Resilience Capacity Reduce the Negative Impact of Shocks on Household Food Security? Evidence from the 2014 Floods in Northern Bangladesh. *World Development, 102*, 358-376.

A more recent body of literature looks at the concept of subjective resilience of individuals and households. Subjective resilience aims at capturing two important factors not included in objective resilience approaches (Jones and Tanner, 2017). The first one corresponds to the subjective elements that influence resilience and are not reflected in socio-economic indicators, such as beliefs, social norms, cultural identity, etc. The second factor is the individual's perception of their own resilience capacities (self-assessment), considered as a bottom-up method to capture voices of individuals (and not external assessment by experts). In this sense, subjective resilience could be seen as a complement to objective resilience. However, further work is needed to better understand the relationships between the two (Jones, Samman and Vinck, 2018).There is currently no clear and widely accepted methodology to measure subjective resilience. Jones and d'Errico (2019) proposed the 'Subjectively self-Evaluated Resilience Score' (SERS) which focuses on the self-assessment of four resilience capacities (anticipative, absorptive, adaptive and transformative) and five resilience attributes (financial capital, social capital, political capital, learning capacities and access to early warning information). Several studies have compared objective and subjective resilience measurements, especially because subjective resilience is quicker and easier to assess. Based on data from a region of Northern Uganda, Jones and d'Errico (2019) found a partial correlation between the results of the two approaches. Similarly, d'Errico and Båsund (2022) found a weak correlation between objective resilience (RIMA-II) and subjective resilience (SERS) when comparing results from nine countries, thereby confirming that the two approaches capture different aspects of households' resilience. They conclude that both methods should be used to investigate the root cause of food security and resilience. Quandt and Paderes (2022) call for further methodological development beyond the SERS that could be inspired by other disciplines (psychology, international development, and participatory geography) to first collect quantitative data collection before developing subjective resilience assessment surveys.

5.2 Attributes for value chain resilience

Just like households, value chains feature attributes that can be used to activate resilience capacities, through they differ significantly. Most of them have been described in the context of supply chain resilience and have been named differently across the literature: drivers of resilience (Hosseini *et al.*, 2019), capability factors (Fiksel *et al.*, 2015), resilience elements or capabilities (Stone and Rahimifard, 2018), resilience-enhancing attributes (Meuwissen *et al.*, 2019) or resilience strategies when attributes have been voluntarily developed (Kumar and Singh, 2021), just to mention a few. For the sake of clarity, this review uses the term "attributes". Looking at supply chains across sectors, Fiksel *et al.* (2015) identified 16 attributes, and more than 300 sub-factors that businesses can leverage to build the resilience of their value chain against severe disruptions. Focusing on agri-food supply chains, Stone and Rahimifard (2018) identified 40 elements of resilience, balanced between individual and collective actions. The most commonly cited attributes in the literature seem to be, at the individual level, flexibility, risk aware culture, redundancy and early warning detection systems; and at the collective level, collaboration, flexibility, agility, visibility and adaptability. Ali *et al.* (2021) narrow down the number of attributes when looking at the resilience of agri-food SMEs to four: supply chain engineering; collaboration; agility; and risk management culture. They argue that the COVID-19 pandemic occurred too rapidly for any SMEs to have any readiness strategy, making reactive approaches the primary focus. Similarly, when focusing on perishable products' agri-food supply chains, Kumar and Singh (2021) identified 16 attributes, though these differ slightly to previous studies due to the perishable nature of the products. Adding to this diversity of attributes, is the challenge of understanding their importance over time. For instance, Weersink *et al.* (2021) explain how fruit and vegetable value chains in the United States of America and Canada are fragmented compared to other value chains like dairy, meat or eggs. This fragmentation was initially perceived as a lack of resilience, while it has in fact been a critical feature of the rapid rebound of these value chains. This partial review of food supply chain resilience illustrates the difficulty to identify the most important attributes. Even more challenging is demonstrating their actual impact on activating resilience capacities. As a result, Stone and Rahimifard (2018) concluded that there is little consensus on the most important element for building resilience.

5.3 Attributes for food system resilience

How to move from supply chain resilience to food system resilience, given the outlined difficulties in identifying food supply chain resilience attributes? To do so, some authors have responded by focusing on specific parts of the food system. For instance, working on farming systems, Meuwissen *et al.* (2019) identified five attributes: functional and responsive diversity; modularity, i.e. different modules fulfil different functions within the system; openness, i.e. connectivity between systems; tightness of feedbacks, i.e. the response of one part of the system to changes in other parts of the system; and, system reserves that actors can access during stresses or shocks provide redundancy and serve as a buffer. Others looked at a particular type of food system resilience. For example, Worstell (2020) studied the ecological resilience of food systems, emphasizing the importance of attributes such as connectivity, local self-organization, innovation, maintenance/ redundancy, accumulation of value-added infrastructure, transformation, ecological integration, and diversity. Finally, a smaller body of work looked at the food system as a whole.

These dimensions correspond to various attributes: autonomy in decision-making, diversity, redundancy, decentralization, coordination, connectivity, and learning capacity. Additionally, Kummu *et al.* (2020) examined the role of global trade in food system resilience, focusing on diversity and redundancy as well as connectivity. Hodbod and Eakin (2015) applied social-ecological resilience thinking to food systems, emphasizing the importance of considering the economic, social and environmental functions of food systems. They consider only two attributes of food systems: functional redundancy and diversity. Jacobi *et al.* (2018) extended Carpenter *et al.'s* (2001) three resilience dimensions—buffer capacity, self-organization, and learning/adaptation capacity—to food systems. These dimensions correspond to various attributes: autonomy in decision-making, diversity, redundancy, decentralization, coordination, connectivity, and learning capacity. Additionally, Kummu *et al.* (2020) examined the role of global trade in food system resilience, focusing on diversity and redundancy as well as connectivity, based on the seven resilience principles of ecosystem resilience defined by Biggs *et al.* (2012).

Based on this literature review, it becomes essential to recognize attributes in three distinct contexts: 1) resilience capacities within food supply chains (especially collective capacities as part of the broader food system), 2) resilience capacities specific to food systems, and 3) attributes that contribute to general resilience. This review identifies the following eight resilience-enhancing attributes as crucial to food system resilience (without assigning a hierarchy):

1. **Diversity**: A diverse range of actors (in size, status, operation mode, etc.) provides different functions within the food system (diverse producers, distributers, wholesalers, retailers, etc.), enabling reorganization in case of shocks and stresses (Hodbod and Eakin, 2015). Diversity is the most important attribute of resilience, even if it sometimes comes at the expense of efficiency (Walker, 2020). Diversity is needed at all levels, from local to global, and in each and every nodes of the food system (Hertel *et al.*, 2023).

2. **Openness**: Local food systems must maintain balanced connections to other local, regional, or global food systems to facilitate the exchange of produce and knowledge (Baker *et al.*, 2021). A system that is either under-connected or over-connected can be vulnerable to shocks (Walker, 2020).

3. **Responsiveness/adaptability:** food system actors are aware of and have the capacities to respond rapidly and efficiently to short, medium- and long-term impacts of shocks and stresses in an innovative manner in line with the needs and capabilities of other actors (Kumar and Singh, 2021). This capacity can only be maintained if the system is not completely isolated from shocks and stresses. Some exposure to disturbances is necessary to build this capacity Walker, 2020).

4. **Flexibility/agility/modularity:** This attribute involves the capacity to slow down and/or diversify sourcing and distribution channels within the food system (find new suppliers, new market channels, new crops, etc. (adapted from Hosseini *et al.*, 2019), and accumulation of non-specific value-added infrastructure (markets, processing plants, etc.) ensuring business continuity with minimal efforts and time. This attribute could be a combination of diversity and responsiveness, with potential trade-offs between modularity and openness (Carpenter *et al.*, 2012).

5. **Connectedness/coordination:** a mechanism exists to identify, involve and coordinate local food system actors for knowledge sharing, problem solving, trust development, resources sharing, and joint planning for collective actions (Kumar and Singh, 2021). This attribute could be seen as a critical means to create feedback loops, including biophysical, about the state of the food system (Hodbod and Eakin, 2015), should happen across scales (Walker, 2020), and aligns with the concept of polycentric governance by Carpenter *et al.* (2012).

6. **Decentralization:** fostering local innovative food system actions to reduce the risk of maladaptation caused by top-down, centralized approaches (adapted from Kumar and Singh, 2021).

7. **Visibility:** a clear, transparent understanding of the identity, location and status of food system actors and their relationships (adapted from Hosseini *et al.*, 2019).

8. **Redundancy/plasticity/reserve:** excess capacities (beyond normal requirements) as a buffer (e.g. multiplication of input suppliers, processors, storage facilities, market channels, etc.) to act as a buffer for normal activities (Ali *et al.*, 2021) and allow actors to slow down (Snow *et al.*, 2021), which could occur across scale (Hodbod and Eakin, 2015). This could also include knowledge or skills, for instance (Carpenter *et al.*, 2012).

These attributes can drive transformation within food systems. Two key objectives should be pursued: 1) fostering these attributes in order to facilitate CRFS transformation, even though no systematic link exists between specific attributes and transformation; and 2) finding the right balance among the different attributes, as their influence on CRFS transformation may vary based on local contingencies (Hodbod and Eakin, 2015).

6. Illustrating the impact pathways of the COVID-19 pandemic

Resilience thinking suggests using crises as windows of opportunity for innovation, and leveraging experience and knowledge to navigate social-ecological transitions (Folke *et al.*, 2010). Disruptions like the impacts of the COVID-19 pandemic provide "momentary glimpses of the fabric of 'normality' as it is fraying and reveal the patterns in which practices and infrastructures are woven together" (Chappells and Trentmann, 2018, p. 198).

The pandemic can thus be seen as an accelerator of food system transformations (Ugaglia *et al.*, 2021). There is no doubt that the pandemic and the restrictions governments have implemented triggered changes, but the key question is whether these changes are merely marginal adjustments or if they have the potential for deeper transformations addressing the root causes of food system unsustainability. . Assuming that changes are potentially transformative, the next question is whether they are temporary and therefore reversible, or whether they actually meet their transformative potential. Finally, if they do, are these transformations strengthening CRFS resilience and sustainability or are they reinforcing unsustainable practices? Rather than answering these questions, this review aims to illustrate how they might be explored.

6.1 A diversity of impacts

The pandemic and related measures have caused significant disruptions within food systems, leading to frictions within daily practices of food systems actors, which are typically stable (Hoolohan *et al.*, 2022). These disruptions have affected all four dimensions of food security: availability, affordability, access, and stability. They are often divided into three categories: impact on households' food security, income and well-being; food supply chain disruptions, including markets and prices; and changes in food demand (quantity, quality) and diets (Swinnen and Vos, 2021).

More than the COVID-19 pandemic itself, the measures undertaken to protect people and health systems such as mobility restrictions and business closures have had short-term impacts on food systems (Bene, 2020). However, very rapidly, providing food to the population has been deemed an essential service in many countries, like in Canada or the US (Weersink *et al.*, 2021), attempting to make food available and affordable to most of the population. Food systems have then benefitted from many adaptations of the initial restrictions so as to ensure continuity of supply in response to changes in consumption behaviour. As a result, the food sector has experienced far less disruptions than many other sectors (air transport, tourism, etc.). Nevertheless, these hard-hit sectors might have had indirect impacts on certain segments of food systems, causing notable disruptions.

Table 3 provides examples of impacts of pandemic-related measures on various food system actors and nodes. . Though not exhaustive, it illustrates the broad range of disruptions faced by food systems. Five key points are worth emphasizing:

- **Varied impacts:** The intensity, magnitude, and duration of the disruptions have varied widely across countries and even across different locations of the same country. Dixon *et al.* (2021) highlight several factors that mitigated these impacts, such as the initial characteristics of farms (e.g., production mix, size) and food systems (food marketing arrangements, infrastructure, etc.), or pre-crisis policies supporting food systems.
- **Reinforcing loops:** Disruption within food systems can lead to reinforcing feedback loops that exacerbate food insecurity, but are often not captured. Huff *et al.* (2015), for instance, note that poor workers who are part of the food system—farmers, truck drivers, and factory workers—may struggle to access food during disruptions, further destabilizing the system.
- **Interlinked impacts:** The interconnections between food systems and other systems warrants further exploration, as some interlinked impacts may be overlooked. In North Carolina, for example, COVID-19 has exacerbated "public health in food desert communities to a greater extent than in communities with better food access, availability, and accessibility" (Liang *et al.*, 2021, p. 126).
- **Potential long-term consequences:** While much of the current literature focuses on the immediate effects of the pandemic, long-term consequences cannot be overlooked. Nordhagen *et al.* (2021) note that many SMEs reduced production, laid off employees, or closed permanently. This could have lasting effects on food system structures and employment, especially in developing countries where business creation is challenging. Dixon *et al.* (2021) argue that these shocks could reduce the long-term sustainability of food systems.
- **Environmental impacts:** While social and economic impacts have been widely mentioned and documented, there is little discussion about the environmental effects of the pandemic on food systems. A few researchers such as Dixon *et al.* (2021) mentioned the return to ancient practices like burning rice residue in Asia which results in increasing air pollution, or changes in agricultural practices leading to soil degradation.

Table 3 Examples of broad categories of impacts of the COVID-19 pandemic on food system actors

Impacts	Affected food system actors	References
Income loss / reduced farm cash income / lower selling prices: → due to difficulties in the distribution from farm gate to processing or final markets → due to shortage of labour, contraction of demand → due to lower off-farm employment opportunities	Farmers and family members Consumers	Blessley and Mudambi (2022); Cable *et al.* (2021); Dixon *et al.* (2021); Dudek and Śpiewak (2022); Hirvonen, de Brauw, and Abate (2021); Maredia *et al.* (2022); Mthembu, Mkhize, and Arthur (2022); Snow *et al.*. (2021); Vargas *et al.* (2021); Weersink *et al.* (2021); Egger *et al.*. (2021); Mahmud and Riley (2021)
Increase in post-harvest losses or waste of perishable products → due to limited harvest resulting from labour shortage, lack of market access, contraction of demand, etc.) → could potentially lead to lower production targets	Farmers	Blessley and Mudambi (2022); Boyacı-Gündü *et al.* (2021); Dixon *et al.* (2021); Dudek and Śpiewak (2022); FAO (2020b); Mthembu *et al.* (2022); OECD (2020); Prosper Bright *et al.* (2021) ; Teng *et al.*. (2021)
Limited access to extension services (including veterinary services)	Farmers	FAO (2020b); Mthembu *et al.* (2022); Prosper Bright *et al.* (2021)
Restricted/limited access to inputs and/or lower quality of inputs (fertilizers, seeds, animal feed, day-old chicks, fish fingerlings, equipment replacement parts, etc.)	Farmers	Dixon *et al.* (2021); Dudek and Śpiewak (2022); FAO (2020b); Mthembu *et al.* (2022); Snow *et al.* (2021); Teng *et al.* (2021); Tittonell *et al.* (2021); Zhan and Chen (2021);
Reduced production: → due to delayed planting → due to lower investments in farm inputs following income losses → due to lower production targets following increase in post-harvest losses	Farmers	Dixon *et al.* (2021); Teng *et al.* (2021);
Confinement of animals exacerbating chances of zoonosis	Farmers, breeders	Tittonell *et al.* (2021)
Halting food safety inspection of food and facilities	Food processors, manufacturers, retailers	Cable *et al.* (2021)
Reduced capacity in processing plants, including temporary closure (e.g. meat processing plants), leading to income loss	Food processors	Boyacı-Gündüz *et al.* (2021); Cable *et al.* (2021); Snow *et al.* (2021); Teng *et al.* (2021); Weersink *et al.* (2021); Dou *et al.* (2021)
Disruption in supply of labour, inputs and transport	Farmers, agro-industries	Boyacı-Gündüz *et al.* (2021); FAO (2020b); O'Connell *et al.* (2021) ; Van Hoyweghen *et al.* (2021) ; Teng *et al.* (2021); Snow et al. (2021)
Shortage/lack of cool storage capacity	Farmers / Processors	OECD (2020)
Decreased sales coupled with lower access to inputs and financing amid limited financial reserve	Small and medium agrifood enterprises	Nordhagen *et al.* (2021)
Low level of cooperation between farmers	Farmers	Dudek and Śpiewak (2022)
Just in time food supply chains, profitable in usual circumstances, lack resilience when unexpected supply disruptions occur	Suppliers/retailers	Whelan *et al.* (2021); Teng *et al.* (2021)
Lower food consumption + decline in dietary diversity + child undernutrition and mortality → due to reduced wages, job losses, and increased unemployment → due to higher food prices, including opportunistic behaviour of food system intermediaries seeking high margins → due to a lack of access: closure of canteens, restaurants, markets, etc.	Poor and/or vulnerable households	Boyacı-Gündüz *et al.* (2021); Cable *et al.* (2021); Dou *et al.* (2021); Dixon *et al.* (2021); Dudek and Śpiewak (2022); Laborde *et al.* (2021); Maredia *et al.* (2022); Mthembu *et al.* (2022); Zhang *et al.* (2021), Vargas *et al.* (2021); Osendarp *et al.* (2021); Teng *et al.* (2021); Shahzad *et al.* (2021) ; Weersink *et al.* (2021); Osendarp *et al.* (2021); Egger *et al.* (2021) Hirvonen *et al.* (2021) do not observe any change in food security or malnutrition in Addis Ababa (Ethiopia), neither do Aggarwal *et al.* (2022) in rural Malawi and Liberia where subsistence farming 'protect' farmers from income losses and shortage of food in markets.
Lack of access to reliable information	All actors	O'Connell *et al.* (2021)

Sources: See references.

The imbalanced focus of research might reflect the short-term versus long-term impact of disruptions. The implicit hierarchy of impacts suggests that strong social and economic impacts have led to sidelining environmental impacts in pandemic-related research.

6.2 Responses based on capacities of individuals

The reactions of CRFS actors to the pandemic – and other compounding shocks and impacts – have varied widely from one city to the other due to a multiplicity of factors, such as their role in the CRFS, their individual resilience capacities, the length and intensity of the disruptions, etc. Table 4 provides some examples of food system actors' behavioural changes. While this set of individual responses is not exhaustive and therefore has limited representativeness, it still allows us to cluster them into four broad coping scenarios:

1. **Seizing opportunities for long-term change:** Some actors have had the capacity to invest and capitalize on new opportunities, adapting their livelihoods or business models in ways with potentially significant consequences on the functioning of CRFS in the long run, its level of resilience and sustainability. This could include engaging in urban agriculture, adopting new technologies, or sourcing local production. The long-term impact on the CRFS depends on whether actors adopt a short- or long-term perspective when deciding on specific absorption or adaptation strategies, whether they favour short term robustness over long term transformation, and whether they have absorptive, adaptive, or transformative capacities.

2. **Temporary absorption or adaptation with minimal costs:** Other actors have been able to absorb the shock or adapt to its impacts by making low-cost or temporary changes, such as reducing food waste, stockpiling, reallocating family labor, or diversifying suppliers. These adjustments are often reversible and have limited or no lasting impact on the CRFS in the short run.

3. **Decapitalization and increased vulnerability:** Some actors have had no option but to decapitalize (e.g. selling assets or reducing food consumption and quality), which compromises their ability to sustain their livelihoods and increases their vulnerability to future shocks.

4. **Reliance on external support:** For many actors, external support such as social safety nets or food banks became crucial. The timing of access to social protection programs is critical, as it can help actors avoid more severe impacts. The impact on the CRFS depends on how these programs are designed and implemented (e.g. whether food banks source local food, or whether assistance comes in the form of food or cash transfers).

It remains very difficult to determine whether these situations could lead to temporary or permanent changes, whether resilience and sustainability will be improved. At stake is to determine whether individuals, while developing and implementing initiatives based on their own perspective, can actually work toward a same goal while following different pathways. This would require the aggregation and weighing of the different situations previously described, the unravelling of consequences of individual choices on other actors – leading to a second set of behaviour changes – and on the CRFS as a whole. In developed countries, the most permanent changes have been related to increased home deliveries, online sales, and the use of digital payments (Burgos and Ivanov, 2021). However, these changes alone offer limited insight into the long-term sustainability of food systems.

Table 4 Examples of individual behavioural changes following the COVID-19 pandemic

Food system actors	Behavioural changes	References	Capacities[1] (tentative attributes)
Consumers	Change in shopping and consumption patterns, including reduced frequency of shopping, higher demand for home delivered food or groceries (of high quality), and hoarding behaviour, reallocation of food expenditure from the hospitality sector to the retail sector, longer shelf-life (canned/frozen) and highly transformed produce. NB: unknown short and long-term impact on diet (Whelan *et al.*, 2021)	Cable *et al.* (2021); OECD (2020); Dudek and Śpiewak (2022); El Bilali *et al.* (2021); Janssen *et al.* (2021); Tittonell *et al.* (2021);Vargas *et al.* (2021); O'Meara *et al.* (2022); Whelan *et al.* (2021); Snow *et al.*(2021); Deaton and Deaton (2020)	Absorptive (cashing savings) / adaptive (human capital, access to information)
	Increased importance of short mileage, short-chain food, locally produced food, direct producer-to-consumer sales	El Bilali *et al.* (2021); Tittonell *et al.* (2021); O'Meara *et al.* (2022)	Adaptive (bridging and linking social capital; aspiration and confidence to adapt)/ transformative (bridging and linking social capital; access to markets; access to services)
	Engagement in urban agriculture activities	Paul (2023)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information; women empowerment)
	Increase in culinary capabilities, home cooking, food literacy	El Bilali *et al.* (2021); O'Meara *et al.* (2022)	Adaptive (human capital)
	Reduction in food waste at household level	Vittuari *et al.* (2021); O'Meara *et al.* (2022)	Adaptive (access to information; human capital)
Poor consumers	Increased demand for food bank services	Blessley and Mudambi (2022)	Absorptive (access to safety nets)
	Spend savings, sell assets, borrow money, seek other jobs	Vargas *et al.* (2021); Mahmud and Riley (2021)	Absorptive (asset ownership)
	Dietary change, rationing, decrease in size and number of meals, decrease in food expenditure	Shahzad *et al.* (2021); Whelan *et al.* (2021); Mahmud and Riley (2021)	Absorptive
Farmers / Producers	Development of local food production	Campbell (2021); FAO (2020b); Nemes et al. (2021); O'Connell et al. (2021)	Adaptive (bridging and linking social capital; aspiration and confidence to adapt)/ transformative (bridging and linking social capital; access to markets; access to services)
	Diversification of production, add more and new food crop to the farms for household consumption, sometimes at the expense of cash crops (depending on agro-climatic conditions), for local, national or regional markets, from perishable to non-perishable, from labour intensive to less labour-intensive productions	Meuwissen *et al.* (2021); Vargas *et al.* (2021);	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)
	Adoption of new technology	O'Connell *et al.* (2021)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)
	Re-allocation of family labour	Vargas *et al.* (2021)	Adaptive (diversity of livelihoods)
	Changes in marketing channels and strategies (vacuum packaging, home deliveries, online sales, pickup points, or drive-through markets, etc.) thereby developing new skills, platforms and channels, or repurposing old ones	Benedek *et al.* (2022); Clapp and Moseley (2020); Tittonell *et al.* (2021)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)
	Strengthening social networks	O'Connell *et al.* (2021)	Adaptive (bridging and linking social capital) / Transformative
	Shift from export-oriented commodity crops towards food crop production	Clapp and Moseley (2020) Meuwissen *et al.* (2021)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)
	Reduce investments in agricultural inputs, sell productive assets	Egger *et al.* (2021)	Absorptive
	Farm bankruptcies (middle size farms), and consolidation of farms	Cable *et al.* (2021)	Absorptive
Food banks	Expansion of food bank activities through various types of organizational innovations, especially new strategies, new internal structures, and new types of external network relations with other firms and/or public organizations	Blessley and Mudambi (2022); Capodistrias *et al.* (2021); Nemes *et al.* (2021); Deaton and Deaton (2020)	Adaptive (human capital; aspiration and confidence to adapt; access to information)
Agri-food enterprises (including input provision, storage, distribution, wholesale, retail, processing)	Reduction of production volume (including reducing working hours and downsizing the workforce) and changing product prices (mostly lower selling prices)	Nordhagen *et al.* (2021)	Absorptive
	Change in production practices, processing and shelf-stable products, healthy and safe food, diversified packaging, automation where activities are highly labour intensive	El Bilali *et al.* (2021); Meuwissen *et al.*, (2021); Weersink *et al.* (2021)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)
	Source alternate suppliers and logistics outside their usual suppliers	Whelan *et al.* (2021)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)
	Alternate commerce models, notably cashless e-commerce, online sales, digital payment	Teng *et al.* (2021); Burgos and Ivanov (2021)	Adaptive (human capital; aspiration and confidence to adapt; asset ownership; access to information)

Sources: See references.

1 Resilience capacities and attributes (tentative) are used here, based on the framework developed by Smith and Frankenberger (2018), and summarized in Table 2.

6.3 Collective intiatives and public interventions

The potential role of public policies and collective initiatives in building food system resilience were discussed in Section 4.3. **Table 5** presents examples of public policies and collective actions in response to the COVID-19 pandemic. The definition from Section 5.3 is used to categorize the interventions. Although the examples listed are not exhaustive, they align with findings from Dixon *et al.* (2021), who observed that pre-pandemic food and agricultural policies in Asia played only a modest role in mitigating the vulnerability of food systems. Preparedness was very limited compared to the initial impacts of the pandemic. This suggests that many of the initiatives in the table reflect reactive measures rather than anticipatory ones, despite previous pandemic experiences (e.g., SARS1, H1N1) (Caballero-Anthony, Teng and Montesclaros, 2020). Moreover, responses to the pandemic have been a combination of bottom-up and top-down responses, with local governments and communities taking action alongside national efforts in regions with informal norms and local customs, especially in rural areas (Vargas *et al.*, 2021).

Key insights can be drawn from the table, though with caution to avoid generalizations. One notable pattern is that most CRFS actors, including governments at various levels, relied on absorptive and adaptive capacities to respond to the pandemic. Absorptive capacities were essential for supporting food accessibility and affordability, addressing growing food insecurity and potential social unrest (Barrett, 2020). Such demand-side measures, aimed at supporting consumers, especially the most vulnerable, were multifaceted—both through public policies and collective actions (e.g., food banks, humanitarian organizations, religious groups). Supply-side measures were equally diverse, providing support to food system actors like producers, processors, and manufacturers, through a wide variety of instruments.

When looking at the examples enclosed in the table, it is hard to determine whether some of measures undertaken to support CRFS actors can also help them to strengthen their resilience capacities, i.e. whether these safety nets are used for adaptive social protection objectives (Bowen *et al.*, 2020). Since most interventions were reactive, it is very likely that they lack the systemic, long-term view required for safety nets to strengthen households' adaptive capacities. Many reasons could be put forward to explain this inability: gap in coverage and limited adequacy, no adjustment mechanism in case of shocks, lack of coordination, lack of adaptability, lack of financing, or lack of coordination with other disaster risk management pillars as Williams and Martinez (2020) noticed in Latin America. Therefore, safety nets only equate absorptive measures aim at addressing the symptoms of a lack of resilience (no-choice situation), not its root cause. Adaptive capacities, utilized to compensate for disruption and find new ways of doing mostly the same things also covered a wide variety of actors. Solutions were proposed to help them continue to operate. The technical, human, financial capacities of public authorities seem to be an important determinant of the type of response provided. Unclear is the temporary or permanent nature of adaptive measures, and whether they provide solutions to temporary effects or address the root cause of the food system failures. The COVID-19 pandemic is sometimes seen as an accelerator of the food system digitalization. However digital technologies seem to be circumscribed to adapt value chains to new challenges like shocks, but have not yet been able to transform food system (Brassesco, Pintado and Coscueta, 2022).

The line between adaptive and transformative actions can be very thin. While it seems that transformative capacities have been poorly mobilized as reported in this table, one should be cautious with such a conclusion as initially adaptive measures might become transformative in the long run. This being said, transformative capacities seem to have stemmed from mostly collective initiatives and local governments. They appear to be limited, which question the COVID-19 pandemic as a window of opportunity to speed up food system transformation. They focused on shortening value chains through for instance community supported agriculture, and fostering local food production including the development of community gardens or urban farms, with a strong emphasis on sustainable food production practices, such as agroecology, regenerative agriculture, and conservation agriculture. Unclear is the impact of such transformative measures. Tittonell *et al.* (2021, p. 10) emphasize "the role played by family agriculture and the agroecology movement in different parts of Latin America to face the COVID-19 crisis and contribute to rural and urban food security."

To enhance resilience to future shocks, anticipative and preventive measures are needed. Very few are included in the table. Collecting data and monitoring the CRFS is the only preventive measure mentioned. While highly relevant, this requires heavy resources and a careful selection of data. Anticipative capacities refer to buffer stocks aimed at ensuring food availability for consumers, and to region-to-region cooperation mechanisms as a means to connect CRFS and ensure solidarity. All these examples are from China, a country where, by law, regions and cities are mandated to support food production and ensure food security. Local governments then dedicate adequate means to meet this remit (Zhan and Chen, 2021).

Table 5 Examples of collective actions and public policies in response to the COVID-19 pandemic

Beneficiaries	Actions / Policies	Leaders	References	Resilience capacities
All CRFS actors	Food and agriculture declared essential services and exempted from some movement restrictions	Governments	Dixon *et al.* (2021)	Adaptive
	Opening of "green channel" for fresh agricultural products and banning unauthorized roadblocks / "green corridors" enabling border procedure within the Trans-European Transport Network		Lu *et al.* (2022); Zhan and Chen (2021); Dudek and Śpiewak (2022)	
	Provision of information to food system actors on protecting workers and consumers		OECD (2020)	
	Enhanced monitoring and guidance in food Sector / real time disaggregated data and cross-sectoral coordination mechanisms monitoring vulnerabilities		Dixon *et al.* (2021); Fan *et al.* (2021); Lu *et al.* (2022)	Preventive
	A national strategy on food security featuring food self-sufficiency and absolute security of staple food based on domestic grain production		Zhan and Chen (2021)	Transformative
Farmers	Changes in sale channels, including but not limited to producer-to-consumers food sales; Support e-commerce and contactless delivery, digital inclusion of small producers; Building an online public service platform and aimed to normalize the use of this platform as a long-term mechanism to assist matching agricultural production with sales, especially for products in poorer areas.	Government / Local government / Group of farmers	Zhan and Chen (2021); Benedek *et al.* (2022); Vargas *et al.* (2021); Tittonell *et al.* (2021)	Adaptive
	Citizen-driven initiatives supported domestic producers, particularly local farmers, upsurge in Community Supported Agriculture	Civil society / Citizens	Nemes *et al.* (2021); Clapp and Moseley (2020)	Transformative
	Development of short chains of commercialisation	National or local government	Tittonell *et al.* (2021)	
	Support farmers' access to and use of machineries to compensate for labour shortage => potential long-term reduction of farm labour	Government	Dixon *et al.* (2021)	Adaptive
	Online channels to provide technical services to guide and support farmers' production / provide live streaming classes and technical posts on websites and social media platforms.		Zhan and Chen (2021)	
Farmers / Retailers Private entities operating in the food supply chain, including farmers, manufacturers, hospitality sector	Re-organizing food logistics / relocation of markets / alternative spaces / specific measures to keep markets running	Local governments	O'Connell *et al.* (2021); Fattibene *et al.* (2023)	Adaptive
	Financial support: Granting flexibilities on deadlines for applying for subsidy payments / granting tax cuts, fee exemptions, credit support, cost reductions and subsidies; social insurance premium exemptions, employment subsidies, controlled wholesale and retail prices and margins, tax breaks, deductions of taxpayers' losses, support in employing workers, extension of foreigners' residence and work permits, easier access to e-administration services, postponed loan instalment payments, preferential credit and loan terms, measures increasing work time flexibility, reducing rent, and delaying payment of social insurance premiums	Governments	OECD (2020); Zhan and Chen (2021); Teng *et al.* (2021); Dudek and Śpiewak (2022); Weersink *et al.* (2021); Meuwissen *et al.* (2021); Cable *et al.* (2021); Deaton and Deaton (2020)	Absorptive
	Increased collaboration of actors in some segments of the food system or along some value chain	Groups of private actors	Kumar and Singh (2021); Weersink *et al.* (2021)	Adaptive
Agribusiness	Policies to support marketing activities by agrifood businesses or market support	Governments	OECD (2020); Dixon *et al.* (2021)	
Local governments	Pair-wise aid model, in which relatively wealthy provincial governments use their resources to directly aid a disaster-stricken county on a one-to-one basis		Zhan and Chen (2021)	Anticipative
Consumers	Emergency response systems characterized by strategic food reserves with secured storage and releasing the reserve to the market in response to food shortages and price hikes		Zhan and Chen (2021)	
	Price regulation (existing system or new) mostly for perishable produce (e.g. milk)	National or regional public entities, or cooperatives	Weersink *et al.* (2021)	
	Solidarity initiatives to promote social justice, and facilitate access to food for the poor	Civil society / Citizen	Nemes *et al.* (2021)	Absorptive
	Replacing school meals with emergency meals (grab and go) to pick up in public locations	Local governments	Cohen (2022)	
	Food delivery to homebound people		Cohen (2022)	
Vulnerable households	Safety nets for vulnerable households, which could be in the form of cash or in-kind transfers, sometimes accompanied by interventions by health and nutrition officials. Additional funding for existing food assistance programme (food donation, financial support); new food assistance programme / right to food; linking food aid to vulnerable people; solidarity initiatives to promote social justice, and facilitate access to food for the poor / supporting food pantries and soup kitchens financially / with produces	Governments / Solidarity networks / local government	Clapp and Moseley (2020); Nemes *et al.* (2021); OECD (2020); Teng *et al.* (2021), Shahzad *et al.* (2021); Tittonell *et al.* (2021); Zhan and Chen (2021); Dixon *et al.* (2021); Cohen (2022); Blessley and Mudambi (2022); Deaton and Deaton (2020)	
Households	Increased local food production / urban agriculture / vegetable gardens; training on, support for or promotion of sustainable food production for self-consumption	National or local government / civil society / citizens	Kumar and Singh (2021); Tittonell *et al.*, 2021); Nemes *et al.* (2021)	Adaptive

Sources: See references.

6.4 A causal loop diagram of the COVID-19 pandemic impacts and actions

A food system approach demands collating all elements related to shocks and stresses and identify their interplay. Based on the information collected on the impacts of the pandemic (**Table 3**), the individual responses (**Table 4**), and the public policies and collective actions developed (**Table 5**), the following diagram shows how these different variables are interrelated (**Figure 3**). It illustrates the causal pathways of different responses to the pandemic and their proximal and distal impacts on the different dimension of food security and nutrition: food access, affordability and availability. Reinforcing or balancing loops can then be identified. It does not go into country- or local-specific details but aims at providing a global understanding of the mechanisms at play.

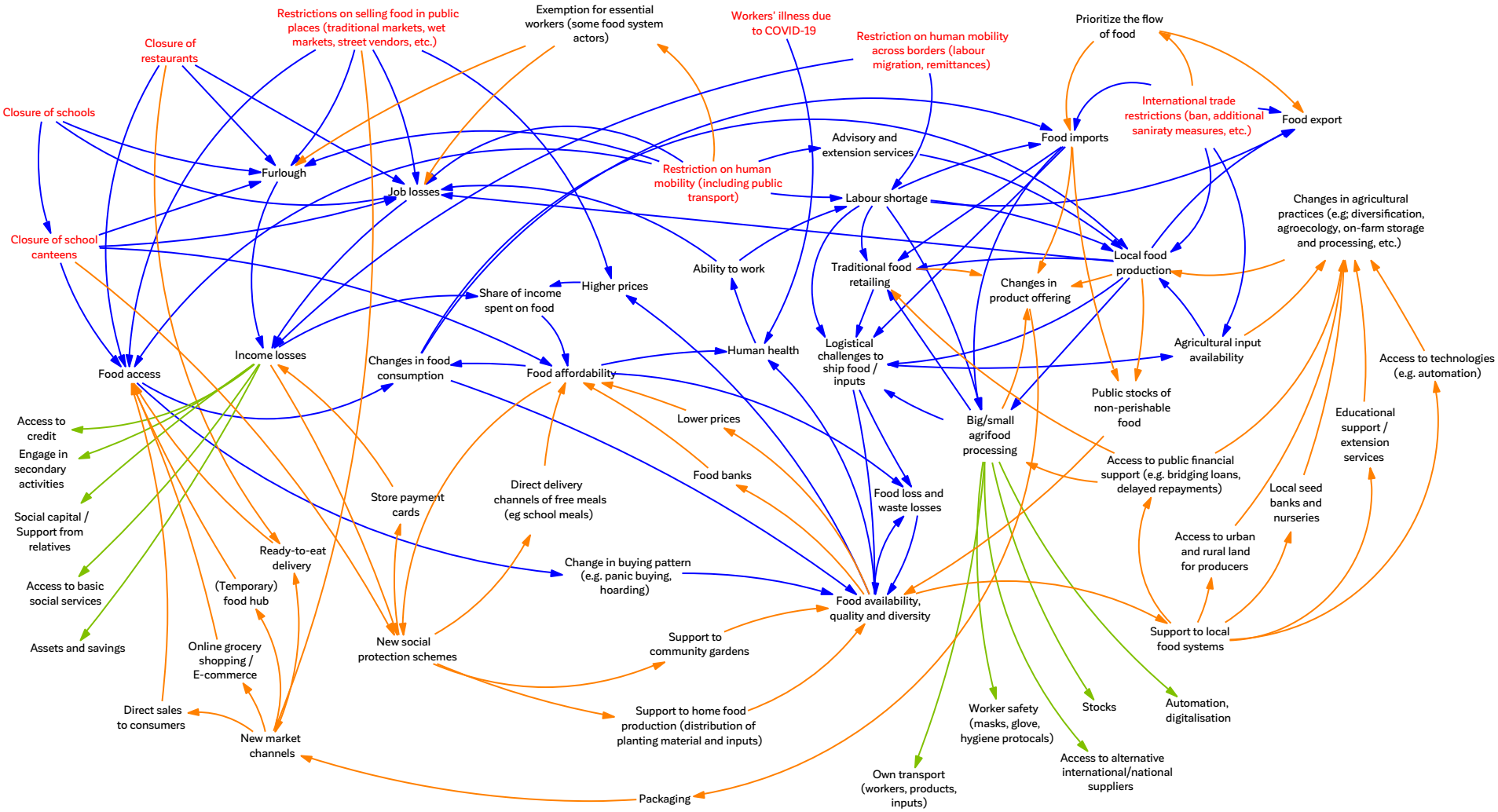
While such a causal loop diagram does not seek to be exhaustive, it allows visualizing the complexity of the system and grasping the ripple effects of interventions by governments interventions and food system actors. In our causal loop diagram, the many different measures taken by governments (in red) to slow the spread of the COVID-19 pandemic (lockdown and social distancing, among others) have negative impacts on food availability, access and affordability through various channels. Many intermediary mechanisms are at play as the blue arrows depict. Conversely, public policies and collective interventions have positive impacts on these three food security dimensions, as the orange arrows show, from how negative impacts trigger policies and how policies respond to the negative impacts, sometimes through different channels. These interventions may target the origin of the disruption, or its outcome.

While such a causal loop diagram seems complex at first, following the arrows remains very simple and facilitate the understanding of the functioning of the system. The interconnectivity between different variables is in some way subjective because additional intermediary variables could be included in the different loops depending on the level of complexity envisaged.

These impact pathways are critical to understand the contribution of the many interventions for food system resilience and sustainability, be they positive or negative, temporary or permanent. It also allows to identify potential missing points of intervention (Roxas, Rivera and Gutierrez, 2019) in addressing some specific impacts, and point out new, or innovative ways to strengthen food system resilience, by creating new loops, or deleting others. Such diagram allows to anticipate how a system could react to policy interventions and what the propagating mechanisms or side-effects could be. Therefore, a causal loop diagram should serve as an evaluation tool to assess any recommendation aiming at strengthening the resilience of food systems. The remaining challenge is now decision-making post disruption (Kumar and Singh, 2021).

While this would need additional work, the mobilization of the different categories of resilience capacities seems to point out that initiatives implemented to build resilience to COVID-19 and other shocks only contribute marginally to the sustainability of food systems. Most initiatives are centred on strengthening current CRFS efficiency, and not increasing their sustainability. This would confirm the findings of Agyemang and Kwofie (2021) who show that most initiatives focus mainly on the end goal of food systems, thereby addressing the symptoms and not the root causes of food systems' lack of sustainability. Better interventions are needed. This raises the question what should be the next innovations in the post-pandemic world to build resilience and strengthen sustainability.

Figure 3 Impact pathways of the COVID-19 pandemic on food systems



Source: Authors' own elaboration. Governments' initial interventions are in red. Their multiple implications on the four dimensions of food security and nutrition (availability, accessibility, affordability and stability) through diverse channels correspond to the blue arrows. The orange arrows show public and private actors' reactions, adaptations, and innovations to the pandemic and other interventions. Finally, the chart includes some illustrative coping mechanisms potentially used by households (all members of the society the food system encompasses) and private companies (green arrows).

7. From diagnostic to recommendations

The many analyses of the COVID-19 pandemic and its consequences on food systems have all come up with a set of recommendations, very diverse depending on local specificities and the capacities of the systems considered. Some recommendations come from the existence of pre-crisis policies that play a key role in alleviating the impacts of the shock, such as social protection schemes or support to farming. In the following section, we point out a few generic comments before turning to two specific points: the seemingly contradictory recommendations on long and short value chains, and the focus on new measures without considering phasing out others.

7.1 A myriad of recommendations covering all reslience capacities

Table 6 compiles a set of recommendations aimed at enhancing food system resilience in response to the COVID-19 pandemic. These recommendations are numerous and touch upon a wide range of issues facing food systems. The diversity of the recommendations raises critical questions about prioritization: where to begin and how the sequencing of changes can influence food system transformation. This underscores the need for identifying where and how transformation should occur within CRFS, based on addressing the root causes and drivers of current food system challenges (Slater, Baker and Lawrence, 2022). Some of these drivers may originate from sectors beyond the food system itself.

The recommendations are clustered according to the five resilience capacities outlined in section 5.3 and the nine attributes identified in section 6.3. The intention is not to be exhaustive or fully representative but rather to provide concrete examples of what could be included under different attributes, acknowledging that such classifications are open to debate. The original language from the references has been preserved where possible, as "the language used in the recommendations matter, and more explicit, outcome driven, decisive language leaves less room for confusion in policy making" (Slater *et al.*, 2022, p. 9). At the same time, the aim is to remain sufficiently generic to avoid overwhelming detail and maintain relevance. Broad recommendations, such as the need for national, regional, and local food security strategies (Blay-Palmer *et al.*, 2021; Caballero-Anthony *et al.*, 2020), strengthening anticipatory capacities and including attributes into food planning (Meuwissen *et al.*, 2021), or shifting from a reactive to a preparatory paradigm (Caballero-Anthony *et al.*, 2020), have been excluded, as have calls for increased financial support and policy interventions (Agyemang and Kwofie, 2021). Some recommendations stem from the public policies and collective actions outlined in **Table 5**, while others address new areas.

Although the recommendations are neither exhaustive nor fully representative, several general observations can be made that align with previous analyses of public policies and collective actions during the pandemic (see section 7.3). First, a low level of preparedness among food system actors is evident. Many recommendations focus on mobilizing preventive and anticipatory capacities, particularly in relation to the attributes of diversity, openness, and visibility. These recommendations span all nodes of food systems, illustrating the broad applicability of these attributes. Addressing preparedness should be deeply embedded into food system planning, as suggested by Dubbeling *et al.* (2017). The absence of such planning can exacerbate food insecurity, as Battersby (2017) argues. However, resilience is rarely emphasized in existing plans, and tools are available to guide city regions in this direction (FAO and RUAF, 2023).

Secondly, contrary to diversity, visibility and openness, some attributes contribute to supporting any of the three other types of capacities – absorptive, adaptive or transformative – without any clear delineation between these attributes and the resilience capacities. The nature of the recommendation dictates the resilience capacity mobilized. Contrary to FAO (2021) who consider diversity a key attribute of absorptive capacities, the classification in this review points out diversity as an attribute of preventive capacities, offering a different perspective on how resilience capacities work together.

Most transformative capacities are linked to recommendations focusing on connectedness, coordination, or responsiveness/adaptability.
Coordination supports the emphasis on the role of governance in driving food system transformation. Governance becomes pivotal because "enabling social, institutional, and governance factors are the actual drivers of the transformative process" (Hellin *et al.*, 2022, p. 3). Transformation remains as "a contested, competitive and political process and not a matter of rational design" (Leeuwis *et al.*, 2021, p. 775). In this respect, decentralization becomes a critical attribute, closely tied to coordination and governance.

Table 6 Examples of recommendations to enhance food system resilience following the COVID-19 pandemic

Attributes	Resilience capacities	Recommendations	References
Connectedness/ coordination	Absorptive	Collaborating across sectors to meet emerging food needs	Thilmany *et al.* (2021)
	Adaptive	Establishing strong cooperation among input suppliers, smallholder farmers associations, extension services, and local retailers	Mthembu *et al.* (2022)
		Ensuring smooth communication along the supply chain to minimize delays and the mismatch of demand and supply	Song, Goh and Tan (2021); Savary *et al.* (2020)
		Discussing animal-based farming systems vis-à-vis public health issues (e.g. zoonosis)	Meuwissen *et al.* (2021)
	Transformative	Multi-stakeholder groups across scales / promoting sectoral cooperation among local departments, vertical cooperation between municipal and subnational/national governments, and horizontal coordination with other local governments.	FAO (2020b); Blay-Palmer *et al.* (2021)
		Establishing/strengthening networks and knowledge exchange between cities	FAO (2020b)
		Establishing, maintaining, developing and shortening direct relations with food consumer customers	Dudek and Śpiewak (2022); FAO (2020b)
		Facilitating and promoting the cooperative and/or producer group model of operation	Dudek and Śpiewak (2022)
		Co-creation needed between food supply chain practitioners, applied researchers and outreach professionals	Thapa Magar *et al.*, 2021; Thilmany *et al.* (2021)
		Confronting behavioural and political barriers to progress	Barrett *et al.* (2021)
		Improving access to decision making processes for all actors, especially smaller ones	Whelan *et al.* (2021)
		Institutional arrangements to enable transformations / the transformative capacity of many farming systems actively enhanced through an enabling environment	Meuwissen *et al.* (2021); (Magar *et al.* (2021)
		Adoption of circular economy in agri-food system / closing waste and resource loops to increase the availability of fertilizers through composting	Lever and Sonnino (2022), Adelodun *et al.* (2021)
Diversity	Preventive	Supporting production diversification at the farm level	Dixon *et al.* (2021)
		Producers' perspective: Diversifying the channels and ways of selling products / diversifying food production and distribution in terms of scale, geography and intent / disseminating information on the conditions, possibilities and ways of conducting direct sales of agri-food products / launching food deliveries directly to customers / supporting the development of e-commerce capacities and skills / supporting the formation of direct sales sites such as marketplaces	Akbar *et al.* (2022); Savary *et al.* (2020); Dudek and Śpiewak (2022); O'Meara *et al.* (2022); Thilmany *et al.* (2021)
		Consumers' perspective: Harnessing the synergistic effects of both conventional and alternative food sources / encouraging diversification in food provision, including local food production / shorter supply chains / direct purchase from local producers / supporting smallholders	O'Meara *et al.* (2022); FAO (2020a); Thulasiraman, Nandagopal and Kothakota (2021; Whelan *et al.* (2021); Vittuari *et al.* (2021); Akbar *et al.* (2022); Nemes *et al.*, (2021)
		Increasing rural non-farm activity by investing in economic activities	Teng *et al.* (2021)
		Encouraging selective farming in urban or peri-urban areas	Teng *et al.* (2021)
		Supporting domestic food production since it is critical but was not resilient / Ensuring access to quality seeds, inputs, machinery, extension services / Minimum support price for farmers / sufficient farm income	Van Hoyweghen *et al.* (2021); Dixon *et al.* (2021); Savary *et al.* (2020)
Openness		Avoiding excessive de-globalization	Barrett *et al.* (2021)
		Avoiding protectionism / securing food imports / Expanding intra-regional food production and trade / Ending trade restrictions that affect access to nutrition:	Barrett, (2020); Caballero-Anthony *et al.*, (2020); Osendarp *et al.*, (2022) Akbar *et al.* (2022); Savary *et al.* (2020)
		Allowing free flow of inputs, labour and supplies related to food	Caballero-Anthony *et al.* (2020)
Responsiveness/ adaptability	Absorptive	Social protection / Building safety nets / Facilitating access to food for the most vulnerable through social protection programmes complemented by efficient, safe and innovative food distribution. Sustain or implement social protection programmes / Injecting liquidity into households can partially make up for capital losses and stimulate production for the next farming cycle	Barrett *et al.* (2021) ; FAO (2020a) (Caballero-Anthony *et al.*, (2020); Fan *et al.*, (2021); FAO (2020b); Osendarp *et al.*, (2022); Teng *et al.*, (2021); O'Meara *et al.* (2022); Dixon *et al.* (2021); Onyango, Crush and Owuor (2021); Savary *et al.* (2020); Egger *et al.* (2021); Vargas *et al.* (2021)
		Mobilizing more resources for humanitarian assistance.	Osendarp *et al.* (2022)
		Workers — even temporarily unemployed workers — must be kept physically healthy	Barrett (2020)
		Campaigns for responsible food purchase behaviour / Managing hoarding behaviours that temporarily disrupt supply chains by limiting the sale of essential goods	FAO (2020a); Barrett (2020)
	Adaptive	Providing support in finding workers for food sector businesses, pursuing a pro-employee hiring policy / keeping borders open to migrant workers	Barrett (2020); Dudek and Śpiewak (2022)
		Addressing schools as a central restarting point for educational campaign and sustainable diets	Vittuari *et al.* (2021)
		Advisory services / subsidised financing / technical assistance for current and new crops to adapt production systems	Vargas *et al.* (2021); Savary *et al.* (2020)
		Redeploy workers: Governments could save on unemployment insurance payments by subsidizing temporary hiring in essential industries, including in health and food systems	Barrett (2020)

continued →

(continued)

Attributes	Resilience capacities	Recommendations	References
Responsiveness/ adaptability	Transformative	Innovation / increasing investments in the agrifood sector through RandD and entrepreneurship, including "disruptive technologies" in the agri-food space / reassessment of the impacts and strategies of long-term and strategic agricultural research	Adelodun *et al.* (2021); Caballero-Anthony *et al.*, (2020); Fan *et al.* (2021); Teng *et al.*, (2021); Dixon *et al.* (2021); Savary *et al.* (2020)
		Provision of specific resources for a desired transition (e.g. innovative knowledge)	Meuwissen *et al.* (2021); Thapa Magar *et al.* (2021)
		Wider promotion and uptake of proven innovations, such as institutional innovation for payment for ecosystem services	Dixon *et al.* (2021)
		Because of the multiple sources of risk and uncertainty including climate variability and change, sustainable decarbonisation should be a central plank of recovery programmes	Dixon *et al.* (2021)
		Developing sustainable and modern food systems, e.g., reducing the cost of aseptic lab-grown meat, reducing the cost of food waste recovery and reutilization in the food chain, and developing new and large food supply chains based on insect and microalgae proteins	Galanakis (2020)
		Strategic dismantling of the corporate food regime	James *et al.* (2021)
Visibility	Anticipative	Emphasizing high-frequency monitoring of food markets (availability and prices)	Barrett *et al.* (2021); FAO (2020a); O'Meara *et al.* (2022)
		Improving information flow to farmers, processors, food manufacturers and traders, on weather, resources, markets and prices	Fan *et al.* (2021)
		Ensuring that the development of policy tools include qualitative and quantitative evaluations on different sustainability dimensions of the food chain.	Vittuari *et al.* (2021); Blay-Palmer *et al.* (2021)
		Food system vulnerability could feed into stress tests of food systems	Meuwissen *et al.* (2021)
		Credit / index-based assurance to farmers/ Business risk management programs (insurance) / promoting agricultural insurance for farmers	Dixon *et al.* (2021); Prosper Bright *et al.* (2021);
		Resilience analysis and planning / developing evidence-based and inclusive policies and plans on food systems' preparedness and resilience to shocks, extreme events and protracted crises → could be aligned with sustainability	Fan *et al.* (2021); FAO (2020b); Thapa Magar *et al.* (2021); Dixon *et al.* (2021)
		Funding and building trust in first-rate science	Barrett *et al.* (2021)
		Governments of high-income countries must expand support for vulnerable populations in low- and middle-income countries	Barrett (2020)
Redundancy/ plasticity/ reserve	Absorptive	Building strategic food and critical inputs reserve	Belik (2020); Dixon *et al.* (2021)
		Expanding storage capacity and protection from pests	Caballero-Anthony *et al.* (2020); Teng *et al.* (2021)
	Adaptive	Investing in value addition equipment and infrastructure as a means of preserving the value of perishables for a prolonged shelf life	Prosper Bright *et al.* (2021)
		Further mechanization to manage labour shortages / Public sector coordination of labour and machines/equipment	Savary *et al.* (2020); Dixon *et al.* (2021)
Decentralization	All capacities	Strengthening local governments with sufficient and competent human resources as well as financial resources	Thapa Magar *et al.* (2021)
		Urban–rural linkages that spread the opportunities and benefits of CRFS from producer to consumer building polycentric food networks	Blay-Palmer *et al.* (2021)

Sources: See references.

7.2 Reconciling short and long value chains

The COVID-19 pandemic has reignited the longstanding debate about whether global or local food systems are more resilient to shocks and stresses, raising questions about the appropriate size of farms and companies (big vs. small) and the length of the value chain (short/local vs. long/global). This debate is reflected in the recommendations collected in **Table 6**, together with the necessary trade-offs between openness, diversity and redundancy. While both global and local supply chains have been disrupted, the consequences of these disruption have been different depending on the local context. Hence, the literature provides arguments – and therefore recommendations – for both the critical role global or local supply chains might have played in responding to the crisis. International trade has become an integral part of local food systems in many countries to maximize economic efficiency and enhance food security. As a consequence, policy makers have often neglected local, typically short, supply chains, especially when they could not compete with imported products, due to higher production costs, varying quality, taste, etc. However, international trade also facilitates the international propagation of shocks (Seekell *et al.*, 2017). Export bans following the reduction of food production in exporting countries were one of the key drivers of the 2008 food crisis. The COVID-19 pandemic added an additional dimension to the role of international trade in food crises. It "has revealed the vulnerability of over-reliance on long-distance shipping, complicated logistics and digital infrastructure to meet food needs" (Thilmany *et al.*, 2021, p. 851). Weersink *et al.* (2021, p. 2) stress that "[lean] manufacturing and just-in-time production, distribution, and storage strategies have resulted in a low-cost food system, but the unusual and widely dispersed stresses of the pandemic economy revealed that this kind of system cannot respond easily or quickly to disruptions that are far outside the normal range." The pandemic has also exposed the role of local food supply in the daily food security of many households. This situation has raised awareness among decision makers. As Campbell (2021, p. 74) noted, "COVID-19 may have caused [local government stakeholders] to reckon with issues of community food systems, food access, and [local food production] for the first time".

Nemes et al. (2021) argue that the pandemic pointed out some of the shortcomings of current food systems, especially the dependence on global value chains and foreign labour, but did not weigh on their environmental impacts. It led actors and local/national governments to pay renewed attention to local food systems. It also highlighted the active role citizen have played in developing collective actions.

In some cases, local food system actors have demonstrated flexibility, agility, adaptability. In the Piemont region in North Carolina (United States of America) "Regional systems' actors were able to pivot more quickly than large-scale systems and presented a more flexible, locally suitable model that will likely prove adaptive beyond the pandemic" (O'Connell *et al.*, 2021, p. 123). Similarly, Thilmany *et al.* (2020, p. 87) noted that in the United States of America, "[local and regional food system] enterprises made agile pivots to new market channels and buyers by leveraging relationships in local food supply chains." They emphasize that local and regional food system adaptations focused on leveraging community networks and resources to find inputs (including labour), and markets (buyers). In the same way, (Dixon *et al.*, 2021) found that in Asia farming and food systems with traditional, shorter market chains proved to be inherently more resilient than those with longer chains.

Conversely, in other contexts, local supply chains faced greater disruption than export-oriented value chains, with small enterprises suffering more than larger ones. Hobbs (2021) observed that adopting smaller-scale, higher-cost food systems could result in higher consumer prices while remaining vulnerable to external shocks. For instance, in Senegal, export-oriented value chains were more resilient during the pandemic, though small farmers faced challenges such as labor shortages and restricted access to inputs and markets, whereas larger agro-industrial enterprises were more insulated due to existing stocks and better access to international suppliers (Van Hoyweghen *et al.*, 2021).

Conversely, in other contexts, local supply chains have been more disrupted than export-oriented value chains, and small enterprises have suffered more than big ones. Hobbs (2021, p. 195) observed that "[adopting] a smaller-scale, higher cost, less efficient food system will result in higher prices for consumers while remaining vulnerable to sudden exogenous shocks." Researching fresh fruits and vegetables in Senegal, Van Hoyweghen *et al.* (2021) observed that the situation was more complex, even if export-oriented value chains were more resilient. Big agro-industries were more insulated due to existing stocks and better access to international suppliers, while small farmers faced challenges such as labor shortages and restricted access to inputs and markets, and sometimes shifted from perishable to staple crops (Van Hoyweghen *et al.*, 2021).

Studying the resilience of community-supported fisheries during the pandemic using network analysis, Carlson, *et al.* (2021) conclude that rather than localism, "resilient food systems stem from spatially mixed networks that are rooted in local suppliers and buttressed by local redundancy and non-local connectivity to provide resilience amid disturbances". They emphasize the importance of metacouplings in strengthening resilience, i.e. the diversity of interaction between actors at different spatial levels,

because it allows for rewiring the network according to the disturbance, and re-building redundancy into the supply side network. Trade is at the centre of the resilience of long/agro-industrial value chains. As Kummu *et al.* (2020) point out, trade is one of the many strategies for mitigating the impacts of both local and global shocks, but trade could also be the propagator of shocks (e.g. the impact of the Russia-Ukraine war on global food markets). They show that at national level, food diversity has increased over the past decades while production diversity has decreased for most food exporting countries. This specialisation translates into higher dependency on food imports for many countries, exporters and importers alike. These findings show the double role of trade as a promoter and a limiter of food system resilience. The dependency on food imports can become an issue when global markets face shocks as in 2007-2008 or today with the COVID-19 pandemic and the Russia-Ukraine war, especially when supply sources are limited in number. The Russia-Ukraine crisis, and the major disruption of energy, fertilizer and food markets it caused, further emphasize how important the diversification of food supply is, including through local value chains. The integration of different types of food crops (fruits, vegetables, livestock, perennials) within local food systems can contribute to the resilience of food systems (Dixon *et al.*, 2021). Consequently, city region food system resilience depends very much on the context. The local vs. global food system debate oversimplifies the actual question behind localism or globalism: the attributes that make food systems resilient. It also questions the definition of city region: while the linkages between local and global food systems, short and long value chains, are critical for resilience, without the right balance, food system resilience could be compromised.

6.3 Many phase-ins but no phase-outs

The recommendations listed in **Table 6** focus on phasing in new measures. This is particularly true when it comes to transformation of food system. Most of the transformative recommendations focus on innovations – be they technical, social, institutional, organizational, cultural, etc. – able to profoundly change a system, along the lines of Schumpeter's (2003 [1942]) creative destruction concept , those so called "radical innovations". The phase-in of these innovations happens when the system is confronted with problems and tensions. It includes reconfigurations, i.e. changes at multiple levels of the same system that link up and reinforce each other – including user practices, regulation, infrastructure, etc. (Geels, 2002).

Similarly, phase-outs can be critical in responding to sustainability challenges, mostly achieved through public interventions such as bans, rules and regulations, taxation, subsidy removal, or performance standards, and to a lesser extent voluntary actions. A necessary condition applies: phase-outs need to go beyond the mere substitution of specific components of a system to trigger transformation, in a perfect timing and pace to prevent lock-ins (Rinscheid *et al.*, 2021). Contrary to the Schumpeterian creative destruction concept, an innovation or the added value of existing ones stem from these phase-outs. This idea of phasing-outs, closely linked to doing with *less* or *without*, is particularly relevant within food systems (Goulet and Vinck, 2022): less meat in diets, less pesticides, reducing loss and waste, no plastic in packaging, low-carbon, reduction of intermediaries in short value chain, etc. Despite the critical role they play, phase-outs often seem to be less appealing than innovations. Both, however, suffer from a limited understanding of the conditions under which they can truly be transformative (Kennedy *et al.*, 2021).

8. Conclusion

In today's world made of poly-crises and compounding impacts, resilience has reemerged as a key focus for addressing vulnerabilities in food systems. While the concept of resilience is appealing on paper, it remains fuzzy and hard to operationalize. Many studies have focused on the resilience of individuals or households, examining individual resilience strategies and capacities, and concentrating on assisting the most vulnerable. Others have looked at the resilience of supply chains, particularly of corporations, to identify ways of maintaining their operations whatever the disruptions. What emerges is that the stability of operations tends to become the only objective. Fewer studies have examined resilience of food systems as such, and even less of CRFS.

The concept of CRFS resilience presents unique characteristics, distinct from the resilience of individuals or supply chains. Resilience thinking applied to CRFS emphasizes a shift from recovery to transformation, framing system resilience as a determinant of individual resilience, rather than the reverse. It also highlights the importance of collective action over individual responses and stresses the need to incorporate both specific and general resilience. These principles align with those proposed by Webb et al. (2023), who suggest that food system transformation should focus on equity, future options, institutional capacity-building, transparency, evidence-based decisions, and feedback mechanisms for continuous adaptation.

Building resilience at the CRFS level involves developing five resilience capacities: preventive, anticipative, absorptive, adaptive, and transformative. The weight of each of these capacities varies depending on the level of analysis, with anticipative, preventive, and transformative capacities being particularly relevant at the food system level. These capacities often require public interventions or collective action. However, the boundaries between these capacities remain difficult to map out and are influenced by the perspectives of different actors and observers. This subjective dimension should not be ignored when assessing resilience capacities of a CRFS.

Resilience capacities are hard to measure. Researchers often rely on to the identification of specific attributes linked to these resilience capacities. Depending on the level of analysis (household, value chain or food system), the task can be either relatively easy or tremendously daunting. When it comes to the CRFS level, there is no consolidated framework that supports the identification of attributes and allows matching them up with resilience capacities.

To explore the interplay between individual and collective actions, resilience capacities, and attributes, a rapid analysis of the COVID-19 pandemic as a shock to food systems was conducted. This review of the literature highlighted several gaps in the way the pandemic's impacts have been analyzed, with a bias toward social and economic impacts, while environmental consequences were largely overlooked. Additionally, the focus has been predominantly on short-term impacts, with long-term effects receiving insufficient attention. This short-term perspective also influenced the responses of CRFS actors and policymakers, which were largely reactive, mobilizing absorptive and adaptive capacities. Preventive and anticipative capacities were notably underutilized, and while transformative capacities emerged from collective initiatives and local governments, their scope was limited. This raises doubts about whether the pandemic was truly a window of opportunity to accelerate food system transformation.

In an attempt to decipher the complex relationships between individual and collective actions, resilience capacities and attributes, a literature review of the impact of the COVID-19 pandemic as a shock on food systems was conducted. This review identified impacts on food systems of the shocks, individual reactions of CRFS actors, and public policies and collective actions. The theoretical causal loop diagram was used to understand in a systemic way the structuring of all these elements. The review identified a series of shortcomings on the way impacts of the pandemic have been analysed. There seems to be a bias towards social and economic impacts, while environmental impacts have been overlooked. Similarly, the focus has mostly been on short-term impacts while long-term consequences were largely ignored. This short-term perspective seems to have also influenced individual reactions of CRFS actors, public policies and collective actions. These mostly mobilized absorptive and adaptive capacities in a reactive manner. Preventive and anticipative capacities were notably underutilized, and while transformative capacities emerged from collective initiatives and local governments, their scope was limited. This raises doubts about whether the pandemic was truly a window of opportunity to accelerate food system transformation.

Finally, the review examined a range of recommendations emerging in the literature aimed at improving food system resilience. These recommendations address various resilience attributes, with a particular emphasis on enhancing diversity and visibility to strengthen preventive and anticipative capacities. However, there is

a noticeable lack of transformative recommendations, despite the urgency of the current challenges. Most suggestions focus on new actions and adding missing elements to build resilience, while few address the removal of existing barriers that hinder resilience.

This review underscores the importance of applying resilience thinking at the CRFS level, though it raises more questions than answers, highlighting the need for clearer definitions and frameworks for resilience in times of poly-crisis and compounding impacts. The insights gathered here have been used as a foundation for designing a global survey to assess the subjective resilience of CRFS in the wake of recent shocks and stresses. The results of this survey can provide further knowledge on the matter and are available on the FAO website.

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