FOOD SYSTEM RESILIENCE

Recommendations for the EU-Africa R&I Partnership on FNSSA

A report submitted to the LEAP4FNSSA project in June 2021

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No. 817663

The study report was prepared and submitted by Thomas Pircher, Karen Tiede, Miriam Ehret, Magdalena Nertinger and Carolin Callenius

UNIVERSITY OF HOHENHEIM

Research Centre for Global Food Security and Ecosystems
Wollgrasweg 43
70599 Stuttgart - Germany

Contact: gfe@uni-hohenheim.de

Views expressed in this report are of the Authors, and do not in any way represent official positions of the University of Hohenheim or the LEAP4FNSSA project partners. The Authors remain responsible for any errors thereof.

Cover photo from Pixabay: https://pixabay.com/photos/wind-blown-crooked-tree-the-hot-sun-1953873/

1 Table of content

List of figures and tables 4
Abbreviations 4
Executive Summary 5
1 Background and scope of the study 7
2 Study Methodology 8
2.1 Expert consultation 8
2.2 Literature review 10
2.3 Participation in workshops and conferences 11
3 Food system resilience - conceptual framework 12
3.1 Food systems and its components, drivers and outcomes 12
3.2 Food system resilience 16
4 Balancing synergies and trade-offs in resilience building 23
4.1 Synergies and trade-offs between resilience and other system properties 23
4.2 Synergies and trade-offs between different levels and scales of food systems 25
4.3 Synergies and trade-offs between different food systems outcomes 26
4.4 Conclusions 27
5 Methodological approaches for food systems analysis 28
5.1 Overview of existing methods to food systems analysis 28
5.2 Comprehensive methodologies for food systems analysis 32
5.3 Conclusions 32
6 Resilience to shocks and stresses 34
6.1 Overview of shocks and stresses to European and African food systems 34
6.2 Case study Covid-19 35
6.3 Conclusions 41
7 Food system resilience in policies of the European Union, African Union, bi-continental cooperation and global frameworks 42
7.1 Food system resilience in policies of the EU 42
7.2 Food system resilience in policies of the AU 45
7.3 EU-AU cooperation 47
7.4 Food system resilience in an international context 48
7.5 Conclusions 49
8 Guiding principles for resilience building and recommendations 51
8.1 Guiding principles for resilience building 51
8.2 Recommendations for R&I 55
9 References 60

List of figures and tables

Figure 1. Information and data sources that guided the development of the study report 8
Figure 2. "Nested" conceptualization of food system approach which is organized around diets as main objective (GloPan, 2016) 13
Figure 3. Updated Food Systems framework developed by the High Level Panel of Experts for Food Security and Nutrition (HLPE, 2020) 15
Figure 4. The food system resilience action cycle (Tendall et al., 2015). 21

Table 1. Panel of experts that contributed to study 8
Table 2. Frameworks for food system analysis 32

Abbreviations

AfCFTA	African Continental Free Trade Area
AU	African Union
CAP	Common Agricultural Policy
CAADP	Comprehensive Africa Agriculture Development Programme
CFS	Committee on World Food Security
EU	European Union
FNSSA	Food and Nutrition Security and Sustainable Agriculture
HLPD	High Level Policy Dialogue on Science, Technology and Innovation
HLPE	High Level Panel of Experts of the Committee of World Food Security
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
LEAP4FNSSA	Long-term Europe-Africa Research and Innovation Partnership for Food and Nutrition Security and Sustainable Agriculture
NEPAD	New Partnership for Africa's Development
UN	United Nations
R&I	Research and Innovation
SCAR	Standing Committee on Agricultural Research
SDG	Sustainable Development Goals

Executive Summary

The European Union's (EU) project *Long-term Europe-Africa Partnership for Food and Nutrition Security and Sustainable Agriculture* (LEAP4FNSSA) supports the EU and African Union (AU) in their joint undertaking in implementing a Research and Innovation Partnership on food and nutrition security and sustainable agriculture (FNSSA). In this capacity LEAP4FNSSA commissioned this study on *Food System Resilience* with the objective to provide recommendations to shape future R&I policies in this research area. The study is primarily intended for policy makers, particularly addressing bi-regional (Africa-Europe) collaboration on R&I.

The overall approach of this study, described in Chapter 2, was to triangulate multiple sources of information, analyse and present these data through a conceptual framework, and synthesize our findings into specific guiding principles and recommendations. A panel of experts was engaged through two online workshops and individual interviews to explore the scope and key issues in food system resilience. We also conducted an extensive literature review and actively participated in online-conferences that addressed the study topic to follow current discussions and developments. The concluding chapter on guiding principles and recommendations draws information from our findings and inputs from a wide range of experts that we consulted throughout the process.

The conceptual framework in Chapter 3 shows that food systems in Africa and Europe vary greatly and different approaches to study these systems exist. Scientific literature suggests using food security as an outcome of food systems that cannot be compromised and therefore serves as a benchmark for resilience. Other conceptualizations take a wider perspective that includes also social and ecological resilience of food systems. The agency of food system actors, which is the ability to adapt or transform a system as a response to shocks and stresses, plays a key role in resilience building. Operationalizing and measuring resilience and resilience building requires a contextualization in terms of resilience of what, against what, and for whom. Yet we identified frameworks on general characteristics of food system resilience that can guide resilience building.

Synergies and trade-offs in resilience building measures can occur between system properties and on various levels and scales of the food system. Our analysis in Chapter 4 suggests that resilience should not be considered as the unique and ultimate goal, but balanced and combined with other system properties. Both, trade-offs and synergies cannot be generalized, but are highly dependent on context and the type of shocks and stress. Stakeholders in food systems need to be engaged in a process of balancing competing interests and complex interactions in food systems. The focus should therefore be more on creating awareness, rather than promoting win-win scenarios, and on methodological approaches to analyse trade-offs and synergies in food systems.

Resilience building requires an ample understanding of food systems including its components, subsystems and boundaries. Chapter 5 provides and overview of methods and tools for food system analysis. Methods for understanding interactions of complex system behaviour can help to assess and anticipate synergies and trade-offs in resilience building. Quantitative monitoring of food system resilience currently lacks both, an agreement on indicators and metrics and datasets over a wider geographical range and timeframe. Foresight exercises can foster participation in defining future-proof food systems in which resilience may play a major role. While the identified methods build a set of useful tools, integrated methodologies are needed to analyse food systems in different contexts and scales and to facilitate transformations towards more resilience

Solutions on how to prepare and cope with shocks and stresses need to be found for each crisis individually and context specific. Chapter 6 provides and overview of shocks and stresses to European and African food systems. Our analysis indicates that crises will occur more frequently in the future as an effect of climate change, social and political unrest, pest and diseases with shocks and stresses reinforcing each other. The Covid-19 pandemic has shown how vulnerable the current food systems are towards global economic shocks and corresponding political measures. The indirect effects (lockdowns, border restrictions) affected all countries globally and in particular vulnerable populations and Low-Income Food-Deficit Countries. The scale of the food system disruption induced by the pandemic is not fully analyzed and final conclusions on food systems cannot yet be drawn.

Our policy analysis in Chapter 7 revealed that food system resilience is not reflected in policies of the AU und EU to date. Also, the interconnections between African and European food systems and joint response mechanisms are not fully explored. A reason might be the relative novelty of the topic and the uncertainty of leverage points and levers on how to transform the systems and to achieve resilience. The complexity of the concept and its, at times, ambiguous definitions might prevent clear boundaries, frameworks or objectives being defined, which are however needed for setting clear outcomes and deliverables. The upcoming UN Food System Summit will provide a platform for conceptualizing systems' change and give impulses for policy opportunities.

Our recommendations for future R&I policies to improve and increase resilience in food systems in Chapter 8 are derived from our findings of the previous chapters and framed around the *7 principles for building resilience* by Stockholm Resilience Center. The principles are (1) maintain diversity and redundancy, (2) manage connectivity, (3) manage slow variables and feedbacks, (4) foster complex adaptive system thinking, (5) encourage learning, (6) broaden participation, and (7) promote polycentric governance. We summarize that achieving food and nutrition security in times of growing risks and uncertainties requires to rebuild our food systems so that they better prevent and cope with crisis, protect the people and the environment, and build back better. For this to happen a common, overarching understanding through a comprehensive framework needs to be developed and agreed upon in a process that includes stakeholders from science, civil society, and policy. Resilience building measures need to consider the specificity of context, the kind of shock or stress, the time span and the area of the food system that should be addressed.

Science can help in identifying transformation pathways in a process with multiple stakeholders. We consider the adoption of adaptive system thinking as useful for analyzing and balancing synergies and trade-offs. The application of the *7 principles for building resilience* can help to develop context specific strategies. Policies are important lever to transform the food systems. Yet, a deeper understanding is needed of the impact that political measures have on resilience. Research & Innovation (R&I) in the Europe-Africa partnership needs to provide evidence for the impact of crises and to identify new pathways to resilience. Food system resilience is however not yet in the focus of the FNSSA partnership's R&I roadmap. We propose that resilience should be established as a cross-cutting theme of the FNSSA's three overarching R&I topics. The identified research gaps can serve as a source of inspiration on where to apply a resilience perspective in collaborative research.

1 Background and scope of the study

The current pandemic of Covid-19 and other zoonotic diseases, the negative effects of climate change (e.g., frequent and severe floods, droughts, storms), pests and plant diseases (e.g. locusts), conflicts and wars reveal how fragile food systems are. The concept of resilience has come to the attention of policy makers in Europe and Africa, asking how food systems can build back better, how they can be shaped to contribute to prevent and deal with crisis, protect the people and the environment, and adapt to change and new challenges without compromising the goal of securing the access to healthy food in the long-term.

Crises provide opportunities to learn, improve and transform. According to Johan Swinnen (the director general of the International Food Policy Research Institute (IFPRI) "shocks open the arena for big changes in the reform of policies" (Webinar in Oct 2020), or as Winston Churchill also stated: "never waste a good crisis". From the impact of crises on food systems we can gain a better understanding of their weaknesses, vulnerabilities, and dynamics. To enable all involved actors to react appropriately and effectively, we need to know more about capacities needed to and possibilities provided by an increased resilience of food systems. The urgency to adopt the concept resilience and increase its applicability in food systems has been recognised, yet the pathways and the specific leverage points of how to address and implement resilience are still to be explored.

Food systems are a core issue on the agenda of the United Nations (UN). The Food System Summit will take place in September 2021 and extensive dialogues and the preparation of five action tracks are already ongoing. One of the action tracks is targeted at resilience: "*Build Resilience to Vulnerabilities, Shocks and Stresses*". It aims to help people everywhere to participate in food systems that, despite shocks and stressors, deliver food and nutrition security and equitable livelihoods for all. Research and innovation (R&I) are key drivers for conducting these analyses and to provide better insights on leverage points and transformation pathways.

The European Union's (EU) project *Long-term Europe-Africa Partnership for Food and Nutrition Security and Sustainable Agriculture* (LEAP4FNSSA) is supporting the EU and African Union (AU) in their joint undertaking in implementing a R&I Partnership on food and nutrition security and sustainable agriculture (FNSSA). FNSSA was the first long-term priority of the High-Level Policy Dialogue on Science, Technology and Innovation (HLPD), a platform for regular exchanges on R&I policy, initiated in 2010. In 2016, the Europe-Africa Partnership approved a roadmap with four priority areas, namely i) sustainable intensification, ii) agriculture and food systems for nutrition, iii) expansion and improvement of agricultural markets and trade, iv) cross-cutting issues.

LEAP4FNSSA commissioned this study with the objective to provide recommendations that could shape future R&I policies in this domain. The study is primarily intended for policy makers, particularly addressing bi-regional (Africa-Europe) collaboration on R&I. The specific aims of the study are to:

- provide an overview on the concept of food system resilience,
- discuss synergies and trade-offs of resilience in food systems,
- assess and describe methods food systems analysis,
- analyse the impact of Covid-19 on the food systems in Europe and Africa,
- review selected AU and EU policies related to addressing food systems resilience,
- derive guiding principles for resilience building and recommendations of future research areas.

2 Study Methodology

The overall approach of this study was to triangulate multiple sources of information, analyse these data through a conceptual framework, and synthesize our findings into specific guiding principles and recommendations (see Figure 1). Firstly, we established a panel of experts that were engaged through two workshops and individual interviews to explore the scope and key issues in food system resilience. Further, we conducted an extensive literature review and actively participated in online-conferences on the study topic to follow current discussions and developments. These three sources of information provided us with a broad knowledge base to develop the develop this report. A conceptual framework (presented in Chapter 3) guided our analysis and structural approach to present our findings in Chapters 4 to 7. The final Chapter 8 on guiding principles and recommendations draws information from our findings and insights in Chapters 3 to 7 and a discussion of those findings in the second expert workshop.

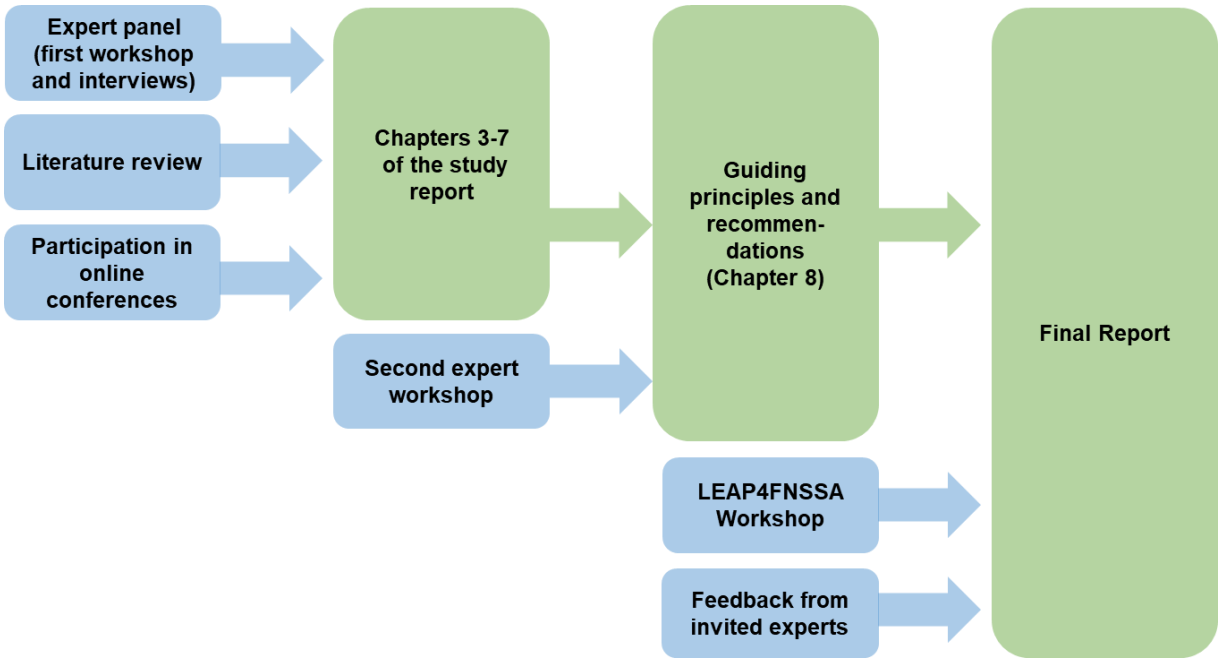

Figure 1. Information and data sources that guided the development of the study report

2.1 Expert consultation

Based on our professional networks, authors of key literature and recommendations by resource persons, we nominated 20 individuals who are experts on the topic of food system resilience in Africa and Europe for our panel (Table 1). The selection criteria were (i) diversity work experience across regions (Africa and Europe), (ii) field of expertise, (iii) gender balance, and (iv) availability on at least one of the dates of the two workshops. The group of experts brought together diverse experiences in the fields of agro-ecology, bioengineering, nutrition, and policy. Overall, the panel spanned expertise and experience across components, scales and levels of food systems.

Table 1. Panel of experts that contributed to study

Name	Organisation	Country of work
Julia Harper	**Stellenbosch University**, Southern African Food Lab	South Africa

Atta-Krah Kwesi	**International Institute of Tropical Agriculture (IITA)**	Nigeria
Hamid El Bilali	**Mediterranean Agronomic Institute of Bari (CIHEAM-Bari)**	Italy
Jessica Fanzo	**Johns Hopkins Bloomberg School of Public** Health, Dept. of International Health	USA
Michael Hauser	**International Crops Research Institute for Semi-Arid Tropics (ICRISAT)**, Innovation Systems for the Drylands Program	Kenya
Miguel de Porras	**Forschungsinstitut für biologischen Landbau (FIBL),** FiBL Europe	Belgium
Maggie Gill	**University of Aberdeen**, School of Biology	United Kingdom
Namukolo Covic	**International Food Policy Research Institute (IFPRI)**	Ethiopia
Noble Banadda	**Makerere University**, Department of Agricultural & Bio systems Engineering	Uganda
Sheryl Henricks	**University of Pretoria**, Department of Agricultural Economics, Extension and Rural Development	South Africa
Marta Guadalupe Rivera Ferra	**University of Vic**, Department of Environmental Sciences and Food Industries	Spain
Monika Zurek	**University of Oxford**, Environmental Change Institute	United Kingdom
Johanna Jacobi	**University of Bern,** Centre for Development and Environment	Switzerland
Paul Fatch	**African Forum For Agricultural Advisory Services (AFAAS)**	Malawi
Julius Ecuru	**International Centre of Insect Physiology and Ecology (ICIPE)**, BioInnovate	Kenya
Haruna Sekabira	**International Institute of Tropical Agriculture (IITA)**	Rwanda
Fergus Sinclair	**World Agroforestry (ICRAF)**	Kenya
Mathias Mogge	**Welthungerhilfe**	Germany
Anna Wissmann	**Food Policy Council**, Taste of Heimat e.V.	Germany
Lindiwe Sibanda	**University of Pretoria, African Research Universities Alliance**, Centre of Excellence in Food Security	South Africa

In the scoping phase of the study, the first workshop "Benefits and trade-offs of food system resilience" was held online on November 11th, 2020. In total 16 members from the expert panel attended the workshop. The aims of the workshop were to (i) exchange knowledge, best practice and views on food system resilience, and (ii) share perspectives on benefits and trade-offs during food systems transformation. After an introduction by the study team, the experts engaged in a moderated discussion, an interactive group work, and a final discussion framing the need for defining, assessing, and building resilience in food systems.

After the workshop we conducted semi-structured interviews with each of the experts, following a guideline with open-ended questions. The questions addressed the aspects of (i) conceptualization of food system resilience, (ii) synergies and trade-offs, (iii) food system analysis, and (iv) policies to enhance food system resilience. The aim of the interviews was not to conduct a full content analysis of responses, but rather to identify new aspects to consider in the study, develop a joint understanding of the topic, and to complement different viewpoints in literature.

The second workshop "Identification of leverage points and the role of R&I towards strengthening the resilience of food systems" was held online on January 19th, 2021. In total 12 members of the expert panel attended the workshop. The aims of the workshop were to (i) complement and critically validate leverage points, and (ii) identify gaps in R&I. The workshop started with a presentation of identified leverage points that the study team identified and sent out to the experts prior to the workshop. The experts then gave their feedback on the leverage points and suggested recommendations for R&I.

In the finalization phase of the study, we had online meetings with resource persons, who have been working extensively on the topic of our study. We appreciate insightful discussions and exchange of unpublished work with Monika Zurek (University of Oxford) and Bart de Steenhuijsen Piters (Wageningen University & Research).

The final draft report was discussed in a public workshop, organized by the LEAP4FNSSA project (see https://www.iita.org/expert-workshop-on-food-systems-resilience-for-europe-and-africa/). Based on the presentation of the study reports, the workshop participants deliberated on the key outcomes and recommendations, and helped to elaborate next action steps, as well as analysis, and foresight that could advance the Europe-Africa partnership in Food and Nutrition Security and Sustainable Agriculture. The following experts were invited to provide feedback on the study report:

- Julian D. May (*University of the Western Cape, South Africa)*
- Bart de Steenhuijsen Piters (*Wageningen University, Netherlands)*
- Victor Ajieroha (*Bill and Melinda Gates Foundation, Nigeria)*,
- Sandrine Dury (*Centre of Agricultural Research for Development (Cirad), France*)
- Bussie Maziya-Dixon (*International Institute of Tropical Agriculture (IITA), Nigeria)*
- Results from both feedback rounds were considered in the final study report.

2.2 Literature review

As we are still in the eye of the storm, much evidence-based analyses of the impact of the Covid-19 pandemic and the related economic crisis are yet to come. Also, the topic of food system resilience is still emerging. Reviewed literature is therefore dominantly grey literature including opinion papers and conceptual analyses. We reviewed key documents as outlined in the terms of reference of the study as well as additional literature sources that experts recommended in workshops and interviews. Out of these documents, we selected most cited and influential relevant scientific articles and policy reports of recent years as core documents for our review. By cross-referencing we identified and included further relevant reports and articles.

In addition to literature suggested by experts, we conducted an extensive literature review using the search engine "google" combined with a bibliographic search on "google scholar" and "researchgate" to capture unidentified relevant scientific and grey literature on conceptualisation of food system resilience, methods for food systems, trade-offs and synergies, policies, and the impact of the Covid-19 crisis. The online search was performed in a systematic and iterative way, using relevant keywords in varying numbers and combinations depending on the obtained results (number and quality of results being too broad or too narrow). Literature on the impact of Covid-19 cover the publication period of February to October 2020. Literature on other study topics was reviewed with a focus on, but not limited to, publications of the last ten years.

2.3 Participation in workshops and conferences

We actively participated in webinars, online workshops and international conferences to follow most recent debates and upcoming issues on the topic, such as the impact of Covid-19 on food system resilience. In case participation was not possible, we followed the discussions by reading proceedings or by watching video recordings. The following events provided us with insights that informed the writing of this report:

- Online Discussions of the Think Tank within the Fit4Food 2030 project on Covid-19 on 19 July 2020 and 18 Sept. 2020.
- Food policies at a time of crisis, SAPEA; 16 Oct 2020.
- Towards a sustainable food system: the EU's role in the global transition, SAPEA; 22 Oct 2020.
- The Farm to Fork Strategy. Cleaning up the EU's agri-food system within and beyond, info point EC-Devco; 27 Oct 2020.
- Opportunities for Enhanced STI Cooperation between the EU & Africa, AERAP; 18 Nov 2020.
- Bold Actions for Food as a Force for Good, a pre-event of the UNs Food Systems Summit; 23 and 24 Nov 2020.
- Working together for resilient food systems: towards a Europe – Africa platform for research and innovation, Leap4FNSSA; 24 Nov 2020.
- Implementing FOOD2030 to future proof Europe's food systems through Research and Innovation, Final conference Fit4FOOD2030; 25 Nov 2020.
- A world in transition: Journey towards a sustainable future, FACCE; 27 Nov 2020.
- SCAR Conference: Natural Resources and Food systems – Transitions towards a safe and just operating space; 14 and 15 Dec 2020.
- Local vs. Global? The role of trade in building food system resilience, IFPRI; 13 Jan 2021.
- Bonding science and policy to accelerate food systems transformation, MUSE-Montpellier Université d'excellence; 4 Feb 2021.

3 Food system resilience - conceptual framework

3.1 Food systems and its components, drivers and outcomes

3.1.1 Development of food system approaches

Food systems are defined as social–ecological systems, formed of biophysical and social factors. The behaviour of a system is defined by an interplay of interacting subsystems, in which feedback plays a key role, rather than a simple chain of cause-effect relationships (van Berkum et al., 2018). Since this process includes feedback loops, the cause-effect relationships are not linear and often not predictable. For example, better access to agri-inputs can lead to more income, which in turn can lead to farmers purchasing more agri-inputs (Dekeyser et al., 2020). Systematic attention is required to understand the complex behaviour of food systems. The system behaviour is defined by interactions between elements or subsystems of the system (e.g., between production and consumption), different levels of the systems (e.g. local and national) and the food system and other influencing systems (e.g. food and energy systems).

The interest in overcoming the linear paradigm to address food security started about 20 years ago. Driven by the Millennium Development Goals (MDGs) and later the Sustainable Development Goals (SDGs), the focus of international efforts in agriculture research and development shifted away from production-oriented perspectives towards a wider understanding of food and nutrition security. Researchers that studied the linkages between global environmental change and food provision coined the concept of 'food systems' that should guide a new policy agenda (Ingram, 2011). In this context Polly Ericksen (2008) developed a holistic food system framework to capture the complex interactions between drivers and activities, and to point out potential trade-offs and synergies between nutritional, environmental and social outcomes. In this definition of food systems, she includes:

- the interactions between and within bio geophysical and human environments, which determine a set of activities;
- the activities themselves (from production to consumption);
- outcomes of the activities (contributions to food security, environmental security, and social welfare) and
- other determinants of food security (stemming in part from the interactions in bullet one).

Holistic food policies that pay also attention to processing food, packaging, distributing food and consumption (e.g. "farm to fork") gave rise to food system approaches in recent years (e.g. Gill et al., 2018). A variety of food system concepts and frameworks were developed further in the last decade, resulting in different definitions in regard to its components, boundaries, and the interactions between components in the systems (Achterbosch et al., 2019; Hospes & Brons, 2016). This plurality of food system approaches and concepts is needed to capture variations in context, level and purpose of application. In this regard, it is important to recognise that "… the system in focus is an artefact with borders decided and elements described for a specific purpose and understanding – it does not exist as such. Thus, any food systems representation is a simplification of the 'real world' and depends on purpose and the perspectives taken by scientists and stakeholders." (Halberg & Westhoek, 2019). With an increasing level of detail, frameworks capture reality better, but at the same time reduce its capacity to become operational for analysis (see also Chapter 5).

3.1.2 Variety of food system approaches

Food systems across the world vary greatly in the context under which they are operating, the interconnectedness of subsystems, and the mechanisms how these sub-systems interact (e.g. feedback loops). For example, industrialized and globally linked food systems in Europe have little in common with localized, indigenous food systems in Africa. Food systems in crisis situations build particular cases that need special attention to the vulnerability of actors. Tools and concepts to analyse these different systems and define areas of actions need to take the myriad types and states of food systems into account. Food system conceptualizations that we describe in the following aim at providing a general and flexible perspective on studying food systems and their outcomes.

Depending on the disciplines (agronomy, nutrition, economics, sociology, etc.), the emphasis on the food system components at focus can change (van Berkum et al., 2018): Recent conceptualization of food systems concentrated on food losses and waste (e.g. HLPE, 2014), on resource use and environmental impact (e.g. UNEP, 2016), interlocking of food systems with other systems (von Braun et al., 2020), such as energy, politics, environment and health (Parsons, K., Hawkes C. & Wells, 2019), and on nutrition and health outcomes. These concepts highlighted certain aspects of a food system to understand its relationships with other components and defined boundaries of the system according to its influence. For example, the Global Panel on Agriculture and Food Systems for Nutrition (2016) highlights synergies and trade-offs of diet quality as well as other food system outcomes and components with a "nested" food system approach (Figure 2). In this framework, consumers engage in "food environments" that provide them with options on food choices and shape people's food preferences, attitudes and beliefs. Food environments are in turn influenced by other food system components. Also Bricas (2019) describe food systems with a circular model of thinking that leads to the three interconnected outcomes of nutrition security, inclusive development and a viable environment for fighting climate change.

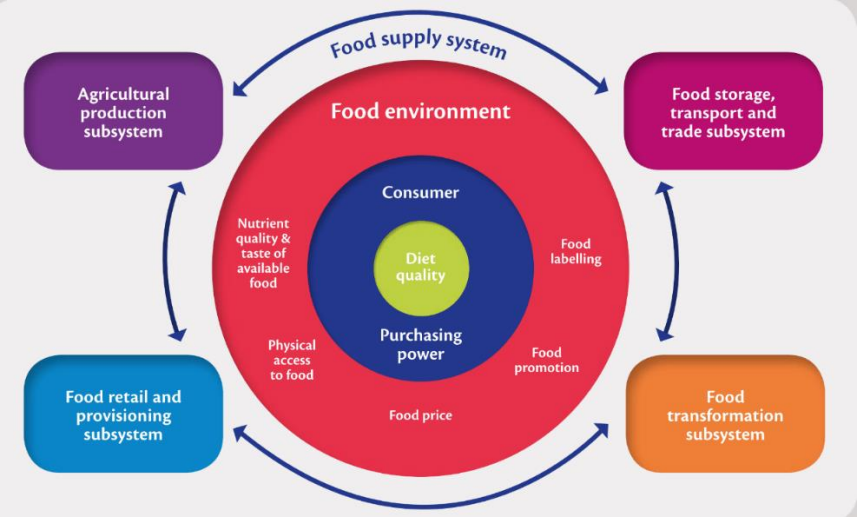

Figure 2. "Nested" conceptualization of food system approach which is organized around diets as main objective (GloPan, 2016)

The High Level Panel of Experts for Food Security and Nutrition (HLPE), which represents the science-policy interface of the Committee on World Food Security (CFS) presented a comprehensive food systems framework in 2017. That conceptualization pays specific attention to nutrition and health outcomes of food systems with the objective to improve people's dietary patterns and nutritional status. The framework is built on earlier reports, such as Ingram (2011), GloPan (2016), Lawrence et

al. (2015), Pinstrup-Andersen and Watson (2011), and Sobal et al. (1998), and provides three additions:

- it highlights **the central role of the food environment** in facilitating nutritious, healthy and sustainable consumer food choices;
- it emphasizes **the role of diets as a core link between food systems and their nutrition and health outcomes**; and
- it takes into account the **impacts of agriculture and food systems on sustainability in its three dimensions (economic, social and environmental)**.

The conceptual framework identifies three core constituent elements of food systems: food supply chains, food environments and consumer behavior. These elements shape diets and determine the final nutrition, health, economic and social outcomes of food systems. The core elements in turn are influenced by five main categories of drivers of food system changes: biophysical and environmental; innovation, technology and infrastructure; political and economic; socio-cultural; and demographic drivers. This framework has been developed for and agreed upon by experts via the foremost intergovernmental and international platform dealing with food security and nutrition. The focus on nutrition and diets of the framework is in line with several international global goal setting agendas, including the UN Zero Hunger Challenge, the UN Decade of Action on Nutrition and the SDGs.

In 2020, the HLPE updated the food systems framework from 2017 into a sustainable food systems framework for analysing food security and nutrition drivers and outcomes that are essential for informing policy developments; and the critical policy shifts needed to support sustainable food systems (HLPE, 2020a). The new framework from 2020 emphasizes on the right to food as a legal framework that is essential for meeting food security and nutrition goals[1]. Moreover, it includes an advanced concept of food security with six dimensions: availability, access, utilization, stability, agency and sustainability (Figure 3). This concept of food security adds the concepts agency and stability to the previously used definition of food security. Agency is described as “what a person is free to do and achieve in pursuit of whatever goals or values he or she regards as important”. Sustainability refers to „the long-term ability of food systems to provide food security and nutrition today in such a way that does not compromise the environmental, economic, and social bases“ (HLPE, 2020a).

[1] “The right to food is the right of every individual, alone or in community with others, to have physical and economic access at all times to sufficient, adequate and culturally acceptable food that is produced and consumed sustainably, preserving access to food for future generations” de Schutter (2014)

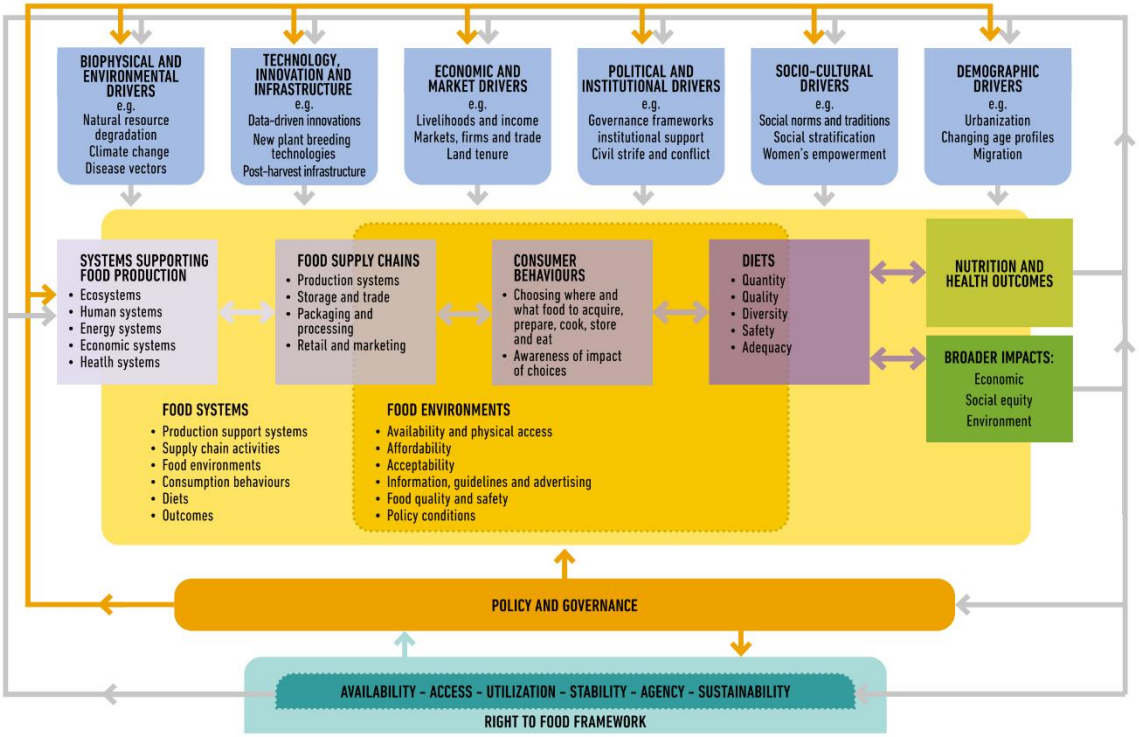

Figure 3. Updated Food Systems framework developed by the High Level Panel of Experts for Food Security and Nutrition (HLPE, 2020)

In addition to the frameworks by the HLPE, there is a large body of scientific and grey literature that highlight different aspects of food systems. For example, Dury et al. (2019) developed a framework that addresses the future risks for food systems in Low-Income and Lower Middle-Income countries. Recent review articles provide an overview on of food system governance (Hospes & Brons, 2016), food system analysis (Brouwer et al., 2020) and drivers of food systems (Béné, Prager, et al., 2019b). As the approach by the HLPE (2020) covers a wide range of aspects in food systems and integrate key concepts for food system analysis in regard to resilience, we use this framework as a conceptual lens for our analysis of food system resilience in this report.

3.1.3 Scales, levels and boundaries of food systems

Food systems are characterized by cross-scale and cross-level interactions (Ericksen, 2008). Scales refer to activities, which can be social, economic, political, institutional and environmental processes. These processes can take place at a local, national, regional and global level, and often interact across levels. The scope of influence on the outcomes of food systems defines the system boundaries. Parsons et al. (2019) differentiate three influential levels for which the term "food system" is commonly used in literature:

1. The Food System: the interconnected system of everything and everybody that influences, and is influenced by, the activities involved in bringing food from farm to fork and beyond.
2. A Food System: the food system in a specific locality or context.
3. Food System**s**: the totality of different types of food systems in different localities and contexts (i.e. multiple forms of "a food system").

Studies that conceptualized approaches and studied food systems range from a local level, such as individual farming communities (e.g. Jacobi et al., 2019) to a national/regional level (e.g. IFPRI, 2020)

and on a global scale (e.g. UNEP, 2016). Considering food systems on different scales and levels as a system of interest, boundaries need to be drawn to analyse a system in focus. The environment of food systems include also other, "neighbouring" systems such as the health system, ecological systems, and the energy system and is impacted by external shocks, such as climate or health or economic shocks (von Braun et al., 2020). Deliberately defining scales levels and boundaries of a systems of focus is required for any type of analysis.

3.1.4 Conclusions on food systems concepts

Food systems are social–ecological systems, formed of biophysical and social factors and defined by an interplay of interacting subsystems. System interactions include feedback loops, the cause-effect relationships that are not linear. Over the past decades, a range of approaches have been developed to address specific aspects of food systems. These approaches serve as a simplification of the "real world" and are defined by scales, levels and boundaries of a system at focus. A plurality of system concepts is needed to capture variations in context, level and purpose of application. For the purpose of our study, we consider the approach developed by the HLPE in 2020 as most suitable as it covers a wide range of aspects in food systems and integrates key concepts, such as agency and sustainability, that are relevant for conceptualizing and discussing food system resilience in the following chapters.

3.2 Food system resilience

3.2.1 Application of the resilience concept to food systems

The word resilience comes from the Latin word *resilio*, which means to spring back, recoil, or rebound. The term was first used by researchers in psychology. In the context of ecological research, the concept of system resilience has been popularized by Holling (1973). The author defined resilience in relation to ecological stability theory as determining "*the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist*". The concept gained popularity in the 1970s from ecologists as it provided an application to deal with the unexpected and unpredictable as the resilience framework perspective "does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take" (Holling, 1973). Since then resilience has been gaining interest in academia and has now become a central paradigm in social-ecological systems where issues of shocks, vulnerability and risks are critical.

Holling's concept of resilience was applied and adapted in different ways across disciplines and applied at different levels, ranging from individual households to global systems. For a summary of the myriad of definitions of resilience that were applied in relation to food and nutrition security from 1996 until 2013, see IFPRI (2013). The concept of resilience have frequently been used in relation to livelihoods and environment (for an overview see Barrett & Constas, 2014; Schipper & Langston, 2015). Especially bilateral and multilateral donor organisations in relation to humanitarian interventions, climate change adaptation or social protection reinforced the use of the concept resilience in the last decade to meet a future world of uncertainty and change (Béné et al., 2012; Schipper & Langston, 2015). Resilience concepts have been used for specific shocks and stresses in agricultural systems (e.g. storms, earthquakes, fires), but also for unknown shocks and stresses, i.e. how systems persist and innovate when facing unknown perturbations (Urruty et al., 2016).

Along with the different application of the concept, also different types of resilience have been described. The initial state of a system is often not satisfactory, and the idea of returning to this initial state is not desirable. Another school of thought, different from the social-ecological perspective on resilience, conceptualized *development resilience*. This perspective focuses on human agency in resilience building, which refers to the capacity of people to change the system's state when it is not able to adapt to shocks and stresses any longer (Bousquet et al., 2016). Development resilience has also been described as *transformative resilience*, i.e. the ability to develop systems better able to deal with change, uncertainty and new conditions (McWethy et al., 2019; Rippon et al., 2020). In this transformation, the system would reach a new state that is more resilient to change than the previous one. Cutter (2016) distinguishes different kinds of resilience between static outcomes and dynamic processes of adaptive learning and change. Static or inherent resilience describes the way the system 'bounces back' to the pre-crisis status. Dynamic resilience, in contrast, refers to the change of the system's state. Both, static and dynamic resilience have a neutral connotation, meaning that the static resilience to bounce back to pre-crisis level may be desired by some parties of the food system, while not being beneficial for others.

Researchers have applied resilience concepts to food systems. While most of these studies focus only on specific components of the food system (e.g. cropping systems, farming systems), particular outcomes (e.g. food security in emergency situations) or particular components of resilience, the existing literature tends however not to account for complex cross-scale and cross-level interactions in food systems (Tendall et al., 2015). Literature on the conceptualization of resilience of food systems that goes beyond the farm level and includes value chains and associated socio-ecological is scarce (Béné, 2020; Meyer, 2020; Tendall et al., 2015). In particular in the context of low and middle income countries, there is a gap in conceptual literature (Meyer, 2020). To conceptualize and operationalize a framework of food system resilience in the context of this study, we drew on the recent key publications on the topic (Hodbod & Eakin, 2015; Pingali et al., 2005; Rotz & Fraser, 2015; Tendall et al., 2015).

3.2.2 Definitions of food system resilience

As mentioned above, the resilience concept is increasingly used to address challenges of uncertainty and complexity in regard to random shocks in food systems (Tendall et al., 2015). The theoretical foundation for conceptualizing resilience of food systems is based on social-ecological systems from the perspective of complex adaptive systems (Folke, 2006; Walker et al., 2004). However addressing the unique nature of food systems requires an adapted concept of system resilience (Hodbod & Eakin, 2015). We therefore identified recent conceptual studies on food system resilience that operationalize the application of resilience thinking in food systems (see Box).

Definitions of food system resilience from literature:

Tendall et al. (2015):

[Food system resilience is the] capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances.

Misselhorn et al. (2012):

A resilient food system is able to withstand economic and environmental shocks and stresses at different temporal and spatial levels. In the context of climate change a resilient food system anticipates risks associated with climate change, and has redundancy built in (an effective system for stocking adequate amounts of food and for their distribution in times of crisis).

Rotz and Fraser (2015):

As applied [social ecological systems work] to the food system, we can define food system resilience as the ability of a food system (which itself is made up of actors who produce, process, transport, and distribute food) to address stresses and disturbances while providing stable levels of consistent nutrition to the public.

Schipanski et al. (2016):

We define resilient food systems as the capacity of people to produce and access nutritious and culturally acceptable food over time and space in the face of disturbance and change.

Although Misselhorn et al. (2012) apply food system resilience primarily to climate change, all four definitions imply that resilient food systems are able to cope with (unforeseen) stresses and disturbances. These can be internal or external, cyclical or structural, sudden or gradual; they can consist of natural, political, social, or economic shocks (Tendall et al., 2015). In social-ecological systems literature, the functional objective of a resilient system is to persist its function and not to collapse despite these stresses and disturbances (Carpenter et al., 2001; Folke, 2006; Holling, 1973). When applying this concept to food system resilience, the functional objective is to ensure accessible and healthy food for all human life - a core function of the system that cannot be compromised (Hodbod & Eakin, 2015).

Another common feature of all definitions is that resilience occurs at the multiple levels of the food system, which include space and time. In that sense, the outcome of resilience food systems relates strongly to food security in the dimensions of availability, access and utilisation, and also its fourth dimension of stability. By defining the normative goal of providing food security to all, food systems become resilient to any form of impact. This makes food systems robust against undesired shocks and stresses on one hand, but on the other hand can make food systems for example more rigid and less dynamic for innovation (Hodbod & Eakin, 2015; Tendall et al., 2015). These effects were also described as undesirable resilience or lock-ins of food systems (Dornelles et al., 2020; Oliver et al., 2018). Also food systems with undesirable outcomes with regards to social welfare and the environment (e.g. polluted air, deprived human rights), can be highly resilient within their functional goal of providing food security (Carpenter et al., 2001). We need to acknowledge that food system resilience, as described above, is a normative concept to food security, but does not per se lead to other outcomes

that are desirable. Therefore, food system resilience is often combined with other system properties such as inclusive, sustainable or equitable, when discussed with regard to the transformation of food systems (see also Section 4.1).

In the context of the upcoming UN Food Systems Summit 2021, the Scientific Group uses a different definition. They define resilience in a wider scope by adding the outcome of equitable livelihoods for all (Hertel et al., 2020):

> *The ambition behind Action Track 5 is to ensure that all people within a food system are empowered to prepare for, withstand, and recover from instability and participate in a food system that, despite shocks and stressors, delivers food security, nutrition and equitable livelihoods for all.*

The action track on resilience therefore includes different types of food system resilience that have normative outcomes in other aspects than food security, namely social resilience, economic resilience, and ecological resilience.

3.2.3 Frameworks for measuring and building resilience in food system

In the literature on food system resilience there is a call for operationalizing the concept into a framework with factors or indicators for resilience (e.g. Béné et al., 2016; Dury et al., 2019). Although a range of resilience frameworks and indicators have been developed, the ability and methods to measure resilience of a system are contested (Schipper & Langston, 2015). Moreover, it is not known to what extent resilience indicators for social-ecological systems are applicable for food systems (Tendall et al., 2015). Carpenter et al. (2001) pointed out that it is not possible to measure a system's resilience without specifying which system configuration and disturbances are of interest: "Resilience of what to what?". Operationalizing and measuring food system resilience requires to define the following (adapted from Ingram et al., 2019; Zurek et al., 2020):

- resilience of what food system activities and outcomes (e.g. processing, packaging, retailing, storing and consuming food)?
- resilience against what (which shock or stress; e.g. fires, floods, social unrest)?
- resilience for whom (e.g. consumers, peasants, women/men farmer, decision makers)?
- resilience over what time (e.g. short term, long term)?

On the other hand, the application of the resilience concept to food systems has received so much attention as it is not limited to the capacity of a system to cope with a specific driver of change, but a wide range of stresses and shocks (Tendall et al., 2015). Also the use of resilience in the context of development and food systems has shifted away from aiming at a certain steady-state of resilience, to return to after a shock, to **resilience as a pathway or process** (Harris & Spiegel, 2019). From this perspective, one would operationalize the **process of resilience building** rather than the outcome of such a process. In this process human agency as the capacity to manage risk and to adapt to changes plays a key role.

Human agency is a key factor in determining how individuals and society respond to change, disruptions, and crises. By enhancing the **adaptive capacity** of food system actors, which refers to the necessary resources for people and systems to adapt and learn, food system resilience can be increased. Agency can refer to food consumers, producers and traders that directly face shocks and crises as well as those who are expected to formulate and implement policy responses. This includes capacity to learn; to innovate, adapt and adopt; and to deal with complex problems that require

collective action. Agency and the ability to adapt and transform a system is therefore at the core of resilience building (communication expert consultation).

Considering the limited empirical data, the conceptual variations of food system resilience, and its openness to various types of stresses and disturbances, there are no metrics that would allow a normative measure of how resilient a food system is. Due to these variations between food systems, the measures for resilience building are defined by its specific context and cannot be generalized. Interventions to build food system resilience therefore need to be designed individually and involve food system stakeholders in the process. Yet, we identified some attempts to operationalize the food system concept in some aspects and general principles to guide resilience building, described in the following.

Rotz and Fraser (2015) infer food system resilience by defining three key dimensions, which they apply to the American and Canadian industrial food system:

- **the diversity of the food system's components,**
- **the degree to which the components are connected,** and
- **the degree of decision-making autonomy within the food system**.

Jacobi et al. (2018) used the three core dimensions of resilience proposed by Carpenter et al. (2001) to apply the resilience concept to food systems: buffer capacity, self-organization, and the capacity for learning and adaptation. According to local relevance and a collaborative assessment process, they developed a set of indicators, which they applied to different food systems (agroindustrial, local, and agroecological) in Kenya and Bolivia. The indicators, related to the resilience dimensions, are:

(1) Buffer capacity: **agrobiodiversity and livelihood assets for buffer capacity**
(2) Self-organization: **decentralization and independence, local consumption of production, interest groups, ecological self-regulation, and connectivity for self-organization**
(3) The capacity for learning and adaptation**: knowledge of threats and opportunities, reflective and shared learning, feedback mechanisms, existence and use of local-traditional knowledge, and a shared food system vision for capacity for learning and adaptation**

Hodbod and Eakin (2015) focus on functional and response diversity as two key attributes of resilient, multifunctional food systems. Functional diversity refers to the number of different functional groups. Response diversity refers to the types of responses to disturbances within a functional group. They apply these attributes to assess the Californian food system during the drought in 2013-2015.

Worstell and Green (2017) and Worstell (2020) define eight qualities of resilient food systems that they synthesized from prominent frameworks of ecological resilience literature and case studies of resilient locally organized food systems in the U.S. South:

(1) Connectivity
(2) Local self-organization
(3) Innovation
(4) Maintenance/redundancy
(5) Accumulation of value-added infrastructure
(6) Transformation
(7) Ecological integration
(8) Diversity

Tendall et al. (2015) conceptualize food system resilience into four component that affecting the behaviour of the food system over time:

(1) **Robustness**, or the capacity to withstand the disturbance in the first place before any food security is lost;
(2) **Redundancy**, or the extent to which elements of the system are replaceable, affecting the capacity to absorb the perturbing effect of the disturbance and avoid as much food insecurity as possible;
(3) **The flexibility and thus rapidity** (or food system reactivity) with which the food system is able to recover any lost food security;
(4) **Resourcefulness and adaptability,** which determines just how much of the lost food security is recovered.

Figure 4. The food system resilience action cycle (Tendall et al., 2015).

These functions are based on the capacities of a system that can perform reactive actions (absorb, react, restore, learn) and preventive actions (build robustness). The latter can not only address the system's capacity to react to shocks but also address stressors that affect the capacities of the system (see

Figure 4).

Ingram (2017) identifies four notions of resilience, which are based on the aim to keep food systems and related food security and other outcomes in a desired state:

(1) **Robustness**, or the ability to resist disruptions to desired outcomes, which requires considerable financial investment;
(2) **Recovery**, or the ability to return to desired outcomes after disruption, which requires contingency planning and funding;
(3) **Re-organisation**, or the ability to make changes in the system to maintain desired outcomes, which is also often termed 'adaption' and requires lateral thinking;
(4) **Re-orientation**, or the ability to accept alternative outcomes; it can also be termed 'transformation';

Harris and Spiegel (2019) reviewed various resilience concepts stretching the importance of adequate policy tools for strengthening food system resilience. They decided to build on the framework of Judith Rodin's (2014) five characteristics, namely **aware, diverse, integrated, self-regulating, adaptive,** as criteria for a resilience-based policy framework and supplement it with an additional characteristic "**inclusive & equitable**". The authors propose to apply food security as "the normative benchmark for guiding advocates and policymakers in resilient food system development and identify policies for promoting resilient food systems, including policy options for supporting each pillar of food security by strengthening a range of resilience attributes". As this framework was developed and applied for policy analysis, we propose to apply the presented five characteristics as a guidance for policy analysis (see Chapter **Errore. L'origine riferimento non è stata trovata.**).

Halloran et al. (2020) apply the following seven principles for building resilience in social-ecological systems, as conceptualized by Biggs et al. (2015), to the Nordic food system:

(1) **Maintain diversity and redundancy**
(2) **Manage connectivity**
(3) **Manage slow changes and feedback**
(4) **Foster complexity and systems thinking**
(5) **Encourage learning**
(6) **Broaden participation**
(7) **Promote polycentric governance**

The framework by Biggs et al. (2015) provide guidance on how to intervene in social-ecological systems to maintain or enhance resilience that supports the well-being of people in a rapidly changing and increasingly crowded world. The seven principles reflected many points that we encountered in literature and that our expert panel pointed out. We therefore opted to use the framework to structure our findings on guiding principles for resilience in food systems in Africa and Europe (see Section 8.1).

3.2.4 Conclusions on food system resilience

There are many different types of food systems and a range of approaches to study these systems. This section shows that there are different conceptualizations of resilience (ranging from its initial socio-ecological view to a perspective of transformative or dynamic resilience) as well as the application of these concepts to food systems. Literature reviewed in this study suggests an approach of using food security as an outcome of food systems that cannot be compromised and therefore serves as a benchmark for resilience. Other conceptualizations, such as used at the UN Food Systems Summit, take a wider perspective that includes also social and ecological resilience of food systems. The agency of food system actors, which is the ability to adapt or transform a system as a response to shocks and stresses, plays a key role in resilience building. We acknowledge that resilience can be positive and negative, and residence building can create trade-offs and synergies with other food system properties (see Section 4.1).

Operationalizing and measuring resilience of a system requires a contextualization in terms of resilience of what, against what, and for whom. To capture the general characteristics of food system resilience and to guide resilience building a range of frameworks with different foci of application exist. We identified suitable frameworks for policy analysis (Harris & Spiegel, 2019) and for structuring general principles for building food system resilience (Biggs et al., 2015). While frameworks and indicators are important to measure and monitor resilience, developing those in a participatory

process ensures their relevance and buy-in from stakeholders. Practitioners and policy-makers acting at the various vertical and horizontal spatial scales of food systems need to be involved.

4 Balancing synergies and trade-offs in resilience building

Understanding synergies and trade-offs are a central part of food system analysis (Béné, Oosterveer, et al., 2019; Ingram, 2011; van Berkum et al., 2018), thus essential for implementing measures for resilience building. Synergies can be created when combining resilience with other food system properties, such as sustainability, equity and production. On the other hand, resilience building can lead to trade-offs. For example, creating food system resilience to any form of change can make food systems also more rigid and less dynamic for innovation (Hodbod & Eakin, 2015; Tendall et al., 2015). Other trade-offs, such as social and ecological degradation, vulnerability or barriers that hinder sustainability transformations, are described as undesirable resilience (Dornelles et al., 2020; Oliver et al., 2018).

In the current political discourse on resilience building, win-win solutions tend to be over-emphasized and trade-offs are often portrayed as "negative side effects". Public discussions are sometimes framed around "managing change in a way trade-offs do not occur" or "making trade-offs to synergies". Bene et al. (2019) described such a tendency based on a literature review of narratives on food system sustainability. They suggest that "a more responsible and realistic approach would be to recognize that those win-win situations are relatively rare and/or difficult to implement and that a lot of the changes that need to be effected (and not just avoided) may be achievable only through difficult societal choices." We acknowledge trade-offs in resilience building as unavoidable and a natural process of balancing synergies and trade-offs dynamically. The following sections describe synergies and trade-offs between system properties, levels and scales of food systems and between food system outcomes.

4.1 Synergies and trade-offs between resilience and other system properties

Food system properties as objectives for transformation are increasingly addressed in policy formulation and implementation. For example, the FOOD 2030 EU policy framework aims to make our food systems 'future-proof', meaning resilient, sustainable**,** responsible, diverse, competitive and inclusive (Gill et al., 2018). In preparation for the UN Food Systems Summit 2021, the Scientific Group has positioned five action tracks to frame action-oriented agenda setting under a food systems framework. The action tracks are (i) ensuring access to safe and nutritious food for all, (ii) shifting to sustainable consumption patterns, (iii) boosting nature-positive production at sufficient scale, (iv) advancing equitable livelihoods and value distribution, and (v) building resilience to vulnerabilities, shocks and stresses (von Braun et al., 2020). Resilience, presented as guiding principle for food system transformation, has synergies and trade-offs with other objectives, such as creating sustainable food systems, reducing vulnerabilities, and the inclusion of social groups.

4.1.1 Sustainable food systems

With much of the world's population inadequately nourished and many of the environmental systems pushed beyond safe boundaries by food production, it is widely recognised that there is an urgent need for more sustainable food systems that can provide healthy diets (HLPE, 2017; Willett et al., 2019). FAO (2018b) characterize sustainable food systems as (i) profitable throughout (economic sustainability); (ii) having broad-based benefits for society (social sustainability); and (iii) having positive or neutral impact on the natural environment (environmental sustainability). Over the last decades, the concept of sustainable food systems has been applied by scholars from diverse schools of thought and disciplines with the objective to define an appropriate agenda for action (Béné, Oosterveer, et al., 2019). Although sustainability and resilience in food systems are both of central

importance for an uncertain in future in the face of global challenges, the relationship between these two concepts remains unclear (Prosperi et al., 2016).

We have identified conceptual studies on the relationship between food system sustainability and resilience. These study describe the relationship as (i) complementary to each other (ii) resilience as part of sustainability or (iii) both concepts interchangeably for different purposes. Tendall et al. (2015) described resilience to sustainability in food systems as being complementary to each other: *"Sustainability implies preserving the capacity of a system to function in the future, which is also one of the conditions of maintaining resilience. However, resilience implies the capacity to continue providing a function over time despite disturbances, and thus forms an essential part of what enables sustainability".* Jacobi et al. (2018), Chaudhary et al. (2018) and Hodbod and Eakin (2015) consider resilience as a system property that can contribute to food system sustainability. Jacobi et al. (2018) conceptualize resilience as one pillar of food system sustainability, next to the capacities of ensuring food security, fulfilling people's right to food and reducing poverty and inequality. In a review of social-ecological systems literature by Prosperi et al. (2016), the authors largely refer to conceptualizations that integrate resilience as part of system sustainability, i.e. that sustainable solutions to problems in food systems require resilience opportunities that take into account the dynamics and uncertainties as represented by system drivers. Redman (2014) suggest to apply sustainability and resilience interchangeably as approaches to increase their strengths by distinctiveness. While the primary objective of system sustainability is on outcomes and pathways to achieve those, resilience aims at building a system's capacity to respond to shocks and stresses without focusing on its outcomes. Depending on the objective of applying food system approaches, the emphasis on sustainability or resilience may shift. For example, with the emergence of crisis situations and efforts to address situations, such as the Covid-19 pandemic, focus of the R&D community shifts from using sustainably to resilience as an ultimate objective of development (Bakalis et al., 2020; Béné et al., 2012).

4.1.2 Reducing vulnerabilities in food systems

The concept "vulnerability" has emerged in relation to natural hazards and was linked to poverty and food insecurity. Vulnerability is often defined differently, but generally includes the lack of a person's or group's capacity to cope with the impact of stresses or disturbances, caused by environmental and social change (Adger, 2006; Janssen & Ostrom, 2006). The lack or existence of adaptive capacity makes work on vulnerability and resilience share common features. Both emphasize that households and individuals are strongly affected by and respond to the settings they find themselves in. However, vulnerability and resilience must not be taken as converse concepts; they focus on different outcomes: While vulnerability research focuses on the question, "Will shocks push people into poverty?", work on resilience asks, "Do shocks or stressors have long-term adverse consequences?" (IFPRI, 2014). A core notion in vulnerability literature is that the adaptive capacity is unevenly distributed across nation, regions, communities and households. As such, food system resilience conceptually falls short addressing social differentiation and the inclusion of social groups. The poor are especially vulnerable and liable to become trapped in vicious cycles of decline because of stressors; the poverty and vulnerability trap mean that recovery to pre-disaster levels of well-being becomes increasingly difficult (communication expert consultation). Béné et al. (2012; 2014) argue that resilience is not a pro-poor concept; it is not related to poverty and cannot replace poverty reduction. There can be trade-offs in creating overall food system resilience and in reducing vulnerabilities of specific system components (Fraser et al., 2005).

While most resilience thinking is lbased on a systems-oriented perspective, vulnerability takes an actor-oriented or people-centred perspective. Understanding vulnerability as part of food system resilience therefore remains a conceptual challenge (Bohle et al., 2009; Ericksen et al., 2012). Vulnerability assessments, which are based on social resilience (not food system resilience), show special attention to agency, i.e. how individuals and certain social groups actively react to change and in turn can influence the system. Often those who have faced most shocks and crises may actually be the best risk managers. To address both food system resilience and vulnerability of social groups, some scholars have combined both approaches complementarily. Bohle et al. (2009) first looked at the entire food system of the megacity Dhaka with a systems analysis and in a second step into issues of food security from and governance from an agency-perspective. The latter perspective places potentialities, creativity and capabilities of social actors in the centre of analysis. Also Pingali et al. (2005) propose a "Twin Track Approach" for the enhancing food system resilience in complex emergencies with two mutually enforcing tracks. While a longer-term strategy enhances food system resilience, a second track provides immediate support to vulnerable groups. Vulnerability and resilience can have complementary roles also in policy making. While a vulnerability approach can be used for establishing benchmarks and eligibility criteria for social services, a resilience approach would serve to create strategies or plans for proactive food system changes (Harris & Spiegel, 2019).

4.1.3 Social inclusion and equity

Many food systems, in particular those in Africa are characterized by inequalities, which can lead to massive increase of informal, vulnerable and extremely poor workers. Young people, women and minorities are often excluded despite their critical role that play in food systems (Dury et al., 2019). Resilience building of food systems is therefore often connected with creating inclusive food systems. Inclusive food systems "reach, benefit, and empower all people, especially socially and economically disadvantaged individuals and groups in society" (IFPRI, 2020). Promoting inclusion means to empower people to make strategic life choices and enable them to gain the skills needed participate in food system activities, e.g. to engage in evolving food value chains. By providing vulnerable people with services and opportunities they need, inclusion relates to social equity (ibid). Equity in food systems stands for a fair and just distribution of resources and the inclusion in democratic participation in food system governance (Allen, 2010).

A transformation towards more resilient food systems can have positive effects for some social groups in society and negative effects for others. For example, opening markets for agricultural imports and reducing prices for food can increase access to food in urban areas, but at the same time jeopardize income and livelihoods of those living in rural areas (see also examples in the next section). To create long-term resilience, food systems need to be inclusive and equitable for those how are mostly affected by shocks and stresses (IFPRI, 2020). In that sense, food system transformation must not only focus on reducing future treats to food production, but also contribute to creating jobs, stabilising livelihoods, reducing inequality between stakeholders and between territories, and preserving and improving environmental integrity (Dury et al., 2019).

4.2 Synergies and trade-offs between different levels and scales of food systems

As described in Section 3.1.3, food systems are characterized by cross-scale and cross-level interactions. Resilience building measures on one place of food systems therefore can result in positive (synergies) or negative (trade-offs) outcomes at other places of food systems. These interactions are highly dependent on the food system in focus and the type of stress or shock against

resilience is measured. Although synergies and trade-offs need to be considered dynamically and in the context of specific food systems, we present some cases from literature and recent public discussion that could serve as examples in a general discussion.

In relation to time, short and longer-term objectives in resilience building can interact. A prioritisation of short-term goals in resilience building measures can undermine the resilience of longer term beneficial outcomes for society (Oliver et al., 2018). For example, increasing agricultural production by expanding crop land area as well as irrigation, fertilizers, and other agriculture inputs can create long-term challenges that may lead to exceeding planetary boundaries (Hertel et al., 2020). Another example is the effect of emergency interventions in crises on a longer-term perspective. Sperling (2020) reports that short-term interventions for seed security can have positive effects over many seasons or years when seed can be replanted. On the other hand, bad seed aid that provides unadapted seed can do very significant harm and increase farmers' vulnerability in the long-term. Some synergies and trade-offs can change dynamically over time; as such trade-offs might temporarily occur on a short-term as a necessary step for long-term resilience building. The application for new climate-resistant crop varieties could help farmers to adapt to a warming planet. But on a longer term the dependence on few staple crops, grown in large- scale, intensive monoculture farming systems could jeopardize the resilience of the food system by reducing genetic diversity and increasing vulnerability in farming and nutrition (World Economic Forum, 2020).

Also across different geographical levels in food systems positive and negative feedback loops of resilience building exist. On a global scale, there could be trade-offs in resilience of food systems concerning interests in the north and in the south (United Nations Food Systems Summit Pre-Event, 2020). Global trade can be an opportunity to supply food to regions in the world that face shortages due to crises and limited access to natural resources for food production. On the other hand, countries that depend on imports are often more vulnerable against global market shocks. Trade does not solve the issue of having limited access to natural resources that are needed to produce locally (Hertel et al., 2020). During the online event "Local vs Global? - The role of trade in building food system resilience", participants agreed that local production and consumption alone is not necessarily leading to more resilience since the vulnerability towards local shocks might increase. Local and global value chains are equally important and the critical question is how to balance the value chains to increase resilience. Furthermore, a distinction is also important regarding the type of food that is considered: while vegetables offer a good opportunity for local production (also in cities), seasonal fruits cannot be produced in every environment and therefore require global trade. On a local level, reduced prices for food can increase access to healthier diets in urban population, but on the other hand, lower farm gate prices decrease income in rural areas. Also resource use conflicts can compromise resilience building measures in regard to diverging rural and urban demands. For example, access to land and water is needed by rural farming communities as well as by urban populations and thus face competition. On the other hand, rural-urban labour mobility can be seen as an opportunity for resilience building (Hertel et al., 2020).

4.3 Synergies and trade-offs between different food systems outcomes

The conceptualizations of food system resilience that we reviewed in Section 3.2 refer to the outcome of food security in the dimensions of availability, access and utilisation, and also its fourth dimension of stability. Taking into account interconnections and feedback loops in food systems, this implies synergies and trade-offs with other food systems outcomes that are social, economic and

environmental (HLPE, 2020a). A main synergy between healthy diets and environmental outcomes can be expected by dietary shifts. Changing diets by limiting animal-based food and shifting towards more plant-based-diets, together with large reductions in food loss and waste, would improve health and create environmental benefits (EAT Lancet Commission, 2019; Willett et al., 2019). On the other hand, a healthy diet does not per se contribute to more sustainable production and positive environmental impacts (Béné, Oosterveer, et al., 2019). Although there is evidence for potential synergies, these are often very difficult to achieve in practice (ibid). Key trade-offs exist between healthy diets and economic outcomes of food systems. More diverse and healthier diets tend to be more expensive, thus resulting in less affordability and profits. Policy induced reduction of food prices to make healthy diets more affordable might affect the income of consumers that comes from informal markets and again lead to less affordability for this group in society (United Nations Food Systems Summit Pre-Event, 2020). Further potential trade-offs and synergies between food system outcomes are also reflected in literature on Sustainable Development Goals (e.g. Mainali et al., 2018; Neve & Sachs, 2020) and outcomes of sustainable food systems (e.g. Béné, Prager, et al., 2019a).

4.4 Conclusions

This chapter shows that potential synergies and trade-offs of resilience and resilience building measures exist between system properties and on various levels and scales of the food system. Examples in our analysis show that resilience building can go at the costs of economic growth and livelihood opportunities. Also resilience conceptually does not sufficiently address poverty, social inclusion and equity. Therefore, food system resilience should not be considered as the unique and ultimate goal of adapting / transforming our food systems, but balanced and combined with other system properties. As it was formulated by the HLPE (2020), “the crisis has been a wake-up call to address the multiple complex challenges facing food systems, and it demands measures to improve food systems to make them not only more resilient to crises, but also more equitable and inclusive, empowering and respectful, regenerative, healthy and nutritious, as well as productive and prosperous for all".

Both, trade-offs and synergies cannot be generalized, but are highly dependent on context and the type of shock / stress under which resilience is considered. While synergies and trade-offs can be dynamically and sometimes temporarily, stakeholders in food systems need to be engaged in a process of balancing competing interests and complex interactions in food systems. The focus should therefore be more on creating awareness, rather than promoting win-win scenarios, and on further developing and applying methodological approaches to analyse trade-offs and synergies in food systems (see Chapter 5). As pointed out at the United Nations Food Systems Summit Pre-Event (2020), in particular the quantitative nature of trade-off and synergies is important to understand major synergies and trade-offs better to create bold actions in food systems.

5 Methodological approaches for food systems analysis

We need to understand functions, dynamics and entry points for transformation of food systems to understand the impact of shocks and stresses, and thus resilience behaviour of a system. Feedback from members of our expert panel indicates that there is a need for methods to analyse food systems in an integrative and inter/trans-disciplinary manner. Also the Standing Committee on Agricultural Research (SCAR) Strategic Working Group on Food Systems recommend the development and evaluation of a widely accepted methodology for food systems analysis as a tool for change agents and policy makers (Halberg & Westhoek, 2019). In the following we describe methods that we identified in interviews with our expert panel and literature.

5.1 Overview of existing methods to food systems analysis

5.1.1 Descriptive analysis of the structure of food systems

One strands of food system analysis aims to advance the understanding of systems by describing the structure and functioning of a food system and its key components (Brouwer et al., 2020; Ruben et al., 2019). These components include drivers, activities, and outcomes as well as interlinkages with other (sub-) systems. The description of food environments, which provide options on food choices and shape people's perceptions on food, plays a central role in better understanding consumers' food choices. Overall, descriptive food system analysis provides an understanding of how food systems look like at one point of time. This can be used as a starting point for discussion about challenges and necessary changes together with stakeholders in the food system.

Established food system frameworks, as presented in Chapter 3, can serve as a conceptual guideline for system mapping on a national and global level (e.g. Ericksen, 2008; GloPan, 2016; HLPE, 2017). Examples on a smaller scale include mapping exercises with farming communities in Kenya and Bolivia (Jacobi et al., 2019) and value chain actors on a district level in Nigeria (Terdoo & Feola, 2020). These studies used a participatory approach that actively involved key stakeholders in a mapping process. Another mapping approach is tracing food flows and sources of food (food flow analysis) by using existing available data and stakeholder interviews in order to identify food system activities and getting a basic understanding of weaknesses and strengths of the system in a rapid assessment (FAO, 2020c). Moschitz and Frick (2020) carried out food flow analysis of two German cities and discuss the potential of the methodology to study where food comes from and through which channels it reaches the consumer.

Considering that food system descriptions can reach from local to global level, it is necessary to define systems boundaries accordingly and make them explicit. Boundaries of food system conceptualizations can be geographical and/or functional or the level of study detail (Dekeyser et al., 2020). Boundaries setting depends on the objectives of project or organization that is guiding the mapping of food systems. Halberg and Westhoek (2019) recognized the importance of defining borders of food systems to better target and focus on specific problems and design interventions in a more consistent manner, but identified a gap in available methods to do so. The authors call for a protocol for food systems research that shows how to define systems boundaries

5.1.2 Understanding interactions of complex system behaviour

Another strand of food system analysis aims to better understand complex system behaviour; i.e. the relations and interactions between (i) elements or subsystems in the system (e.g. between production and consumption), (ii) different levels of the systems (e.g. local and national) and (iii) the food system

and other influencing systems (e.g. health and energy systems). Understanding these relations and interactions better can indicate potential trade-offs, synergies, system lock-ins, leverage points for intervention and other types of feedback loops that influence food system activities and outcomes (Brouwer et al., 2020; Halberg & Westhoek, 2019). Whereas descriptive analyses of food systems aim to map food systems holistically (see Section 5.1.1), methods in this section focus on specific interactions as part of the wider food system.

A specific tooll to study these interactions is drawing and verifying causal loop diagrams of the food system at focus together with stakeholders. This exercise can identify food system dynamics (e.g. with a decrease of production, income from market sales is reduced, while at the same time they need to purchase food). By linking positive and negative relationships, cause loop diagramming helps to identify feedback loops, trade-offs and synergies (Dekeyser et al., 2020). The method was described as part of a food systems decision support tool for the case of Ethiopia (Posthumus et al., 2018c) and also applied in an analysis of the southern Nakuru County food system in Kenya (Dekeyser & Rampa, 2019). These analyses were largely based on qualitative data. Béné, Prager, et al. (2019a) adopted a quantitative approach to understand relationships of food system outcomes. The authors used a spearman-correlation matrix of indicators as defined in a food system sustainability metric to identify positive and negative cross-correlations.

Although not explicitly part of food system analysis, various research methods can elucidate linkages and relationships between food system components. These methods include life cycle assessments of food products (e.g., Poritosh et al., 2009), studying the relationship between rural and urban food systems (Francis et al., 2005), measuring food environments to understand their influence consumer choices (Herforth & Ahmed, 2015), and in turn, analysing narratives of consumers how their food environments nudge behaviour change (comm. expert panel). In general, there is a wide range of methods that can contribute to better understand relations and interactions in food systems. Also in this strand of food system analysis, boundary setting is of central importance to take into account interactions of the system at focus with the wider food system.

5.1.3 Comparison and monitoring of food system performance

There is a need for quantitative approaches that provide metrics for comparing food system components and specific outcomes across countries and regions, and tracking performance and improvement of food systems over time (GloPan, 2015). To address this gap, Fanzo et al. (2020) developed a Food Systems Dashboard which aims to help policy makers to understand their national food systems through visualization of food system indicators. The online tool presents quantitative data to show the interconnection between sectors, allows the comparison between countries and helps to identify key challenges and actions. A similar approach is the development of a holistic global food system index to track and monitor the progress to a more food secure food system, as proposed by IFPRI (2016). The suggested index consists of six key dimensions: nutritious and healthy consumption, market dynamics, enabling environment, productivity and resource efficiency, environmental sustainability and climate resilience, and social sustainability. Each dimension is measured by a set of indicators that are updated with already existing datasets.

There are some approaches to monitor the sustainability of food systems with a set of indicators and global datasets (Béné, Prager, et al., 2019a; CGIAR, EAT, SDSN; Chaudhary et al., 2018; FAO, 2013; Gustafson et al., 2016). Despite the difficulties to operationalize food system resilience, there are proposals of indicator frameworks (see Section 3.2.2). So far, no assessment studies or comparisons

of food system performances have been conducted on a larger scale of time and geographical locations. Another way to analyse food system resilience is to identify vulnerabilities, which can lead to options for strengthening the system's resilience (van Berkum et al., 2018). For a comprehensive review of studies that aim to identify vulnerabilities in food systems see Prosperi et al. (2016). A recent study analysed social, structural, political, and environmental and ecological vulnerabilities of food systems in the Nordic countries that have been brought into focus during the Covid-19 pandemic (Halloran et al., 2020). The authors argued with the identified vulnerabilities to highlight the importance of developing a systems-based resilience strategy for the Nordic Region food system. Other options to measure resilience of a food system is applying stress testing options via a simulation of the food system and measuring its food security outcomes. On local level, a scan of a community to assess the food security status of its members during crisis and evaluating coping mechanisms can provide a quick result on the resilience of a food system (comm. expert panel).

The expert panel of this study indicated that the lack of comparable and representative data over a longer period of time as the biggest challenges for quantitative analysis of food systems. Béné, Prager, et al. (2019a) also pointed out the problem of fragmented data that limits quantitative food system analysis. They recognize the trade-off between the number of indicators (leading to more robust metrics) and the number of countries for which these metrics are available (leading to a more complete map) in their study. The experts also emphasized the importance of diet quality as indicator for food system functioning and also pointed to the limitation of quantitative data often not sufficiently covering mirco-nutrient deficiencies (e.g. iron, Vitamin C, Vitamin A) as food system outcomes, which are particularly relevant for the African context.

5.1.4 Co-design of future-proof food systems

Dynamics of food systems have a focus on relations and feedback-loops to understand the functioning of the system. To allow predictions of the future, food system researchers also need to understand "feed-forward loops", which are projections of how a food system can become more desirable or resilient.. Identifying the desired state requires an open debate meaningful conversations with stakeholders about how the food systems of the future should look like (European Commission, 2017). Foresight exercises are exercises to screen the horizon in order to indicate how to prepare of what might happen in the future (European Commission, 2020e). The results of these processes should inform (research) policies to support transformation of food systems towards the desired future and prepare society in case foresight scenarios became a reality. The importance of creating inclusive processes of stakeholder participation of stakeholders is emphasized in food systems literature as well as by members of our expert panel. As such, the food system approach can help to tackle shared challenges by providing equal partnerships between researchers, innovators and practitioners across disciplines and sectors (Achterbosch et al., 2019).

A concrete example for the involvement of stakeholders is the scenario development of food systems, described by Ingram (2011): The author reports of initiatives that brought together a wide range of food system specialists and stakeholders who had not interacted before to develop plausible future scenarios of how food security outcomes may unfold. In 2017, the Foresight4Food initiative was established to support enhanced foresight and scenario analysis for global food systems (Foresight4Food, 2020). The international collaborative initiative provides a mechanism for better analysis and synthesis of key trends and possible futures in global food systems with an integrated approach to foresight that connects stakeholder processes of foresight analysis. Typical tools of

foresight exercises are workshops, community meetings, social media and surveys. Visualizations of scenarios and serious gaming with stakeholders are particular effective tools, as they speak to policy-makers (experience from expert panel). Participatory tools facilitate learning amongst different stakeholder groups and thus contribute to change public attitudes and behaviour (European Commission, 2020e).

5.1.5 Identification of entry points to food system change

Another purpose to conduct food system analysis is to identify entry points for interventions to alter food system outcomes and improve food system performance in general. Effective entry points to intervene in a system are often described as leverage points (Meadows, 1999): "Places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where small shifts in one thing can produce big changes in everything". Ruben et al. (2019) discuss three strategic interfaces that are critical for identifying and understanding leverage points towards food systems change: a) Intersections with other non-food systems that influence the supply and demand of food; b) Interactions between stakeholders that are engaged at different levels of the food system; c) Incentives that influence the adaptive behaviour and response of food system stakeholders.

Halberg and Westhoek (2019) emphasize the need for methods to understand how food systems function in order to identify leverage points. Methods presented in Sections 5.1.1 and 5.1.2 can provide a better understanding of these functions. Building on such an understanding, causal diagrams can help to visualize leverage points (Posthumus et al., 2018b). Dekeyser et al. (2020) suggest combining a political economy and a food system component to identify realistic entry points for improving the outcomes and sustainability of the studied food systems. This method involves analysing actors and institutions of food systems together with their power relations as well as formal and informal rules. Institutional analysis requires particular attention to informal structures, such as street venders, who play an important role in Africa's food systems and are often points of vulnerabilities in the food system (comm. expert panel). The expert panel suggested the use of case studies and an evaluation of its impact on the food system to explore and verify leverage points.

5.1.6 Understand and facilitate dynamics of food system transformation

The previous sections have outlined a set of methods to map food systems at certain point of time, understand system dynamics and plan for future scenarios of food systems. Transforming food systems from a current state into a desired state involves disentangling competing interests and supporting food system innovations at a policy and practice level. An analysis of governance structures at different stages of the food system transformation is needed to understand how public, private and civic stakeholders interact to influence different food system outcomes (Arslan et al., 2020). Methods for understanding and facilitating food system transformation often build on the multi-level perspective of Geels (2005) as a framework to analyse interactions between niches of innovation and the dominant food environment. For example, targeted nudges to social and technological innovations can create important niches that are supported by a certain degree of protection from ruling 'regimes' (comm. expert panel).

We identified two methods that address food systems governance from a holistic perspective. Termeer et al. (2018) developed a diagnostic framework for governance arrangements to assess what forms of governance are most appropriate to govern food systems in a more holistic way. The authors applied the framework to analyse the strengths and weaknesses of three food governance arrangements in South Africa. FAO (2018a) propose a stepwise approach to examine policy and

intervention opportunities in food systems that lead to a better availability of and access to affordable healthy diets. The approach consists of the following steps: (i) use existing evidence, frameworks and databases to identify the nutrition and food system challenges in a country (ii) map current policies, identify policy opportunities for enabling healthy diets through the food system, and (iii) assess the political economy to bring about policy change. Members of the expert panel suggested to systematically identify barriers of food system transformation and indicate concrete action from policy-makers to address these issues. Policy coherence analysis can help to identify policies that facilitate or hinder transformation.

5.2 Comprehensive methodologies for food systems analysis

The methods presented above can be used to study specific aspects of food systems as stand-alone or combined for a wider food systems analysis. To bridge the gaps between different strands of analysis and to be capable of blending multi-level and multi-stakeholder dynamics, there is a need for integrated approaches of food systems analysis (Ruben et al., 2019). Dury et al. (2019) call for an integrated diagnosis framework that meet a set of essential requirements: "it must be systemic to embrace the locally specific features and combination of risks food systems face; applicable at different scales depending on inner features of food systems; dynamic to unravel past evolutions and imagine future scenarios and their main drivers; and operational to identify the potential policies, projects and programmes – and the critical stakeholders – which could radically transform food systems in the future." We did not identify frameworks that fully cover these requirement. However, the following methodologies combine some of these aspects:

Table 2. Frameworks for food system analysis

Framework	Focus of food systems analysis
City Region Food System (CRFS) Toolkit of FAO (FAO, 2020b)	"The toolkit provides guidance on how to assess and build sustainable city region food systems. It includes support material on how to: define and map your city region; collect data on your city region food system; gather and analyse information on different CRFS components and sustainability dimensions through both rapid and in-depth assessments; and how to use a multi-stakeholder process to engage policymakers and other stakeholders in the design of more sustainable and resilient city region food systems."
Sustainable food systems approach of ECDPM (Dekeyser et al., 2020)	The goal of the approach is to *describe, diagnose, and help develop more coherently, effective, and context-appropriate interventions in food systems to improve their sustainability*. It combined various methods from food system, sustainability, and political economy components and pathway development.
The Food Systems Decision-Support Tool (Posthumus et al., 2018a)	The tool combines theoretical insights from systems thinking literature and tacit knowledge of key informants through expert and policy workshops. The stepwise process builds on insights into the underlying dynamics of food systems and societal challenges and leads towards identifying actors and policies that can bring about transformative change in food systems.

5.3 Conclusions

Our analysis shows that a range of methods and tools have been applied for food system analysis, though some of them are still in an early stage of development. Resilience building requires an ample understanding of food systems including its components, subsystems and boundaries. Methods for understanding interactions of complex system behaviour can help to assess and anticipate synergies and trade-offs of resilience building (see Chapter 4). While indicators and metrics to quantitatively assess food system performance and its sustainability exist, data for these indicators is still scare and

fragmented. Quantitative monitoring of food system resilience lacks both, an agreement on indicators and metrics and datasets over a wider geographical range and timeframe. On the aspect of food system transformation, foresight exercises can foster participation in defining future-proof food systems in which resilience may play a major role. In the realization of these objective, the dynamics of food system transformation and its governance needs to be analysed with a holistic perspective. While the identified methods build a set of useful tools, integrated methodologies are needed to analyse food systems in different contexts and scales and to facilitate transformations towards more resilience.

6 Resilience to shocks and stresses

Crises are different and vary in terms of geographic impact (from very local to global pandemics), duration (short to long-term), and frequency. As not much is known of the impact of the crises on the specific vulnerabilities in the affected food systems, we also have a limited understanding of resilience factors for the different crises. Effective resilience building measures might vary strongly for the mentioned scales and durations and need to be defined context-specific.

Shocks are characterized by a relatively fast onset and include flooding, disease outbreak, or market fluctuations. Stresses are "long-term trends or pressures that undermine the stability of a system and increase vulnerability within it. Stresses could include factors such as population pressure, climate variability, chronic poverty, persistent discrimination, and protracted crises like intergroup conflict" (Sagara, 2018).

People face different crises at the same time or have to deal with repeated shocks and disturbances resulting in increased vulnerability. This also has a negative effect on the severity of the impacts and the recovery, often leading to a lower state of resilience than before (Davies, 2016). How these multiple crises exactly affect the most vulnerable would be important to know help for better preparation and coping with these shocks. According to the World Bank, many poor people lives in areas that are both affected by conflict and facing high exposure to shocks, in particularly floods (World Bank, 2020b). The poor are exposed to multiple risks, most recently and prominently, the triple menace in East Africa "mutually exacerbating disasters, as ongoing heavy rain hampers attempts to deal with swarms of locusts in the midst of the Covid-19 outbreak" (United Nations, 2020).

Despite the fact that every crisis is different, we also see that conflicts can reinforce each other. They can be interlinked and if no counter measures are taken will lead to even bigger problems. Jean Soussana reported at the virtual event "Bonding science and policy to accelerate food systems transformation" (Soussana, 2021) that climate change will have a devastating impact on the stability of food supply. This has also been stressed by the IPCC (Smith et al.; Soussana, 2021). Weather events will increasingly disrupt food chains, the nutritional quality of crops might drop and food prices might increase, leading to increased risk of food insecurity. Soussana concludes that global warming might amplify migration within the continent and across, which might in turn increase political and social unrest. Not only migration, but also national political and globally interconnected crises can destabilize political and social systems and thus resilience. This demonstrates that any resilience measures need to be closely aligned with social equity and sustainability.

6.1 Overview of shocks and stresses to European and African food systems

IFPRI analyzed shocks and stresses and the degree to which they have become more frequent, severe or intense (IFPRI, 2014). The authors conclude that while some shocks have not increased, others have become more severe or intense and will continue to do so in the near future.

6.1.1 Political conflicts

A growing number of countries are currently struggling with destabilized governments, social unrest, conflicts and humanitarian crises. The HLPE reported that violent, armed conflict can lead to the destruction of crops, livestock, land and water systems as well as to disruptions in infrastructure and human resources required for food production, processing, distribution and safe consumption (HLPE, 2017). During conflicts, food prices often increase and people's livelihoods are disrupted, leading to lower incomes, and they may not be able to physically access markets. Protracted crises, including

situations of prolonged or recurrent crises, entail disruption of livelihoods and food systems, increasing rates in morbidity and mortality, and increased displacements among others (CFS, 2015).

6.1.2 Effects due to climate change

Higher average temperatures, changes in precipitation, rising sea levels, as well as the possibility of increased damage from pests and diseases, are trends that are expected to continue and to increasingly affect agricultural sectors. These stresses put food producers under great pressure. The increase in number and frequency of extreme weather events however are major shocks to farmers, fishing communities and livestock holders. These events often destroy critical agricultural assets and infrastructure, disrupting production cycles, trade flows and livelihoods (Dury et al., 2019). Floods occur mainly in tropical countries; records show a higher frequency and increased severity. This is also true for droughts, as the Intergovernmental Panel on Climate Change report indicated for the Mediterranean and Southern Africa (IPCC, 2013). It led to water stress conditions in human and ecological systems in a number of African countries. Dust storms have negative impacts on agriculture. They erode fertile soil, uproot young plants, bury water canals, homes, and properties, and cause respiratory problems (Handmer et al.). The Global Risks Perception Survey reports that “failure of climate change mitigation and adaption” is the number one risk by impact and number two by likelihood over the next ten years (World Economic Forum, 2020).

6.1.3 Economic crises

The world has seen two major food price crises during the past six years. Local and international staple commodity prices rose steadily throughout 2006 and2007, and then sharply early in 2008. By the end of 2008, prices dropped significantly, but then rose again in 2010, with another, less pronounced peak in February 2011 (IFPRI, 2014). Sharp rises in food prices, price volatility and the effect of shocks resulting from trade disruptions have had direct effects on production, income, employment and consequently food security - at least in the short-term, but might also have positive long-term benefits in terms of e.g. higher returns to agriculture (HLPE, 2017).

6.1.4 Crises resulting from pest and diseases

Infestations and diseases at the regional level (e.g. African Swine Fever or Desert Locust outbreaks) or at the global level (e.g. Covid-19) are becoming more frequent and severe, often disrupting the world’s food supply chains (FAO et al., 2020). For example, the Eastern African region has suffered from the desert locust during the last few years. The locusts are the most destructive migratory pest in the world. They are ravenous eaters who consume their own weight per day, targeting food crops and forage. Just a single square kilometer of swarm can contain up to 80 million adults, with the capacity to consume the same amount of food in one day as 35,000 people (United Nations, 2020). Zoonotic diseases do often have devastating impacts on poor households, whose livelihoods depend on livestock, or on their own health; also in cases, not caused by a pandemic such as Covid-19.

6.2 Case study Covid-19

Since the beginning of 2020, Covid-19 has changed the lives of millions of people throughout the world. The FAO estimates that nearly 690 million people are currently suffering from hunger, increased by up to 10 million people in one year. A preliminary assessment suggests that the Covid-19 pandemic may add another 83 to 132 million people depending on the economic growth scenario (FAO et al., 2020). This is not limited to developing countries, but also in industrial countries the pandemic has had an impact on food security. Data to show the bigger picture on the impact of Covid-19 on food systems is still scarce; however, a survey by the British Food Foundation suggests that 15.4

million adults in the UK have already lost household income as a result of Covid-19 and financial worries are one of the main reasons for food insecurity. Up from 2 million people before the first lockdown, 4.9 million people in the UK, including 1.7 million children, are suffering from food insecurity (Trewin Restorick, 2020). Although all countries and population groups around the world are experiencing the effects of Covid-19, the poor and vulnerable suffer the most (Swinnen & McDermott, 2020; World Bank, 2020b). The FAO speaks of an "impending global food emergency, of unknown but very likely very large proportions" (United Nations, 2020). For many people this emergency adds to on-going, often silent, crises such as weather extremes, pests and violent conflicts (World Bank, 2020b) with potential interactions and reinforcing effects still largely unknown.

An assessment of the HLPE on food security and nutrition concludes that Covid-19 will have an impact on all six dimensions of food security: access, availability, stability, utilization, agency, and sustainability (HLPE, 2020b). The current crisis raises especially awareness of 'stability' as a component of food and nutrition security not prominently featuring discussions so far.

The food system is directly affected when food system workers get sick. Various reports stress that those suffering from diabetes and other diet-related non-communicable diseases are among the most vulnerable (Husain et al., 2020; Lancet, 2020). However, in terms of food systems the indirect effects have been more serious. They are mainly triggered by implemented measures of national governments such as lockdowns, physical distancing policies (curfews, closures of markets, restrictions on border crossings and movement limitation measures). But even though measures were taken at national level, cross-border effects could be seen. The local and global food systems are highly interlinked through global value chains of staple ingredients, pesticides, fertilizers, animal feed, personnel and expertise (Torero, 2020b). This led to a number of overlapping and reinforcing dynamics that were affecting the food systems, including disruptions to food supply chains, loss of income and livelihoods, a widening of inequality, disruptions to social protection programs, altered food environments, and uneven food prices in localized contexts (HLPE, 2020b).

Whereas the western system was able to buffer the immediate effects of the Covid-19 crisis on the food system quite well (European Commission, 2020e; Moran et al., 2020), the food systems in the global South were to a much lesser extent able to cope (HLPE, 2020b, 2020c; World Bank, 2020b). It is expected that the impacts in Africa will be more severe than in other parts of the world. A decline in the Gross Domestic Product of almost 9 percent is expected for Africa south of the Sahara, due to the relatively high dependence on trade and primary commodity exports (Laborde et al., 2020). Laborde et al. (2020) suggest that without mitigation measures urban and rural people living in poverty in Africa south of the Sahara could increase by 23 percent. Although the likelihood of a pandemic had been long predicted, the majority of countries were ill-prepared and the impact on national economies has been far greater than anticipated (Gill et al. 2020).

A high degree of uncertainty exists with regards to the short, middle and long-term effects (HLPE, 2020b). Savary et al. (2020) state that mapping out all vulnerabilities in food systems due to Covid-19 would be futile, as the food systems are so diverse and complex by nature. The authors also point out the importance of time and spatial scale dimensions. Some of the described effects were only short term, as for example the empty shelves, the unavailability of certain food items and the export restrictions. The food systems can recover fast from these shocks. Others, such as the economic slow-down, the growing social inequity and the shift in market power will have long term effects and therefore need to be evaluated after a longer period. But even short-term shocks matter if they affect

the livelihood of poor households. Likewise, small enterprises will be hit harder as for example large corporate companies.

6.2.1 Vulnerable populations

In various ways, the pandemic has had an impact on different populations in different locations, as food systems vary in-between and within countries. Urban population might be more affected than rural population. This is especially true for Africa, where informal employment is the main source of income, accounting for 85.8 percent of all employment (Kiaga, 2020). The informal food traders are important for urban food systems, providing income for farmers and nutrition for poor consumers (Resnik Danielle, 2020; Wegerif, 2020). Their jobs are extremely labor-intensive with high densities of workers in small spaces (Kiaga, 2020; Reardon Thomas et al., 2020) and under extremely difficult conditions (Béné, 2020). The same is true for casual and low wage (migrant) food workers (FAO, 2020d; HLPE, 2020b; Klassen & Murphy, 2020; Moseley & Battersby, 2020). All of the mentioned groups face health hazards, loss of income and also lack the necessary social protection and support mechanisms. In addition, Thurlow (2020) assumes that primarily the urban non-poor will be hit, as manufacturing and business services facing the strictest lockdowns are often concentrated in cities and employ better-educated workers. As a consequence of the hard-living situation, in some regions people left the cities and moved back to rural areas.

Often the vulnerable and marginalized populations (gender, youth, elderlies, people living with handicaps, ethnic minorities) however suffer most and do not have the necessary resilience capacity. With the closing of school canteens many children lost access to much needed school lunches (WFP, 2020). The FAO also pointed out, that refugees are 60 percent more likely to be financially impaired by Covid-19 (FAO, 2020f). For South Africa, Mukumbang et al. (2020) showed that the political measures hit asylum-seekers, refugees, and undocumented migrants tremendously, while being left out of social protection responses. Very likely the crisis will also affect women differently than men and this will need special attention (Quisumbing et al., 2020). The pandemic exacerbates existing gender inequalities due to restricted access to basic services, increasing domestic and work responsibilities, escalating gender-based violence and the loss of working opportunities in the informal sector (Kiaga, 2020).

In this respect the crisis highlights the ‘ability to adapt’ to changing conditions. The ability to decide between different options and choices is at the heart of resilience. This ability can take place on different levels, e.g. household, company or country level (Belik, 2020) and it is the ‘agency’ or empowerment to adapt to shocks. Their ability is inseparably linked to their capabilities, opportunities and assets. Therefore, in the crisis social protection schemes have proven to be important to help consumers to buffer shocks. Redistribution has also been a key element to make the European food system more resilient. Cash transfer for food system workers and enterprises was an effective way to reduce the negative effects of Covid-19 measures in many countries (Béné, 2020). Thus the HLPE point to the need of providing robust targeted social safety nets and emergency aid (HLPE, 2020b). A special attention also needs to be given to above-described vulnerable groups. Beside protecting these populations in crises, it is important to discuss how societies might center justice and equity in an effort to build back better (Ashford et al., 2020; Klassen & Murphy, 2020).

6.2.2 Vulnerabilities in the Food system

Food systems can face structural, political, environmental and social vulnerabilities (Halloran et al., 2020).

Structural vulnerabilities: During the Covid-19 pandemic all food system actors experienced structural vulnerabilities and disruption of supply chains. The crisis reveals the dependency on well-functioning public infrastructure (such as roads, storage and markets) and logistics: delays in just-in-time delivery in wholesale and retail occurred, processing of compound food and packaging was interrupted (Bakalis et al., 2020; HLPE, 2020b; Ihle et al., 2020; Savary et al., 2020). Especially, farmers, livestock holder and fishermen are affected by the pandemic globally as production is dependent on input (e.g. seeds, fertilizers, pesticides, feed, advisory services, farm labor) (Arouna et al., 2020; FAO, 2020d; OECD, 2020) and reliable market structures. There have also been disruptions in the supply chain mainly for i.e. perishable products that need cooling, have a short shelf life (i.e. fruits, vegetables, meat, fish, dairy) (FAO, 2020e) and high losses before farm gate.

Political vulnerabilities: The power concentration in the food system has raised issues relating to resilience and fair access (SAPEA, 2020). Moseley and Battersby (2020) state that African "food policy has sometimes been captured by corporate agricultural interests, and the response of the state has not been informed by the food practices of the poor. The result has often been the privileging of large-scale agriculture, formal sector suppliers, and supermarketization in some areas. Furthermore, these policies have been reinforced by historical biases against informal sector actors". Also, the demand side of global trade showed remarkable effects worldwide. The closing of restaurants and canteens and the cancellation of public and private events led to a sudden decline in demand of high value products (e.g. specialized agricultural and fisheries products, coffee) (Akiwumi, 2020; Belik, 2020). The closing of local markets further boosted the dominance of large supermarket chains, which were allowed to stay open. This also resulted in some consumers buying more processed and ultra-processed food (Belik, 2020; Moseley & Battersby, 2020). Many other consumers changed their diets to less nutritious food, either because it was not available to them, too costly or because they did not have the resources (Béné, 2020; Laborde et al., 2020; Savary et al., 2020).

Social vulnerabilities: On the one hand, export restrictions, trade barriers and the closing of boarders for migrant workers led to an increase in prices; on the other hand, in some cases, the problem of marketing or processing led to a price decline (FAO, 2020d; OECD, 2020; Savary et al., 2020). As many countries are net-food importers, the increase of prices for staple crops (mainly rice and wheat) may threaten livelihoods (FAO et al., 2020; Laborde et al., 2020). On a global scale, reduced income led to lower purchasing power of families (Torero, 2020a; World Bank, 2020a).

Environmental vulnerabilities: The concerns about human nutrition and their reliance on a reduced number of crops is related to the loss of diversity on the fields. Crop diversification can have added benefit in times of the pandemics and can improve resilience in a variety of ways: e.g. by engendering a greater ability to suppress pest outbreaks and dampen pathogen transmission, or by being able to provide local markets with a variety of fresh and nutritious products.

6.2.3 Interlinkages with other systems

There is a growing recognition that diversity loss and the homogenization of agroecosystems will reduce the resilience and sustainability of agriculture, by directly affecting abundance and diversity of natural enemies and finally will increase the emergence of pests and diseases (Altieri & Nicholls, 2020). Cazzolla Gatti et al. (2021) describe it as a phenomenon that emerges from and affects the whole total environment, as a complex evolving system composed of interdependent spheres: Geosphere, Biosphere, and Anthroposphere. While still further research is needed, we can already say that climate change combined with other global changes such as the intensification of farming systems, the globalization of trade and the erosion of biodiversity will accelerate the emergence infectious vector-borne zoonotic diseases, crop pests and antimicrobial resistance (Dury et al., 2019). Intensive livestock production is amplifying the risks of diseases emerging and spreading. The probability of outbreaks of high-impact animal diseases is increased by the confinement of large numbers of animals in small spaces, narrowed genetic diversity, fast animal turnover, and habitat fragmentation through expansion of livestock production (IPES-Food, 2020). Additionally, the discussion on selling of wild animal meat in crowded wet markets and the associated health problems received growing attention (Bakalis et al., 2020). Generally, risks are amplified by enhanced human-wildlife interaction, which can be exacerbated by habitat destruction due to commercial agriculture, urbanization, land and resource grabs (IPES-Food, 2020).

The pandemic made us aware of the interrelatedness of the different systems. Not only ecosystems, but also people's health is interconnected with food security and can lead to further vulnerability: "When people's livelihoods and incomes are jeopardized, they are less able to cope with other shocks, such as extended hospital stays or the death of family members, which leave them even more exposed and vulnerable. As access to nutritious food declines, so too will their health" (FAO, 2020a). But furthermore, the crisis taught us that beyond the interrelatedness with the health systems, our food system is dependent on the transport infrastructure, mobility of the work force, social protection among others.

6.2.4 Connectivity and dependency

The interconnectedness makes it difficult for food policies to target specific issues, yet policies are important drivers for the transformation of our food systems. The HLPE states that "this means moving from a singular focus on increasing food supply through specialized production and export to making fundamental changes that diversify food systems, empower vulnerable and marginalized groups and promote sustainability across all aspects of food supply chains, from production to consumption" (HLPE, 2020b). Ashford et al. (2020) analyze 30 interventions that target economic growth and social equality. They conclude that "any intervention focused on growing the economy, must also be accompanied by interventions that offset the resulting compromises to health, safety, and the environment" as well as that reducing inequality and improving the environment must be addressed together (Ashford et al., 2020). Savary et al. (2020) presented a list of recommendations for policy makers and academia to improve the resilience of the food system, global to local, and in the short, medium and long term.

Research and policy makers need to reinvestigate market and trade policies to achieve the goal of food system resilience. The debate on liberalized markets and trade versus short and local value chains (Moseley & Battersby, 2020; Torero, 2020a) has been revived, as well as the dependency of many

African countries on the export of natural resources and the import of food (African Union, n.d.). The African Union (n.d.) calls for diversifying and transforming the economies by strengthening the productive capacity of the African private sector to process raw materials locally. This way, the AU wants to improve mobilization of domestic resources and reduce the continent's dependence on external financial flows. Also, the HLPE calls for better protection of countries that depend on food imports (HLPE, 2020b). The AU counts on the implementation of the African Continental Free Trade Area (AfCFTA) for improvement in this area: African countries will benefit through greater economic diversification (added value and intra-African trade) as well as the creation of jobs and revenue to fight poverty and food insecurity (Akiwumi, 2020). In the opinion of the HLPE, territorial markets that are embedded in local and regional contexts can be important in strengthening livelihood opportunities for local food producers, processors and sellers (HLPE, 2020b). Further, they have the potential to reduce national and community dependence. There is a need to analyze, model and create transformation strategies for all levels of the food system (global to local), including and addressing all interlinkages and align these realistically with consumer preferences (IPES-Food, 2020; Moran et al., 2020). This also includes evaluating existing power concentration in the food system in terms of resilience and fair access (SAPEA, 2020).

6.2.5 Opportunities for change

Crises are always an opportunity for change. In the pandemic science and policy have been working hand in hand (Cazzolla Gatti et al., 2021). This is an important lesson. Much knowledge that we have on food system need to be implemented, other pathways are still to be explored.

Some authors focus on new approaches, mindsets or knowledge that emerged in the last year. Hawkes points to the fact that "Covid-19 has also provided an unprecedented opportunity for innovation, a space in time when immediate needs have spurred responses never seen before, a base on which to redesign food systems for the better" (Hawkes, 2020). Reardon Thomas and Swinnen (2020) suggested to have a closer look on the innovations emerged during the pandemic. They wrote that "there is little systematic data available on these entrepreneurial and creative institutional responses. Anecdotal information suggests that these innovations are important and could have a major impact on the future of food systems and food supply chains in developing countries — in particular buttressing their resilience." These innovations can be in the field of social innovations, business strategies, new technologies, financial innovations, or e-commerce (Reardon Thomas & Swinnen, 2020). Changes often start in niches before they become trends and contribute to transformation (Gill et al. 2020). An assessment of innovations contributing to resilience during the Covid-19- crisis need to be done and further supported by R&I.

Further, the Covid-19 pandemic has demonstrated that the reorganization of working arrangements is possible: shorter and/or flexible working hours could benefit both, workers' health and their productivity. In addition, "more free time would indirectly foster home-cooking and food growing, allowing more sustainable behavior and increasing the possibilities for gender equality in caring activities such as cooking" (European Commission, 2020c). The digitalization in all spheres of life has seen a tremendous leap forward, including the uptake of digital tools in the food system.

The behavior of citizens has also changed: people started to engage more e.g. in urban gardening, shopped more locally (or shifted their shopping to the internet); they supported local businesses and neighbors. Some see the active role of citizens in the crisis as an opportunity for food democracy as it "generates a strong framework for multilevel food governance by putting the emphasis on local and

regional production that encourages the consumption of seasonal and healthy produce, employing local agricultural workers and establishing better relationships between producers and retailers, whilst ensuring that the security and diversity of food are maintained" (Petetin, 2020).

6.3 Conclusions

Shocks and stresses may disturb food system functions and contribute to a rise in numbers of people living in poverty as well as threaten their food security. Solutions on how to prepare and cope with shocks and stresses need to be found for each crisis individually and context-specific. Nevertheless, building up food system resilience in general will enhance the adaptive capacity of people for unforeseen shocks and also concurrent multiple crises. We expect that crises will occur more frequently in the future, e.g. as an effect of climate change, social and political unrest, pest and diseases with shocks and stresses reinforcing each other. People that are affected by multiple crises lose their ability to respond and become more vulnerable. Resilience can and needs to be built on all different levels (individual, household, enterprise, …, regional, national, global).

The Covid-19 pandemic has shown how vulnerable the current food systems are with regards to global economic shocks and corresponding political measures. It made the feedback loops within food systems very visible. Thus, the crisis exposes – more than before – the importance of the logistics in the value chain and the central role of the food system workers (with special focus on migrant workers and the informal sector). We will learn our lessons from the dependencies and interrelatedness of actors in the food system to see the changes that are needed to increase the agency to cope with future similar crises and to build back better.

While the pandemic, mostly by their indirect effects (lockdowns, border restrictions) affects all countries globally, the vulnerable populations and Low-Income Food-Deficit Countries were hit more severe. Much depends on the agency of the people which might be limited or even getting lost due steady political crisis, conflict or chronic poverty. The current COVID-19 crisis thus also demonstrates that many actors in the food systems lack financial, social or natural capital to act according to their priorities. Public economic packages, social protection mechanisms and innovative partnerships led to a situation where some food systems and some people were able to cope better. The differences between the countries and strategies, as well as the interlinkages of food systems from local to global need to be explored further.

As Covid-19 unfolded in the beginning of 2020, there is already an abundance of literature available looking at all scales. Not surprisingly, the majority of available literature is based on opinions and conceptual analysis (grey literature) and very few analyses built on empirical evidence, due to the short period of time. Therefore, the scale of the food system disruption induced by the pandemic is neither fully analyzed, nor can final conclusions be drawn with regard to resilience in food systems. In the coming months, new survey data, model simulations and better insights on the impact of the pandemic as well as policy makers' responses will enhance our understanding of the food system and how to make it more resilient.

7 Food system resilience in policies of the European Union, African Union, bi-continental cooperation and global frameworks

7.1 Food system resilience in policies of the EU

In spite of the calls to develop an EU food policy, the EU currently does not possess an overarching policy on food systems in a holistic manner. Resilience of food systems is not explicitly addressed. So far, EU food governance is characterised by a fragmented landscape with responsibilities in different directorates and institutions which affect the EU food system. Thus experts call for a better policy integration to solve complex challenges (Group of Chief Scientific Advisors, 2020; IPES-Food, 2019).

In this study we have looked at policies in different policy areas that address food system resilience, in one way or the other, e.g. in terms of shocks and crises or by aiming towards sustainability from a food system approach. We belief that existing policies may already contribute to or show potential for the development of a more resilient EU food system. Rudloff (2020) point out that policies can show diverging understandings of resilience and critical infrastructures, which "may lead to conflicts and counterproductive results for resilience". They differentiate between (1) cross policy risks (if food is defined as "critical" by one policy but not others, or by Member States but not the EU), (2) cross-sectoral risks (if interlinkages between infrastructures are ignored, e.g. food is defined as critical but water for agricultural production is not, and (3) Cross-national risks (if the spatial dimension of vulnerability is overlooked) (Rudloff, 2020).

A common food policy for the EU could be a way forward to achieve more resilience in the food system. In fact, the EU Commission plans a legislative proposal for a framework for a sustainable food system by 2023 "promoting policy coherence at EU and national level, mainstream sustainability in all food-related policies and strengthen the resilience of food systems" (European Commission, 2020b). For this, also a framework on definitions, general principles and requirements for sustainable food systems and foods including all actors is envisaged. It is anticipated that certification and labelling on the sustainability performance of food products and targeted incentives will give preference to sustainable practices and raise sustainability standards (European Commission, 2020b). These plans for a framework for a sustainable food system could potentially provide the basis to encompass the concept of resilience within the food system. To achieve this aim, EU competences on national level of member states have thus to be aligned. Whereas some areas of governance such as agricultural policy and fisheries policy fall within the EU's competence, other areas including public health remain largely within the responsibility of member states (IPES-Food, 2019). SAPEA (2020) points out that the legal possibility of such an EU framework is possible: "In principle, the high degree of harmonisation of food-related legislation under the single market allows the Commission to draw on Article 114 paragraph 3 of the Treaty of the Functioning of the EU to take a high level of protection of health, safety, environment, and consumers as a base."

SAPEA (2020) also states that policies need to follow an iterative approach as the effects of policies are often uncertain and specific policy interventions cannot be clearly attributed to observed changes. The prediction of feedback loops and how these can be dealt with remains an open question. It is assumed that it is only possible to understand the effect of changes after they have been made. Policy performance across different dimensions may thus vary significantly and existing policies show often no synergies, but competing goals. Also, food systems do not operate in isolation from other systems

such as energy and mobility and wider society, which in turn shape the context in which the food system operates (SAPEA, 2020).

Changing food systems is not only at the national level but also at smaller scale: e.g. agenda setting, decision making, representation and accountability. Polycentric governance, in which "multiple governing bodies interact to make and enforce rules within a specific policy arena or location" (Simonsen et al., n.d.), can achieve collective action to deal with disturbance and change adequately. It ensures collaboration and thus improves connectivity as well as learning across scales and cultures. Well-connected governance structures can deal with disturbances more effectively and in a timely manner (Simonsen et al., n.d.).

7.1.1 FOOD 2030

In 2015, at the World Expo in Milan, the EU's R&I policy "FOOD 2030" was launched. The overall objective of FOOD 2030 is to strengthen the enabling role of R&I for a transformation to sustainable, resilient, diverse, inclusive and competitive food systems for the benefit of society (enough affordable, nutritious food leading to a healthy life). Fostering new scientific and technological advances in combination with different forms of innovation (including institutional, governance, business model and social innovation) is considered to be the way forward. The focus lies on the whole food value chain and farm-to-fork approaches promoting scale up, digitization as well as open innovation, education and skills. Within this framework, food systems encompass all activities, sectors and actors of the primary production, food processing and distribution, logistics and storage, retail, food services, food preparation, consumption, and nutrition for health and wellness.

Resilience is mentioned in many publications of the FOOD 2030 policy framework as an important area of research, as for example, the authors of the FOOD 2030 conference outcome report, Plovdiv, 2018 (European Commission, 2018b) discuss the importance of "broadening the understanding of the relationships between 'diversity' and 'resilience'" as well as stretch the importance of the empowerment of farmers. In the recent published "FOOD 2030 pathways for action" the European Commission presents key levers of change where R&I can have a deep and multiple impact in realizing the food system vision (European Commission, 2020d). The strategy acknowledges that "resilience against global challenges and shocks […] depends on the successful implementation of policies, actions and development strategies, which all need to be facilitated by high quality and efficient governance […]. The many challenges related to food systems have made clear that we urgently need to improve our food system governance beyond today's fragmented, siloed approach" (European Commission, 2020d).

The SCAR 's Food Systems Strategic Working Group has performed a mapping of food related policies and food system related public R&I funds in EU Member States (European Commission, 2018a). The mapping shows that public-funded R&I relevant to food systems is generally fragmented across different international, European, national and regional programs funded by different ministries and agencies. Findings show that, so far, R&I was targeted mainly at specific parts of the food system (e.g. primary production, nutrition or food processing), whereas linking land and sea, connecting producers to consumers, or engaging different sectors and actors within the food value chain were neglected. (European Commission, 2018a).

7.1.2 The European Green Deal and the Farm to Fork Strategy

Climate action is at the heart of the European Green Deal – an ambitious package of measures ranging from reducing greenhouse gas emissions to investing in cutting-edge R&I, to preserving Europe's natural environment – with all EU actions and policies having to contribute to the European Green Deal objectives. The European Deal can be considered a coherent policy response to resilience in the face of global climate change, recognizing that climate change is the biggest threat to our future. The report of the European Commission to the European Parliament on the Green deal (European Commission, 2020a) states that "policy response must be bold and comprehensive and seek to maximize benefits for health, quality of life, resilience and competitiveness".

The Farm to Fork Strategy is a fundamental part of the Green Deal and addresses the "transition to just and fair food systems respecting the planetary boundaries" taking up the food system approach (European Commission, 2020d). Also the need for food to be considered as a common good and not just a trading commodity is highlighted (European Commission, 2020d). The EU's goals are "to reduce the environmental and climate footprint of the EU food system and strengthen its resilience, ensure food security in the face of climate change and biodiversity loss and lead a global transition towards competitive sustainability from farm to fork and tapping into new opportunities", clearly stretching the importance of resilience of food systems (European Commission, 2020b; Rampa et al., 2020), whereas not elaborating in detail how resilience will be enforced or measured.

The transition goals must also be implemented by existing policies, such as the Common Agricultural Policy (CAP) (Rampa et al., 2020; SAPEA, 2020). The SCAR Foresight Report (European Commission, 2020e) assumes that some of the current policy directions of CAP "may hinder rather than promote a transition towards a safe and just operating space". The report puts across the question whether an agricultural policy could address all food-related issues. "CAP should, some now argue, become a food and agriculture policy rather than a farm policy alone. Others say that, also in light of Farm to Fork, a brand-new policy framework should be designed". This would require "the involvement of a much wider set of stakeholders and administrative bodies – connecting policy on food, health, climate, the environment, circular economy and, of course, farming" (European Commission, 2020e).

The report of the Group of Scientific Advisors shows that there is a "general lack of interaction between and misalignment of various policies, which is a critical barrier towards a sustainable food system". This coherence would also be important for making the food system resilient against shocks and stresses (Group of Chief Scientific Advisors, 2020).

7.1.3 EU policies on Humanitarian Assistance and Development Cooperation

The term "resilience" is to date unsurprisingly more frequently used in policies relating to disaster risk reduction, crisis management or development cooperation. The EU provides humanitarian assistance and prioritises food security as one of its main goals relating to resilience with regard to food systems and security, e.g. by considering "opportunities to reinforce crisis-affected communities' resilience to future disasters, and to protect or strengthen their existing capacities to meet their own food needs, as well as the capacities of national systems to sustainably promote and maintain food-security" a key element.

The EU's humanitarian food assistance also "seeks to avoid undermining community resilience and coping capacity". This should include joint analysis and planning with development partners in order to increase synergies: "While responding to humanitarian needs, it is possible to develop policies,

systems and skills, that are compatible both within an emergency and development context. The support is aimed at local and national capacities to manage undernutrition in emergencies and to face seasonal peaks, and to build resilience to face existing and upcoming shocks" (European Commission, 2013).

7.2 Food system resilience in policies of the AU

The AU promotes socio-economic integration and development of the continent and fosters the cross-border regional cooperation among member states. There is however no policy integration as can be seen e.g. for the European CAP, incorporating a common organisation of markets and rules on trade. African countries develop and implement their own national policies and strategies. The programmes described in this chapter can be seen as member states' commitments, expected to serve as a framework that adds value to national and regional strategies. Resilience strategies are likely to be built on national or even local level, but are nested in regional and international settings.

7.2.1 CAADP

The Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD), established in 2003 (Maputo declaration), is directed at Africa's policymakers. It was prepared to address the "crisis situation of Africa's agriculture", which has made the continent "import-dependent", "vulnerable to climate change", and "dependent on food aid" (African Union & NEPAD, 2003). The most promising intervention points were identified as: (i) extending the area under sustainable land management and reliable water control systems; (ii) improving rural infrastructure and trade-related capacities for improved market access; and (iii) increasing food supply and reducing hunger; and (iv) agricultural research, technology dissemination and adoption (African Union & NEPAD, 2003). The CAADP Program is a sectoral policy, which does not address food system as a whole. Nevertheless, it is an important framework recognising that "comprehensive food and agricultural policies at national levels and strategic policy frameworks at regional level are indispensable to achieving food security and harmonious rural development" (African Union & NEPAD, 2003).

The Malabo Declaration, adopted in 2014, commits to enhancing the "resilience of livelihoods & production systems to climate variability and other shocks" (CAADP & NEPAD, n.d.). Clear targets are set, for instance: "Ensure that by 2025, at least 30 percent of farm/pastoral households are resilient to shocks" (NEPAD, 2011). A key decision from the Malabo Declaration was to develop a dedicated implementation strategy and roadmap to guide CAADP and African agriculture from 2015-2025 to support the CAADP implementation at all levels including the private sector, farmer organizations, civil society, development partners, public and specialized technical institutions (CAADP Results Framework 2015 - 2025). As a central part of the CAADP implementation strategy, the results framework provides all stakeholders with parameters to benchmark progress in agricultural performance with the aim to reinforce results-based programming and performance monitoring. This should then in turn ensure "improvements in livelihood parameters, including wealth and job creation, poverty alleviation, food and nutrition security and resilience and prosperity among the African population" (CAADP & NEPAD, n.d.). In more detail, the framework encompasses standardized tools and economic, social and environmental indicators, which are used by CAADP stakeholders at country, regional and continental level to measure agricultural performance and progress. Countries are encouraged to strengthen or develop country-level result frameworks for their respective National Agriculture Investment Plans (NAIP). The NAIP aim to generate results on three levels: relates to (i)

Agriculture's Contribution to Economic Growth and Inclusive Development; (ii) Agricultural Transformation and Sustained Inclusive Agricultural Growth; and (iii)Strengthening Systemic capacity to deliver results. Result areas refer to "resilience and sustainability" using RIMA - Resilience Index Measurement and Analysis, a tool developed by FAO - and "increased resilience of livelihoods and improved management of risks in the agriculture sector".

The two AU declarations aim "to optimize linkages among national, regional and continental mandates" adhering to the subsidiarity principle based on the fact that agriculture development is a national responsibility. "There are, however, critical support functions, such as harmonization of policies, standards, and regulations across member states, which are best provided at both regional and continental levels where the comparative advantage lies" (African Union Commission, n.d.). While CAADP aims to increase resilience in the agricultural sector, it does not explicitly address the concept resilience in the food system at a whole. We assume that still the aims and objectives will likely help to improve food system resilience, addressing "emergency-related food security" including calamities and disasters, or in averting the degradation of natural resources and erosion of biodiversity in order to improve the "systems' resilience".

7.2.2 Agenda 2063

The Agenda 2063 is a set of initiatives adopted by the AU in 2013 as a plan for the next 50 years including a list of "aspirations". Good quality of life for all will be achieved through strategies that address economic development, political integration, improvements in democracy and justice, establishment of security and peace on the entire African continent.

Although a goal is to eradicate poverty and achieve food security as well as a sustainable transformation in agriculture and a sustainable exploitation and management of Africa's diversity, among others, food systems and food system resilience are no inherent parts of the Agenda 2063. However, the goals set for e.g. African agriculture and agro-business are expected to contribute to increase food system resilience. This includes the aim of elimination of hunger and food insecurity, reduction of imports of food and increase intra-Africa trade in agriculture and food, introduction of modern agricultural systems, technology, practices and training, development and implementation of affirmative policies and advocacy to ensure women's increased access to land and inputs and economically empower women and youth by enhancing access to financial resources for investment (African Union Commission, 2015).

7.2.3 Strategy for agricultural transformation in Africa 2016-2025

In 2015, a high-level Ministerial Conference on "Feed Africa: An Action Plan for African Agricultural Transformation" was held. A strategy was developed to achieve the CAADP goals of contributing to elimination of hunger, malnutrition, poverty, and increase prosperity, in partnership with alliances including farmers, agribusiness, and civil society (Johm et al., 2016). This also includes exploiting regional comparative advantages and opportunities for trade and collaborations while ensuring that key outcomes beyond growth of the agricultural sector include enhanced capacity of governments and multilateral institutions, increased representation for women and youth, and improved resilience to climate variability and shocks (Johm et al., 2016). Clear targets were set, some relating to resilience, such as:

- Ensure that by 2025, at least 30 percent of farm/pastoral households are resilient to shocks

- Enhance investments for resilience building initiatives, including social security for rural workers and other vulnerable social groups, as well as for vulnerable ecosystems
- Mainstream resilience and risk management in policies, strategies and investment plans
- Commitment to mutual accountability to actions and results

7.2.4 The African Continental Free Trade Area

The AfCFTA is a trade agreement among the AU member states for the development of a single market, but is seen as a tool of transformation with far-reaching policy impact. The general objectives of the AfCFTA are e.g. to create a single market for goods and services and expedite the regional and continental integration processes (Sebahizi, 2019). Although the AfCFTA is a continental agreement, the implementation will be done at the national level. In "The Futures Report – Making the AfCFTA Work" it is stated that the AfCFTA aims not only at fostering business, production and trade, but to enhance efforts to achieve the Sustainable Development Goals, and the Agenda 2063 of the AU (AfCFTA Secretariat & UNDP, 2020). Further, opportunities opened up by the AfCFTA should now be translated into policy measures and investments to ensure that e.g. "women and youth, business owners and workforce, can be better integrated into the value chains". The report elaborates that the AfCFTA is "central to recovering from the coronavirus disease pandemic and enhancing Africa's resilience" (AfCFTA Secretariat & UNDP, 2020). Although food system resilience is not explicitly mentioned, the document refers to e.g. resilient food supply chains (mainly pandemic-related), climate resilience and livelihood resilience. It is interesting to note that a special focus is laid on young people being described as one of the greatest assets for resilience.

7.3 EU-AU cooperation

7.3.1 EU-AU Partnership

Two main frameworks govern EU relations with Africa: the Cotonou Agreement, later updated by the Lisbon Declaration (of the EU and the ACP countries), which provides the legal basis for relations, and the Joint Africa-EU Strategy, adopted at the Lisbon Summit in 2007. The new EU-Africa strategy will be endorsed at the EU-AU Summit in 2021. This summit offers an opportunity to reaffirm joint commitments towards implementing the Paris Agreement and its agreed-to goals. The communication of the EU states that the EU and Africa "must join efforts to reach the SDG of zero hunger and address the challenges of nutrition and food security by boosting safe and sustainable agri-food systems. A partnership on agriculture would support the development of environment friendly agricultural practices, promote local production and integrate biodiversity concerns. This includes setting sanitary and phyto-sanitary standards and the protection of natural resources. Trade between the EU and Africa plays an instrumental role supporting opportunities for sustainable food systems" (European Commission, Brussels, 2020).

7.3.2 EU-AU R&I Partnership

The JAES Strategy laid the ground for improved cooperation in the field of science, technology, and innovation relationship. In 2010, the Africa-EU HLPD in Science, Technology and Innovation was created as a platform for regular exchange on R&I policy and aims to formulate and implement long-term priorities to strengthen Africa-Europe cooperation on science, technology and innovation (European Commission, 2018c).

The role of science, technology and innovation is considered key for human development, sustainable and inclusive growth, and to tackle societal challenges such as food security. The HLPD has adopted FNSSA as its first priority in 2014 with a 10-year Roadmap on R&I leading the way. This roadmap

intends to increase coherence between and build upon the many projects within the FNSSA domain at the national, bilateral or bi-regional (Europe and Africa) level. It also provides an opportunity for alignment of the different networks linked to agriculture research that currently exist.

The initiative aims at transforming the food systems to become more sustainable, deliver better nutrition, avoid undernutrition and obesity, reduce food losses and waste, adapt to and mitigate climate change, and create jobs for young people. The roadmap defined three priority themes and a group of cross-cutting issues for a joint research agenda: i) Sustainable intensification, ii) Agriculture and food systems for nutrition, iii) Expansion and improvement of agricultural markets and trade.

Resilience is mentioned in the selection criteria of these priorities: “Expected impact of research and likelihood of uptake contributes to solutions and evidence for policy change, to positive agricultural and nutritional outcomes and to significant improvements in economies, wellbeing and resilience” (EU-Africa HLPD STI, 2016).

Analyzing the roadmap, we find that the topic focusing on food systems and nutrition does not mention the challenges associated with shocks and stresses. Whereas the definition of “Sustainable Intensification” in this document is given as “to produce more outputs with a more efficient use of all inputs on a durable basis, while building resilience and the social and natural capitals, reducing environmental damage and improving the flow of environmental services”. In this context, resilience seems to be an outcome of sustainable intensification and not a stand-alone property of the food system dealing with shocks and stresses.

Future R&I in the area of resilience were announced in the “FOOD 2030 pathways for action” as. i) improving food system governance in crisis situations (such as pandemics, droughts, floods, changing weather) and ii) aligning predictive climate models, on food security, supporting data driven decision making (European Commission, 2020d).

7.4 Food system resilience in an international context

7.4.1 Sustainable Development Goals

The SDGs, launched by the UN in 2015, are a global framework for development to be reached in the year 2030. As commonly argued the goals are closely linked. SDG 2 of ending hunger is dependent on the accomplishment of other goals (e.g. SDG 1, 3, 5, 6, 12, 14, 15, 16). Resilience is very important for the accomplishment of the goals, as the effects of shocks and stresses can reverse years of development gains and efforts. Target 1.5 specifically focusses on resilience by aiming to “build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters” (United Nations, 2021). The indicators for this target show quite well the importance of resilience indicators.

7.4.2 Committee for World Food Security

The Committee for World Food Security (CFS) is the foremost inclusive international and intergovernmental platform for all stakeholders to work together to ensure food security and nutrition for all. The CFS develops and endorses policy guidance on a wide range of topics, most recently the Voluntary Guidelines on Food Systems and Nutrition. As a so-called “soft law instrument”, they shall provide a global norm of reference in the governance of food systems and provide principles and practices that governments can refer to when making laws and administering food systems for

sustainable development. As such they shall help to strengthen the resilience and adaptive capacity of food systems in response to climate change and humanitarian crises (CFS, 2020).

7.4.3 Food System Summit

In 2021, the UN Secretary-General will convene the UN Food Systems Summit which has the aim to help transform the way the world produces and consumes food, delivering progress on all 17 SDGs. The Summit aims to provide a platform for new actions, innovations, and plans to transform food systems. The Scientific Group of the summit stated that "conceptualizing systems' change is relevant for policy opportunities and for setting ambitions for the Food Systems Summit" (von Braun et al., 2020). The preparations for the Summit are underway. The summit has defined five priority work streams, called action tracks, in order to ensure inclusiveness. Action track 5 will explicitly address building resilience to vulnerabilities, shocks and stresses. The authors state that action tracks should solely be addressed together to achieve efficient solutions and to be able to acknowledge system-wide effects.

7.4.4 International trade policies

Domestic or local shocks tend to be more frequent and more severe than international shocks (OECD, 2021). Trade policies show cross-country effects and can play an important role by making use of world markets to buffer domestic and global shocks (OECD, 2013), if countries at the same time avoid policy measures that undermine the functioning of international markets (OECD, 2021). In global supply chain crises, such as the supply chain disruption during the Covid-19 pandemic, many governments tried to stabilize their domestic market by border measures (limits of export or imports) creating economic inefficiencies and undermining the functioning of international markets (OECD, 2021; Rudloff, 2020). Moreover, declining terms of trade and the volatility of global commodity prices, which are largely determined by commodity futures markets, can have an adverse effect on import-dependant countries (Tröster & Küblböck, 2020) and aggravate existing crises.

International policies - especially with regards to trade and the WTO as executive organisation in this respect – have thus great potential to enhance the resilience of global food systems. Although existing agreements set out rules for governing well-known risks, there is discussion to what extend these agreements allow for novel legislations addressing e.g. public health or climate action (SAPEA, 2020). These discussions could also be broadened to explicitly address food system resilience.

7.4.5 Transboundary external effects

In the past, EU policies have been criticized for having negative external effects on global food security (i.e. agricultural and trade policies), which could be addressed by decoupling subsidies for European agriculture and the abolition of export subsidies (Bureau & Swinnen Johan, 2017). Still, the way we consume and the intensity of production (i.e. of meat with a high degree of feed imports) do have external effects on climate change, deforestation, degradation of habitats and accelerated biodiversity loss (Benton & Carling Bieg, 2021), which, in the end, are essential for resilient food systems and food security.

7.5 Conclusions

We found that in the current discussion, the transformation of food systems is being discussed widely, but often replaces the discourse on food and nutrition security, while the latter being the main outcome. We also observed that food system resilience is not reflected in policies of the AU und EU to date. Also, the interconnections between African and European food systems and joint response

mechanisms are not fully explored. A reason might be the relative novelty of the topic and the uncertainty of leverage points and levers on how to transform the systems and to achieve resilience. The complexity of the concept and its, at times, ambiguous definitions might prevent clear boundaries, frameworks or objectives being defined, which are however needed for setting clear outcomes and deliverables. The UN Food System Summit will provide a platform for conceptualizing systems' change and give impulses for policy opportunities.

8 Guiding principles for resilience building and recommendations

The Covid-19 pandemic revealed the vulnerabilities of current food systems. The crisis disclosed important system functions such as transportation and logistics, the role of informal food workers, interlinkages with the ecosystem and the health system that had previously been overlooked or neglected. The pandemic showed highly variable effects on food systems in different countries and even within a country, also leading to a wide range of lessons learned. While we can learn from this crisis, it may not help us with other crises as the disturbances might be completely different. Different types of crises vary in length, intensity, geographic scale and the affected parts of the food system (see Chapter 6). Very often we also face situations of multiple crises, that are exacerbated by interactions. Specific and adapted measures are needed for prevention and responses. Drawing universal conclusions and providing general recommendations for leverage points is thus not possible. In this chapter we point to guiding principles that can lead the way to enhance food system resilience. Since R&I can play a crucial role in providing solutions, specific recommendations are outlined in the concluding section of this chapter.

8.1 Guiding principles for resilience building

As described in Chapter 3, researchers have developed principles and approaches for measuring and building food system resilience. In this section we refer to the 7 principles for building resilience conceptualized by Biggs et al. (2015), as the framework reflected many points that we encountered in literature and emerged from expert consultations. The principles are important features of complex systems, potentially contributing to the emergence of resilience rather than build resilience in and of themselves (Lindow et al., 2020). The principles refer to socio-ecological systems in general, but have previously also been applied and adapted to food systems by e.g. Kummu et al. (2020) and Halloran et al. (2020). In the following, we briefly introduce and then apply these principles to findings and insights from the previous chapters and expert discussions.

8.1.1 Maintain diversity and redundancy

Maintaining diversity, and especially response diversity, in combination with functional redundancy can increase resilience of social-ecological systems. Attention should be put to the costs of increasing biodiversity and redundancy, which requires balancing potential costs and benefits.

Response diversity refers to the diversity of types of responses (e.g. human decisions and action) to disturbances within a functional group. This means that multiple options are available within the system for reorganization, which increases resilience. Widening options and choices, such as diversifying livelihood portfolios with multiple sources of income can decrease dependency and increase the agency of people to respond to shocks and stresses in times of crisis. Functional redundancy (different actors or actions providing the same function) also results in a higher response diversity.

Our findings suggest that diversity in food systems can be promoted in farming systems (e.g. through nature-based solutions and agro-ecological production principles), in food environments (e.g. access to a diversity of nutritious food), and in structures across value chains (e.g. through access to inputs, logistics, retail, processing, and markets). This is also true for redundancy across value chains e.g. by reducing bottlenecks and dependencies by multi-sourcing.

Diversity and redundancy have a buffer function in food systems, e.g. against shortages, but also need to be thoroughly balanced as actions might be cost-intensive and are interlinked. It is also assumed

that redundancy can cause or increase food waste, which needs to be taken in consideration and should be avoided. Here policies play a key role in creating and balancing diversity and redundancy in food systems. The expert panel suggested that existing policies should be carefully reviewed to identify the extent to which they foster or prevent diversity and redundancy in food systems. Policies should then be adapted or replaced accordingly. In any case, this will require to prioritize the management of all functions that lead to food security at multiple scales rather than continuing to aim for profit maximization.

8.1.2 Manage connectivity

Managing connectivity, meaning the structure and strength of interaction of resources, species or social actors, can build a system's resilience. An enhanced flow of energy, material and information is fundamental for a resilient response to shocks and disturbances. On the opposite side, high connectivity bares the risk of disturbances to spread.

Vulnerabilities in value chains (e.g. dependency on migrant workers, uneven market power, overlooked informal sector) need to be analyzed to increase connectivity and collaboration of food system actors. Limitations and bottlenecks in the physical structure need to be removed in order to strengthen the connectivity by building and maintaining good infrastructure (e.g. roads, electricity, water), removing gaps in market structures (e.g. in packaging, trade), connecting remote rural and coastal areas to cities and avoiding food deserts. On a local level these connections can be established with the help of territorial markets, organizational arrangements to link food system actors (e.g. e-platforms), or strengthening local capacities for production and processing. Resilience can also profit from horizontal integration, and the inter-connectedness to other disciplines and sectors (e.g. agriculture, forestry, markets, environment, water and energy).

Whereas connectedness in food systems can increase resilience (e.g. through food provision in times of crisis), increased global connections can also create vulnerabilities through sectorial dependencies (i.e. food dependencies). Strong interregional and international cooperation (in trade and beyond), such as the AfCFTA, might have a stabilizing effect. Global governance arrangements to address the vulnerabilities in global food systems can manage decisive responses to shocks by building on greater global cooperation and coordination (cross border trade during crisis, mitigation of non-tariff barriers to trade, mobility, development cooperation and humanitarian assistance). They form the framework for different levels of governance.

As stated above, connectivity can have positive or negative effects. High connectivity increases spreading the risk to other food system actors. The connectivity of the food system was clearly shown in the Covid-19 situation, for example when restaurants were closed and demand from farmers delivering to the restaurants dropped, employers in the food service lost their income, consumer habits had to change and less left overs were available for charity activities.

8.1.3 Manage slow variables and feedbacks

Desired ecosystem services in social-ecological systems are based on slow variables and feedbacks that interact to sustain the current state of the system. If a system is producing a desired set of ecosystem services, slow variables and positive feedback mechanisms should be sustained to increase resilience. If the system is locked into an undesired state, negative feedback mechanisms that prevent the system from changing into another configuration might be weakened to transform the system.

Slow variables of food systems refer to slow, often unseen, changes that place the environment or a system at risk. The feedback loops between slow and fast variable are often not linear, but complex. In farming slow variables can for example be related to the status for soil; how degraded, how fertile and the compaction are influencing the yield potential. Slow variables of food system resilience can be manifested patterns of consumer behavior and cultural rooted diets and beliefs. They can either be strong feedback mechanisms that maintain a given system in its current undesirable state, or push a social–ecological system towards a tipping point and prepare for a system change. Childhood malnutrition was described as slow variable that can lead to a life-time and inter-generational consequences of acute malnutrition (communication from expert consultation). Institutional, community and individual capacities and particularly learning, innovation and adaptation can be seen as positive slow variable that can create windows of opportunities for change. Further research on identifying slow variables and related feedback loops in food systems would be needed to identify mechanisms that can enhance food system resilience.

8.1.4 Foster complex adaptive system thinking

Adapting a complex adaptive system thinking for management decisions has proven to enhance resilience in social-ecological systems. Complex adaptive thinking can be fostered by: adaption of a systems framework, tolerating and embracing uncertainty, investigating critical thresholds and non-linearities, acknowledging epistemological pluralism, bringing institutions together for joint analyses.

Decision-makers in food systems, who are expected to formulate and implement policy responses and prevention of stress and shocks, are at the core of resilience building. They need capacities to learn; to innovate, adapt and adopt; and to deal with complex problems that require collective action. The assessment of structural, economic, social and ecological vulnerabilities can be an approach to analyze food system resilience from different perspectives. Science can help in jointly identifying transformation pathways with stakeholders such as cross-ministerial working groups. We consider adoption of adaptive system thinking also useful for analyzing and balancing synergies and trade-offs. Acknowledging interdependencies and trade-offs within food systems, but also between food system outcomes and food system assets by adapting a complex adaptive system thinking, will help decision-makers to better predict the impact of introduced measures. Building on jointly developed framework for food system resilience (see Chapter 3) and applying methods for food system analysis (see Chapter 5) can help to understand system dynamics better and to identify leverage points for resilience building.

8.1.5 Encourage learning

A continuous learning process can enhance the resilience of social-ecological systems. Furthermore, through the complexity of social-ecological systems, knowledge always remains partial which makes learning an important part in a changing complex system. Learning can be supported through long-term monitoring, diverse participation, appropriate facilitation, sufficient financial and human resources and social networking.

In food systems, we consider innovations (technological and social) as important part of the learning process. Resilience building innovations (e.g. more diverse and better-connected value chains) should be enhanced through innovation support services and innovation hubs. People's and institutions' adaptive capacity to react to unpredictable, changing conditions (shocks such as pandemics) and slow evolving stresses (e.g. climate change) need to be strengthened through investment and training. Local entrepreneurship and food businesses can be stimulated through better access to information,

stronger cooperation, more inclusion, transparency and higher levels of aspiration and self-efficacy. Innovation and solutions of consumers, entrepreneurs and producers (e.g. niche technologies and behaviors in the crisis) can be spread as good practice and, if applied at scale, become trends.

Since the number of shocks and crises are likely to increase, a learning environment should be created in order to use the opportunity to draw conclusions ("lessons learned") and prepare for upcoming challenges by running a robust risk analysis across sectors and by building up an early warning system and social protection measures. This needs to be done on all levels. The provision of adapted social grants, school feeding and other forms of insurance could allow farmers and consumers to address their food needs while avoiding ecological destructive choices. Local communities can build up buffer capacities and risk protection schemes (insurances, food storage systems, inclusive saving and credit systems), although this is not yet fully explored. Often it is financially less cost intensive to invest in prevention rather than response measures.

8.1.6 Broaden participation

The active engagement of relevant stakeholders can range from informing stakeholders to equally shared power between stakeholders. Participation can increase transparency, sharing of knowledge, trust, legitimacy of decision and facilitate learning. These mechanisms help to detect disturbances and shocks in social-ecological systems but also to facilitate collective action for response.

The participation in food systems needs to consider the heterogeneity of food system actors. Inequal access to power and resources has resulted over time in socio-economic and political disaggregation in food systems. To increase resilience, we need to engage these actors in decision-making (see also next Section 8.1.7) and empower them by increasing the agency of individuals and institutions. When people have the capacity to act on their own priorities, there is the potential to achieve better and more durable outcomes. Strengthening the adaptive capacity of these people's food systems can only be achieved when they have adequate voice in processes resilience building. During the Covid-19 crisis we have seen enterprises that were able to respond to the challenges quite quickly. There were also social innovations, such as consumers and farmers starting new partnerships. Resilience strategies would foster stakeholders to reflect on their own perspectives, experience and behaviors to shape the context in which they operate. Access to information, enhanced capacities for active involvement and reducing power imbalances across the food system will build up fundamental elements of resilience.

8.1.7 Promote polycentric governance systems

Polycentric governance structures can enhance learning, institutional diversity and a broader level of participation and connectivity between stakeholders and therefore have the potential to enhance resilience. Nevertheless, Biggs et al. (2015) emphasize that there is a lack of knowledge regarding the operationalization of polycentric governance structures in social-ecological systems.

Food system governance reflects the priorities and power of different actors — in the public, civil society and private sectors. Prevailing governance models have allowed food systems to evolve in unpredictable ways that often led to less resilience. Polycentric governance structures are most capable of responding to priorities of different stakeholders in a food system. It builds on the heterogeneity of people in a food system in their different roles (consumer, retailer, processor etc.) and positions (gender and other types of social differentiation). Co-creation of resilience happens at the local level (e.g. rural communities or cities) and local, sometimes informal governance structures that are often overlooked. Food systems are a highly uneven political playing field, with actors with

tremendous power and economic interest. Agency and participation of all food system actors are therefore not easy to achieve. But policies can be created to hand back decision making power to the local actors and their representations. The local structures need to be embedded and vertically integrated into decision making at a higher level and "outer layer" of the food system. There needs to be a balance between decreasing dependency in responding quickly to change and creating an enabling policy and inclusive institutional environment at national, regional and international levels.

8.2 Recommendations for R&I

Achieving food and nutrition security in times of growing risks and uncertainties requires to rebuild our food systems to better prevent and cope with crisis, protect the people and the environment, and build back better. R&I in the Europe-Africa partnership needs to provide evidence for the impact of crises and join hand with others to identify new pathways to resilience.

8.2.1 Develop a common understanding and forge actions in resilience building

The types of food systems and their functioing varies greatly across Europe and Africa (see Section 3.1.2). In our analysis of food system resilience concepts, we showed that the term resilience and its application to food systems are often interpreted differently. A common, overarching understanding through a comprehensive framework needs to be developed and agreed upon in a process that includes stakeholders from science, civil society, and policy. Such a framework also needs to address needs of all food system actors, including informal institutions, and recognize the role of human agency and innovation in resilience building (see Chapter 3).

Resilience building measures cannot be defined generally, but need to take into account variations in food systems and context. These measures need to recognize potential trade-offs between (i) resilience and other guiding principles, such as economic growth, (ii) resilience on different levels and scales, and (iii) food security and other food systems outcomes (see Chapter 4). Methods for food system analysis can contribute to assess, faciliate and monitor the impact of resilience building. However, improved metrics with comparable indicators and parameters (on different levels and scales of food systems), capacity building in complex, adaptive systems thinking, inter-/ transdisciplinary skills and intrateged approaches are needed to build the foundation of a more effective dialogue between stakeholders from different sectors and disciplines.

The Food System Summit organised by the United Nations General Secretary in autumn 2021 is a good opportunity to work together to develop global resilience strategies for food systems. The dialogue and discussions of the action tracks are important processes to bring together key stakeholders. General principles for resilience building, such as outlined in Section 8.1, can inform the design of specific measures. This requires in-depth discussions of opportuntines for resilience building, while taking into account trade-offs and other challenges. It is a cross-cutting topic across all action tracks that requires joint effort and balancing of interests.

8.2.2 Create a research agenda to guide policy making in Europe and Africa

Neither the EU and AU nor most of their member countries currently have an overarching food system policy and thus also no common policy for resilience of food systems. A fully 'integrated' policy approach towards food systems needs to include resilience in order to react to a wide range of risks. Although some policies that help to withstand short-term shocks are in line with the aim of increasing productivity and sustainability, other measures should focus on food price stability. We believe that

potential trade-offs, such as competing goals of maximising output or efficiency, need to be analysed to make resilience a political goal.

While the policy framework on continental and national level is important, a nested approach to food system governance is needed. Governance structures on a local level may react quickly to crises, but on a longer-term may require national / continental support. A polycentric governance can create an important momentum in building resilience. For this aim stakeholders need the capacity to monitor and analyze vulnerabilities against a wide range of shocks and stresses, including potential interactions, and context-specific risk management strategies across levels and scales of food systems. What specific types and forms of governance would be best fo resilient food system in the different policy fields (trade, market, land-use, etc) and how to manage these new government structures remain open research questions.

R&I can take a guiding role in identifying context-specific leverage points for resilience building by studying and addressing vulnerabilities and imbalances in food systems. In such a role, R&I could support policy makers e.g. through forecasting methods and simulations (including system modeling, scenario building, judgmental probability, horizon scanning), development of hypotheses to be tested in practice, and by making recommendations for conducive levers, such as regulatory policies, investments, training or further research. For this research should engage in multi-stakeholder settings at different levels.

Based on insights from the previous chapters and discussion with the expert panel, we identified research areas that are likely to advance the understanding of resilience in food systems and potential measures for resilience building. Based on these insights, we propose a research agenda that addresses the following issues:

- **The principles**, presented in Section 8.1 can guide initiatives that aim at resilience building. But big knowledge gaps remain concerning the application of the principles in a specific context, on the extend and their interrelatedness. To test the principles and their application in specific situations of African and European food systems could be a research program on its own.
- **Connectivity** can create resilience; it is however unknown to what extent interdependencies are favourable for resilience or how dependencies affect a system's vulnerability. Also, there is no universal recipe of success to establish an enabling environment for co-creation of resilience at local level or to build coalitions and mechanisms for change in governance. Traditional networks have been weakened and undermined, but have the potential to increase collaboration and connectivity as well as to help food systems to adapt and reorganise. Local initiatives should be integrated within a nested governance approach, but more research is needed to assess the different levels influencing each other and to analyse how this vertical integration works best. This also includes a better knowledge on the often missing intermediate levels.
- **Diversity** is a recognized strategy towards resilience. There are however knowledge gaps regarding the level (local to global), scale (production to consumption) and type of diversity (functioning despite of or in response to shocks; response diversity) being the most effective to create resilience. An unknown balance between specialization and diversification might also exist. **Redundancy** leads to more resilience in food systems. Similar to diversity, knowledge gaps exist with regards to the level, scale and type as well as impact and trade-offs of redundancy to successfully enhance resilience in food systems. Finally, diversity is not limited to the food system itself. The Covid-19 pandemic brought to our attention the need to see the close links between

the agro-food system and the ecosystems. We do have a very limited understanding of the tipping points. Policy measures have to aim at rebuilding natural capital.

- **International trade** can reduce volatility by enabling countries to make use of world markets in the face of domestic shocks. On the other hand, dependency on these markets during international crises like Covid-19 might put these countries at risk. Therefore, the relation of trade, the dependency and interdependency related to food security, need to be revisited from a resilience perspective. Territorial approaches as proposed by the Task Force Rural Africa might have a strong potential to mitigate risk and build resilience. Further investigations on territorial approaches (such as territorial markets), their performance, drivers and associated challenges are however needed.
- **Policies** are important levers to transform the food systems. Yet, a deeper understanding is needed of the impact that political measures can have on resilience. Measures such as fiscal policies, incentives and financing, regulatory policies, market and trade instruments, as well as standard settings need to be analyzed to see whether the lever works effectively and as expected. In detail, it needs to be assessed how these levers relate or interact with other policy instruments, and how they can contribute to build buffers in the system. The intersection and collaboration between the public and private actors need to be better investigated, as the private sector plays a key role in food systems, often able to react to shocks quickly and with high capacities. Moreover, the government should be responsible for supporting the vulnerable. Social protection schemes have proven to be important and effective to help individuals at risk buffer shocks.
- Food system governance reflects **power relations between different actors in food systems**. Shocks and stresses can re-inforce inequalities between social groups. Building resilience requires to address imbalances between formal and informal, public and private sector, and the role of NGOs that represent the voices of less powerful social groups. Research is needed to understand current response mechanisms to shocks and stresses, i.e. who meets with whom to determine which suite of responses is to be enacted; who sets the agenda for action, and with what implications; who convenes the meetings, and who is included and excluded; who ultimately determines the flow of resources, and with what implications for revenue generation to fund these flows?
- **Human agency and the adaptive capacity of the people** to mobilize their resources to deal with shocks are at the core of resilience building. People across the food system need an enabling environment, effective governance and supporting infrastructure, such as easy access to credit, saving and insurance facilities and access digital technologies to react and adapt to shocks and stress. A better knowledge base and effective strategies to increase the resilience capacities of the people are needed. Special focus must be placed on vulnerable people, e.g. by financing and de-risking women farmers as well as reducing power imbalances in value chains. Digital technologies can create new opportunities in the field of learning, knowledge exchange and marketing before, in and after the crises. However, we need to know how to harness the potential of these technologies to better support people when responding and adapting to shocks and stresses.

Addressing these issues needs interdisciplinary research, including humanities, to examine and understand the functioning of food systems. To create impact on food system across Africa and Europe, we need to link general principles of resilience building with a broader research agenda on building a new food systems narrative with a focus on human nutrition and planetary health, research,

innovation, social protection systems, financing, leadership, fair trade and smart partnership from regional and bi-continental perspectives.

In March 2021, Bakker et al. (2021) published the white paper "Towards a Future Research Agenda on Food System Resilience". The report identified knowledge gaps and proposes a set of research questions and issues with strategic importance for enhancing the resilience of food systems in African and Europe:

Shocks and stressors to food systems

- How do shocks and stressors relate to each other and what happens when they combine or overlap to create compounding shocks and stressors?
- How do shocks and stressors affect actors, activities and food system segments differently?
- What are the unique challenges for food systems as compared to other societal systems?

Synergies and trade-offs:

- Short-term and long-term gains
- Rural and urban demands
- Diversifying and specializing functions
- Self-sufficiency and import dependency
- Intensified versus sustainable and regenerative use of natural resources

Leverage points for resilience building:

- Which market failures leave food systems ill-prepared for shocks and stressors?
- How do interventions for food system resilience interact?
- What is the potential role of digital solutions in resilience building?

Governance of food system resilience

- Can food systems be transformed 'from above' and through policies, or will change emerge only from pressure 'from below'?
- How to achieve more inclusive forms of food system governance?
- What is the role of government in multi-stakeholder governance?
- How do formal and informal governance relate to each other?

8.2.3 Include food system resilience in the research partnership

As Europe and Africa are already highly interconnected, the partnership between the AU and the EU can scale up regional integration for more resilience through cooperation, coordination and knowledge exchange as well as address the highlighted research needs in this report. Long term alliances and collaboration in R&I is an important pillar of this cooperation and key to priority schemes of international relevance among research funders. Finding appropriate answers to upcoming crises such as pests, diseases and the effects of climate change should be high up on the agenda and find appropriate finance mechanisms.

As research programmes are still scattered across different sectors and disciplines, the research landscape for commissioning R&I should adequately address the issues and knowledge gaps we have raised above. Funding and long term support for trans-regional and transdisciplinary research efforts,

engagement of scientific and policy communities as well as an understanding of differences occurring within and in-between regions and developing interregional/global approaches should be supported.

The research partnership should serve as a mutual learning and knowledge sharing opportunity where research results can be interlinked and up-scaled. Establishing communities of exchange related to specific crises could also be useful. Different regions facing similar shocks or stresses should engage in exchange on best-practice and leverage points. An in-depth analysis of the political and economic interconnections between the two continents will help to shape strategies improving resilience in African and European foods systems. This could be aimed at, e.g. more inclusive value webs, joint response mechanisms and mutual learning platforms, also proposed by the Task Force Rural Africa.

Resilience is not yet in the focus of the FNSSA partnership's R&I roadmap (see Chapter 7). We propose that resilience should be established as a cross-cutting theme of the three overarching R&I topics as outlined above. Our identified research gaps can provide a framework on how to apply a resilience perspective across all topics and collaborative research. In that context, the issues do not need to be studied in general terms; food system resilience needs to be specified in terms of food system levels and scales, types of shock or stresses, and most vulnerable groups affected by those.

9 References

Achterbosch, T. J., Escudero, A. G., Dengerink, J. D., & van Berkum, S. (2019). *Synthesis of existing food systems studies and research projects in Europe*. Brussels. European Commission, Directorate-General for Research and Innovation.

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

AfCFTA Secretariat, & UNDP. (2020). *The Futures Report: Making the AfCFTA work for women and youth*. https://au.int/sites/default/files/documents/39689-doc-ss_afcftafuturereport.pdf

African Union (n.d.). Impact of the Coronavirus (Covid 19) on the African Economy. https://au.int/sites/default/files/documents/38326-doc-covid-19_impact_on_african_economy.pdf

African Union, & NEPAD. (2003). *Comprehensive Africa Agriculture Development Programme*. New Partnership for Africa's Development. http://www.commit4africa.org/sites/default/files/CAADP2003.pdf

African Union Commission. (n.d.). *CAADP: Implementation Strategy and Roadmap to Achieve the 2025 Vision on CAADP*. Addis Ababa.

African Union Commission. (2015). *Agenda 2063*. Addis Ababa.

Akiwumi, P. (2020). *COVID-19: A threat to food security in Africa: Development Matters OECD*. https://oecd-development-matters.org/2020/08/11/covid-19-a-threat-to-food-security-in-africa/

Allen, P. (2010). Realizing justice in local food systems. *Cambridge Journal of Regions, Economy and Society*, *3*(2), 295–308. https://doi.org/10.1093/cjres/rsq015

Altieri, M. A., & Nicholls, C. I. (2020). Agroecology and the reconstruction of a post-COVID-19 agriculture. *The Journal of Peasant Studies*, *47*(5), 881–898. https://doi.org/10.1080/03066150.2020.1782891

Arouna, A., Soullier, G., Mendez del Villar, P., & Demont, M. (2020). Policy options for mitigating impacts of COVID-19 on domestic rice value chains and food security in West Africa. *Global Food Security*, *26*, 100405. https://doi.org/10.1016/j.gfs.2020.100405

Arslan, A., van Berkum, S., Cavatassi, R. E., Di Nucci, C., Ruben, R., Smaling, E., Stefanelli, T., Steenhuijsen Piters, B. de, Reyes, S., & Winters Paul. (2020). *IFAD RDR 2021 – Framework for the Analysis and Assessment of Food Systems Transformations*. https://www.wur.nl/en/show/IFAD-framework-food-system-transformations.htm

Ashford, N. A., Hall, R. P., Arango-Quiroga, J., Metaxas, K. A., & Showalter, A. L. (2020). Addressing Inequality: The First Step Beyond COVID-19 and Towards Sustainability. *Sustainability*, *12*(13), 5404. https://doi.org/10.3390/su12135404

Bakalis, S., Valdramidis, V. P., Argyropoulos, D., Ahrne, L., Chen, J., Cullen, P. J., Cummins, E., Datta, A. K., Emmanouilidis, C., Foster, T., Fryer, P. J., Gouseti, O., Hospido, A., Knoerzer, K., LeBail, A., Marangoni, A. G., Rao, P., Schlüter, O. K., Taoukis, P., . . . van Impe, J. F. M. (2020). Perspectives from CO+RE: How COVID-19 changed our food systems and food security paradigms. *Current Research in Food Science*, *3*, 166–172. https://doi.org/10.1016/j.crfs.2020.05.003

Bakker, D., Termeer, E., & de Steenhuijsen Piters, B. (2021). *Towards a Futute Research Agenda on Food Systems Resilience*. Wageningen, the Netherlands. Wageningen Universtiy and Research. https://edepot.wur.nl/543213

Barrett, C. B., & Constas, M. A. (2014). Toward a theory of resilience for international development applications. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(40), 14625–14630. https://doi.org/10.1073/pnas.1320880111

Belik, W. (2020). Sustainability and food security after COVID-19: relocalizing food systems? *Agricultural and Food Economics*, *8*(1). https://doi.org/10.1186/s40100-020-00167-z

Béné, C. (2020). Resilience of local food systems and links to food security - A review of some important concepts in the context of COVID-19 and other shocks. *Food Security*, 1–18. https://doi.org/10.1007/s12571-020-01076-1

Béné, C., Headey, D., Haddad, L., & Grebmer, K. von (2016). Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. *Food Security*, *8*(1), 123–138. https://doi.org/10.1007/s12571-015-0526-x

Béné, C., Newsham, A., Davies, M., Ulrichs, M., & Godfrey-Wood, R. (2014). REVIEW ARTICLE: RESILIENCE, POVERTY AND DEVELOPMENT. *Journal of International Development*, *26*(5), 598–623. https://doi.org/10.1002/jid.2992

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., Haan, S. de, Prager, S. D., Talsma, E. F., & Khoury, C. K. (2019). When food systems meet sustainability – Current narratives and implications for actions. *World Development*, *113*, 116–130. https://doi.org/10.1016/j.worlddev.2018.08.011

Béné, C., Prager, S. D., Achicanoy, H. A., Toro, P. A., Lamotte, L., Cedrez, C. B., & Mapes, B. R. (2019a). Global map and indicators of food system sustainability. *Scientific Data*, *6*(1), 279. https://doi.org/10.1038/s41597-019-0301-5

Béné, C., Prager, S. D., Achicanoy, H. A., Toro, P. A., Lamotte, L., Cedrez, C. B., & Mapes, B. R. (2019b). Understanding food systems drivers: A critical review of the literature. *Global Food Security*, *23*, 149–159. https://doi.org/10.1016/j.gfs.2019.04.009

Béné, C., Wood, R. G., Newsham, A., & Davies, M. (2012). Resilience: New Utopia or New Tyranny? Reflection about the Potentials and Limits of the Concept of Resilience in Relation to Vulnerability Reduction Programmes. *IDS Working Papers*, *2012*(405), 1–61. https://doi.org/10.1111/J.2040-0209.2012.00405.X (IDS Working Papers, 2012(405), 1-61).

Benton, T., & Carling Bieg, H. H. (2021). *Food system impacts on biodiversity loss: Three levers for food system transformation in support of nature*. Chatham House Research Paper Energy, Environment. 2021-02-03-food-system-biodiversity-loss-benton-et-al.pdf

Biggs, R., Schlüter, M., & Schoon, M. L. (Eds.). (2015). *Principles for building resilience: Sustaining ecosystem services in social-ecological systems*. Cambridge University Press.

Bohle, H.-G., Etzold, B., & Keck, M. (2009). Resilience as Agency. *IHDP Update*(2), 8–13.

Bousquet, F., Botta, A., Alinovi, L., Barreteau, O., Bossio, D., Brown, K., Caron, P [Patrick], Cury, P., d'Errico, M., DeClerck, F., Dessard, H., Kautsky, E. E., Fabricius, C., Folke, C., Fortmann, L., Hubert, B., Magda, D., Mathevet, R., Norgaard, R. B., . . . Staver, C. (2016). Resilience and development: mobilizing for transformation. *Ecology and Society*(21), 18. https://doi.org/10.5751/

Brouwer, I. D., McDermott, J., & Ruben, R. (2020). Food systems everywhere: Improving relevance in practice. *Global Food Security*, *26*, 100398. https://doi.org/10.1016/j.gfs.2020.100398

Bureau, J. C., & Swinnen Johan (2017). EU Policies and Global Food Security: LICOS Discussion Paper Series; Discussion Paper 392/2017.

CAADP, & NEPAD. (n.d.). *The CAADP Results Framework 2015-2025: Going for results and impacts*. Sustaining CAADP momentum. African Union Commission; NEPAD Planning and Coordinating Agency. https://au.int/sites/default/files/documents/31250-doc-the_caadp_results_framework_2015-2025_english_edited_1-1.pdf

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? *Ecosystems*, *4*(8), 765–781. https://doi.org/10.1007/s10021-001-0045-9

Cazzolla Gatti, R., Menéndez, L. P., Laciny, A., Bobadilla Rodríguez, H., Bravo Morante, G., Carmen, E., Dorninger, C., Fabris, F., Grunstra, N. D. S., Schnorr, S. L., Stuhlträger, J., Villanueva Hernandez, L. A., Jakab, M., Sarto-Jackson, I., & Caniglia, G. (2021). *Diversity lost: Covid-19 as a phenomenon of the total environment* (Vol. 756). https://doi.org/10.1016/j.scitotenv.2020.144014

CFS. (2015). *Framework for Action for Food Security and Nutrition in Protracted Crises.* Committee on World Food Security. http://www.fao.org/3/a-bc852e.pdf

CFS. (2020). *Voluntary Guidelines on Food Systems and Nutrition, Zero Draft*. http://www.fao.org/fileadmin/templates/cfs/Docs1819/Nutrition/CFS_Zero_Draft_Voluntary_Guidelines_Food_Systems_and_Nutrition.pdf

CGIAR, EAT, SDSN. *Integrated Indicators for Sustainable Food Systems and Healthy Diets in the Post-2015 Development Agenda. Final Statement September 17th 2015*. https://cgspace.cgiar.org/handle/10947/4011

Chaudhary, A., Gustafson, D., & Mathys, A. (2018). Multi-indicator sustainability assessment of global food systems. *Nature Communications*, *9*(1), 848. https://doi.org/10.1038/s41467-018-03308-7

Cutter, S. L. (2016). Resilience to What? Resilience for Whom? *The Geographical Journal*, *182*(2), 110–113. https://doi.org/10.1111/geoj.12174

Davies, S. (2016). *Adaptable Livelihoods: Coping with Food Insecurity in the Malian Sahel*. Palgrave Macmillan Limited.

de Schutter. (2014). *Final Report:The transformative potential of the right to food. Presented to the 25th Session of the UN Human Rights Council, United Nations General Assembl*. http://www.srfood.org/en/documents

Dekeyser, K., & Rampa, F. (2019). *Connecting the dots for sustainable food systems in Kenya (blog post)*. https://ecdpm.org/talking-points/connecting-dots-sustainable-food-systems-kenya/

Dekeyser, K., Rampa, F., D'Alessandro, C., & Bizzotto Molina, P. (2020). *The food systems approach in practice: Our guide for sustainable transformation - ECDPM Discussion Paper 278*. Maastricht. European Centre for Development Policy Management.

Dornelles, A. Z., Boyd, E., Nunes, R. J., Asquith, M., Boonstra, W. J., Delabre, I., Denney, J. M., Grimm, V., Jentsch, A., Nicholas, K. A., Schröter, M., Seppelt, R., Settele, J., Shackelford, N., Standish, R. J., Yengoh, G. T., & Oliver, T. H. (2020). Towards a bridging concept for undesirable resilience in social-ecological systems. *Global Sustainability*, *3.* https://doi.org/10.1017/sus.2020.15

Dury, S., Bendjebbar, P., Hainzelin, E., Giordano, T., & Bricas, N. (Eds.). (2019). *Food systems at risk. New trends and challenges*. FAO, CIRAD and European Commission. https://doi.org/10.19182/agritrop/00080

EAT Lancet Commission. (2019). *Healthy Diets From Sustainable Food Systems*. https://eatforum.org/content/uploads/2019/01/EAT-Lancet_Commission_Summary_Report.pdf

Ericksen, P. (2008). Conceptualizing food systems for global environmental change research. *Global Environmental Change*, *18*(1), 234–245. https://doi.org/10.1016/j.gloenvcha.2007.09.002

Ericksen, P., Bohle, H.-G., & Stewart, B. (2012). Vulnerability and Resilience of Food Systems. In J. Ingram, P. Ericksen, & D. M. Liverman (Eds.), *Food Security and Global Environmental Change.* Taylor and Francis.

EU-Africa HLPD STI. (2016). *Roadmap towards a jointly funded EU-Africa Research & Innovation Partnership on Food and Nutrition Security and Sustainable Agriculture*. Addis Ababa. EU-Africa High Level Policy Dialogue on Science, Technology and Innovation. https://ec.europa.eu/research/iscp/pdf/policy/eu-africa_roadmap_2016.pdf

European Commission. (2013). *Humanitarian Food Assistance: From Food Aid to Food Assistance*. DG ECHO Thematic Policy Document n° 1. https://ec.europa.eu/echo/files/policies/food_assistance/them_policy_doc_foodassistance_en.pdf

European Commission. (2017). *Future-Proofing our Food systems through Research and Innovation*. https://fit4food2030.eu/wp-content/uploads/2018/02/food2030-future_proofing_our_food_systems.pdf

European Commission. (2018a). *Assessment of Research and Innovation on Food Systems by European Member States*. Brussels. https://ec.europa.eu/research/bioeconomy/pdf/publications/Assessment_of_R_and_I_on_food_systems.pdf

European Commission. (2018b). *Research and innovation for food and nutrition security:: transforming our food systems 2nd FOOD 2030 high level event : conference outcome report, 14-15 June 2018 in Plovdiv (Bulgaria)*. Publications Office of the European Union.

European Commission. (2018c). *Roadmap for EU - African Union S&T cooperation*. https://ec.europa.eu/research/iscp/pdf/policy/africanunion_roadmap_2018.pdf

European Commission. (2020a). *The European Green Deal: Communication from the Commission to the European Parliament,the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions*. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

European Commission. (2020b). *Farm to Fork Strategy.* European Union. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf

European Commission. (2020c). *Food 2030 pathways for action:: Research and innovation policy as a driver for sustainable, healthy and inclusive food systems.* European Union. https://ec.europa.eu/info/sites/info/files/research_and_innovation/research_by_area/documents/report-2020.2044_en_04.pdf https://doi.org/10.2777/104372

European Commission. (2020d). *Food 2030 Pathways for action: Research and innovation policy as a driver for sustainable, healthy and inclusive food systems*. https://op.europa.eu/en/publication-detail/-/publication/86e31158-2563-11eb-9d7e-01aa75ed71a1

European Commission. (2020e). *Resilience and Transformation: Report of the 5th SCAR Foresight Exercise Expert Group - Natural resources and food systems: Transitions towards a 'safe and just' operating space.*

European Commission. (Brussels, 2020, March 9). *Towards a comprehensive Strategy with Africa: JOINT COMMUNICATION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL*. JOIN(2020) 4 final. https://ec.europa.eu/international-partnerships/system/files/communication-eu-africa-strategy-join-2020-4-final_en.pdf

Fanzo, J., Haddad, L., McLaren, R., Marshall, Q., Davis, C., Herforth, A., Jones, A., Beal, T., Tschirley, D., Bellows, A., Miachon, L., Gu, Y., Bloem, M., & Kapuria, A. (2020). The Food Systems Dashboard is a

new tool to inform better food policy. *Nature Food*, *1*(5), 243–246. https://doi.org/10.1038/s43016-020-0077-y

FAO. (2013). *Sustainabilty assessment of food and agriculture sytems (SAFA) indicators*. Rome. http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/SAFA_Indicators_final_19122013.pdf

FAO. (2018a). *Strengthening sector policies for better food security and nutrition results. Policy guidance note 12.* http://www.fao.org/3/CA2797EN/ca2797en.pdf

FAO. (2018b). *Sustainable food systems: Concept and framework.* Food and Agriculture Organization of the United Nations. http://www.fao.org/3/ca2079en/CA2079EN.pdf

FAO. (2020a). *Addressing the impacts of COVID-19 in food crises (April–December 2020), FAO's component of the Global COVID-19 Humanitarian Response Plan*. Rome. http://www.fao.org/3/ca8497en/CA8497EN.pdf

FAO. (2020b). *City Region Food System Toolkit*. http://www.fao.org/in-action/food-for-cities-programme/toolkit/introduction/en/

FAO. (2020c). *Food flow mapping, City*. http://www.fao.org/in-action/food-for-cities-programme/toolkit-old/crfs-scan/characterisation-of-the-crfs/food-flow-mapping/en/

FAO. (2020d). *Impact of COVID-19 on agriculture, food systems and rural livelihoods in Eastern Africa: policies and programmatic options.* Accra. http://www.fao.org/3/cb0552en/CB0552EN.pdf

FAO. (2020e). *Mitigating risks to food systems during COVID-19: Reducing food loss and waste*. http://www.fao.org/3/ca9056en/CA9056EN.pdf https://doi.org/10.4060/ca9056en

FAO. (2020f). *Responding to COVID-19 food disruptions in Africa*. http://www.fao.org/3/cb0551en/CB0551EN.pdf https://doi.org/10.4060/cb0551en

FAO, IFAD, UNICEF, WFP, & WHO. (2020). *The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets* (State of food security and nutrition in the world). Rome. http://www.fao.org/3/ca9692en/CA9692EN.pdf https://doi.org/10.4060/ca9692en

Folke, C. (2006). *Resilience: The emergence of a perspective for social–ecological systems analyses* (Vol. 16). https://doi.org/10.1016/j.gloenvcha.2006.04.002

Foresight4Food. (2020, December 21). *A Framework for Understanding Foresight & Scenario Analysis*. https://www.foresight4food.net/a-framework-for-understanding-foresight-scenario-analysis/

Francis, C., Lieblein, G., Steinshold, H., Breland, T,A, Helenius, J, Sriskandarajah, N., & Salomonsson, L. (2005). Food Systems and Environment: Building Positive Rural-Urban Linkages. *Human Ecology Review*, *12*(1), 60–71.

Fraser, E. D., Mabee, W., & Figge, F. (2005). A framework for assessing the vulnerability of food systems to future shocks. *Futures*, *37*(6), 465–479. https://doi.org/10.1016/j.futures.2004.10.011

Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change*, *72*(6), 681–696. https://doi.org/10.1016/j.techfore.2004.08.014

Gill, M., den Boer, A. C. L., Kok, K. P., Breda, J., Cahill, J., Callenius, C., Caron, P [P.], Damianova, Z., Gurinovic, M. A., Lähteenmäki, L., Lang, T [T.], Laperrière, A., Mango, C., Ryder, J., Sonnino, R., Verburg G., Westhoek. H., Regeer, B. J., & Broerse, J. E. W. (2018). FIT4FOOD2030 A Systems Approach to Research and Innovation for Food System Transformation. https://fit4food2030.eu/eu-think-tank-policy-brief/

Global Panel on Agriculture and Food Systems for Nutrition. (2015). *Improved metrics and data are needed for effective food system policies in the post-2015 era. Technical Brief.* London, UK. Global Panel on Agriculture and Food Systems for Nutrition.

Global Panel on Agriculture and Food Systems for Nutrition. (2016). *Food systems and diets: Facing the challenges of the 21st century.* London, UK.

Group of Chief Scientific Advisors. (2020). *Towards a Sustainable Food System: Moving from food as a commodity to food as more of a common good*. Scientific Opinion No.8. Brussels. European Commission.

Gustafson, D., Gutman, A., Leet, W., Drewnowski, A., Fanzo, J., & Ingram, J. (2016). Seven Food System Metrics of Sustainable Nutrition Security. *Sustainability*, *8*(3), 196. https://doi.org/10.3390/su8030196

Halberg, N., & Westhoek, H. (2019). *SCAR SWG Food systems Policy Brief: The added value of a Food Systems Approach in Research and Innovation*. Brussels. https://op.europa.eu/en/publication-detail/-/publication/99b01497-e006-11e9-9c4e-01aa75ed71a1/language-en

Halloran, A., Wood, A., & Sellberg, M. (2020). *What can the COVID-19 pandemic teach us about resilient Nordic food systems?* https://doi.org/10.6027/nord2020-038

Handmer, J., Honda, Y., Kundzewicz, Z., Arnell, N., Benito, G., Hatfield, J., Mohamed, I. F., Peduzzi, P., Wu, S., Sherstyukov, B., Takahashi, K., & Yan, Z. Changes in Impacts of Climate Extremes: Human Systems and Ecosystems: A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). In https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap4_FINAL-1.pdf In: Managing theRisks of Extreme Events and Disasters to Advance Climate Change Adaptation.

Harris, J [Jenileigh], & Spiegel, E. J. (June 2019). *Food Systems Resilience: Concepts & Policy Approaches*. https://www.vermontlaw.edu/sites/default/files/2019-07/Food%20Systems%20Resilience_Concepts%20%26%20Policy%20Approaches.pdf

Hawkes, C. (2020, December 10). *COVID-19 and the promise of food system innovation | Blog: IFPRI : International Food Policy Research Institute*. https://www.ifpri.org/blog/covid-19-and-promise-food-system-innovation

Herforth, A., & Ahmed, S. (2015). The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Security*, *7*(3), 505–520. https://doi.org/10.1007/s12571-015-0455-8

Hertel, T. W., Elouafi, I., & Ewert, F. (2020). *Building Resilience to Vulnerabilities, Shocks and Stresses - a paper on Action Track 5 - Draft for discussion.* Scientific Group for the UN Food Systems.

HLPE. (2014). *Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome.

HLPE. (2017). *Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome.

HLPE. (2020a). *Food security and nutrition: building a global narrative towards 2030. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome.

HLPE. (2020b). *Impacts of COVID-19 on food security and nutrition: developing effective policy responses to address the hunger and malnutrition pandemic: HLPE issues paper*. Rome.

HLPE. (2020c). *Interim issues paper on the impact of COVID-19 on food security and nutrition (FSN): High-Level Panel of Experts on Food Security and nutrition (HLPE). (2020). Interim issues paper on*

the impact of COVID-19 on food security and nutrition (FSN). Rome, Italy: Committee on World Food Security.

Hodbod, J., & Eakin, H. (2015). Adapting a social-ecological resilience framework for food systems. *Journal of Environmental Studies and Sciences*, *5*(3), 474–484. https://doi.org/10.1007/s13412-015-0280-6

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*(4).

Hospes, O., & Brons, A. (2016). Food System Governance: a systematic literature review. In A. Kennedy & J. Liljeblad (Eds.), *Food Sysetm Governance. Challenges for Justice, Equality and Human Rights.* Routledge.

Husain, A., Sandström, S., Greb, F., Groder, J., & Pallanch, C. (2020). *COVID-19: Potential impact on the world's poorest people: A WFP analysis of the economic and food security implications of the pandemic*. Rome. World Food Programme.

IFPRI. (2013). *Definitions of Resilience: 1996–Present*. Washington, DC. http://www.2020resilience.ifpri.info/files/2013/08/resiliencedefinitions.pdf.

IFPRI. (2014). *Resilience for food and nutrition security*. Washington, DC. https://doi.org/10.2499/9780896296787

IFPRI. (2016). *Global Food System Index. Concept Note: Prepared by IFPRI under its Compact2025 initiative with input from the World Bank, Rabobank, and Landesa*. Submitted to the World Economic Forum (WEF) Global Agenda Council (GAC) on Food and Nutrition Security.

IFPRI. (2020). *2020 Global Food Policy Report: Building Inclusive Food Systems*. Washington, DC. https://doi.org/10.2499/9780896293670

Ihle, R., Rubin, O. D., Bar-Nahum, Z., & Jongeneel, R. (2020). Imperfect food markets in times of crisis: Economic consequences of supply chain disruptions and fragmentation for local market power and urban vulnerability. *Food Security*, *12*(4), 1–8. https://doi.org/10.1007/s12571-020-01084-1

Ingram, J. (2011). A food systems approach to researching food security and its interactions with global environmental change. *Food Security*, *3*(4), 417–431. https://doi.org/10.1007/s12571-011-0149-9

Ingram, J. (2017). Food system resilience. *Food Science and Technology*, *31*(4), 21–23. https://doi.org/10.1002/fsat.3104_6.x

Ingram, J., Zurek, M., Sykes, R., & O'Kane, E. (2019). *Exploring the resilience of the UK food system in a global context*. UK. Global Food Security's 'Resilience of the UK Food System in the Global Context. https://www.foodsecurity.ac.uk/publications/

IPES-Food. (2019). *Towards a Common Food Policy For The European Union*. http://www.ipes-food.org/_img/upload/files/CFP_FullReport.pdf

IPES-Food (2020). COVID-19_Communique, COVID-19 and the crisis in food systems: Symptoms, causes, and potential solutions. http://www.ipes-food.org/_img/upload/files/COVID-19_CommuniqueEN%283%29.pdf

Jacobi, J., Mukhovi, S., Llanque, A., Augstburger, H., Käser, F., Pozo, C., Ngutu Peter, M., Delgado, J. M. F., Kiteme, B. P., Rist, S., & Ifejika Speranza, C. (2018). Operationalizing food system resilience: An indicator-based assessment in agroindustrial, smallholder farming, and agroecological contexts in Bolivia and Kenya. *Land Use Policy*, *79*, 433–446. https://doi.org/10.1016/j.landusepol.2018.08.044

Jacobi, J., Wambugu, G., Ngutu, M., Augstburger, H., Mwangi, V., Zonta, A. L., Otieno, S., Kiteme, B. P., Delgado Burgao, J. M. F., & Rist, S. (2019). Mapping Food Systems: A Participatory Research Tool

Tested in Kenya and Bolivia. *Mountain Research and Development*, *39*(1), R1-R11. https://doi.org/10.1659/MRD-JOURNAL-D-18-00024.1

Janssen, M. A., & Ostrom, E. (2006). *Resilience, vulnerability, and adaptation: A cross-cutting theme of the International Human Dimensions Programme on Global Environmental Change* (Vol. 16). https://doi.org/10.1016/j.gloenvcha.2006.04.003

Johm, K. B., Oladapo, O., Odhiambo, W., Mpyisi, E., & Yinusa, M. (2016). *Feed Africa: Strategy for Agricultural Transformation in Africa 2016-2025*. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Feed_Africa-_Strategy_for_Agricultural_Transformation_in_Africa_2016-2025.pdf

Kiaga, A. (2020). *The impact of the COVID-19 on the informal economy in Africa and the related policy responses: ILO Brief 14/4/2020.*

Klassen, S., & Murphy, S. (2020). Equity as both a means and an end: Lessons for resilient food systems from COVID-19. *World Development*, *136*, 105104. https://doi.org/10.1016/j.worlddev.2020.105104

Kummu, M., Kinnunen, P., Lehikoinen, E., Porkka, M., Queiroz, C., Röös, E., Troell, M., & Weil, C. (2020). Interplay of trade and food system resilience: Gains on supply diversity over time at the cost of trade independency. *Global Food Security*, *24*, 100360. https://doi.org/10.1016/j.gfs.2020.100360

Laborde, D., Martin, W., & Vos, R. (2020). *Estimating the Poverty Impact of COVID-19 The MIRAGRODEP and POVANA frameworks 1.* https://doi.org/10.13140/RG.2.2.36562.58560

Lancet, T. (2020). Covid-19: A new lens for non-communicable diseases. *Lancet (London, England)*, *396*(10252), 649. https://doi.org/10.1016/S0140-6736(20)31856-0

Lawrence, M. A., Friel, S., Wingrove, K., James, S. W., & Candy, S. (2015). Formulating policy activities to promote healthy and sustainable diets. *Public Health Nutrition*, *18*(13), 2333–2340. https://doi.org/10.1017/S1368980015002529

Lindow, M., Preiser, R., & Biggs, R. (2020). Exploring resilience capacities with food innovators: a narrative approach. *Global Sustainability*, *3.* https://doi.org/10.1017/sus.2020.23

Mainali, B., Luukkanen, J., Silveira, S., & Kaivo-oja, J. (2018). Evaluating Synergies and Trade-Offs among Sustainable Development Goals (SDGs): Explorative Analyses of Development Paths in South Asia and Sub-Saharan Africa. *Sustainability*, *10*(3), 815. https://doi.org/10.3390/su10030815

McWethy, D. B., Schoennagel, T., Higuera, P. E., Krawchuk, M., Harvey, B. J., Metcalf, E. C., Schultz, C., Miller, C., Metcalf, A. L., Buma, B., Virapongse, A., Kulig, J. C., Stedman, R. C., Ratajczak, Z., Nelson, C. R., & Kolden, C. (2019). Rethinking resilience to wildfire. *Nature Sustainability*, *2*(9), 797–804. https://doi.org/10.1038/s41893-019-0353-8

Meadows, D. (1999). *Leverage points: Places to intervene in a system*. Hartland. The Sustainability Institute.

Meyer, M. A. (2020). The role of resilience in food system studies in low- and middle-income countries. *Global Food Security*, *24*, 100356. https://doi.org/10.1016/j.gfs.2020.100356

Misselhorn, A., Aggarwal, P., Ericksen, P., Gregory, P., Horn-Phathanothai, L., Ingram, J., & Wiebe, K. (2012). *A vision for attaining food security* (Vol. 4). https://doi.org/10.1016/j.cosust.2012.01.008

Moran, D., Cossar, F., Merkle, M., & Alexander, P. (2020). Uk food system resilience tested by COVID-19. *Nature Food*, *1*(5), 1. https://doi.org/10.1038/s43016-020-0082-1

Moschitz, H., & Frick, R. (2020). City food flow analysis. A new method to study local consumption. *Renewable Agriculture and Food Systems*, 1–13. https://doi.org/10.1017/S1742170520000150

Moseley, W. G., & Battersby, J. (2020). The Vulnerability and Resilience of African Food Systems, Food Security, and Nutrition in the Context of the COVID-19 Pandemic. *African Studies Review*, 1–13. https://doi.org/10.1017/asr.2020.72

Mukumbang, F. C., Ambe, A. N., & Adebiyi, B. O. (2020). Unspoken inequality: How COVID-19 has exacerbated existing vulnerabilities of asylum-seekers, refugees, and undocumented migrants in South Africa. *International Journal for Equity in Health*, *19*(1), 141. https://doi.org/10.1186/s12939-020-01259-4

NEPAD. (2011). *Synthesis of the Malabo Declaration on CAADP and Other Related AU Decisions.* NEPAD Planning and Coordinating Agency.

Neve, J.-E. de, & Sachs, J. D. (2020). The SDGs and human well-being: A global analysis of synergies, trade-offs, and regional differences. *Scientific Reports*, *10*(1), 15113. https://doi.org/10.1038/s41598-020-71916-9

Nicolas Bricas. (2019). The scope of the analysis: food systems. In S. Dury, P. Bendjebbar, E. Hainzelin, T. Giordano, & N. Bricas (Eds.), *Food systems at risk. New trends and challenges.* FAO, CIRAD and European Commission.

OECD. (2020). *COVID-19 and Global Food Systems* (Tackling Coronavirus (Covid-19): Contributing to a Global Effort).

OECD. (2021). *Making Better Policies for Food Systems*. Paris. OECD Publishing. https://doi.org/10.1787/ddfba4de-en

Oliver, T. H., Boyd, E., Balcombe, K., Benton, T. G., Bullock, J. M., Donovan, D., Feola, G., Heard, M., Mace, G. M., Mortimer, S. R., Nunes, R. J., Pywell, R. F., & Zaum, D. (2018). Overcoming undesirable resilience in the global food system. *Global Sustainability*, *1.* https://doi.org/10.1017/sus.2018.9

Parsons, K., Hawkes C., & Wells, R. (2019). *Brief 2. What is the food system? A Food policy perspective. In: Rethinking Food Policy: A Fresh Approach to Policy and Practice.* London, UK. Centre for Food Policy.

Petetin, L. (2020). The COVID-19 Crisis: An Opportunity to Integrate Food Democracy into Post-Pandemic Food Systems. *European Journal of Risk Regulation*, *11*(2), 326–336. https://doi.org/10.1017/err.2020.40

Pingali, P., Alinovi, L., & Sutton, J. (2005). Food security in complex emergencies: Enhancing food system resilience. *Disasters*, *29 Suppl 1*, S5-24. https://doi.org/10.1111/j.0361-3666.2005.00282.x

Pinstrup-Andersen, P., & Watson, D. D. (2011). *Food Policy for Developing Countries: The Role of Government in Global, National, and Local Food Systems*. Cornell University Press. http://www.jstor.org/stable/10.7591/j.ctt7v910 https://doi.org/10.7591/j.ctt7v910

Poritosh, R., Daisuke, N., Orikasa, T., Qingyi, X., Okadome, H., Nobutaka. Nakamura, & Shiina, T. (2009). A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering*, *90*(1), 1–10. https://doi.org/10.1016/j.jfoodeng.2008.06.016

Posthumus, H., Steenhuijsen-Piters, B. de, Dengerink, J., & Vellema, S. (2018a). *A decision-support tool for the design of food & nutrition security programming.* KIT Royal Tropical Institute and Wageningen University & Research.

Posthumus, H., Steenhuijsen-Piters, B. de, Dengerink, J., & Vellema, S. (2018b). *Food systems : From concept to practice and vice versa*. Wageningen.

Posthumus, H., Steenhuijsen-Piters, B. de, Dengerink, J., & Vellema, S. (2018c). *The Food Systems Decision-Support Tool : Application in the case of Ethiopia*. The Hague. https://doi.org/10.18174/464053

Prosperi, P., Allen, T., Cogill, B., Padilla, M., & Peri, I. (2016). Towards metrics of sustainable food systems: a review of the resilience and vulnerability literature. *Environment Systems and Decisions*, *36*(1), 3–19. https://doi.org/10.1007/s10669-016-9584-7

Quisumbing, A., Kumar, N., Meinzen-Dick, R., & Ringler, C. (2020). Why gender matters in COVID-19 responses — now and in the future. In *COVID-19 and global food security.* Washington DC,

Rampa, F., Schutter, O. de, Woolfrey, S., Jacobs, N., Bilal, S., van Seters, J., & Frison, E. (2020). *EU trade policy for sustainable food systems: Briefing Note.* ecdpm; IPES FOOD. https://ecdpm.org/wp-content/uploads/EU-Trade-Policy-Sustainable-Food-Systems-IPES-Food-ECDPM-Joint-Briefing-Note-October-2020.pdf

Reardon Thomas, Bellemare, M. F., & Zilberman, D. (2020). *How COVID-19 may disrupt food supply chains in developing countries*. https://www.ifpri.org/blog/how-covid-19-may-disrupt-food-supply-chains-developing-countries

Reardon Thomas, & Swinnen, J. (2020). COVID-19 and resilience innovations in food supply chains. In *COVID-19 and global food security.* Washington DC. https://www.ifpri.org/blog/covid-19-and-resilience-innovations-food-supply-chains

Redman, C. L. (2014). Should Sustainability and Resilience Be Combined or Remain Distinct Pursuits? *Ecology and Society*, *19*(2). https://doi.org/10.5751/ES-06390-190237

Resnik Danielle. (2020). COVID-19 lockdowns threaten Africa's vital informal urban food trade. In *COVID-19 and global food security.* Washington DC,

Rippon, S., Bagnall, A.-M., Gamsu, M., South, J., Trigwell, J., Southby, K., Warwick-Booth, L., Coan, S., & Woodward, J. (2020). Towards transformative resilience: community, neighbourhood and system responses during the COVID-19 pandemic. *Cities & Health*, 1–4. https://doi.org/10.1080/23748834.2020.1788321

Rodin, J. (2014). *The resilience dividend: Being strong in a world where things go wrong* (1. ed.). PublicAffairs.

Rotz, S., & Fraser, E. D. G. (2015). Resilience and the industrial food system: Analyzing the impacts of agricultural industrialization on food system vulnerability. *Journal of Environmental Studies and Sciences*, *5*(3), 459–473. https://doi.org/10.1007/s13412-015-0277-1

Ruben, R., Verhagen, J., & Plaisier, C. (2019). The Challenge of Food Systems Research: What Difference Does It Make? *Sustainability*, *11*(1), 171. https://doi.org/10.3390/su11010171

Rudloff, B. (2020). *Challenges for a coherent approach to food system resilience within the EU: Commentary No. 2 of the MigResHub at the Migration Policy Centre, RSCAS, European University* (Commentary No. 2). https://migrationpolicycentre.eu/docs/migreshub/MigResHub-commentary-No2.pdf

Sagara, B. (2018). *Resilience Measurement Practical Guidance Note Series 2: Measuring Shocks and Stresses: Produced by Mercy Corps as part of the Resilience Evaluation, Analysis and Learning (REAL) Associate Award.* https://reliefweb.int/sites/reliefweb.int/files/resources/GN02_ShocksandStressesMsmt_Final.pdf

SAPEA. (2020). *Sustainable Food System for the European Union*. Berlin. Science Advice for Policy by European Academies. https://doi.org/10.26356/sustainablefood

Savary, S., Akter, S., Almekinders, C., Harris, J [Jody], Korsten, L., Rötter, R., Waddington, S., & Watson, D. (2020). Mapping disruption and resilience mechanisms in food systems. *Food Security*, 1–23. https://doi.org/10.1007/s12571-020-01093-0

Schipanski, M. E., MacDonald, G. K., Rosenzweig, S., Chappell, M. J., Bennett, E. M., Kerr, R. B., Blesh, J., Crews, T., Drinkwater, L., Lundgren, J. G., & Schnarr, C. (2016). Realizing Resilient Food

Systems. *BioScience*, *66*(7), 600–610. https://doi.org/10.1093/BIOSCI/BIW052 (BioScience, 66(7), 600-610).

Schipper, L., & Langston, L. (2015). *A comparative overview of resilience measurement frameworks - analysing indicators and approaches*. Working Paper 422. London, UK. Overseas Development Institute (ODI).

Sebahizi, P. (2019). Agreement Establishing the African Continental Free Trade Area. *African Journal of Legal Studies*, *10*(4), 239–312. https://doi.org/10.1163/17087384-12340025

Simonsen, S. H., Biggs, R., Schlüter, M., Schoon, M. L., Bohensky, E., Cundill, G., Dakos, V., Daw, T., Kotschy, K., Leitch, A., Quinlan, A., Peterson, G., & Moberg, F. (n.d.). *Applying resilience thinking Seven principles for building resilience in social-ecological systems*. www.stockholmresilience.su.se

Smith, P., Nkem, J., Calvin, K., Campbell, D., Cherubini, F., Grassi, G., Korotkov, V., Hoang, A. L., Lwasa, S., McElwee, P., Nkonya, E., Saigusa, N., Soussana, J.-F., & Taboada, M. A. *Interlinkages Between Desertification, Land Degradation, Food Security and Greenhouse Gas Fluxes: Synergies, Trade-offs and Integrated Response Options.: In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.- O. Portner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]*. In press. https://www.ipcc.ch/site/assets/uploads/sites/4/2019/11/09_Chapter-6.pdf

Sobal, J., Kettel Khan, L., & Bisogni, C. (1998). *A conceptual model of the food and nutrition system* (Vol. 47). https://doi.org/10.1016/S0277-9536(98)00104-X

Soussana, J.-F. (2021, February 4). *Perspective on key issues: Virtual event "Bonding science and policy to accelerate food systems transformation".* MUSE-Montpellier Université d'excellence. http://www.agropolis.org/news/2021-food-systems-science-policy-event.php

Sperling, L. (2020). Seed security response during COVID-19: Building on evidence and orienting to the future. *Food Security*, *12*(4), 1–5. https://doi.org/10.1007/s12571-020-01068-1

Swinnen, J., & McDermott, J. (2020). *COVID-19 and global food security*. Washington DC. https://doi.org/10.2499/p15738coll2.133762

Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., Kruetli, P., Grant, M., & Six, J. (2015). Food system resilience: Defining the concept. *Global Food Security*, *6*, 17–23. https://doi.org/10.1016/j.gfs.2015.08.001

Terdoo, F., & Feola, G. (2020). Rapid participatory system mapping builds agri-food system resilience: evidence from Nigeria. *African Geographical Review*, 1–13. https://doi.org/10.1080/19376812.2020.1761410

Termeer, C. J., Drimie, S., Ingram, J., Pereira, L., & Whittingham, M. J. (2018). *A diagnostic framework for food system governance arrangements: The case of South Africa* (Vol. 84). https://doi.org/10.1016/j.njas.2017.08.001

Thurlow, J. (2020). COVID-19 lockdowns have imposed substantial economic costs on countries in Africa. In *COVID-19 and global food security.* Washington DC,

Torero, M. (2020a). Prepare food systems for a longhaul fight against COVID-19 COVID-19 and global food security. In *COVID-19 and global food security.* Washington DC. http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/133816/filename/134029.pdf

Torero, M. (2020b). Without food, there can be no exit from the pandemic. *Nature*, *580*(7805), 588–589. https://doi.org/10.1038/d41586-020-01181-3

Trewin Restorick. (2020, October 16). *Will the Covid-19 shock change the UK food system? | Hubbub Foundation*. https://www.hubbub.org.uk/blog/will-the-covid-19-shock-change-the-uk-food-system

Tröster, B., & Küblböck, K. (2020). Unprecedented but not Unpredictable: Effects of the COVID-19 Crisis on Commodity-Dependent Countries. *The European Journal of Development Research*, 1–20. https://doi.org/10.1057/s41287-020-00313-9

UNEP. (2016). *Food Systems and Natural Resources. A Report of the Working Group on Food Systems of the International Resource Panel. Westhoek, H, Ingram J., Van Berkum, S., Özay, L., and Hajer M.*

United Nations. (2020). *The Impact of Covid-19 on Food Security and Nutrition: Policy Brief*. https://www.un.org/sites/un2.un.org/files/sg_policy_brief_on_covid_impact_on_food_security.pdf

United Nations. (2021). *SDG Indicators - Metadata repository*. https://unstats.un.org/sdgs/metadata/?Text=&Goal=&Target=1.5

United Nations Food Systems Summit Pre-Event. (2020). *Bold Actions for Food as a Force for Good.* United Nations. https://www.un.org/en/food-systems-summit/events/bold-actions-food-force-good

Urruty, N., Tailliez-Lefebvre, D., & Huyghe, C. (2016). Stability, robustness, vulnerability and resilience of agricultural systems. A review. *Agronomy for Sustainable Development*, *36*(1), 1–15. https://doi.org/10.1007/s13593-015-0347-5

van Berkum, S., Dengerink, J., & Ruben, R. (2018). *The food systems approach: Sustainable solutions for a sufficient supply of healthy food* (Wageningen Economic Research 2018-064). The Hague. Wageningen Economic Research.

von Braun, J., Afsana, K., Fresco, L., Hassan, M., & Torero, M. (2020). *Food Systems – Definition, Concept and Application for the UN Food Systems Summit (draft version).* United Nations Food Systems Summit 2021 Scientific Group. https://www.un.org/en/food-systems-summit/leadership#scientific-group

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig A. (2004). Resilience, Adaptability and Transformability in Social–ecological Systems. *Ecology and Society*, *9*(2), 5.

Wegerif, M. C. A. (2020). "Informal" food traders and food security: Experiences from the Covid-19 response in South Africa. *Food Security*, *12*(4), 1–4. https://doi.org/10.1007/s12571-020-01078-z

WFP. (2020). *Global Monitoring of School Meals During COVID-19 School Closures*. https://cdn.wfp.org/2020/school-feeding-map/index.html

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T [Tim], Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L. J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J. A., Vries, W. de, Majele Sibanda, L., . . . Murray, C. J. L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, *393*(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

World Bank. (2020a). *Global Economic Prospects*. Washington, DC. https://doi.org/10.1596/978-1-4648-1553-9

World Bank. (2020b). *Poverty and Shared Prosperity 2020 : Reversals of Fortune*. Washington, DC. https://doi.org/10.1596/978-1-4648-1602-4

World Economic Forum. (2020). *The Global Risks Report 2020*. http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf

Worstell, J. (2020, October 6). *View of Ecological Resilience of Food Systems in Response to the COVID-19 Crisis*. https://www.foodsystemsjournal.org/index.php/fsj/article/view/806/791

Worstell, J., & Green, J. (2017). Eight Qualities of Resilient Food Systems: Toward a Sustainability/Resilience Index. *Journal of Agriculture, Food Systems, and Community Development*, 1–19. https://doi.org/10.5304/jafscd.2017.073.001

Zurek, M., Garbutt, G., Lieb, T., Hess, T., & Ingram, J. (2020). Increasing Resilience of the UK Fresh Fruit and Vegetable System to Water-Related Risks. *Sustainability*, *12*(18), 7519. https://doi.org/10.3390/su12187519