CHAPTER 13

A Consumer–Food Security Nexus Framework Analysis for Resilient Agrifood Value Chains

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Introduction

There is a global consensus that the current food system, involving the production, processing, transport, and consumption of food, is failing—threatening our food security, nutritional security and health, social justice, and natural resources—and therefore requires an immediate transformation if the global "zero hunger by 2030" agenda is to be achieved (HLPE 2017; HLPE 2020). The United Nations Committee on World Food Security defines "food security" as the state in which "all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life" (FAO 2002, Glossary). Food security is increasingly under threat: a report on global food security crises shows that 108 million people from 48 countries suffered from acute food insecurity in 2016 (FAO 2017). By the end of 2019, the number had increased to 135 million in 55 countries (FSIN 2020). By the end of 2020, the impacts of the COVID-19 pandemic had nearly doubled this number to 265 million people (WFP 2020).

Food insecurity, undernutrition, and overnutrition have been characterized as a triple burden (Pinstrup-Andersen and Watson 2011); this burden is a global challenge that is worsening by the day. The implications are dire and affect millions, including through the incidence of diseases and conditions such as diarrhea, obesity, anemia, cardiovascular disease, growth retardation, and many others (FAO, IFAD, and WFP 2014). Although the triple burden has multiple causes, the diets of consumers play a critical role (Gómez and Ricketts 2013).

Food undergoes a variety of processes before reaching consumers' tables. These processes are known as the value chain and operate in conjunction with agents who work to provide food products (Beretta et al. 2013). The nature of the food value chain influences the availability, accessibility, acceptability, physical and nutritional quality, and utilization of food. Agrifood value chains, within which consumer preferences and needs are embedded, also influence food and nutrition security (Alkire et al. 2014). Disruptions within agrifood chains due to shocks, such as COVID-19, floods, locusts, and others, have a direct impact on food security. Thus, optimizing agrifood value chains is essential to addressing food security issues and consumer needs.

Considering the dynamic environment within which value chains operate, their ability to deal with and overcome unpredictable disruptions (extreme weather, pandemics, etc.) is critical to their performance. An inability to adapt and recover leads to an inability to address the needs and wants of consumers and endangers food security. A value chain analysis (VCA) that does not use a resilience lens cannot reveal the factors that hinder or enhance resilience. Information about these factors can facilitate measures to reduce the costs of disruptions or set up better systems and structures to enable value chains and their actors to adapt to shocks (Carluccio et al. 2020).

The main goal of agrifood value chains is to ensure that a sufficient quantity of nutritious and quality food is made physically and economically accessible to all. The ability to meet this goal despite potential disturbance is embodied by the concept of stability, which is another food security pillar beyond availability, accessibility, acceptability, quality, and utilization (Tendall et al. 2015). Thus, a key step in building resilient food systems is to first understand and assess food value chains through the lens of resilience. This approach requires assessing food value chains with a consumer and food security focus, as well as a with a holistic view comprising social, economic, environmental, and other factors. Such a framework for food value chain analysis can reveal weaknesses in different areas of the value chain and help policymakers better build capacities in the food system to deal with current challenges and future uncertainties (Tendall et al. 2015).

Practically, assessing the value chain through a resilience lens begins with identifying the sources of risks or threats. This identification is necessary to predict and prevent potential shocks and put mitigation strategies into place. The assessment aims to gather information that can be used to help prevent foreseen shocks and to design the strategies necessary to help value chains recover from unforeseen shocks. An understanding of how the value chain can meet consumer preferences and contribute to the achievement of food security is useful for predicting shocks, planning for future mitigation of shocks, and strengthening resilience (Carluccio et al. 2020).

Existing assessment frameworks encompass the social, environmental, and economic aspects of agrifood value chains. However, there has not been any work on a framework with a consumer focus. Current agrifood value chain assessments are usually centered on activities at the production stage, and there is a disconnect with consumers, who are usually the end target of functioning value chains. There are no tools, methods, or frameworks that adequately assess the impact of agrifood value chains from a consumer- and food security–based perspective. This type of tool is crucial during severe disruptions of the supply chain, such as those caused by the COVID-19 pandemic. It is widely recognized that the pandemic placed enormous pressure on food supply chains as a result of social distancing requirements, labor shortages, and widespread lockdowns. In these situations, hardcore economic considerations typically trump the consumer considerations that are crucial for ensuring sustainable production and access to nutritious foods.

In this chapter, we argue for the importance of a consumer focus in agrifood value chain assessments and present a methodological framework for such an assessment. The first section defines a holistic framework for a consumer-centered value chain. Then, a system for the selection of criteria, indicators, and dimensions for performance assessment is outlined. Based on this system, the method of assessment for each dimension and the interrelatedness between dimensions is presented.

Agrifood Value Chains

VCA techniques have been used by businesses for many years to determine strategies to improve competitiveness. This type of analysis has been applied widely in the literature in different fields, including food and agriculture. The majority of agrifood VCAs are focused on identifying product flow and relationships, estimating financial returns, and assessing challenges and opportunities (Dalipagic and Elepu 2014; Kelemework 2015; Tesfaw 2015; Zhang, Ren, and Liu 2012; Kirimi et al. 2011; de Souza and D'Agosto 2013). The primary trend among the studies is an assessment of the value chain from the production perspective, with a focus on improving production quantity, reducing costs, and increasing profits. Hardly any studies have been conducted with the aim of providing more value for consumers while improving economic benefits for value chain actors (Zokaei and Simons 2006).

Agrifood value chain activities are interrelated and interdependent (Flynn and Bailey 2014). Due to these linkages, analysts have proposed that value chains should pursue sustainable development, which is core to fostering consumer satisfaction and contributing to society, the environment, and economic viability (Mitchell, Keane, and Coles 2009). The introduction of a set of different assessment dimensions aims to achieve better alignment between resource allocation, consumer value, and management toward sustainability and profitability. This holistic approach to assessing agrifood value chains will aid value chain actors, policymakers, and other stakeholders in designing and implementing strategies that are effective, applicable, and adapted to the dynamic nature within which the agrifood system functions—thus leading to increased consumer satisfaction, economic viability, and food security.

Recently, environmental and social dimensions have gained importance because of the strong linkages between agrifood industries, society, and the environment (Marsden and Morley 2014), and the failed quest to meet established goals in these areas (McCullough, Pingali, and Stamoulis 2008). A focus on social dimensions has become necessary due the impact of agrifood value chains on the welfare of actors. Thus, issues related to worker safety, gender imbalance in employment, access to inputs and services, labor issues (Ndanga, Quagrainie, and Dennis 2013), and welfare impacts on value chain actors are assessed. Environmental challenges such as land degradation, water scarcity, and climate change resulting from natural resource abuse (Nellemann et al. 2009) have created the need for environmental assessments. These multidimensional assessments focus on ensuring that the agrifood sector is transformed to sustainably feed growing populations (Fritz and Schiefer 2008).

Value chains will not be sustainable without an efficient governance structure and the ability to adapt quickly to changes in the surrounding socioeconomic environment (Bachev 2017). The loss management dimension is important in understanding the factors that contribute to physical, economic, and nutritional losses, especially because these losses have implications for the availability, accessibility, affordability, and nutrient composition of food. A food quality assessment, for instance, is necessary to understand how activities affect the quality attributes preferred by consumers.

Although a focus on sustainability has been proposed, only the primary sustainable development dimensions (economic, social, and environmental) have been integrated into food value chain assessments. The aspect of consumer satisfaction has received little attention, even though the consumer is the ultimate target of the activities undertaken along the value chain. The analysis is not focused on identifying how the activities along the value chain meet consumer needs or influence food security.

The definition of food security centers around the four pillars of availability, access, utilization, and stability (World Summit on Food Security 2009). Food availability focuses on the physical presence of a sufficient quantity of quality food that is made available through domestic production, import, food aid, or stocks (FAO et al. 2019). Food access is the ability to secure food that is adequate to make up a nutritious diet by having access to income and adequate resources (FAO 2008). Food utilization centers on the means by which the body uses the nutrients available in food. This is influenced by diet, eating habits, preparation, and hygiene practices, among others (FAO et al. 2019). Food stability occurs met when all four pillars are met at the same time (FAO 2008) thus focuses on achieving availability, accessibility, and utilization over time. It addresses short- to long-term instabilities caused by economic, climatic, social, or political factors (FAO et al. 2019).

The value chain approach can be used to achieve food security objectives because it helps to identify incentives (or other strategies) to produce and market nutritious foods that meet consumer demands without overlooking production costs. Due to its capacity to reveal underlying constraints in the whole-product production and marketing system, it tends to be a more holistic and sustainable approach to equipping food value chains to better contribute to achieving food security objectives with long-term impacts. This goal is ultimately accomplished by guiding and influencing the activities of value chain actors to meet the needs and preferences of the target market or consumers (Marketlinks n.d.).

VCA approaches operate under the assumption that effective supply chains and cost efficiencies will lead to acceptable consumer satisfaction. This approach is inadequate because the lack of consumer focus will result in production activities that do not respond to shifts in consumer expectations (Thublier, Hanby, and Shi 2010). According to Capper (2013, 157-71), "If a production practice is economically viable and reduces environmental impact yet is unacceptable to the consumer, the system is out of balance." For the consumer, value includes the product's taste, color, size, nutritional content, safety, and convenience of use, among other factors. Therefore, from a subjective point of view, the true value of the product being offered cannot be inferred from assessing value as a benefit-cost ratio. Limited attention has been given to evaluating nonmonetary benefits in a VCA. Making consumers the focus of agrifood value chains is important because food is no longer viewed as something that simply meets a basic need, but also as something that fits into a particular lifestyle and achieves a desired goal (Costa and Jongen 2006). Consumer needs and lifestyles are constantly changing.

Consumers' preferences and needs have not been translated into product features and value chain measures. This makes it difficult to determine how to adequately measure the performance of the value chain in meeting consumer needs and to address these needs. This premise assumes that meeting consumers' needs will lead to consumer satisfaction after consumption. Agrifood sectors need to be upgraded to address newly diversified and expanded consumer demand for high-quality, safe, nutritious, healthy, and convenient foods (Hazell and Wood 2008).

Further, agrifood value chains have not been assessed to determine their effectiveness in positively contributing to the pillars of food security. To expand on the earlier definition, stability represents the ability of the food value chain to continually make nutritionally and culturally appropriate food available in sufficient quantities that are physically and economically accessible to all, even in the midst of a disturbance (Tendall et al. 2015). Resilience is therefore important for food security and directly linked with the functions of food systems (Alinovi, Hemrich, and Russo 2008, 274). Value chain indicators that have direct links with the pillars of food security need to be developed for agrifood value chain assessments. Considering that there has been a consensus about the potential of agrifood value chains to contribute to achieving food security, there should be studies that evaluate the performance of agrifood value chains in doing so (Alkire et al. 2014). Food value chains determine whether food produced is available, accessible, and affordable. They also determine whether the product is acceptable based on consumer preferences, whether consumption and nutritional needs are being met consistently, and whether the system as a whole has the capacity to adequately meet those needs when there is a disturbance.

Food insecurity and malnutrition are caused by challenges on both the demand side (consumer) and the supply side (food value chain). On the demand side, lack of income, employment problems, gender inequality, issues with household food diversity, and low awareness of nutrition are some of the leading causes of food insecurity and malnutrition (Arimond et al. 2010; Black et al. 2013). However, households make food choices based on what is available (including the state, form, desirability, price, and quantity of the products), as well as when, where, and how the food is made available, all of which are impacted by the value chain. Activities along the food supply chain influence what is provided to consumers and, therefore, their food security. Much attention has been paid to understanding and mitigating food insecurity at the household level. While this is important, it is also necessary to transform the agrifood sector (Maestre, Poole, and Henson 2017).

A clear understanding is needed of the conditions within which these value chains operate and how they impact consumer preferences and food security. The ability to develop this understanding will depend on the technique applied to assess food value chains. Assessment tools are structured to assess performance levels, with measurable sub-areas and indicators. Existing tools and indexes take two to five (or more) different dimensions into consideration. Some indexes are more complex than others and include more than 60 broad parameters (Sulewski and Kloczko-Gajewska 2018).

The major dimensions in value chain and sustainability assessments are economic, environmental, and social (Hayati 2017). However, there are no consumer-centered indicators or indicators that are linked to both consumer preferences and the pillars of food security. This chapter presents a methodological approach for the development of consumer-focused indicators to assess the agrifood value chain and its association with food security.

Design and Application of the Consumer-Based VCA Model

Consumer-focused value chains are defined as chains that perform activities in a socioeconomically and environmentally efficient way to meet consumer needs and preferences at all times. The consumer-oriented VCA approach focuses on evaluating the effectiveness of agrifood value chains in meeting consumer preferences, along with achieving food security and meeting nutrition needs. Based on this approach, a conceptual framework was developed as well as a performance index.

The framework helps identify the necessary criteria for agrifood chains to be successful in meeting consumer preferences holistically within a food security context. It reveals the constraining factors and provides policymakers with a more efficient way to design and implement strategies that create an appropriate operational environment for value chains.

Conceptual Model of a Consumer–Food Security Nexus for Agrifood VCA

The model begins by identifying consumer preferences and needs at the household level. It introduces a concept known as household value chain analysis (HVCA), which focuses on consumers and their experiences with a product. An HVCA enables product suppliers to comprehensively understand product users, their relationship with each other, and the use of the product. It identifies the processes that a product goes through from purchase to disposal (the consumption chain) and the product's final users. An HVCA is based on the idea that the product purchased is an input that is transformed into different valued commodities (outputs) within the household to obtain maximum utility. This analysis provides a wide range of information, such as purchase location, delivery, purchase options, price, availability, accessibility, and marketing strategy. It also provides information on household preferences, constraints in the product's utilization, and the quality of the product available to the consumer. It also considers factors that influence preparation, storage, and consumption, and the effect of preparation and storage on the physical and nutritional composition and safety of the product, including constraints and satisfaction with product use.

In the application of an HVCA, product attributes are weighted by observing visible changes or measuring the changes (increases or reductions) in the product's attribute levels as it moves along the consumption chain. For example, if beans become darker in storage, they will be less desirable to consumers who prefer light-colored beans. Information on the importance of product quality attributes can be obtained by asking consumers to rank or rate different levels of product attributes. The ranking or rating of attributes by consumers is useful in determining the level of utility provided by the commodity.

Choice-based models and hedonic price models can be applied to reveal the importance that consumers place on different attributes, trade-offs they are willing to make, and value (willingness to pay a discount or premium for the attribute). The level of satisfaction that consumers have with different attributes as the product goes through different processes can also be solicited. Understanding the different processes (purchase, storage, preparation, consumption) that the product goes through during and after purchase reveals consumer preferences and needs for certain product attributes. The completed HVCA should provide a clear understanding of what is valuable to the consumer. This knowledge will shape the activities performed by value chain actors through process optimization and product development to ensure the sustained demand and consumption of targeted foods.

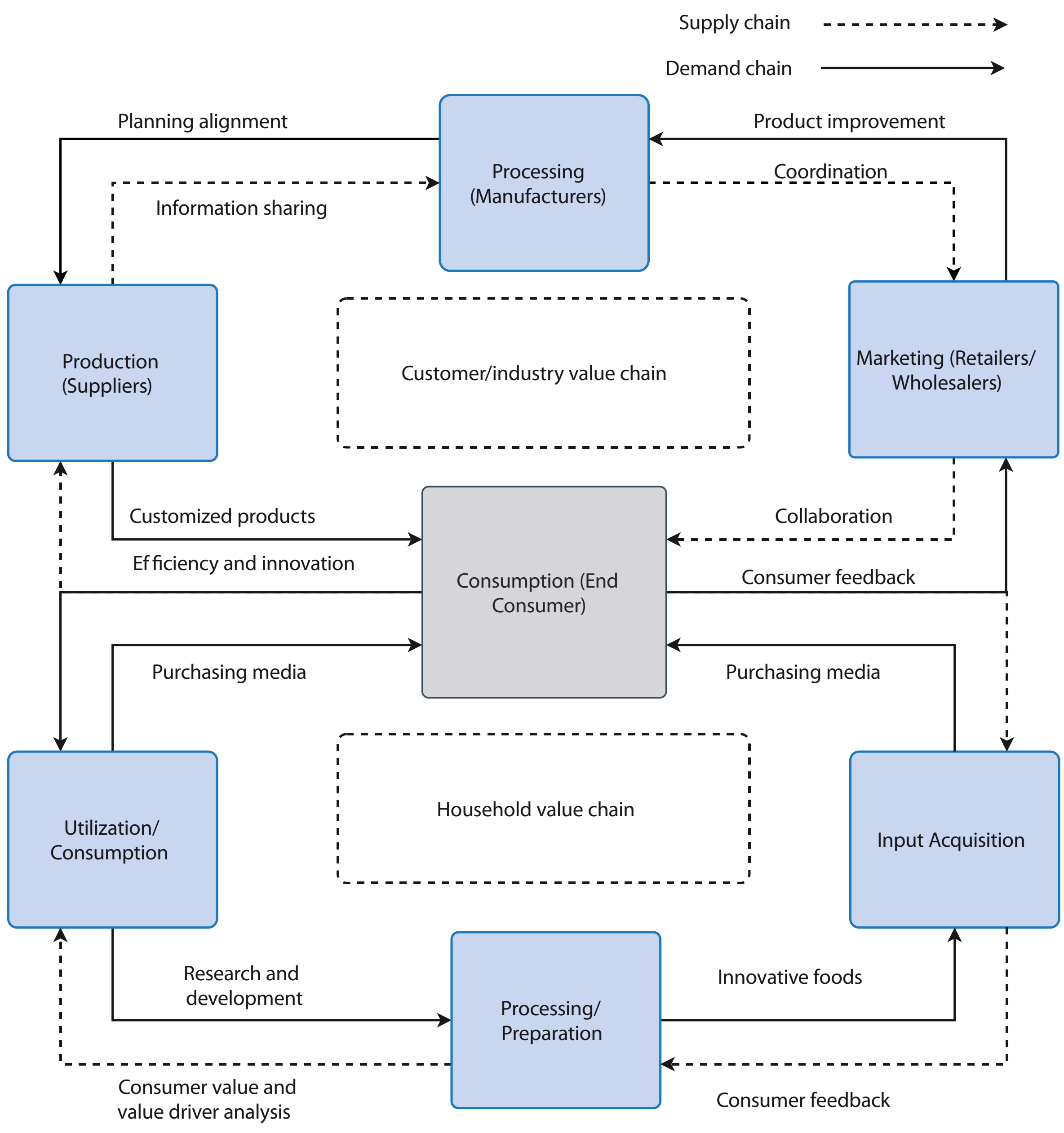
The approach to modeling a consumer–food security nexus for agrifood VCA starts at the consumer/household level, and then the gathered information is used in the food value chain to enable value chain actors to meet identified preferences and needs. The information on consumer preferences and needs is also linked to each food security pillar. Connecting specific consumer preferences to each pillar allows the preferences to serve as sub-indicators of the food security pillars. The sub-indicators are useful for identifying ways to measure and track food security by meeting consumer preferences.

Conceptual Model

Figure 13.1 represents a consumer-based value chain model made up of the product supply and demand chains. The demand chain is the consumption stage, which emphasizes the activities performed by the consumer after the purchase of a product. The demands of the consumers are defined at this stage. These demands are then used as guidelines in evaluating how well the value chain meets consumer preferences and needs. Such information is useful to product supply chain actors such as producers, processors, and marketers. The supply side of the chain focuses on shaping, satisfying, and sustaining consumer demands. Since consumer demands are linked to the food security pillars, satisfying consumer demands will have a positive impact on food security.

Figure 13.2 presents the elements to be considered in a consumer-based VCA. Due to the introduction of food security elements in the analysis, Figure 13.2 also represents a

FIGURE 13.1—CONSUMER-BASED VALUE CHAIN



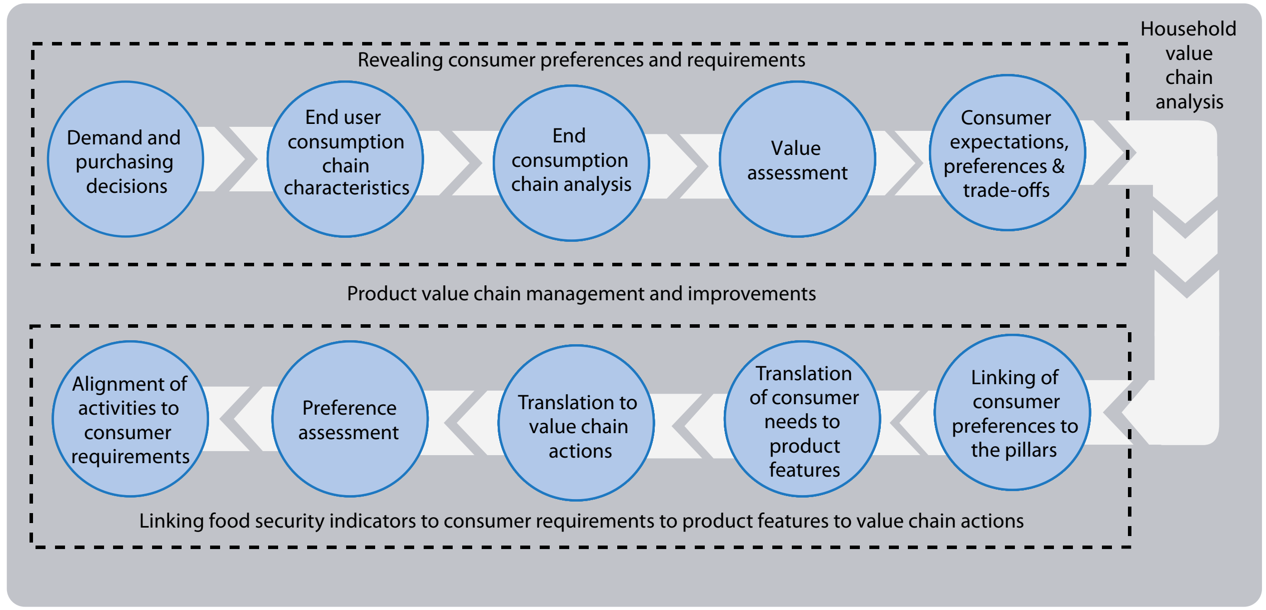
Source: Authors.

consumer–food security nexus for agrifood VCA. The concept centers around the following steps:

1. Effectively capture final consumer requirements, that is, consumer preferences and needs, and categorize their links according to each pillar of food security.
2. Translate preferences and needs, which are sub-indicators of the pillars of food security, into measurable product features and value chain actions. The consumer requirements are linked to the food security pillars (CRFSP), which are then associated with supply chain dimensions (comprised of indicators). This will give value chain actors a clear way to incorporate consumer requirements into their activities.
3. Identify indicators and dimensions at the supply chain level that are output parameters in order to evaluate the chain's performance in meeting consumer requirements and food security pillars.
4. Identify and implement strategies to meet consumer requirements.

The overall concept depicted in Figure 13.2 centers around the determination of consumer requirements, linking consumer requirements to food security pillars; an assessment of the supply chain's performance in meeting consumer requirements and aligning with food security pillars; and the identification and implementation of strategies to close the gaps. The focus is on addressing the following questions: What are consumers' requirements and what values do they desire from a product? How are these requirements and desired values linked to food security pillars? How can profitable operations along the value chain be adjusted to provide the desired value while positively impacting food security?

FIGURE 13.2—FLOW OF CONSUMER-BASED VALUE CHAIN ANALYSIS



Source: Authors.

Application of the Consumer-Based Model

Analysis of the Consumption Chain

Different forms of assessment can be used to analyze the consumption stage of the product value chain, including the following:

1. Determine what consumers require, factors influencing their requirements, and the value expected from the use of a product. This assessment answers questions such as: What do consumers do with the product? How do they use it? Why do they use it that way? What do they prefer?
2. Identify and assess the different activities performed, the resources (time, energy, etc.) used for each process during the utilization of the product, and the factors influencing the different activities performed.

3. Assess how consumers make trade-offs between different products and product attributes. For instance, during a purchase, consumers might have to choose a product based on a group of attributes (taste, size, color, etc.) with different characteristics (tasty/bland, small/large, white/brown, etc.). Considering that their desired attributes may not all be available in one product, consumers would have to make trade-offs between attributes. Supply chains make many trade-offs in determining how to create more value for consumers. Instead of making such decisions based only on industry capacities and timeframes, consumer preference information can enable industries to make sounder and more profitable trade-offs.
4. Identify constraints and satisfaction with the product at different levels of the consumption chain (input acquisition, preparation/procession, and utilization).

Connecting Consumer Preferences with Food Security Pillars

Information gathered from the consumption chain assessment on consumer preferences can then be linked to food security pillars. These preferences make up the measurable indicators which will be linked to the food security pillars. The food security pillars considered in the framework are availability, accessibility, affordability, acceptability, utilization, and stability. These food security pillars and the consumer requirements that can be linked to them are explained below.

1. Availability: The food must be physically available through farm production and easily accessible to traders and processors who purchase for redistribution and value addition. Consumer requirements related to availability include frequency/seasonality, quantity, and variety.
2. Accessibility: The food must be physically accessible to consumers at a relatively low cost in the locations where they reside or perform livelihood activities. Consumer accessibility requirements in relation to time, frequency/seasonality, quantity, variety, distance to market, and the availability of different types of markets can be linked to this pillar.
3. Affordability: Consumers should have the economic capacity to purchase foods. The ability of value chains to provide low-cost foods is dependent on the availability of price incentives (Hawkes et al. 2012) and the undertaking of cost-efficient measures. Consumer price requirements or concerns and their implications for purchase can be linked to this pillar.
4. Acceptability: Food must be acceptable to consumers in meeting their tastes and requirements. These requirements include physical appearance, ease of preparation, compliance with cultural norms, and consumption patterns. Consumers do not want to make trade-offs between requirements when purchasing specific foods, even if those foods happen to be nutritious. Consumer requirements regarding taste, size, freshness, convenience, color, packaging, and cleanliness, among others, can be linked to this pillar.
5. Consumption/utilization: At the point of consumption, food must be safe, nutrient-dense, and in different forms that meet the requirements of diverse groups of consumers ranging from infants to adults. Consumer requirements regarding safety, nutrition, and value-added products, for example, can be linked to this pillar.
6. Stability: This pillar requires that consumers have access to adequate food at all times, including in the event of sudden shocks (FAO 2006). The other five pillars mentioned above all hinge on this one, which reinforces the need to assess the performance of agrifood value chains in meeting food needs in both the short and long term. This performance assessment should consider the capacity of agrifood value chains to prevent or mitigate risk, and withstand and adapt to disturbances over time. Basically, value chains should be resilient enough to withstand and recover from disruptions in ways that ensure there is always a sufficient supply of acceptable and accessible food for all.

Consumer-Based Performance Assessment Index for Agrifood Value Chains

The consumer-based assessment index for agrifood value chains is developed in a four-step process.

Step 1: Translation of CRFSP product features

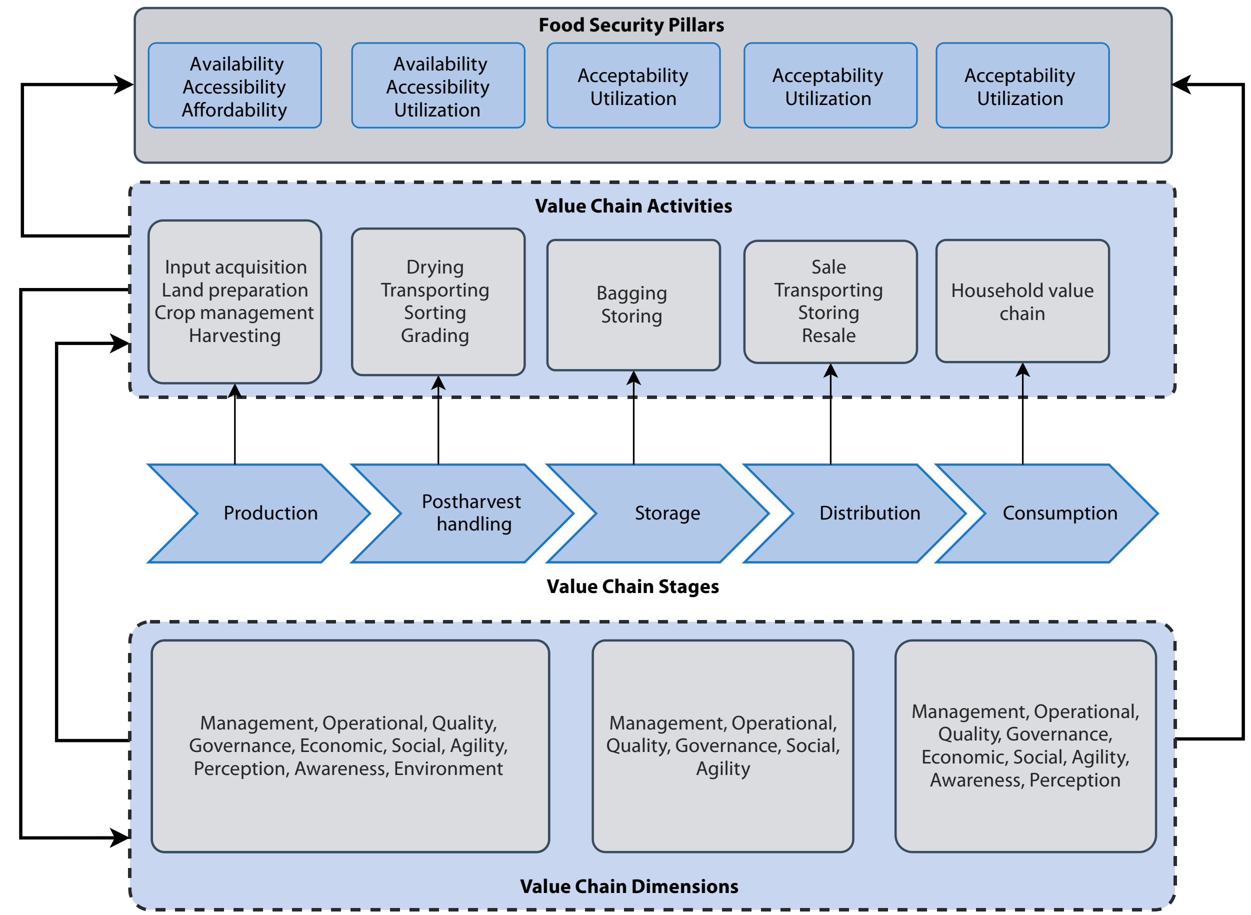
Consumer requirements can be used to define product features that consumers desire in the market. After linking consumer requirements to food security pillars, the requirements are further translated into product features.

Step 2: Translation of CRFSP into value chain actions

It is important for consumer requirements to be translated into measurable value chain actions. Information gathered on consumer requirements can then be translated into product features and processes. For each food security pillar, the authors first assessed what the consumer requires and values when a product is considered. How will this preference then be translated into a product feature? What actions along the value chain need to be taken to provide this feature? Lastly, how will the efficiency of the value chain actions be measured? Translating consumer requirements into value chain actions aims to determine the factors and activities along the value chain that are needed to meet these consumer requirements. The value chain actions are used as indicators to assess the performance of the chain in meeting consumer requirements.

In this step, we develop a performance index based on a system for selecting indicators, criteria, and dimensions with a focus on consumers and food security. For each dimension, there is a corresponding set of value chain indicators that are made up of value chain actions. The dimensions are further linked to food security pillars that have consumer requirements as sub-indicators. The value chain indicators are measurable parameters of the different dimensions. The tool is a multidimensional performance-based index that determines not only how the chain is performing across the different dimensions but how these dimensions influence consumers and food security (Figure 13.3). It considers more than one dimension, value chain stage, and actor (meaning producer and trader, both performing activities at different locations). The food security pillars and value chain dimensions represent areas of possible impact, while the indicators are the practical measures of assessment. Their scores determine the overall performance of the value chain (Shmitt et al. 2016).

FIGURE 13.3—THE INFLUENCE OF VALUE CHAIN ACTIVITIES AND THEIR OPERATIONAL ENVIRONMENT ON FOOD SECURITY PILLARS



Source: Authors.

The framework is significant because it goes beyond recommending production and quality improvements to specify what should be improved and produced. At the end of the assessment, activities that negatively impact consumer value and food security should be eliminated or adjusted, if possible. Furthermore, a future state of the value chain can be generated based on recommendations that could range from short- to long-term interventions.

Step 3: Determination of indicators, criteria, and dimensions

The dimensions are factors to be assessed and linked with measurable indicators. Indicators provide information that can be used as a benchmark in decision-making. Indicators need to be clearly linked to objectives. They should be reliable, appropriate within a particular location and context, easy to identify, and acceptable to a wide range of stakeholders (Meszaros et al. 2015). The indicators should also be practical, that is, measurable and representative of the system under study.

Lebacq and colleagues (2013) recommend the use of a set of indicators instead of a single indicator, a suggestion which the authors included in their own selection of indicators. These indicators should be few in number, consistent, and sufficient to jointly answer the applicable question (Lebacq, Baret, and Stilmant 2013). These factors were taken into consideration in the selection of indicators. The individual indicators were obtained from survey data and aggregated to obtain a composite indicator. Aggregation was achieved through sums and normalization techniques (Finn et al. 2009).

Consumer requirements were selected based on information gathered from consumer studies (DeYoung et al. 2017; Schilima, Mapemba, and Tembo 2016; Mishili et al. 2009; Medard, 2017; Hella et al. 2013; Quaye et al. 2011) and were categorized as sub-indicators within each food security pillar. The indicators selected for this framework can be applied to other food value chains, though these particular ones are slightly tailored to the consumers and value chain of legumes. The value chain indicators were selected with the demand-side indicators in mind to ensure that they are directly linked and have implications for the consumer–food security pillars.

The process of identifying the value chain indicators was based on both a literature review and subjective decisions, as the indicators provided in the literature were not all relevant to assessing the performance of value chains with a consumer and food security focus. Thus, some of the indicators were based on existing studies (Liu et al. 2019; Bachev 2017; Sulewski and Kloczko-Gajewska 2018; Meszaros 2015; Fedorova and Pongracz 2019; Bevilacqua et al. 2019; Matias et al. 2018; Watabaji, Molnar, and Gellynck 2016) and others were created based on a survey (interviews and data gathered from stakeholders along different stages of the product value chain who were able to provide adequate information on activities and challenges along the value chain). Indicators considered in the index also include some that have been proposed by the Food and Agriculture Organization of the United Nations as important in achieving food security, such as public-private partnerships, value addition, and policies to promote agribusiness and food value chains.

Focusing the analysis on the consumer requires the inclusion of other indicators beyond social, environmental, and economic dimensions. A conceptual approach used primarily in the social sciences was adopted to develop the indicators (Kuhndt, von Geibler, and Eckermann 2004). The approach requires breaking down the concept into dimensions, categories, aspects, and then indicators. The indicators selected for each segment were clearly specified with different units of measurement (percentages, ratios, quantities, and averages). Quantitative indicators are easier to measure, but qualitative indicators were also chosen when required.

Step 4: Selection of food value chain assessment dimensions and indicators

Agrifood value chains can be simple or complex. A chain comprises persons, processes, and products. The processes are the activities required to transform materials into outputs (products) by value chain actors equipped to perform those activities. The activities performed, actors' interactions, flow of information, costs, benefits, social incentives, and governing structures, among other factors, influence the performance of the chain (Maestre, Poole, and Henson 2017). Thus, understanding the functioning of the product chain along different dimensions and the subsequent implications for meeting food security outcomes is essential. The dimensions were selected based on different factors and explained below.

Environment dimension

The food value chain needs to be able to conserve natural resources to ensure its continuous use. The contribution of the value chain to resource sustainability or scarcity through its operations must be considered and assessed. Overexploitation impacts the pillars of food security, as the pillars are inputs to agrifood activities. Without them, consumer requirements cannot be fulfilled sustainably.

Quality dimension

Quality attributes vary on a wide range to meet consumers' needs for products that align with their preferences and lifestyles (Trienekens et al. 2012). These attributes influence the acceptability of a product and its consumption. This dimension addresses the effect of value chain activities on physical, nutritional, and safety attributes.

Social dimension

The agrifood value chain needs to perform activities to ensure that the conditions and health of the actors are not negatively impacted. Functional social networks and acceptable working conditions are necessary for agents to perform their activities consistently along the chain (Hampel-Milagrosa 2007, 74). Adequate working conditions lead to lower labor costs and prices and to increased work efficiency. These conditions translate into greater productivity and higher economic performance, which positively impacts food security. This dimension evaluates safety, trust, employment, collaboration, and social networks along the chain.

Economic dimension

The agrifood value chain needs to be productive and profitable to ensure financial stability. Value distribution along the value chain reflects the economic power of the agents. High costs and unequal value distribution can translate into high prices for consumers, which can affect product affordability, acceptability, and utilization.

Management dimension

The management dimension primarily considers two factors: postharvest loss management and knowledge management. A significant level of food losses affects the availability and accessibility of food for consumption (Gustavsson et al. 2011). In turn, affordability is affected when supply is not able to meet demand. Losses can also involve quality, where certain products do not meet consumer requirements, which affects acceptability, and, in cases where losses involve nutrients, consumption and nutrition. Losses are often due to a lack of knowledge of management practices. Thus, this dimension includes evaluation of timely and frequent access to knowledge on activity performance, consumer requirements, loss management, and so on.

Governance dimension

Functional governing structures oversee the efficient coordination and sharing of information, policies, regulations, and public and private interactions. These structures are necessary to ensure maximum efficiency in the performance of activities within the chain. The value chain environment can increase costs, contribute to uncertainty, limit entry into the chain, or discourage consumer-centered activities (Maestre, Poole, and Henson 2017; Camanzi et al. 2018). These factors are considered in this dimension.

Awareness and perception dimension

Given that the actions of agents along the agrifood value chain can be influenced by their perceptions and awareness, it is important to include such variables in assessing performance. The agents' knowledge of consumer requirements and their attitudes, perceptions, and willingness to meet those requirements affect their value chain activities and the food security pillars.

Agility dimension

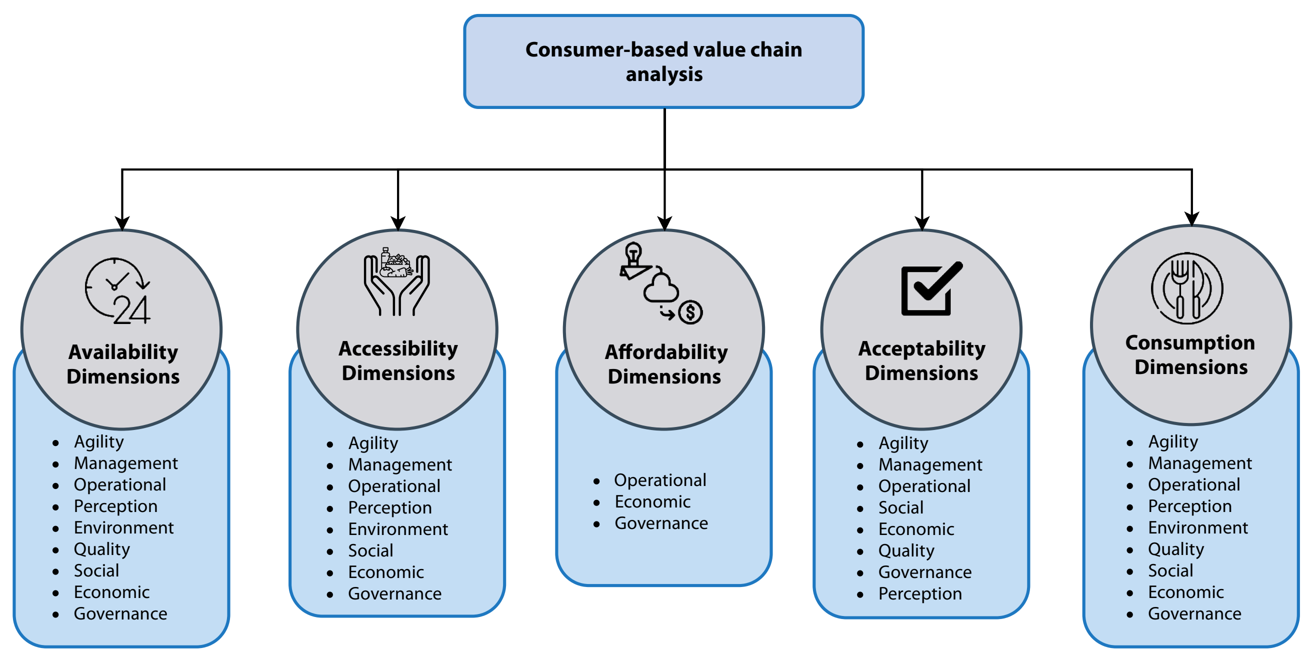
Agrifood chains are embedded within complex social, environmental, political, and economic systems as well as the physical, financial, and human institutions that govern these systems (Mahoney and Pandian 1992), coupled with changing consumer demands. Resilience in the agrifood system is necessary to produce and market nutritious, diverse, quality, and affordable foods amid disturbances; recover from shocks; and adapt to ongoing changes (Biggs, Schlüter, and Schoon 2015). Furthermore, agility is necessary when the element of food security and stability is taken into consideration. Stability requires that all of the other food security pillars be stable throughout the year, which depends on the ability of the chain to adjust adequately to changes.

Operational dimension

Activities performed along the chain from farming to marketing, and the processes involved in each activity, affect product features and consumer requirements. The efficiency with which they are performed affects the food security pillars.

A breakdown of the dimensions constituting each food security pillar (except stability) in the performance index is presented in Figure 13.4.

FIGURE 13.4—DIMENSIONS USED IN THE ASSESSMENT OF FOOD SECURITY PILLARS



Source: Authors.

Methodology

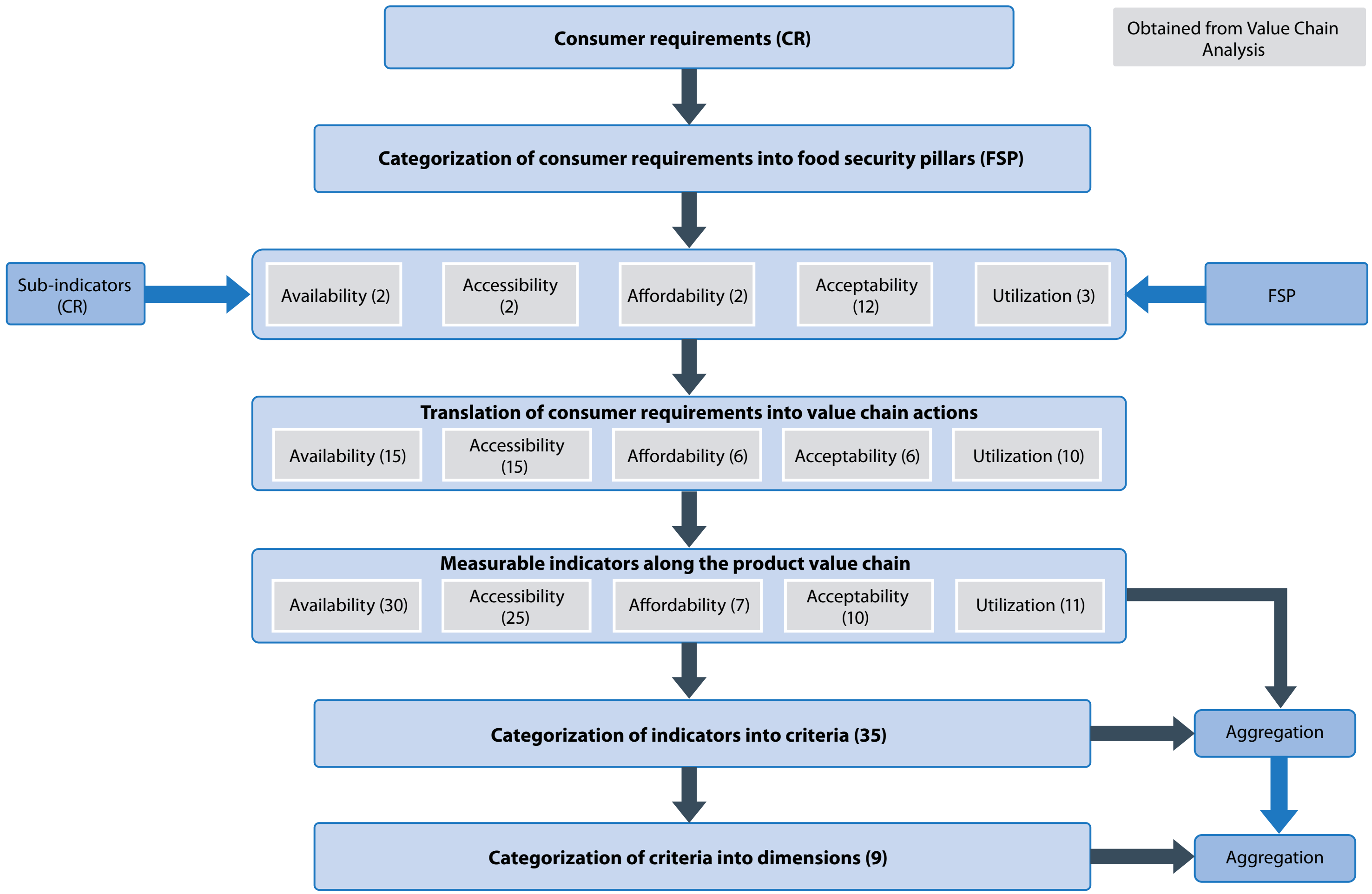
Following the selection of dimensions, criteria, and indicators, data were gathered to measure the indicators. The next step is the normalization of indicators for comparison, followed by aggregation. In the index, there are 9 dimensions, 35 criteria, and 51 indicators. Some studies have combined different dimensions to understand agricultural systems, with a varied number of components ranging from 12 to 41 indicators and up to 60 parameters (Kania and Kapłon 2014; Feledyn-Szewczyk and Kopiński 2015; Bojarszczuk, Księżak, and Feledyn-Szewczyk 2017). The dimensions were assessed through a sum of indicators, using a multiple-weight method and assigning scores through expert assessment.

Indicators that represent the context of a food system and could be measured were selected for the index. The procedure and relations between the dimensions, criteria, and indicators are presented in Figure 13.5. The groupings in the figure are broad categories that encompass different numbers of indicators (2, 15, 30, etc.). The selected indicators, though clearly defined, do not have a uniform measurement unit. The indicators also were not weighted according to their importance; instead, it was assumed that all indicators, categories, and dimensions had equal weight for simplicity of analysis.

In the process of normalization, various methods can be employed to reduce outliers. These methods include rescaling, percentage relations, mathematical transformation, and distance measurements (Salzman 2003). Aggregation can also be performed through addition, factor analysis, means, and the use of weights and rules (Mazziotta and Pareto 2013). The normalization and standardization techniques used were based on Sulewski and Kloczko-Gajewska (2018). A mathematical transformation was employed for normalization, while additions and means were used in aggregation. The output parameters for the indicators were scaled along the 0 to 1 range. Data on different subjects were gathered through varied types of measurement. Continuous variables, such as yield values, were transformed into the 0 to 1 range based on the quantiles (deciles) method; that is, the distribution is segmented into 10 sections. After being sectioned, they are then provided with scores ranging from 0 to 1. This means, for example, that for values falling within the ninth and tenth deciles, a point of 1 is assigned; if they fall within the eighth and ninth deciles, they are given a value of 0.9.

This method helped in assigning points to variables that would have been difficult to value objectively. With this method, the need for expert assessment

FIGURE 13.5—PICTORIAL VIEW OF THE FRAMEWORK



Source: Authors.

at the indicator level is eliminated. The approach by Ostasewicz, Rusnak, and Siedlecka (2011) is applied in estimating the value of individual deciles:

$$Q_k = X_{Qk} + \frac{N_{Qk} - \sum_{i=1}^{k-1} n_i}{n_m} i_{Qk}, \quad (1)$$

where Q_k is the symbol of the k-th decile; X_{Qk} is the lower limit of a given range; N_{Qk} is the position of a given decile calculated based on $kN/_{10}$; $\sum_{i=1}^{k-1} n_i$ is the number cumulated to the range preceding decile; i_{Qk} is the span of the range in which the right deciles are located; k is the number of the range in which the corresponding decile follows; and N is the collectivity size.

In cases in which ordinal variables were measured through the use of a Likert scale, the distance between the ranks is divided into equal sections. The sections are divided to be within 0 and 1, with equal distances between the ranks. For instance, if a four-level scale is used, the correct answer or the highest score is given a point of 1 and then 0.75 and so on. In cases in which the variable is dichotomous, such as in cases with “yes” or “no” options, the expected response is assigned 1 and the other 0.

After the indicators were normalized, they were aggregated through summation to obtain performance scores for the different dimensions. However, care was taken to ensure that an average was not estimated for parameters that are not comparable. Aggregation was performed by estimating sums and means of the various indicators and criteria as follows:

$$Performance\ of\ Criteria\ (PC) = \sum(Sum\ of\ Indicators, SI)/_{n} \quad (2)$$

$$Performance\ of\ Dimension\ (PD) = \sum(Sum\ of\ Criteria, SC)/_{n} \quad (3)$$

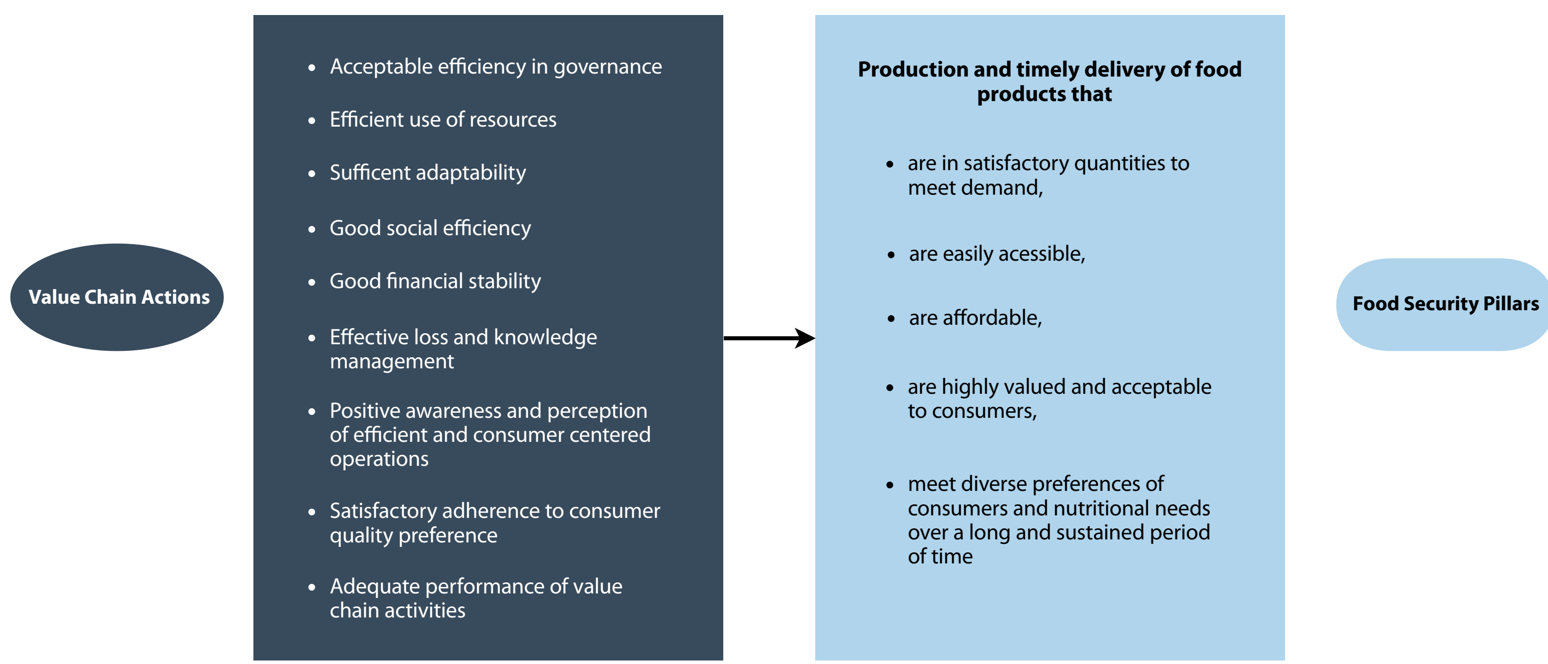
$$Performance\ of\ Food\ Security\ Indicator\ (FSI) = \sum(Sum\ of\ Dimensions, SD)/_{n} \quad (4)$$

where n = number of indicators, criteria, and dimensions.

The dimensions were employed in measuring the major pillars of food security. Thus, the dimension scores corresponding to each food security element were also aggregated to obtain the value chain performance score in meeting each food security element. The performance scores were interpreted as high (0.83–1), good (0.50–0.82), low (0.22–0.49), and poor (0.00–0.20). The performance of the product supply chain in meeting each food security pillar is then assessed based on standards (Figure 13.6). These standards are the levels or states that the dimensions being assessed are supposed to attain.

The quantile method was used to transform the data to ensure that they were all on the same scale, with a minimum score of 0 and a maximum score of 1. The scores for each dimension and food security element were standardized by dividing by the number of indicators that made up each parameter (total possible score to be attained). This ensured that a comparison could be made. In the performance index, performance levels for the dimensions and food security elements were determined based on percentage ranges: the closer the score is to 100 percent, the better it is. However, for certain indicators, such as the amount of fertilizer and pesticides required per hectare, adequate storage length, and temperature, etc., information gathered from the literature served as benchmark in determining whether there was a deviation from the expected result.

FIGURE 13.6—SATISFACTORY STANDARDS FOR THE PRODUCT VALUE CHAIN AND FOOD SECURITY PILLARS



Source: Authors.

For variables such as income, profits, processing times, losses, and yields, value chain actors with higher amounts had higher scores. For variables that required ranking, responses that leaned toward the most positive response or the expected response had higher scores. The performance index was designed to take the entire product value chain into consideration, because understanding and tackling issues affecting food security and nutrition will not be comprehensive if only one stage of the chain is studied.

Test of Correlation

The variables included in the design of an index should be as comprehensive as possible and correlated with the index. This is because poorly correlated variables may be measuring something different than expected (Babbie 1995; Sulewski and Kloczko-Gajewska 2018). Thus, an analysis of the correlation matrix was used to determine the variables to be included in the index, after which poorly correlated variables (those lacking statistical significance) were removed (Sulewski and Kloczko-Gajewska 2018). Spearman's correlation analysis was used to estimate the coefficient between indicator and dimension scores as well as dimension scores and scores for each food security element. This was done to ensure that the indicators used in assessing the performance of the chain on the pillars of food security are correlated to the measurement index. The correlation coefficients ranged between the dimension scores, and the food security scores ranged between 0.23 to 0.87. The variables that did not have any correlation were removed. The correlation analysis results have been presented in the Appendix.

Alignment of Value Chain Activities to Meet Consumer Requirements and Improve Food Security

Following the performance evaluation, strategies should be put in place to align value chain activities to product features based on consumer requirements. At this stage, activities are adjusted to physically bridge the gap between the potential and actual value that the consumer could derive from the product. By doing this, the food value chain draws nearer to closing the gap between current food security achievements and desired goals.

The framework and index were employed in studying the common bean value chain in Zambia as a case example. The common bean value chain in Zambia (specifically, the northern province) is made up of only two main stages or activities, namely production and marketing. Common beans are produced in Zambia mainly by smallholder farmers who cultivate local varieties. Average yields range from 0.3 to 0.5 metric tons per hectare, which are low compared to 2 tons per hectare when high-yielding and resistant varieties are used (Mwansa 2004). The marketing system is uncoordinated and largely informal, with uneven power distribution between traders and producers (Amanor-Boadu and Williams 2004). The industry is characterized by information asymmetry and no price transparency (Mwansa 2004). For poor households, beans are usually the closest substitute to other protein sources such as meat and fish (Beebe 2012). Pele (2007) found that consumers in Zambia allocated a small proportion of their food expenditure to beans, indicating that beans were not significant in the food basket. Bean consumption is low; however, this can be increased if appropriate activities along the value chain are undertaken within the right policy environment (Birachi 2012; Mwansa 2004). Improvement should be directed towards providing adequate quantities of nutritious, safe, acceptable and affordable food to growing populations within a dynamic environment (Marsden and Morley 2014). Applying the value chain concept to achieving this is advantageous because it allows for a systematic evaluation of the different stages and processes in the chain to identify discrepancies.

Conclusion

Agrifood value chains have an essential role to play in contributing to the achievement of food security. Realizing food security is inherently linked with meeting the requirements of consumers, which are based on their preferences. Thus, there is a need for assessment methods that have both a consumer and a food security focus. The importance of resilience for food security (particularly during pandemic situations) and its direct link with the functions of food systems further highlights the need to have a consumer–food security nexus framework for agrifood VCA. The authors present a conceptual framework and a performance index that focuses on the requirements of the consumer and connects them to food security. The framework also introduces a way to link consumer requirements with value chain actions, making it easy to identify improvement opportunities. Characteristics such as convenience, speed, variety, low price, sufficient quantity, and others have been translated into agrifood chain characteristics such as delivery, volume, quality, value addition, and efficiency. This approach has the potential to change the way products are designed, developed, and delivered to consumers while meeting food security challenges.

The selection and measurement of variables is difficult, especially since it is best to use different variables to measure a specific indicator, given that no one particular indicator can be used to adequately explain a dimension. Information from multiple sources was used to deal with this challenge. The limitation of some of the variables selected for the index is that they require laboratory and survey data, which can be costly and time-consuming to obtain.

Overall, the framework contributes to quantifying performance and understanding the food system. It is useful in determining the challenges that limit the capacity of the agrifood chain to meet consumer requirements and impact food security.

Appendix

Spearman's Correlation Analysis

This section presents information on Spearman's correlation between dimensions and food security pillars and the variables (value chain indicators) used in creating them. The dimensions are aggregated value chain indicators that describe a similar value chain function. Correlation analysis was used in the study as a statistical measure of the relationship between the value chain indicators and dimensions, as well as the dimensions and food security pillars. Correlation is a good indication of the strength and direction of the relationship between two variables. All correlations between dimensions and food security pillars were positive and statistically significant from zero.

The consumer-food security nexus framework and performance index were applied to assess the common bean value chain in northern Zambia as a case study. For each food security indicator, a link was made between the indicator and the specific consumers requirement(s) that must be met by value chain actors based on how their activities are performed. A correlation matrix was also employed to ensure that only indicators with a statistically significant correlation with the overall dimension score were included in the index to estimate performance scores for food security pillars. Those that did not have any correlation were removed.

A range of correlation coefficients is reported since different indicators were used in estimating the dimension score but not all could be presented. Only those that were statistically significant were included in the table. The positive linear correlations indicate that as the score of one variable increases, the score of the other also increases. Correlation coefficients above 0.5 indicate strong linear correlations between the scores, while those at 0.3 and lower indicate weak correlations.

1. Availablity

TABLE 13A.1—SPEARMAN'S CORRELATION BETWEEN VARIABLES USED IN ASSESSING THE PERFORMANCE OF THE VALUE CHAIN IN CONTRIBUTING TO FOOD SECURITY PILLARS (FSP) (AVAILABILITY)

Criteria	Indicator	Correlations: Indicator vs. Dimension	Dimension	Correlations: Dimensions vs. Availability	FSP
Production	Production capacity	0.24–0.45	Operational	0.34	Bean availability
	Land productivity	0.23–0.48			
	Production/value chain practices	0.20–0.45			
Technology	Technical capability	0.43v0.58			
Market	Delivery reliability	0.47			
Market	Product quality/Market surplus	0.40	Management	0.27	Bean availability
Loss management	Loss management	0.25			
Knowledge/Communication	Information access	0.22–0.65			
Agro-technique	Agro-techniques	0.99	Environment	0.32	Bean availability
Activity management	Governing activity	0.20–0.76	Governance	0.33	Bean availability
	Relationship	0.60–0.62			
Institutions	Stakeholder involvement	0.23			
Profitability	Production value	0.54	Economic	0.40	Bean availability
Financial capability	Production investments	0.67			
	Income stability	0.67			
Employment	Employment	0.44–0.75	Social	0.35	Bean availability
	Worker efficiency	0.18–0.40			
Safety	Health/Safety	0.26			
Adaptability	Consumer adaptability	0.44–0.47	Agility	0.36	Bean availability
	Environment Adaptability	0.31–0.44			
Attitude and perception	Actor attitude and perception	0.77–0.82	Attitude and Perception	0.33	Bean availability

Note: Only statistically significant variables at p-value of 0.05 are reported. FSI=Food Security Indicator.

2. Accessibility

TABLE 13A.2—SPEARMAN'S CORRELATION BETWEEN VARIABLES USED IN ASSESSING THE PERFORMANCE OF THE VALUE CHAIN IN CONTRIBUTING TO FOOD SECURITY PILLARS (ACCESSIBILITY)

Criteria	Indicator	Correlations: Indicator vs. Dimension	Dimension	Correlations: Dimensions vs. Availability	FSP
Market	Product delivery	0.70	Operational	0.37	Bean accessibility
	Delivery reliability	0.73–0.77			
Market	Product quality	0.60	Management	0.017	Bean accessibility
	Loss management	0.56			
Information access	Market/consumer knowledge	0.62			
Governance of activity	Trust/Relationship	0.43	Governance	0.30	Bean accessibility
	Entry restrictions	0.62			
Profitability	Production value	0.72–0.83	Economic	0.34	Bean accessibility
Financial stability	Sources of funds for investment	0.63			
Employment	Employment	0.49–0.58	Social	0.18	Bean accessibility
	Efficiency of worker	0.33–0.59			
Adaptability	Consumer adaptability	0.40–0.79	Agility	0.33	Bean accessibility
Attitude and perception	Actor attitude and perception	0.99	Attitude	0.50	Bean accessibility

Note: Only statistically significant variables at p-value of 0.05 are reported. FSI=Food Security Indicator.

3. Affordability

TABLE 13A.3—SPEARMAN'S CORRELATION BETWEEN VARIABLES USED IN ASSESSING THE PERFORMANCE OF THE VALUE CHAIN IN CONTRIBUTING TO FOOD SECURITY PILLARS (AFFORDABLITY)

Criteria	Indicator	Correlations: Indicator vs. Dimension	Dimension	Correlations: Dimensions vs. Affordability	FSP
Cost efficiency	Cost efficiency/ Pricing scheme	0.97	Operational	0.87	Bean affordability
Trust	Trust	0.99	Governance	0.23	Bean affordability
Cost	Cost	0.35	Economic	0.30	Bean affordability
Price	Average price	0.57			
	Price fluctuation	0.53			
	Gross margin	0.52			

Note: Only statistically significant variables at p-value of 0.05 are reported. FSI=Food Security Indicator.

4. Acceptability

TABLE 13A.4—SPEARMAN'S CORRELATION BETWEEN VARIABLES USED IN ASSESSING THE PERFORMANCE OF THE VALUE CHAIN IN CONTRIBUTING TO FOOD SECURITY PILLARS (ACCEPTABILITY)

Criteria	Indicator	Correlations: Indicator vs. Dimension	Dimension	Correlations: Dimensions vs. Availability	FSP
Product reliability	Adherence to consumer quality preferences	0.22–0.86			Bean acceptability
Efficiency of system	Quality control	0.70	Operational	0.22	Bean acceptability
	Defect rate	0.87			
Profitability					Bean acceptability
Loss management	Loss management	0.92	Management	0.55	
Knowledge acquisition	Market knowledge	0.40			Bean acceptability
Adaptability	Consumer adaptability	0.99	Agility	0.47	Bean acceptability
Attitude and perception	Actor attitude and perception	0.67–0.81	Attitude and Perception	0.37	Bean acceptability

Note: Only statistically significant variables at p-value of 0.05 are reported. FSI=Food Security Indicator.

5. Utilization and consumption

TABLE 13A.5—SPEARMAN'S CORRELATION BETWEEN VARIABLES USED IN ASSESSING THE PERFORMANCE OF THE VALUE CHAIN IN CONTRIBUTING TO ACHIEVING FOOD SECURITY PILLARS (UTILIZATION AND CONSUMPTION)

Criteria	Indicator	Correlations: Indicator vs. Category	Dimension	Correlations: Dimensions vs. Availability	FSP
Actor attitude and perception	Attitude towards processed products, safety, and nutrition	0.50–0.72	Attitude	0.60	Bean utilization/consumption
Knowledge acquisition	Knowledge of market and value addition	0.99	Management	0.61	Bean utilization/consumption
Safety	Safety	0.64	Quality	0.51	
Product quality	Stored product quality	0.43			Bean utilization/consumption
Efficiency of system	Efficiency to detect and remove infested beans	0.38–0.46	Operational	0.27	Bean utilization/consumption
Product diversity	Level of product diversity	0.80			Bean utilization/consumption
Technology and assets	Technical and financial capacity	0.33			

Note: Only statistically significant variables at p-value of 0.05 are reported. FSI=Food Security Indicator.