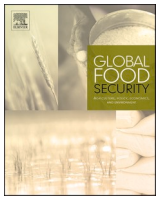
Global Food Security 32 (2022) 100591

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs



Invited Research Article

Putting food systems thinking into practice: Integrating agricultural sectors into a multi-level analytical framework

Gareth D. Borman [a,*], Walter S. de Boef [a], Flo Dirks [a], Yeray Saavedra Gonzalez [a], Abishkar Subedi [a], Marja H. Thijssen [a], Judith Jacobs [a], Ted Schrader [a], Salome Boyd [a], Hermine J. ten Hove [a], Edwin van der Maden [a], Irene Koomen [a], Sheila Assibey-Yeboah [b], Coulibaly Moussa [b], Assumpta Uzamukunda [a], Annabelle Daburon [a], Asaah Ndambi [c], Simone van Vugt [a], Joost Guijt [a], Jan Joost Kessler [d], Jan Willem Molenaar [d], Siemen van Berkum [e]

[a] Wageningen Centre for Development Innovation (WCDI), Wageningen University & Research (WUR), Wageningen, the Netherlands
[b] SNV Netherlands Development Organisation, The Hague, the Netherlands
[c] Wageningen Livestock Research (WLR), WUR, Wageningen, the Netherlands
[d] Aidenvironment, Amsterdam, the Netherlands
[e] Wageningen Economic Research (WEcR), WUR, The Hague, the Netherlands

ARTICLE INFO

Keywords:
Food systems
System innovation
Agricultural sector
Rapid assessment
United nations food systems summit

ABSTRACT

In the wake of the United Nations Food Systems Summit - the first of its kind - practitioners need to capture the abstract concept of the food system and learn how the process of transformation that they engage in contributes to food system outcomes or risk operating in silos. With that aim, we focus on sector analysis, interpreting changes in sector performance as food system outcomes. This makes food systems thinking more actionable. We share an application of the integrated framework in a particular case: rapid assessments of the impact of COVID-19 on the functioning of the horticulture, sesame, and seed sectors across seven low- and middle-income countries. We highlight lessons learned from applying the multi-level integrated framework for putting food systems thinking into practice.

1. Introduction

The food system framework is increasingly used as an analytical tool to enhance our understanding of agriculture, food security and nutrition, and shape policies and strategic interventions for more desirable system outcomes. It is an application of systems thinking that links the production, processing, distribution, preparation, and consumption of food, with elements of the environment, people, inputs, infrastructure, and institutions. It describes the connections and feedback loops between those elements and processes, and shows how the outputs of all activities impact food security and nutrition, and socio-economic and environmental outcomes (HPLE, 2017; De Brauw et al., 2019; UN, 2012). Combining the three broad and interconnected development domains pursuing food security and nutrition, inclusive and equitable economic development, and environmental sustainability, is critical to food systems thinking and its application (HLPE, 2017; Eriksen, 2008; Global Panel on Agriculture and Food Systems for Nutrition, 2016; UNEP, 2016; UN, 2021). Food system analysis is an important first step towards making strategic interventions at global, national and local levels. One ambition of analysis is to initiate a process of transforming food systems to achieve desired results in the three connected domains (Dekeyser et al., 2020; Posthumus et al., 2018; Ruben et al., 2018; Van Berkum et al., 2018).

Parallel to the increased use of the food system approach, the sector framework has emerged as another application of systems thinking. It builds upon a common and widely used concept of the value chain but takes a more holistic perspective that captures the dynamics of sector governance. Molenaar et al. (2017) acknowledge the shift away from government-led interventions in agricultural markets and sector organization in the 1990s, and the increase in public sector support for individual private entities in the sourcing and supply of agricultural commodities in value chains. These authors acknowledge the benefits

* Corresponding author.
E-mail address: gareth.borman@wur.nl (G.D. Borman).

https://doi.org/10.1016/j.gfs.2021.100591
Received 5 July 2021; Received in revised form 21 October 2021; Accepted 8 November 2021
Available online 17 November 2021

derived from the organization of value chains around a specific group of consumers and the producers they connect, but recognize that this excludes others, does not make the sector any less vulnerable to systemic problems, and ignores how it is governed. The sector framework can be used to guide the transformation of various sectors that cover the range of cash and food crops, as well as livestock. The framework places these agricultural sectors within the larger context of policies, the environment and people. Using this framework helps to build an understanding of sector dynamics and subsequently design and direct efforts to transform them in a manner that they contribute to desired sector outcomes (Molenaar and Kessler, 2021). The integration of the sector within the food system framework makes more evident either the alignment or trade-offs between outcomes pursued at both levels.

Professionals working at the research, policy and practice nexus related to agricultural development engage more and more with the food system and the sector frameworks as multi-level perspectives. Understanding food systems can help global, national, and local development organizations in drawing up, implementing, monitoring and learning from action plans inspired by commitments made at the United Nations Food Systems Summit (UNFSS) (UN, 2021). It is essential that the professionals who are responsible for putting those plans into practice can capture the abstract and macro-level concept of food systems and contextualize it to their own reality at meso- and micro-levels of scale. These professionals must understand the connections and feedback loops within food systems thinking. They need to learn how transformation - i.e., the result of turning plans into actions - at their level of operation, be it a sector, value chain or another level, contributes to the three primary food system outcomes, namely: food security and nutrition, socio-economic, and environmental outcomes. This is where food system thinking and sector analysis meet.

The purpose of this paper is to show that abstract-level food systems thinking can become more actionable by adopting an intermediate perspective, like that of agricultural sectors, which we demonstrate with a practical case. Our paper has two target groups of agricultural development professionals: fellow practitioners and policymakers. Our aim is that practitioners will be able to integrate their sector work into food systems, and that through using the integrated framework both practitioners and policymakers will gain insights into the application of food systems at practical level.

2. Integration of the food system and sector frameworks

A key reference that we use in structuring and visualizing the food system is Van Berkum et al. (2018). Box 1 provides background and policy context for developing this framework. Fig. 1 shares an adaptation of their graphical presentation of the food system framework. Van Berkum and his colleagues position food system activities in a state of flux, with both socio-economic and environmental drivers moderating their contribution to food security. Their framework illustrates how food system activities can be guided in contributing to socio-economic and environmental outcomes. When defining food security, they refer in their framework to the dimensions of food utilization, access, and availability (FAO, 1996). It should be noted that this definition omits food stability as the fourth dimension of food security, and considers nutrition as an attribute of food utilization. Following FAO et al. (2020), we consider food security and nutrition, including food stability, as food system outcomes.

The identification of food system outcomes varies, depending on the weight that policymakers, donors, and practitioners give to food security and nutrition, socio-economic and environmental outcomes, and on the extent to which they seek synergy between these outcomes (Brouwer et al., 2020; Posthumus et al., 2018). Applying the food system framework is (mainly) about understanding relationships between activities, drivers and outcomes, and the feedback loops that occur. A complementary value of the framework is that it serves as a lens that brings into view broadscale patterns that are missed at finer resolution. Zooming out is necessary for larger trends to come into view. Zooming in at the meso level, such as an agricultural sector, or even closer at the scale of activities within the sector, allows for guiding practical action. Consequently, agricultural sectors, which include food and non-food agricultural commodities, emerge as one subset of food system activities, as visualized in Fig. 1.

When we refer to agricultural sectors, sectors of relevance to food systems are staple crops, horticulture, livestock, dairy, and fisheries. We also consider food and non-food export commodities in the sector framework, e.g., coffee, sesame, cotton, and flowers. Zooming in closer, we find agricultural input sectors, such as seed and fertilizers. Directly or indirectly, these sectors are critical in reaching food system outcomes such as food security and nutrition. For example, the sesame sector in Ethiopia, where small-scale farmers from highland areas provide seasonal labor to the sector and use their wages for buying inputs to food crops critical to food security back home. The single and shared relationships of specific agricultural sectors with socio-economic and environmental drivers shape the dynamics of the larger food system.

Agricultural sectors add granularity within the food system, while placing their transformation within the boundaries of the food system. Zooming in on a sector makes it possible to detect more practical expressions of its operation, and to assess how sector activities respond to socio-economic and environmental drivers, and impact food system outcomes positively or negatively. It also makes it possible to identify

Box 1
WUR's food system framework: background and policy context

Since 2014, the international development policy of the Ministry of Foreign Affairs of the Netherlands has centered food security around three themes: elimination of hunger and malnutrition, inclusive and sustainable growth, and environmentally sustainable food systems (Kamerbrief, 2014). Moreover, the Ministry of Foreign Affairs began to adopt an integrated approach to food security, climate, energy, water, and biodiversity challenges, calling for a balanced inclusion of sustainable development goals. The food system approach has emerged as a useful and powerful tool for showing the relationship between these policy priorities and themes. In 2017, the Netherlands Ministry of Agriculture, Nature and Food Quality identified a need to explore the usefulness of the increasingly prominent food systems approach in shaping its policies on food security, aid, trade, and investment. Responding to this need, Wageningen University & Research (WUR) prepared an important report on the food systems approach (Van Berkum et al., 2018). Using existing concepts, Van Berkum et al. (2018) configured a food system framework, including powerful visualizations of, and relationships between, its components, and advised the Ministry of three important uses.

First, it provides a checklist for the topics that should in any event be addressed in order to improve food security, certainly in relation to other policy objectives, and it identifies the actors and other parties who should be involved. Second, it helps to document the impact of environmental and climate changes on food security by pointing out different vulnerabilities in the food system. In that sense the concept can help in the search for ways of enhancing the system's resilience to climate change. Third, it helps to determine the most limiting factors when it comes to achieving food security, and thereby to identify effective interventions aimed at improving food security. (p. 25)

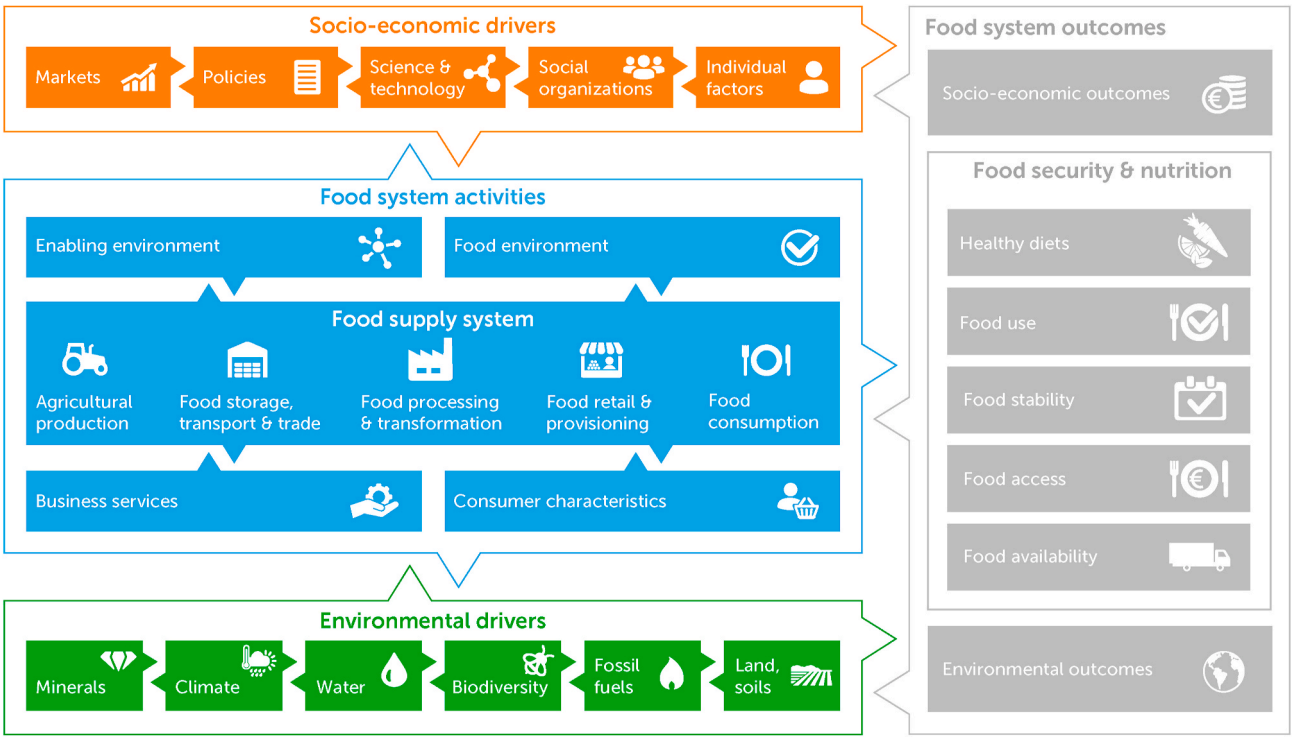


Fig. 1. The food system framework.
Adapted from Van Berkum et al. (2018).

interventions enhancing the performance of the sector in contributing to the transformation of the food system. The integrated framework makes it easier to zoom in and out, see and understand the dynamics of and between sectors, and connect with other subsets of the food system, moderated by socio-economic and environmental drivers. In this way, the integrated framework helps practitioners understand the value of systems thinking in conceptualizing, defining and delineating the activities in sectors and value chains within a larger food system.

For its integration into the food system framework, we have adapted the sector concept developed by Aidenvironment and partners (Molenaar et al., 2015, 2017; Molenaar and Kessler, 2021). A sector comprises eight different activities, which are described in Table 1. The sector activities are influenced by socio-economic and environmental drivers in a similar way to the food system as a whole. Particular subsets of the socio-economic and environmental drivers of the food system are relevant to these sectors in terms of relationships and feedback loops. In Table 1, we define and give attributes to the activities, drivers, and outcomes of a sector in its contribution to the food system. In Fig. 2, we integrate the sector within the food system framework.

The main aim of conducting an analysis using the integrated framework is to connect practical activities with desired outcomes and assess the extent to which activities deliver these outcomes or whether intervention is needed. Accordingly, analysis should aim to generate actionable recommendations that can guide transformation and contribute to change. The starting point is to define the food system objectives, and thus the food system outcomes. Conducting the analysis generates insights into what changes in the food system and sector are needed to deliver intended outcomes. The framework is an application of systems thinking; it is a tool that provides insights into system archetypes (or origins of system behaviors), and uses the insights gained to make decisions on ways to innovate, influence and change dynamics within a sector and the food system (Posthumus et al., 2018). In summary, analysis is intended to inform and decide on system innovations (Hall and Dijkman, 2019) and to guide the transformation in the direction of desired outcomes (Posthumus et al., 2021).

3. Application of the integrated framework in rapid sector assessments

3.1. Methodology for assessing the impact of COVID-19 on agricultural sectors

Deeply concerned by the pandemic and the implications of society's response to it for our food system, Wageningen University & Research (WUR) and partners assessed the impact of the pandemic on the functioning of a range of agricultural sectors in multiple countries (WUR, 2021). Using a rapid, participatory and action-oriented approach, they complemented the growing body of knowledge on the impact of COVID-19 on food systems (Goswami et al., 2021; Nordhagen et al., 2021; Stephens et al., 2020; Vos and Cattaneo, 2021). Rapid assessments advocated for immediate and practical action to prevent or remedy negative impact on the activities, drivers and outcomes of these sectors, and informed stakeholders' decisions.

Rapid assessments were conducted within sector programs in which WUR collaborates with international and local partners. For the purposes of learning about the integrated framework, we have chosen three experiences (Table 2): (i) the sesame sector in Ethiopia; (ii) the horticulture sector in Côte d'Ivoire, Ghana and Rwanda; and (iii) the seed sector in Ethiopia, Myanmar, Nigeria and Uganda. Each rapid assessment was led by a team of (on average) five representatives from the partnerships of those programs, uniting both proponents of food systems thinking and local development practitioners.

The methodology for conducting the rapid assessments was developed for the seed sector applying the concept of the sector alone (Molenaar et al., 2017) and subsequently tailored to other sectors whilst increasingly considering more drivers and outcomes of the food system. De Boef et al. (2021) and WCDI (2020) describe the methodology in detail. Box 2 provides a concise outline of each step in the methodology. Rapid assessments were conducted through a remote survey and followed by focus group discussions (FGDs). Each team leading a rapid assessment was guided in the design of the survey by the eight activities

Table 1
Definition and attributes of activities, drivers and outcomes of an agricultural sector.

Activity	Definition	Attributes	Sources*
Production	Information pertaining to the farm or basic production unit, including what is produced and how	Farming system's viability, social inclusion, and resilience for a specific segment of the market	a,b
Value chain development	Details about market linkages like storage, trade, transport, processing, distribution and retail	Efficiency, transparency, traceability and fairness of trading practices, and dis/incentives for good practices	a,b
Service provision	Delivery models of services to stakeholders in the chain (e.g., labor, advice, agro-inputs, machinery, transport, finance)	Quality, feasibility and differentiation of service provision, and inclusiveness	a,b
Consumption	Promotion and utilization of products, and management of waste arising therefrom, occurring at different proximities to the farm and levels of value addition	Consumer preferences, customs, knowledge, and behaviors in determining the suitability of products to their needs	a,b
Stakeholder organization	Organizations around producers (e.g., cooperatives, federations); value chains (e.g., partnerships and procurement); traders (e.g., markets); and services (e.g., service centers)	Effectiveness and inclusiveness of organizing stakeholders to improve their access to inputs, services and markets; empower individuals; and increase their collective agency	a,b
Regulation	Rules, systems and procedures governing the sector, including market management, policies, laws, regulations and directives; and informal norms, customs and power dynamics, including the way these structure the operations of stakeholders and their organizations	The implementation of policies and law enforcement; the coherence of regulations with stakeholder norms, customs and practices; the compliance of practices with regulations; and the effectiveness of regulations in achieving policy objectives	a,b
Coordination	Details about sector strategic frameworks (e.g., sector plans and roadmaps) and forums (e.g., sector platforms and governing agencies/boards), and codes of conduct (e.g., sector compacts)	Quality of dialogue and alignment of stakeholders operating at different levels around a shared vision, strategy, standards and guidelines, in sector-wide monitoring and learning, and for advocacy	a,b
Investment	Mechanisms of the fiscus or non-state bodies to collect revenue (e.g., taxes, duties, levies and fees), reinvest it in the sector (e.g., subsidies and funds), and pull additional private and public investments	Ability to capture a share of the value created by the sector and make strategic pre-competitive investments in research, education, development, regulation and governance, complemented with the attractiveness for investment by private sector, financial institutions and donors	a,b
Drivers	*Definition*	*Attributes*	*Sources**
Socio-economic drivers	Understanding of the interplay between cultural, social and economic processes, including customs and traditions, structure and agency, power and political economy	Influence over the sector of trends in market systems; policies, traditions and customs relating to, e.g., land tenure and land use, labor and food safety; science and technology; and the values of individuals	a,b,c
Environmental drivers	Biophysical environment, including climate, natural resources and ecosystems - such as land, soils, water, nutrients, biodiversity and energy - and the ecosystem services they provide	The sustainability of the availability, accessibility and effective and efficient management and utilization of natural resources and ecosystem functions	a,b,c,d,e
Sector outcomes	*Definition*	*Attributes*	*Sources**
Food security and nutrition	Impact of the sector on food security and nutrition through production, distribution and exchange	In/direct outcomes of improving healthy diets, food use, food stability, food accessibility and food availability	a,b,c,f
Socio-economic outcomes	Impact of the sector on welfare (i.e., health, wealth and wellbeing)	Benefit to (specific groups in) society and the economy	a,b,c
Environmental outcomes	Sustainability of natural resources and ecosystem management	The integrity of the biophysical environment that the sector depends upon and contributes to	a,b,c

* Adapted from the following sources: a) Molenaar and Kessler (2021); b) Van Berkum et al. (2018); c) Eriksen, 2008; d) Ingram (2011); e) Millennium Ecosystem (2003); f) FAO, 1996.

and food system outcomes of the integrated framework (Table 1; Fig. 2). The generic list of questions that formed part of the sesame, horticulture and seed surveys are shared as supplementary material respectively in Tables S1, S2 and S3. The measurements in the survey refer to the frequency of perceptions captured on a five-point Likert scale, from 'highly negatively impacted' on one end, through 'not significantly impacted' to 'highly positively impacted' on the other. It should be noted that the surveys were tailored to specific seasonal and geographic contexts. To conduct the assessments, national partners established a panel that comprised a diverse range of local experts. Table 2 provides the total number of respondents, stakeholders, and stakeholder groups for each of the surveys. There were variations in the ways that the assessment teams ensured the participation of men and women as respondents, and in the representation of particularly vulnerable groups, such as small-scale farmers and laborers (De Boef et al., 2021). Participants of the FGDs verified the challenges, and identified and planned remedial and preventative actions. The outcomes of the survey and FGDs were shared in an alert document that was used to inform decision makers in government, industry, science, and civil society on where the impact was felt the most, what action was needed, and who should initiate and drive the action (WUR, 2021). Within the various sector programs, WUR and partners advocated for the immediate implementation of recommended practical actions to cope with the impact. The integrated sector and food system framework (Table 1 and Fig. 2) has been used to structure the compilation of sesame, horticulture and seed 'dashboards' (Figs. 3–5). While the integrated framework refers to environmental drivers, these have not been included in the rapid assessments because of their

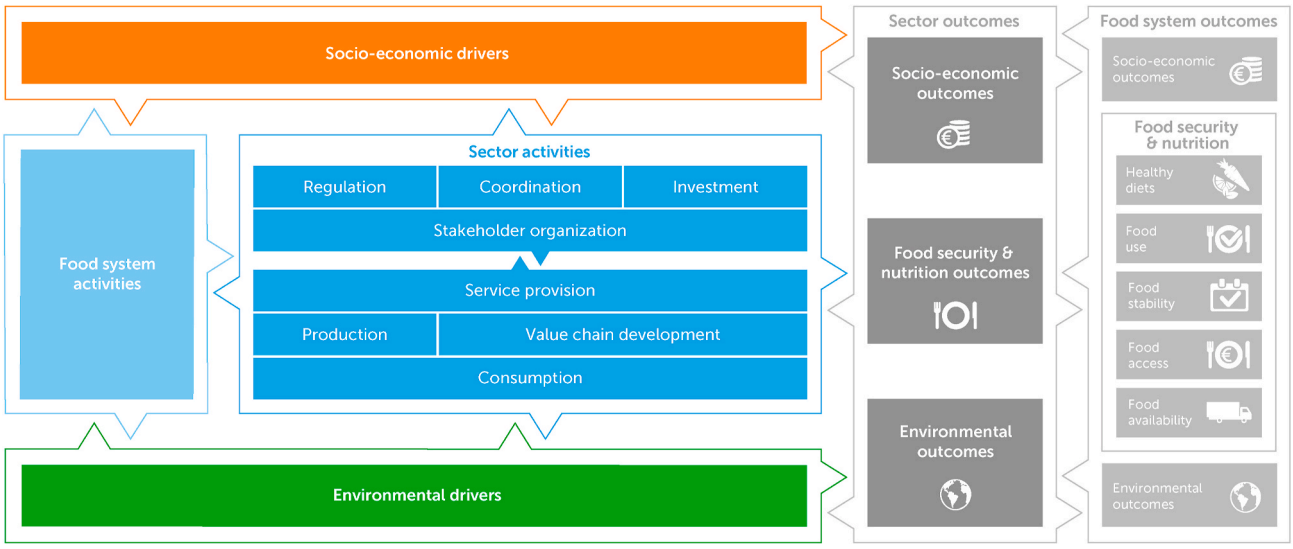


Fig. 2. The integrated sector and food system framework.

Table 2
Overview of the rapid assessments of the impact of the COVID-19 crisis on the functioning of the sesame, horticulture and seed sectors in various countries and iterations, conducted by WUR and partners, 2020

Country	Month	Survey *			Sector development programme and partnership
		# respondents	# types of stakeholders	# stakeholder organizations	
Sesame					
Ethiopia	May	74	9	28	**BENEFIT/SBN;**
	August	82	9	32	WUR, in collaboration with the Ministry of Agriculture, Amhara Regional Agricultural
	October	62	9	29	Research Institute, and Tigray Agricultural Research Institute
Horticulture					
Côte d'Ivoire	August	36	9	32	**HortiFresh project;** WUR, with various partners
Ghana	July	36	10	33	
Rwanda	July/ August	52	10	47	**HortInvest project;** SNV Netherlands Development Organisation, in collaboration with WUR and other partners
Seed					
Ethiopia	May	33	6	23	**BENEFIT/ISSD;**
	June	53	6	33	WUR, in collaboration with Bahir Dar University, Haramaya University, Hawassa University, Mekelle University, and Oromia Seed Enterprise
Myanmar	May	29	6	23	**ISSD Myanmar;**
	July	30	6	25	WUR, in collaboration with the Ministry of Agriculture, Livestock and Irrigation; Welthungerhilfe; and Resilience BV
Nigeria	May	34	8	18	WUR, in collaboration with the National Agricultural Seeds Council, and Sahel
	June	34	7	19	Consulting Agriculture & Nutrition
Uganda	May	25	8	18	**ISSD Plus;**
	June	20	6	20	WUR, in collaboration with the Ministry of Agriculture, Animal Industry and Fisheries, and the National Agricultural Research Organization

Notes: # respondents: total number of respondents in the survey; # types of stakeholders: number of stakeholder groups represented among the respondents in the survey; # stakeholder organizations: number of stakeholders' organizations represented in the survey; BENEFIT: Bilateral Ethiopia Netherlands Effort for Food, Income and Trade Partnership; SBN: Sesame Business Network Program; ISSD: Integrated Seed Sector Development.

immediate focus on societal responses to the COVID-19 pandemic.

The assessment process, which involved designing, implementing, and sharing the results of the assessments, varied in time between two and eight weeks. The assessments were fast; they provided a snapshot of sector dynamics within the setting of COVID-19 and the season in which they were conducted. The speed of the assessments did not allow for the compilation of quantitative data, but available secondary data was taken into account during FGDs. Furthermore, the assessments lacked a clear point of comparison, i.e., a pre-COVID-19 baseline. Steps were taken to reduce bias towards stakeholder representation in the survey by weighting responses (De Boef et al., 2021). It should be recognized that the FGDs targeted the participation of different stakeholders in each session, but in retrospect we should be mindful of which stakeholders had the time to participate, and to what extent the participants considered themselves free to present their reality and interests. Despite those limitations, the COVID-19 rapid assessments were appreciated, and served their purpose to trigger action among various sector stakeholders.

3.2. *The sesame sector in Ethiopia*

3.2.1. *Three rapid assessments in one sesame production area*

Three rapid assessments were conducted in the two main sesame-growing regions of Amhara and Tigray, in the north-western part of Ethiopia. The first assessment was conducted shortly after the onset of the COVID-19 crisis in Ethiopia, in May 2020. The third and final

Box 2
Steps to apply the integrated framework in rapid assessments

Step 1: Setting sector boundaries

Determine the scope of the assessment according to relevant subsectors, such as specific crops or value chains. Consider seasonal differences to decide on the timing and number of iterations of the assessment.

Step 2: Establishing a panel of experts

Approach representatives of all relevant stakeholder groups to participate in the assessment. Be aware of geographic distribution, various administrative levels and minimum number of people per group.

Step 3: Developing the survey

Guided by the sector transformation framework define questions for each of the sector activities, drivers and outcomes, if relevant (refer to Step 1).

Step 4: Implementing the survey

Choose the channels to run the survey, for instance by email, phone or face to face, and design the survey in the appropriate (online) tools and languages.

Step 5: Identifying impact areas

Process and analyse the survey results to identify the most important impact areas. The results are presented in a dashboard reflecting the sector framework.

Step 6: Identifying immediate actions in focus group discussions (FGDs)

Discuss the survey results that provide insight into the most urgent sector challenges to identify immediate actions and responsible stakeholders.

Step 7: Framing alerts and the action required

Reporting on the FGDs, draft a first narrative of an alert document and share it with participating stakeholders and leadership (e.g. coordinating ministry, agency, board, platform or association) of the sector for verification and consolidation.

Step 8: Advocating for immediate, practical, preventative and remedial action

Publish the alert document and share it in relevant media to raise awareness and support advocacy efforts.

assessment was carried out in August 2020, which was before severe political unrest and fighting began in Tigray. Each assessment focused on specific seasonal activities such as planting, harvesting, and marketing. Fig. 3 presents the results in a dashboard that is structured using the integrated sector and food system framework.

3.2.2. Assessment findings: sector activities

The rapid assessments identified production and services as the sector activities that were most negatively impacted by the COVID-19 crisis. The cultivation area and yields were reduced, and access to production resources, especially labor and capital, were constrained. The locust plague further impeded production. Stakeholders expected that trade relations would be disrupted; consequently, both small-scale farmers and large-scale investor producers decided to reduce the area planted with sesame. Their interest in sesame as a cash crop had already declined because of increasing costs of production and various reforms in the previous year that had resulted in a decrease in expected revenues. Small-scale farmers have limited access to finance, which diminishes their capacity and willingness to use good agricultural practices and technological innovations. A consequence of this is that productivity remains low.

Restrictions on mobility and social gathering negatively impacted sesame farmers' access to inputs, and extension and financial services. Beyond the ambiguity present in the sector resulting from market reforms, COVID-19 increased uncertainty beyond an acceptable threshold for several stakeholders. Due to the limited mobility of both financial service providers and farmers, access to finance was reduced. This increased farmers' dependency on informal money lenders, threatened the timely implementation of critical production activities, reduced profit margins due to high interest rates, and increased marketing credit shortages for producer organizations.

For labor-intensive weeding and harvesting, the sesame sector is dependent on the services of small-scale farmers in the neighboring highlands, and youth from surrounding areas. Normally, these farmers and young people travel to the sesame production areas in the lowlands to work as seasonal laborers. During the onset of the crisis, the government implemented critical measures restricting mobility. Farmers expected that labor availability would become a serious challenge. However, later in the season, some of the restrictions on mobility were lifted, and labor availability was not as negatively impacted as was

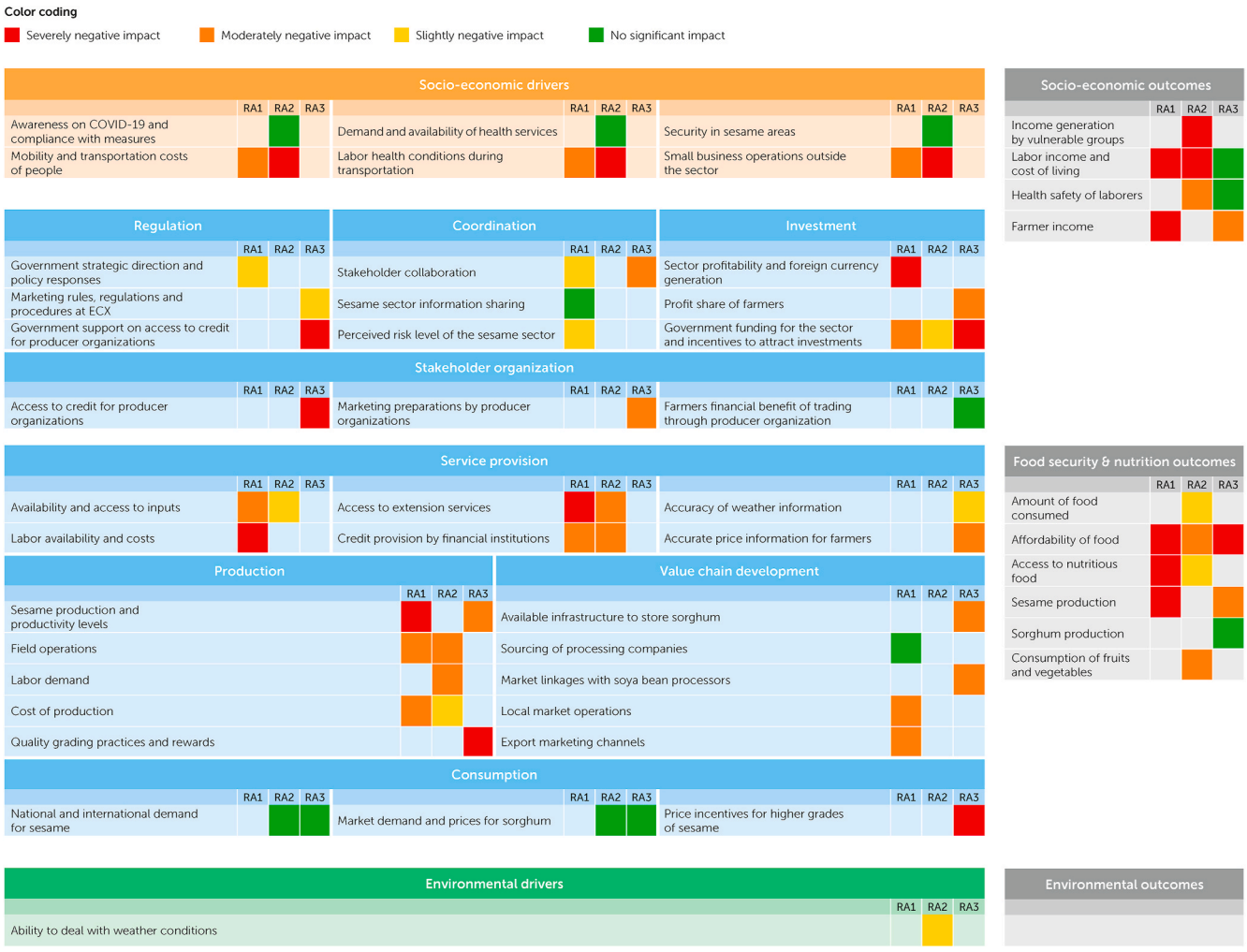


Fig. 3. Synthesis dashboard of the three rapid assessments of the impact of COVID-19 and other challenges on the functioning of the sesame sector in north-western Ethiopia in 2020.
Note: RA1, RA2 and RA3 refer to the rapid assessments conducted in May, June and August 2020 respectively.

expected. The second assessment therefore focused more on the transport and working conditions of laborers, showing that laborers could not adhere to social-distancing and hygiene measures (e.g., washing hands and wearing face masks) and were being exposed to the risk of COVID-19 infection. As migrant workers, their access to healthcare is seriously lacking. The conditions under which the laborers work in the sesame sector has enhanced the vulnerability of the sector amidst the COVID-19 crisis. Stakeholders agreed to air several radio programs with important information on COVID-19 preventative measures. Also, a discussion on the topics of the alert document was broadcasted on television and influenced the agenda of many stakeholders. Labor and Social Affairs Offices of regional governments, as well as large-scale investor producers, have taken measures to improve the working conditions of the seasonal laborers. The pandemic and associated measures put in place to mitigate the spread of the virus have revealed the vulnerability of laborers within the sector, illustrating in particular the limitations of its social and economic viability. During the FGDs, stakeholders suggested organizing strategic discussions with decision makers on topics such as finance, and improving coordination and collaboration between various authorities to address the challenges identified (WUR, 2021).

3.2.3. *Assessment findings: sector and food system outcomes*

The COVID-19 crisis made the structural challenges of the sesame sector tangible for various stakeholders, especially regarding income loss and the sustainability of the sesame sector. Farmers, laborers, service providers and businesses in sesame-growing areas generated less income; households faced higher costs of living, such as for food and transportation. Seasonal laborers, small-scale farmers, and households in remote areas faced severe challenges resulting from a loss of income. The harsh working conditions, low level of health and safety, and structural uncertainty for laborers in the sesame sector received more attention during the COVID-19 crisis and demonstrated an urgent need for improvement. With decreased investment by sesame producers and the reduced presence of migrant laborers, the entire economy in the sesame-growing areas was severely impacted, resulting in a decrease in opportunities for those small businesses still in operation. Incentivized by government food security measures, farmers increased the acreage planted with sorghum, reducing that of sesame. This increased the availability of a food crop but also created challenges to store, distribute and process the surplus produce.

The crisis reduced incomes and savings among sesame farmers. Likewise, it reduced employment opportunities in the sesame sector for seasonal laborers, and thus their income and savings, which coupled with the increased cost of living impacted their ability to invest in agricultural production in their locations of origin. Stakeholders reported an impact on the sesame sector that has aggravated poverty, decreasing food security among vulnerable stakeholders beyond those in the immediate proximity of the sector. The rapid assessments have raised awareness of structural weaknesses in the sesame sector and brought various stakeholders together to discuss these challenges.

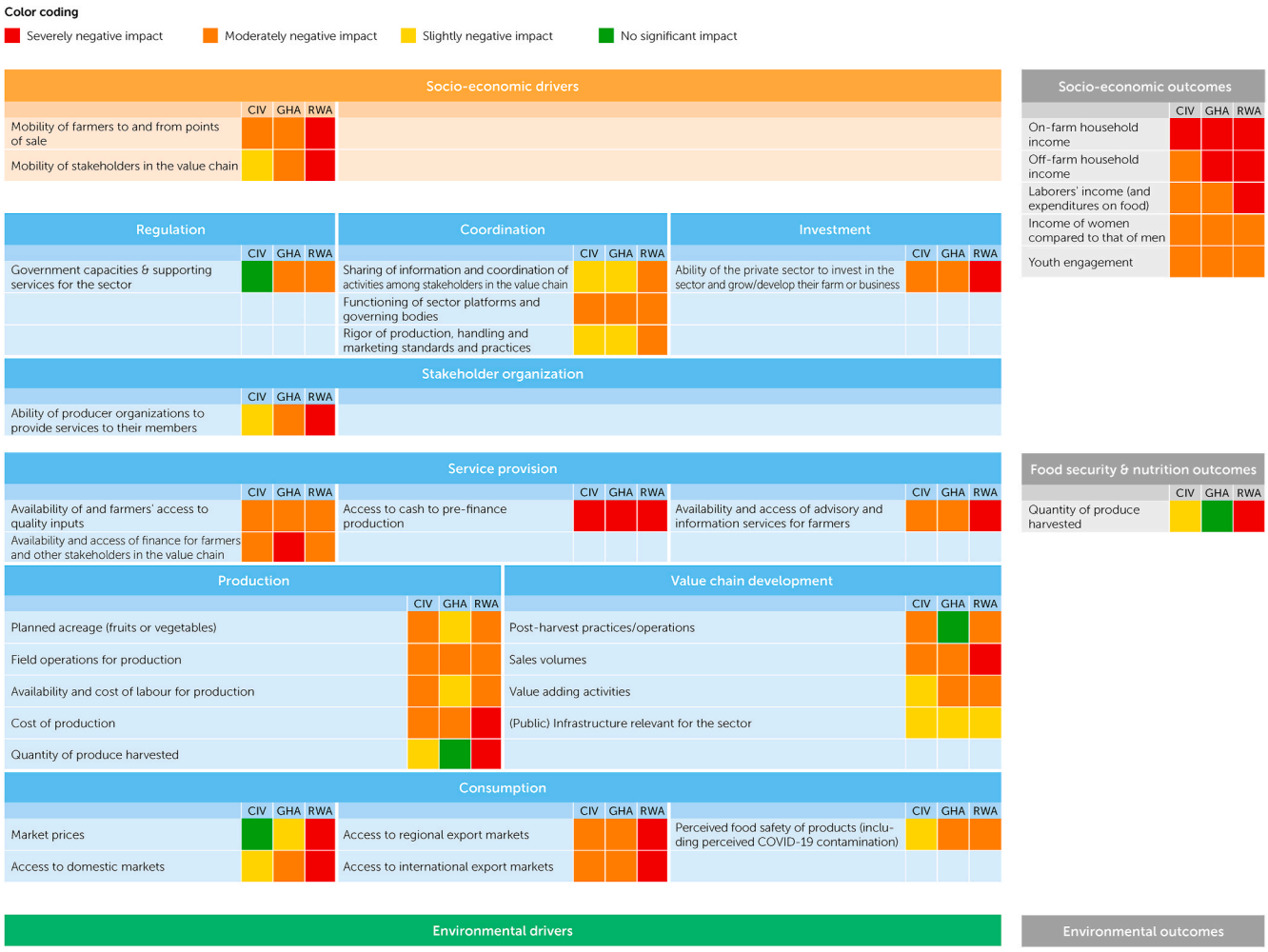


Fig. 4. Synthesis dashboard of the rapid assessments of the impact of COVID-19 on the functioning of the horticulture sector in Côte d'Ivoire, Ghana, and Rwanda in 2020
Note: CIV: Côte d'Ivoire; GHA: Ghana; RWA: Rwanda.

3.3. The horticulture sector in côte d'Ivoire, Ghana, and Rwanda

3.3.1. A rapid assessment focusing on fruit and vegetables

The project team in Rwanda assessed the impact of the COVID-19 crisis on the functioning of the vegetables sector. The team in Côte d'Ivoire assessed the impact on the fruit sector, while the team in Ghana assessed the impact on both the fruit and vegetables sector. They conducted the rapid assessments between May and August 2020, when sector stakeholders were worried about how the pandemic and the accompanying government measures would affect the transport of goods, the mobility of people, the availability of labor, and access to markets for both traders and consumers. The timing of the assessments allowed the teams to consider the end of one production season and the beginning of the next for vegetables and fruits. The rapid assessment documents (WUR, 2021) identified major impacts. Fig. 4 presents the dashboard that synthesizes the assessment results from the three countries using the integrated sector and food system framework.

3.3.2. Assessment findings: sector activities

Government-imposed restrictions on both mobility and physical meetings disrupted the supply of inputs to farmers. The restrictions also hindered the ability of input suppliers to replenish their stocks. Farmers cultivated relatively smaller areas and marketable yields dropped. Farm-level employment shrank due to the limits on mobility and market demand decreased; a sharp fall in employment was reported in Rwanda. The functioning of formal and informal markets was somewhat hampered. Health guidelines and social distancing were enforced in marketplaces to limit the spread of COVID-19 and circumvent future market closures.

The vast majority of vegetable and fruit markets experienced supply disruptions and dwindling sales. Restricted cross-border trade in Rwanda impeded access to an important market for horticultural products in the neighboring Democratic Republic of the Congo. Mango exports from Côte d'Ivoire to the European market were affected by a plummet in demand. Stakeholders in Côte d'Ivoire proposed the inclusion of fruit exports in trade negotiations with a new market in Morocco. Domestic markets in all three countries experienced disruptions. Important institutional markets, such as schools, but also restaurants and hotels, reduced their demand for horticultural products. The crisis impacted the cash flow in vulnerable households in rural and urban areas. These consumers began to prioritize staples over fruits and vegetables.

Financial institutions started to become more risk-averse because of the uncertainty, which hindered access to finance for several business services and farmers. A consequence of this was the stagnation of businesses and the drying up of entire value chains. To halt this downward trend, the Government of Rwanda established a national recovery fund with loans at low interest rates. However, small-scale farmers, as well as small- and medium-sized enterprises, struggled to meet the strict eligibility criteria. Stakeholders in the FGDs highlighted the urgent need

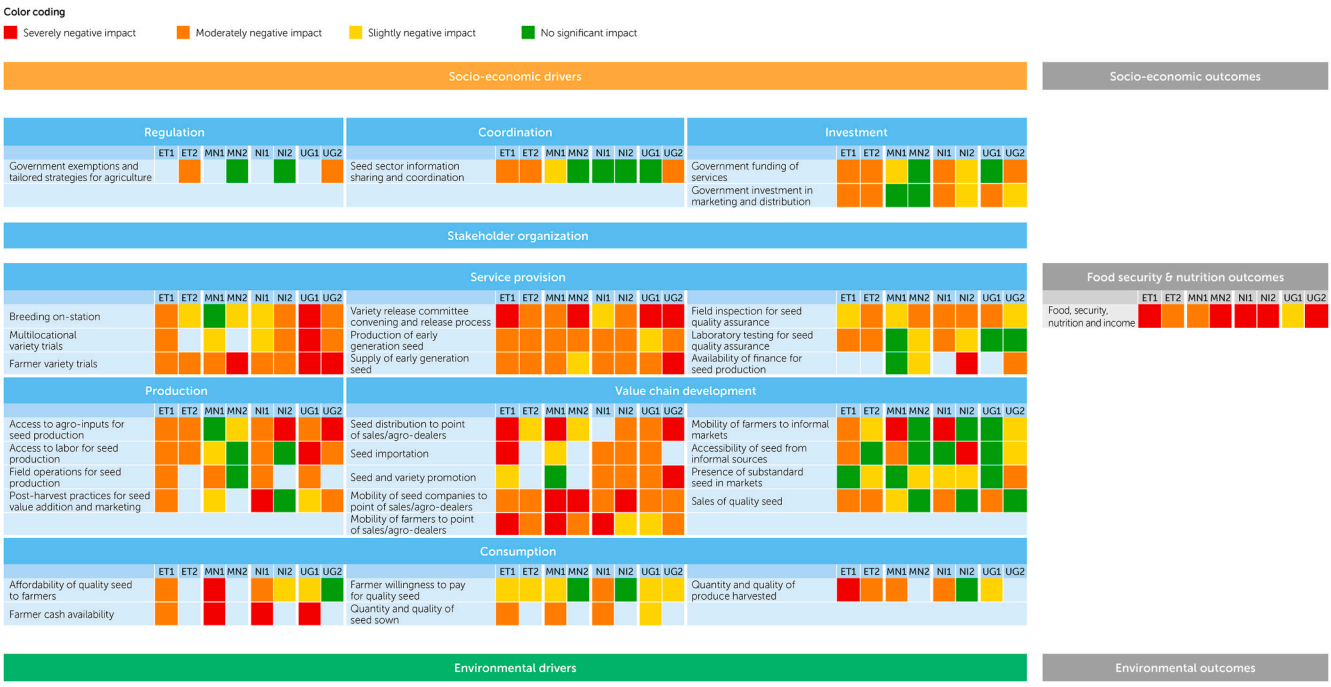


Fig. 5. Synthesis dashboard of the rapid assessments of the impact of COVID-19 on the functioning of the seed sector in Ethiopia, Myanmar, Nigeria and Uganda in 2020

N

ote: ET1: first rapid assessment, Ethiopia; ET2: second rapid assessment, Ethiopia; MN1: first rapid assessment, Myanmar; MN2: second rapid assessment, Myanmar; NI1: first rapid assessment, Nigeria; NI2: second rapid assessment, Nigeria; UG1: first rapid assessment, Uganda; UG2: second rapid assessment, Uganda.

for the introduction of services that facilitate faster payments for farmers, e.g., through the use of phone and online financial applications. Such services would support their entry into the formal economy, increase their eligibility for microloans to purchase or pre-finance inputs, and allow them to save money.

Restrictions in mobility and face-to-face meetings disrupted the functioning of horticulture sector platforms and governing bodies. In Ghana, such restrictions hindered the ability of horticulture platforms to coordinate a joint and effective response to the crisis; as such, the crisis contributed to a fragmentation of the stakeholders in the sector. In Rwanda, decision makers and representatives of government bodies followed up actions recommended in the alert documents, for example in facilitating access to finance and stabilizing labor availability.

3.3.3. *Assessment findings: sector and food system outcomes*

The COVID-19 crisis exposed significant vulnerabilities in the horticulture sector in the three countries. Both production and markets were negatively impacted, which resulted in income loss for farmers and value chain stakeholders. Households relying on horticulture for their income experienced a severely negative impact on their livelihoods; many needed to cut expenditures on food, education and/or health. The mobility restrictions also seriously affected other economic, off-farm income opportunities. COVID-19 impacted businesses and livelihoods of specific stakeholders in the sector in different ways, exposing and increasing inequalities. Farm-level laborers saw their working hours reduced, or worse yet, lost their jobs. Amongst laborers, women were particularly badly affected in their employment and thus livelihoods. The impact of the income loss is likely to spill over into the next seasons as the resilience of small- and medium-sized enterprises to future shocks has been reduced. Farm workers, and oftentimes small-scale farmers, have been left with less purchasing power to acquire food as well as inputs for the production of food crops. The resilience of the horticulture sector has been weakened, leaving particularly the poorer rural households more vulnerable to future crises and shocks. As the pandemic passed the one-year mark, these impacts have become more visible. Despite the blur of COVID-19, stakeholders have expressed their commitment to turn the tide on the outlook of their horticulture sector, and increase the resilience of the sector, recognizing the important role that horticulture plays in enhancing their country's food security and nutrition. The exercise of conducting the rapid assessments strengthened the relationship between various sector stakeholders in the three countries. Moreover, it reinforced sector-wide platforms, e.g., the Rwanda Horticulture Working Group, in their role and purpose in supporting sector transformation.

3.4. *The seed sector in Ethiopia, Myanmar, Nigeria and Uganda*

3.4.1. *A rapid assessment focusing on seed*

Rapid assessments were piloted by coalitions of partners in the seed sectors in Ethiopia, Myanmar, Nigeria and Uganda in May 2020, and were repeated up to six weeks later for advocacy purposes. Through the rapid assessments, these coalitions aimed to increase the resilience of the seed sector, by fostering continuity in farmers' access to quality seed in the current as well as forthcoming seasons. The May assessments were conducted during, or just after, maize planting in several countries in sub-Saharan Africa, whilst the June assessments coincided with the sowing of wheat in Ethiopia and rice in Myanmar. As such, the countries were at different stages in their agricultural seasons, which made the experience interesting for comparison and provided a glimpse into the future. Lessons were offered from one country to another. Fig. 5 presents the results in a dashboard that synthesizes the assessment results from the four countries using the integrated sector and food system framework.

3.4.2. *Assessment findings: sector activities*

De Boef et al. (2021) provide a synthesis of findings across the rapid assessments conducted in all four countries, which we summarize here. Reduced mobility was the root cause of disruptions in the supply of seed and complementary inputs to farmers. Disruptions throttled or in some cases ground to a halt seed production, processing and distribution, and

service provision in the seed industry, causing it to operate at reduced capacity. Had governments not done so already, the rapid assessments helped classify agriculture and input provision as essential to ease the movement of seed and workers during lockdown. Despite exempting agriculture from the lockdown at the onset in Uganda, the decision was not communicated clearly, and had to be confirmed during the country's first media briefing after entering lockdown. Those two weeks in late March-early April were crucial for sowing, and as a result many farmers could not access quality seed.

Producers in all four countries faced difficulty in obtaining sufficient early generation seed. Several seed producers in Ethiopia had to delay their payment and collection of available early generation seed, which exacerbated perceptions of inequality in the allocation and distribution of this scarce and highly sought-after input. Seed producers in all four countries were in need of support for seed production, in terms of making land, irrigation and finances available for use. In all countries, the rapid assessments raised awareness among and prompted seed companies and producers to attract, mobilize and secure labor by providing safe transport, board and lodgings. The provision of seed quality assurance services, like field inspection and laboratory testing for seed certification, faltered. It was reported that only powerful bidders like state-owned or large private companies were able to obtain services owing to the reduced capacity of service providers.

Sales of quality seed were also perceived to be negatively affected due to delays in distribution, weakened marketing efforts, and the limited presence of farmers at markets. An increase in the cost of transactions during the early stages of the pandemic was observed. This sparked concerns of seed scarcity and high prices, which have subsequently subsided. Bottlenecks in the import of traded goods like vegetable seed have likely made replenishing stocks difficult for agro-dealers. This was also exacerbated by falling foreign currency reserves, in Ethiopia in particular.

The release and registration of new varieties was delayed. National variety release committees in Ethiopia, Myanmar and Uganda failed to convene at the onset of the pandemic, and during the early stages of the crisis. As a result, they did not evaluate or approve several candidate varieties for release. Research organizations and breeding companies have not been able to demonstrate and multiply quality seed of these new promising varieties. Farmers are unlikely to benefit from the investments in crop improvement for at least another season or more in each case. Now underway in Ethiopia and Nigeria are efforts to reform variety release and registration. Rapid assessments pointed to major challenges to the efficacy of these processes in both countries.

The rapid assessments revealed how the pandemic actually facilitated the uptake of digital technologies by various stakeholders. It expedited the use of digital seed tracking technologies at scale in Nigeria and Uganda. Stakeholders were encouraged to explore exhaustively the possibilities of going digital in their service provision and internal procedures.

3.4.3. Assessment findings: sector and food system outcomes

The pandemic exacerbated structural weaknesses in the organization of formal seed systems in the four countries. It applied pressure that exceeded the limits to their resilience. Whilst these structural weaknesses were well-known in the four countries, in a fortunate turn of events the pandemic may just be the catalyst of long overdue reforms. In all four countries, governments exercised what were called palliative measures. In Ethiopia, these included selected exemptions from and strategic relaxation of seed regulatory controls, which the alert documents called for. In Nigeria, a seed subsidy intervention was put in place, enhancing farmers' access to quality seed. Seed producers in Myanmar received financial support, which was part of the country's COVID-19 fund and Economic Relief Plan (CERP).

The majority of respondents in the rapid assessments perceived a real threat to their countries' food security, nutrition and income. With reduced availability, access to and use of quality seed and genetic gains among farmers as a likely outcome, crop productivity is expected to fail to increase or worse yet, fall, resulting in a less diverse portfolio of crops and lower volume of food produced.

4. Lessons learned

The integrated framework creates an opportunity to better understand the dynamics, including drivers and trade-offs, of an agricultural sector as a subset of the food system. It provides stakeholders with an actionable tool for analyzing and guiding the performance of practical activities within an agricultural sector, which complements the analytical and decision-making potential of the food system framework with tangible outcomes. This will be useful as practitioners and policymakers attempt to fulfil commitments made by leaders at the UNFSS or because of it.

We applied the integrated framework with the specific purpose of assessing the impact of COVID-19 on three distinct agricultural sectors. Even though driven by urgency and consequential methodological limitations, the use of the framework increased our understanding of sector dynamics at an early stage of the pandemic. The framework was instrumental in assessing, in a holistic manner, the impact of the crisis on the performance of sectors in contributing to food system outcomes. It informed strategic decisions, and without it, interventions would have stood less chance of being well integrated and coordinated among stakeholders. The likelihood that solutions at different levels of scale would also complement each other would have been reduced.

The crisis exacerbated pre-existing structural weaknesses in the three sectors studied. Highlighting interdependencies and causality, which in some cases crossed sectoral boundaries, helped stakeholders within and beyond these sectors to review the impact of their actions on the continuity of sector functioning, as well as on food security and nutrition as an outcome. The power of linking the various activities within a sector to food system outcomes raised the stakes for authorities to act upon recommendations. Engaging multiple stakeholders, disciplines, and skillsets in the multi-stakeholder participatory process of rapid assessment and learning built consensus, cooperation, ownership, and a stronger collective call to action.

Assessing the impact of COVID-19 on agricultural sectors and identifying short-term solutions to mitigate immediate threats is just one of the framework's applications. We acknowledge that the food system and sector frameworks have been developed to identify and engage in longer term transformation processes. The integrated framework can be - and is already - used for the development and design of longer-term strategies guiding sector transformation, most recently for the seed sector in Ethiopia and Nigeria (MoA, 2019; NASC and SEEDAN, 2020). It has also been used for the design, monitoring and evaluation of multi-annual bilateral programs aimed at different outcomes of sector transformation (Molenaar et al., 2018; Thijssen et al., 2020; Borman et al., 2021).

The UNFSS marks the first of its kind; it is an indicator of the growing importance and relevance given to the concept of food systems, and how this can connect multiple agendas in a process of food system transformation. Commitments have been made at this level. For these commitments to trigger change, development professionals need to become systems practitioners and be able to translate abstract food systems thinking into practical action. The integrated framework emerges as an instrument to guide stakeholders in the transformation of agricultural sectors for attaining multiple and interconnected food system outcomes.

The integrated framework has helped unravel differences in our understanding of what transformation means. As professionals working at the policy, research, and practice nexus, we need to remain cognizant that food systems and sectors are social constructs; they exist only to the extent that people agree on their usefulness (Checkland, 1981). By joining in systems thinking, agreeing on which food system outcomes to pursue, and identifying the purpose for assessing the performance and contribution of agricultural sectors, we are putting systems thinking into

systems practice.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We recognize the tremendous commitment of sector stakeholders in Côte d'Ivoire, Ethiopia, Ghana, Myanmar, Nigeria, Rwanda, and Uganda, and their efforts in conducting and participating in rapid assessments with Wageningen University & Research (WUR). All projects in which rapid assessments were embedded, and where WUR works with partners on the transformation of agricultural sectors, are supported by the Ministry of Foreign Affairs of the Government of the Netherlands through respective Embassies of the Kingdom of the Netherlands in Abidjan, Abuja, Accra, Addis Ababa, Kampala, Kigali and Yangon. WUR provided knowledge and innovation resources for the conclusion of this article. We acknowledge the contributions of Anita Simons in designing the figures, and Elizabeth O'Keeffe in copy-editing the text. Finally, we would like to thank Astrid Mastenbroek, Melle Leenstra, Geert Westenbrink, and two anonymous reviewers, for their constructive reflections and suggestions for improving the paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2021.100591.

References

Borman, G.D., Hassena Beko, M., Admassu Estizia, M., Van den Hurk, A.M., 2021. Ethiopia-Netherlands Seed Partnership 2021 – 2025; Proposal for the Embassy of the Kingdom of the Netherlands in Addis Ababa. WCDI-21-138-Rev2. Wageningen Centre for Development Innovation, Wageningen.

Brouwer, I.D., McDermott, J., Ruben, R., 2020. Food systems everywhere: improving relevance in practice. Glob. Food Sec. 26, 100398. https://doi.org/10.1016/j.gfs.2020.100398.

Checkland, P.B., 1981. Systems Thinking, Systems Practices. John Wiley, Chichester.

De Boef, W.S., Borman, G.D., Gupta, A., Subedi, A., Thijssen, M.H., Aga, A.A., Hassena, M.B., Thein, S.Z.M., Thein, W., Okelola, F., Olusegun, O., Olusegun, Ojo P. O., Agbara, C., Otim, G., Ssemwogerere, P., Ntare, B., Oyee, P., 2021. Rapid assessments of the impact of COVID-19 on the availability of quality seed to farmers: advocating immediate practical, remedial and preventative action. Agric. Syst. 188, 103037. https://doi.org/10.1016/j.agsy.2020.103037.

De Brauw, A., Van den Berg, M., Brouwer, I.D., Snoek, H., Vignola, R., Melesse, M.B., Lochetti, G., Van Wagenberg, C., Lundy, M., Maître d'Hôtel, E., Ruben, R., 2019. Food System Innovations for Healthier Diets in Low and Middle-Income Countries. IFPRI Discussion Paper 1816. IFPRI, Washington-DC. http://www.ifpri.org/publication/food-system-innovations-healthier-diets-low-and-middle-income-countries. (Accessed 5 May 2021).

Dekeyser, K., Rampa, F., D'Alessandro, C., Bizzotto Molina, P., 2020. The Food Systems Approach in Practice: Our Guide for Sustainable Transformation. European Centre for Development Policy Management, Maastricht. https://ecdpm.org/wp-content/uploads/Food-Systems-Approach-In-Practice-Guide-For-Sustainable-Transformation-ECDPM-Discussion-Paper-278-2020.pdf. (Accessed 2 April 2021).

Eriksen, P.J., 2008. Conceptualizing food systems for global environmental change research. Global Environ. Change 18, 234–245. https://doi.org/10.1016/j.gloenvcha.2007.09.002.

FAO, 1996. Rome Declaration and World Food Summit Plan of Action. FAO, Rome. http://www.fao.org/3/w3613e/w3613e00.htm. (Accessed 1 April 2021).

FAO, IFAD, UNICEF, WFP, WHO, 2020. The State of Food Security and Nutrition in the World 2020. Transforming Food Systems for Affordable Healthy Diets. FAO, Rome. https://doi.org/10.4060/ca9692en.

Global Panel on Agriculture and Food Systems for Nutrition, 2016. Food Systems and Diets: Facing the Challenges of the 21st Century. Global Panel on Agriculture and Food Systems for Nutrition, London. https://www.glopan.org/foresight1/. (Accessed 1 April 2021).

Goswami, R., Roy, K., Dutta, S., Ray, K., Sarkar, S., Brahmachari, Nanda M.K., Mainuddin, M., Banerjee, H., Timsina, J., Majumdar, K., 2021. Multi-faceted impact and outcome of COVID-19 on smallholder agricultural systems: integrating qualitative research and fuzzy cognitive mapping to explore resilient strategies. Agr. Syst. 189, 103051. https://doi.org/10.1016/j.agsy.2021.103051.

Hall, A., Dijkman, J., 2019. Public Agricultural Research in an Era of Transformation: the Challenge of Agricultural System Innovation. CGIAR Independent Science and Partnership Council (ISPC) Secretariat and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Rome and Canberra. https://cas.cgiar.org/sites/default/files/pdf/syntetic-study-web-def.pdf. (Accessed 1 April 2021).

HLPE, 2017. Nutrition and Food Systems. A Report by the High Level of Experts on Food Security and Nutrition of the Committee on World Food Security. HLPE, Rome. http://www.fao.org/3/i7846e/i7846e.pdf. (Accessed 2 April 2021).

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

Kamerbrief, 2014. Kamerbrief over Nederlandse Inzet Voor Wereldwijd Voedselzekerheid. 18 November 2014. Minister van Buitenlandse Zaken en Ontwikkelingssamenwerking, Staatsecretaris voor Economische Zaken. Referentie: DME-2014.601068. https://zoek.officielebekendmakingen.nl/kst-33625-147.html. (Accessed 2 May 2021).

Millennium Ecosystem, A., 2003. Ecosystems and Human Well-Being: a Framework for Assessment. Island Press, Washington. https://pdf.wri.org/ecosystems_human_well_being.pdf. (Accessed 1 April 2021).

MoA, 2019. Transforming the Ethiopian Seed Sector. Issues and Strategies. Ministry of Agriculture, Addis Ababa. https://issdethiopiablog.files.wordpress.com/2019/11/seed-sector-transformation-guiding-document-final-july-2019-vfinal.pdf. (Accessed 14 May 2021).

Molenaar, J.W., Gorter, J., Heilbron, L., Simons, L., Vorley, B., Blackmore, E., Dallinger, J., 2015. Sustainable Sector Transformation: How to Drive Sustainability Performance in Smallholder-Dominated Agricultural Sectors? White Paper 1. Commissioned by IFC. Aidenvironment, Amsterdam; New Foresight, Utrecht. IIED, London. https://pubs.iied.org/16584iied. (Accessed 4 April 2021).

Molenaar, J.W., Vorley, B., Blackmore, E., 2017. Reaching beyond the Value Chain. How Sector Governance Can Improve the Performance of Agricultural Commodity Sectors. Aidenvironment, Amsterdam; IIED, London; Sustainable Food Lab, Hartland. http://www.sustainablefoodlab.org/wp-content/uploads/2017/05/Sector-Governance-Full-Report_May2017.pdf. (Accessed 4 April 2021).

Molenaar, J.W., Short, D., Emana, B., Kebede, D., 2018. Mid-term Review of the BENEFIT Partnership. Aidenvironment, Amsterdam.

Molenaar, J.W., Kessler, J.J., 2021. Sector Transformation: a Systems Approach to Transforming Commodity Sectors. Aidenvironment, Amsterdam.

NASC, SEEDAN, 2020. National Seed Road Map for Nigeria. National Agricultural Seeds Council, Abuja; Seed Entrepreneurs Association of Nigeria, Abuja. Wageningen Centre for Development Innovation, Wageningen. https://seedcouncil.gov.ng/wp-content/uploads/2020/03/National-Seed-Road-Map_Nigeria-NASC-Adopted.pdf. (Accessed 5 May 2021).

Nordhagen, S., Igbeka, U., Rowlands, H., Shine, R.S., Heneghan, E., Tench, J., 2021. COVID-19 and small enterprises in the food supply chain: early impacts and implications for longer-term food system resilience in low- and middle-income countries. World Dev. 141, 105405. https://doi.org/10.1016/j.worlddev.2021.105405.

Posthumus, H., de Steenhuijsen Piters, B., Dengerink, J., Vellema, S., 2018. Food Systems: from Concept to Practice and Vice Versa. Wageningen University & Research, Wageningen; KIT Royal Tropical Institute, Amsterdam. https://doi.org/10.18174/464054.

Posthumus, H., Bosselaar, J., Brouwer, H., 2021. The Food System Decision Support Tool – a Toolbox for Food System Analysis. KIT Royal Tropical Institute, Amsterdam; Wageningen University & Research, Wageningen. https://doi.org/10.18174/541410.

Ruben, R.R., Verhagen, J., Plaisier, C., 2018. The challenge of food systems research: what difference does it make? Sustainability 11 (1), 171–185. https://doi.org/10.3390/su11010171.

Stephens, E., Martin, G., Van Wijk, M., Timsina, J., Snow, V., 2020. Editorial: impacts of COVID-19 on agricultural and food systems worldwide and on progress to the sustainable development goals. Agr. Syst. 183, 102873. https://doi.org/10.1016/j.agsy.2020.102873.

Thijssen, M., De Boef, W., Van Koesveld, F., Van den Hurk, F., Okelola, F., Nwuneli, N., Tidjani, F., Haegens, R., Piñán González, L., 2020. Collaborative Seed Project Contributing to the Nigeria-Netherlands Seed Partnership. Proposal for the Embassy of the Kingdom of the Netherlands in Abuja. Wageningen Centre for Development Innovation, Wageningen University & Research, Wageningen.

UN, 2012. United Nations secretary-general's zero hunger challenge. https://www.un.org/zerohunger/content/challenge-hunger-can-be-eliminated-our-lifetimes. (Accessed 30 April 2021).

UN, 2021. Food systems Summit 2021. https://www.un.org/en/food-systems-summit. (Accessed 30 April 2021).

UNEP, 2016. Food Systems and Natural Resources. A Report of the Working Group on Food Systems of the International Resource Panel. UNEP, Nairobi. https://www.resourcepanel.org/reports/food-systems-and-natural-resources. (Accessed 1 April 2021).

Van Berkum, S., Dengerink, J., Ruben, R., 2018. The Food Systems Approach: Sustainable Solutions for a Sufficient Supply. Wageningen Economic Research, Wageningen. https://doi.org/10.18174/451505.

Vos, R., Cattaneo, A., 2021. Poverty reduction through the development of inclusive food value chains. J. Integr. Agr. 20 (4), 964–978. https://doi.org/10.1016/S2095-3119(20)63398-6.

WCDI, 2020. Methodology Brief. Wageningen Centre for Development Innovation, Wageningen file:///C:/Users/boef004/Downloads/Rapid%20Assessments%20Methodology%20(1).pdf. (Accessed 14 May 2021).

WUR, 2021. The Effects of COVID-19 on Food Systems: Rapid Assessments. Wageningen University & Research, Wageningen. https://www.wur.nl/en/Research-Results/Research-Institutes/centre-for-development-innovation/Our-Value-Propositions/Guiding-Sector-Transformation/The-effects-of-COVID-19-on-food-systems-rapid-assessments.htm. (Accessed 2 April 2021).