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REVIEW

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Food and nutrition security and sustainability transitions in food systems

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Abstract

The concepts of food security and food sustainability are two main paradigms in the food system discourse—however, they are often addressed separately in the scientific literature. We argue that this disconnect hinders a coherent discussion of sustainability transitions, which will be necessary to solve problems (environmental, social, economic, and health) generated by conventional food systems. Our review highlights linkages between sustainability transitions and food and nutrition security using the perspective of sustainable food systems. We explore the diversity of food security narratives and food sustainability paradigms in the agro-food arena, analyze relations between food security and food systems sustainability, and suggest options to foster a transition toward sustainable food systems. It is widely acknowledged that food systems sustainability must entail long-term food and nutrition security in its availability, access, utilization, and stability dimensions. For food systems to deliver food and nutrition security for present and future generations, all their components need to be sustainable, resilient, and efficient. These linkages between food sustainability and food and nutrition security intersect at global, national, local, and household levels. Different strategies can be pursued to foster sustainability transitions in food systems: efficiency increase (e.g., sustainable intensification), demand restraint (e.g., sustainable diets), and food systems transformation (e.g., alternative food systems). Creating sustainable food systems requires moving from an agriculture-centered to a food system policy and research framework. This will be fundamental to foster the complex and holistic transformation necessary to achieve sustainable food systems, which is, in turn, a prerequisite to achieving sustainable food and nutrition security.

KEYWORDS

alternative food networks, food security, sustainability transitions, sustainable diets, sustainable food systems, sustainable intensification

1 | INTRODUCTION

Attempts to eradicate hunger are as old as human civilization (Fraser & Rimas, 2010; Vernon, 2007). Food crises and famines—such as the Great Irish Potato Famine 1840s–1850s (Donnelly, 2001; Ó Gráda, 1989), the Great El Nino 1789–93 (Grove, 1998, 2007), and the Great Chinese Famine 1958–1962 (Song, 2010; Wang, Wang, Kong, Zhang, & Zeng, 2010)—shaped the history of humanity. Unfortunately, food crises are not only part of the history of humanity; they are an actual issue in many countries and regions. The *Global Report on Food Crises 2018* (Food Security Information Network, 2018) shows that about 124 million people across 51 countries and territories faced crisis levels of acute food insecurity in 2017 thus requiring urgent humanitarian action. These food crises are largely attributed to prolonged drought conditions and/or conflicts in countries such as Afghanistan, Democratic Republic of Congo, Myanmar, Nigeria, Somalia, South Sudan, Syria, and Yemen.

Food systems are at the center of global environmental, social, and economic challenges such as resource scarcity, ecosystem degradation, and climate change (Freibauer et al., 2011; Garnett, 2014; Gladek et al., 2016; IPES-Food, 2015; Lang, 2009; Searchinger et al., 2013; WWW-UK, 2013). Poverty, hunger and malnutrition, inadequate diets, land degradation, water scarcity, social inequalities, biodiversity loss, and climate change are inherently rooted in the way we produce, distribute, and consume food (FAO, 2014a; Foresight, 2011). Current food systems are generating negative outcomes such as land, water, and ecosystem degradation; biodiversity loss; excessive greenhouse gas emissions; persistent malnutrition and hunger, and fail to eradicate poverty particularly of rural populations in the global South (FAO, IFAD, & WFP, 2015; Foresight, 2011; Godfray et al., 2010a; WWW-UK, 2013). Currently, more than enough food is produced to feed the global population (Dyson, 1996), but the food insecurity problem persists—characterized by large differences between countries, even within the same country and even the same household (FAO, 2002; FAO, IFAD, & WFP, 2015). Future food systems will have to provide food and nutrition security while facing unprecedented sustainability challenges—this underlines the need for a transition to more sustainable food systems (Vermeulen, Campbell, & Ingram, 2012; World Bank, 2015).

Food and nutrition security and transitions to sustainable food systems are currently major discourses in the agro-food arena. However, the different concepts are mostly discussed in separation—we argue that this disconnect needs to be overcome to accelerate the necessary transition toward sustainable food systems. Viable transition strategies have to take into account food and nutrition security as well as sustainability dimensions.

The objective of this review is thus to highlight linkages between food and nutrition security and sustainable food system concepts. Based on the insights, we explore options to foster such a transition toward sustainable food systems providing food and nutrition security. The review is structured as follows: section 2 evolution of concepts of food and nutrition security and food sustainability; section 3 linkages between sustainable food systems and food and nutrition security; and section 4 pathways for transitions toward sustainable food systems providing food and nutrition security.

2 | FOOD SECURITY AND FOOD SUSTAINABILITY: MAIN CONCEPTS AND PARADIGMS

2.1 | Food and nutrition security

While the world currently produces enough food for its citizens, hundreds of millions of people are undernourished (FAO, IFAD, UNICEF, WFP, & WHO, 2017; IFPRI, 2016), while more than one billion is overweight or obese (Swinburn et al., 2011). The most recent data on the incidence of food insecurity, from *The State of Food Security and Nutrition in the World 2017*, show that the number of chronically undernourished people in the world reached 815 million in 2016. With respect to 2015, the food security situation worsened in many regions—especially western Asia, southeastern Asia, and sub-Saharan Africa—mainly due to conflicts and/or conflicts combined with natural disasters such as floods and droughts, exacerbated by climate change. Meanwhile, the triple burden of malnutrition (undernutrition, overnutrition, and micronutrient deficiency) is still widespread. Many countries experience simultaneously different forms of malnutrition such as child undernutrition, anemia among women, and adult obesity (FAO, IFAD, UNICEF, WFP, & WHO, 2017). The prevalence of obesity doubled between 1980 and 2008 to affect more than half a billion people worldwide (Finucane et al., 2011; Stevens et al., 2012), while about 950 million adults are overweight (Stevens et al., 2012). Today, the number of obese and overweight people is almost 2 billion (WHO, 2016) and may increase to 3.3 billion by 2030 (UNSCN, 2017). What is even more alarming is that overweight affects 42 million children (UNICEF, WHO, & World Bank Group, 2016). Meanwhile, micronutrient (such as vitamin A, iron, iodine, and zinc) malnutrition ("hidden hunger") affects approximately 2 billion people worldwide, which represents about one third of the global population (Bioversity International, 2014; United Nations, 2012a). Moreover, nutrition security is challenged by foodborne pathogens, antibiotic resistance, pesticide, and chemical contamination as well as diet-related chronic diseases (Story, Hamm, & Wallinga, 2009). Diet-related noncommunicable

TABLE 1 Definitions of some terms relating to food security

Term	Definition	Source
Food security	Food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life	FAO (1996)
Nutrition Security	Nutrition security can be defined as adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times	IFPRI, 1995 *in* Committee on World Food Security (2012)
	Nutrition security exists when food security is combined with a sanitary environment, adequate health services, and proper care and feeding practices to ensure a healthy life for all household members	World Bank, 2006 *in* Committee on World Food Security (2012)
	Nutrition security exists when all people at all times consume food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care	FAO/AGN, 2012 *in* Committee on World Food Security (2012)
Food and nutrition security	Food and nutrition security is achieved when adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily used and utilized by all individuals at all times to live a healthy and active life	UNICEF, 2008 *in* Committee on World Food Security (2012)
	Food and nutrition security exists when all people at all times have physical, social and economic access to food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care	FAO/AGN, 2011 *in* Committee on World Food Security (2012)

diseases (NCDs) have now replaced infectious diseases as the number one cause of mortality at the global level (World Health Organization, 2014).

In response to these challenges, concerns about food security have gained momentum in the 20th century at UN conferences devoted to food and agriculture (United Nations, 1975)—ever since, food security has been a key concept for policymakers (Jones, Ngure, Pelto, & Young, 2013; Lang & Barling, 2012). Nevertheless, definitions and concepts of food security are still subject of debate (DEFRA, 2006; Spring, 2009)—a review by Smith, Pointing, and Maxwell (1996) found that "food security" was used in nearly 200 different ways. Table 1 provides an overview of definitions of some terms relating to food and nutrition security.

The definition of food security endorsed by the 1996 World Food Summit (FAO, 1996) is still widely used today, with the sole addition of the word "social" to the phrase "physical, social and economic access."

Mostly, food security has been discussed from the angle of agriculture and markets, while malnutrition has been mainly considered a health problem. *Nutrition security* focuses on individual/household food consumption and on how food is utilized. The Road Map for Scaling-Up Nutrition (SUN), 2010, elaborated on the World Bank's definition of nutrition security as follows: "Nutrition security is achieved when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, to ensure a healthy and active life for all household members." Indeed, as emphasized by FAO (2012c), hunger goes hand-in-hand with hidden hunger—forms of malnutrition such as deficiencies of proteins, vitamins, and minerals.

Food security and nutrition security have been combined in two ways: *food security and nutrition*, or *food and nutrition security*. The term "food security and nutrition" acknowledges the importance of nutrition for achieving food security but maintains the traditional focus on food availability, access, and stability. This perspective emphasizes that food security is a precondition to adequate nutrition (Committee on World Food Security, 2012). The concept of *food and nutrition security* has become mainstream in many organizations (e.g., IFPRI, FAO, and UNICEF) and academia. For instance, the International Food Policy Research Institute (IFPRI) has used the term "food and nutrition security" since the mid-1990s. Food and nutrition security (FNS) underlines the need for greater integration of nutrition and food security in programs, policies, and research and considers appropriate levels of nutrition the ultimate goal of food security.

In its currently used form, food and nutrition security considers energy, protein, and nutrient needs for a healthy life (Committee on World Food Security, 2012). It is built on four

pillars (Committee on World Food Security, 2012; Ericksen, 2008; FAO, 2008; Timmer, 2012; United Nations System High Level Task Force on Global Food Security, 2011):

1. *food availability*: sufficient quantities of food available on a consistent basis. Food availability is determined by the level of food production, net trade, and food stock levels.
2. *food access*: sufficient resources to obtain appropriate food for a nutritious diet. Three elements can be used to describe food accessibility: affordability, preference, and allocation. Accessibility relates to economic access (i.e., food purchasing power), physical access (i.e., transport and infrastructure), as well as sociocultural access and preferences. Addressing concerns regarding food access means greater focus on food prices, incomes, expenditure, and markets.
3. *food utilization*: appropriate use based on nutritional value, food safety, and social value. Utilization is the result of feeding practices, food preparation, diet diversity, and fair intrahousehold food distribution.
4. *stability* in food availability, access, and utilization. Crises and shocks such as political instability, adverse weather conditions, or economic factors have an impact on long-term food security.

Food insecurity is a problem at the individual, household, local, national to the global level. Full food security necessitates that all four interrelated and interdependent dimensions are present (Berry, Dernini, Burlingame, Meybeck, & Conforti, 2015). If any of the four dimensions is not fulfilled, the food system is in a state of long-term, chronic food insecurity or short-term, transitory food insecurity. Seasonal food insecurity falls between the two extremes and is associated with seasonal fluctuations (e.g., cropping patterns, work opportunities, climate, and disease incidence; FAO, 2008). Following this systematic, the *Five Rome Principles for Sustainable Global Food Security* (FAO, 2009) proposed a twin-track approach toward food security that consists of immediately tackling hunger while eliminating the root causes of hunger and poverty to achieve medium and long-term food security and nutrition. As apparent from the multidimensional concept of food and nutrition security, any approach to sustainably improve food security has to be systemic and take into account interactions and interconnectedness between the dimensions of food and nutrition security and address the full food chain (United Nations System High Level Task Force on Global Food Security, 2011).

When food security is related to political demands, the emphasis shifts—Windfuhr and Jonsén (2005) stated that "food security is more of a technical concept, and the right to food a legal one, food sovereignty is essentially a political concept." Food sovereignty calls for local control and self-sufficiency and has inspired many food movements—typically putting smallholders, sustainable and short food chains in the center (Holt-Giménez, 2011).

The complexity of food and nutrition security has been increasingly acknowledged by taking a systemic perspective on causes and solutions (Beddington et al., 2012; Foresight, 2011; Garnett, 2014; Godfray et al., 2010b; HLPE, 2014a). The focus has, therefore, turned to food systems (HLPE, 2014a), their functioning, governance, and sustainability (Dumont & Rosier, 1969; George, 1976; OECD, 2013; Sen, 1981). According to the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2014a) "A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes" (p. 29).

Nevertheless, the discourse on food system sustainability has stayed mostly separated from the discourse on food security (Capone, El Bilali, Debs, Cardone, & Driouech, 2014). The same is true for nutrition. Until lately, most of current food-related policies and interventions, especially those related to agriculture, were rarely designed with nutrition as their primary objective or their primary concern (FAO, 2013b; United Nations System Standing Committee on Nutrition, 2016).

As a response to this disconnect, the High Level Panel of Experts on Food Security and Nutrition, in its note on critical and emerging issues, called for an integration of food security and nutrition and sustainable food system approaches (HLPE, 2014b).

2.2 | Food system sustainability

Food systems are shaped by a multitude of factors, such as geography, demography, urbanization, and globalization; socioeconomic status and income, marketing, and consumer attitude; and religion and culture (Kearney, 2010). These factors impact also food security at national, local, and household level. Elaborating on the work of Nugent (2011), Fanzo, Cogill, and Mattei (2012) broke down the food system into compartmentalized areas of production, consumption, and nutrition and defined the key determinants of each area: food production (agriculture, food storage and processing, distribution, wholesaling and retailing, and food marketing); food consumption (food quantity, food availability, food quality, food affordability, dietary diversity, dietary habits, cultural and social influences, taste and enjoyment, and physical environment); and nutrition (balanced diets, malnutrition, and wellness). In doing so, they stressed the importance of connecting production and consumption while considering the far-reaching implications of food systems in terms of nutrition and health (cf. diets). Likewise, Johnston, Fanzo, and

TABLE 2 Definitions of concepts related to food sustainability

Concept	Definition	Reference
Sustainable agricultural development	Sustainable agricultural development is agricultural development that contributes to improving resource efficiency, strengthening resilience and securing social equity/responsibility of agriculture and food systems in order to ensure food security and nutrition for all, now and in the future	HLPE (2016: 29)
Sustainable diets	Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources	Burlingame & Dernini (2012), FAO, & Bioversity International, (2010)
Sustainable food system	A sustainable food system (SFS) is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised	HLPE (2014a: 31)
	A sustainable food system exists when production, processing, distribution and consumption are integrated and related practices regenerate rather than degrade natural resources, are socially just and accessible, and support the development of local communities and economies	American Dietetic Association (2007: 16)

Cogill (2014) point out that the main determinants of sustainable diets fall into five categories, that is, (a) agriculture, (b) health, (c) sociocultural, (d) environmental, and (e) socioeconomic dimensions. They also highlight the interconnectedness of these determinants and point out that changes in one determinant category affect others and, consequently, the level of diet sustainability.

In general, the historical development of food sustainability concepts has followed a path similar to that of food security. It has been introduced to the international discourse mainly through sustainable development concepts (United Nations, 1987). It includes different aspects such as sustainable agriculture, sustainable diets, and sustainable food systems (Table 2). Despite the increased attention to the concept of sustainable food systems, very few definitions of the term exist (American Dietetic Association, 2007; American Public Health Association, 2007; CRCResearch, 2013; Edgar & Brown, 2013; HLPE, 2014a). The definition provided by the HLPE (HLPE, 2014a) can be considered as a baseline definition.

Beyond the traditional notion of sustainability rooted in ecology, sustainable food systems include social sustainability, as well as international, intra-, and intergenerational equity. Sustainable food systems require fair access to production opportunities and inputs and a balanced distribution of production costs, goods, and services associated with resource use. They also address the well-being of the least advantaged groups within society and are concerned with secure food producing capacities for the future generation (Brklacich, Bryant, & Smit, 1991). Moreover, sustainable food systems are anchored in a web of sectoral policies and regulatory frameworks (e.g., agriculture, health and safety, environment, energy, and trade; IPES-Food, 2015), which makes more difficult transitions toward more sustainable food systems.

Concepts of transition (Gazheli, Antal, & van den Bergh, 2012) and transition studies have increasingly received attention both in the policy arena and academic literature (Elzen, Augustyn, Barbier, & Van Mierlo, 2017; European Environment Agency, 2016, 2018; Falcone, 2014; Lachman, 2013; Loorbach, Frantzeskaki, & Avelino, 2017; Markard, Raven, & Truffer, 2012). Ambiguity, complexity, interconnectedness, and multidimensionality of sustainability problems imply that incremental changes are no longer sufficient and that there is a need for transformative change at system level (STRN, 2010). In line with sustainable food system definitions, sustainability transitions aim to comprehensively address key challenges of societies through harmonizing ecological integrity and social equity (Markard et al., 2012). Currently, a transition to sustainable food systems is the objective of many initiatives in the food arena (e.g., UNEP, 2017). Despite the broad agreement that a sustainability transition is necessary, different pathway narratives are advocated (Luederitz, Abson, Audet, & Lang, 2017). A key challenge in operationalizing sustainability transitions is identifying what the sustainability problems to be addressed actually entail so that suitable measures can be taken (Darnhofer, 2015). A typical example of this challenge is the transition toward sustainable food systems and the key outcome of food and nutrition security. In the following section, we explore the multifaceted linkages between sustainable food systems and food and nutrition security.

3 | FOOD AND NUTRITION SECURITY AND SUSTAINABLE FOOD SYSTEMS: EXPLORING MULTIFACETED LINKAGES

Linkages between food security and food system sustainability are both functional and operational. Food and nutrition security (FNS) is affected by what and how food is produced, processed, transported, distributed, and consumed, so the functioning of the food system. Linkages are also operational as strategies (programs, projects, policies, and action plans) to promote food security will affect food system sustainability and vice versa. These linkages are increasingly considered by scholars (Berry et al., 2015; Buttriss & Riley, 2013; Prosperi, Allen, Padilla, Peri, & Cogill, 2014) and international organizations (e.g., FAO, Bioversity International, and UNEP).

Sustainable food systems are increasingly seen as a precondition for assuring food security (Burlingame & Dernini, 2012; Buttriss & Riley, 2013; FAO & Bioversity International, 2010; Prosperi et al., 2014; UNEP, 2012a). The definition of sustainable food systems provided by HLPE (HLPE, 2014a) underlines the strong linkage between food security and food sustainability; food system unsustainability is the main reason for food insecurity and malnutrition. For ensuring food security, all components of food systems should be sustainable, resilient, and efficient. Where food systems do not perform adequately, food security and nutrition are threatened. The definition also positions FNS as a central indicator to assess food systems' sustainability. It also highlights the importance of addressing simultaneously environmental, economic, and social dimensions of sustainability at every stage of a food system by adopting a multidimensional approach in all the food chain stages including production, transport, processing, retail, and consumption (United Nations, 2015a).

There has been increasing agreement among scholars that sustainability is very relevant to food security (Garnett et al., 2013; Hanson, 2013; Lang & Barling, 2013; Pinstrup-Andersen, 2009; Pinstrup-Andersen & Herforth, 2008; Richardson, 2010; Smith & Gregory, 2013). The interconnectedness and interdependency of food security and sustainability found its expression in the term "sustainable food security" (Garnett, 2014). Environmental, economic, and social sustainability of food systems is a precondition for long-term food security (Berry et al., 2015) and is a general concept applicable across all food security dimensions (Gitz, 2015). In turn, the relationships between food security and food sustainability are seen as reciprocal as food security can be a condition for sustainability (Berry et al., 2015). Therefore, sustainability should be regarded as an integral part of food security planning, monitoring, and evaluation (Searchinger et al., 2013). After analyzing the multiple interconnected dimensions of sustainable food systems and food and nutrition security, Prosperi et al. (2014) pointed out that "Food security and food system sustainability are then indispensable prerequisites to each other, and they need to be jointly analysed" (p. 2). The task ahead is, thus, to build food security on sustainability and vice versa (Tilman & Clark, 2014), and the common higher level goal of all these efforts is sustainable food and nutrition security (Berry et al., 2015).

Indeed, international actors increasingly apply sustainability and food security in combination (Daily et al., 1998; Ericksen, 2008; Pinstrup-Andersen & Herforth, 2008; Richardson, 2010). For instance, FAO (2012a) analyzed interactions between the four pillars of food security and nutrition with the dimensions of sustainability. It related food availability and natural resource use, food access and decent rural livelihoods and rights, the stability of food security and green economy environment, and food utilization with sustainable diets. Moreover, the Committee on World Food Security (2009), via the reports prepared by the High Level Panel of Experts on Food Security and Nutrition (HLPE), has discussed the influence of sustainability challenges (e.g., climate change and water scarcity) on food security (FAO, 2017a). We summarize the food security—food sustainability nexus in global strategies and frameworks in Box 1.

There is also increasingly attention paid to the relations between improved nutrition and food system sustainability (Neff, Parker, Kirschenmann, Tinch, & Lawrence, 2011; Nesheim, Oria, & Tsai, 2015). One of the main objectives of the *New Nutrition Science* is to address sustainability challenges. It incorporates a more comprehensive understanding of the relation between food systems sustainability and good nutrition (Anonymous, 2005; Leitzmann & Cannon, 2005). Indeed, the sustainability of food systems is considered a prerequisite to achieving improved nutrition (Box 2). Linkages between good nutrition and sustainable food systems are also on the spot in the recently published HLPE report entitled "Nutrition and food systems" (HLPE, 2017b).

We conclude that the concepts of food security and food system sustainability are increasingly integrated, so that Lang and Barling (2012) proposed that "[…] the notion of food security may even fade into obscurity and be replaced by a more all-encompassing term such as sustainable food systems […]. […] at the very least, concerns about sustainability are reinvigorating old debates about food security" (p. 323).

4 | PATHWAYS FOR TRANSITIONS TOWARD SUSTAINABLE FOOD SYSTEMS

How to change the current unsustainable food system is a fundamental question for sustainability and agri-food

BOX 1 Food security—food system sustainability nexus in global food-related strategies and frameworks

The UN's Secretary-General's vision for a future free from hunger—the *Zero Hunger Challenge initiative*—links food security to food systems sustainability. The initiative has five objectives: 100% access to adequate food, all year-round; zero stunted children under two years of age; all food systems are sustainable; 100% growth in smallholder productivity and income; and zero food is lost or wasted (United Nations, 2012a,b). The core objective of "all food systems are sustainable" element is to transform the way food is produced, processed, distributed, and consumed (United Nations, 2015a). The very idea of sustainability transition is crucial to achieving this objective.

The vision of the *Programme on Sustainable Food Systems* (SFS) within the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns (10YFP) is that "All food systems are sustainable, delivering food security and nutrition for present and future generations," which strongly connects food systems sustainability and to food and nutrition security (UNEP, 2017).

In 2015, the General Assembly of the United Nations adopted a set of 17 goals to end poverty, protect the planet, and ensure prosperity for all as part of the new sustainable development agenda. The *second Sustainable Development Goal* (SDG2) is to "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture". As Berry et al. (2015) put it "Food security and nutrition for present and future generations is … both an integral part and a goal of sustainable development" (p. 5). SDG2 has a series of targets to support its three interrelated components, that is, ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture. Most targets concern the third goal component, which is assumed to contribute to achieving food and nutrition security and ending hunger (Scholes, Ringler, & von Braun, 2015).

There are many interactions between the 17 SDGs, as most of them address environmental, social, and economic dimensions of sustainable development among their targets (OECD, 2015). For instance, SDG2 contains targets related to environmental (e.g., climate resilience and agro-biodiversity), economic (e.g., financial services and agricultural productivity), and social dimensions (e.g., vulnerability and malnutrition; Nilsson, Griggs, Visbeck, & Ringler, 2016). A commonly discussed set of interactions related to SDG2 lies in the food-water-energy nexus (Weitz, Nilsson, & Davis, 2014). However, interactions with SDG2 are not limited to water and energy as they also stray into several other SDG areas (HLPE, 2017a; Nilsson et al., 2016; United Nations Conference on Trade and Development, 2017). In fact, SDG2 moves in tandem with SDG1 (no poverty), SDG3 (good health and well-being), SDG4 (quality education), SDG5 (gender equality), SDG10 (reduced inequalities), and SDG12 (ensure sustainable consumption and production patterns); but there might be trade-offs between SDG2—especially its target aiming to double agricultural productivity—and the environmentally focused targets of SDG6 (clean water and sanitation), SDG7 (affordable and clean energy), SDG13 (climate action), SDG14 (life below water, especially target 14.5: marine areas conservation), and SDG15 (life on land; Scholes et al., 2015). Sustainability in agriculture and food systems—including food waste reduction (target 12.3)—is also one of the major focus areas of SDG12 (responsible consumption and production; United Nations, 2015b). The Agenda 2030 confirms sustainability as an overarching goal for future food systems (Whitmee et al., 2015). Indeed, Rockström and Sukhdev (2016) position the SDGs in a hierarchy to be delivered on within a safe operating space for humanity.

scholars (Hinrichs, 2014). Different pathways were proposed to initiate a transition toward sustainable food systems that assure food and nutrition security for a growing world population. According to Garnett (2014), we can take basically three perspectives: efficiency, demand restraint, and food system transformation (Table 3). These three perspectives reflect different conceptualizations and visions on what is desirable or practically achievable and are underpinned by different ideologies, ethics, and values. Nevertheless, they are not mutually exclusive so that a composite approach to tackling the problem of food sustainability, integrating, and drawing upon all three perspectives is possible. This section analyzes examples for each of these perspectives.

4.1 | Efficiency-oriented pathway—Sustainable intensification

Many initiatives dealing with food systems and food security have been disproportionately centered on boosting food production. This focus has found a reincarnation in the term "sustainable intensification," which is now widely used in political and scientific arenas as a means of combining environmental concerns with the imperative to grow more food more quickly for a growing population. However, this tendency to narrow the food system on productivity issues risks perpetuating scientific and political biases to a "green revolution" paradigm that prioritizes

BOX 2 Sustainability of food systems in global nutrition-related documents and strategies

The global nutrition targets as agreed on by the World Health Assembly (WHA) in 2012, the Global Action Plan for the Prevention and Control of NonCommunicable Diseases (NCD) 2013–2020 (World Health Organization, 2013), and the Framework for Action (FFA) of the Second International Conference on Nutrition (ICN2) provide a clear direction for eradication of all forms of malnutrition (United Nations System Standing Committee on Nutrition, 2017). The ICN2 had as a vision to eliminate all malnutrition forms with an emphasis on the contribution of both food and health systems. The Rome Declaration on Nutrition (FAO & WHO, 2014a) also underlined the relevance of trade, education, and social protection sectors. The Rome Declaration has been operationalized through the ICN2 Framework for Action (FFA). The FFA comprises 60 recommendations for action that address all forms of malnutrition. It also attempts to prevent malnutrition by fostering healthy diets in a sustainable food system. Sustainable and resilient food systems for healthy diets are one of six focus areas of the FFA that makes a crucial link between nutrition and the sustainability agenda of the SDGs (FAO & WHO, 2014b). Although many issues related to malnutrition are addressed especially by SDG2 (food security and nutrition) and SDG3 (health; United Nations, 2015a,b), nutrition should be seen as a crosscutting and essential issue to the achievement of the SDGs and 2030 Agenda (United Nations System Standing Committee on Nutrition, 2017). In fact, nutrition is embedded in many SDGs targets (United Nations Standing Committee on Nutrition, 2014). To accelerate progress toward the goal of eliminating all forms of malnutrition by 2030, the United Nations have adopted the UN Decade of Action on Nutrition, from 2016 to 2025. It is a follow-up of ICN2, especially its Framework for Action (FFA), and it serves as a major driving force for achieving SDGs especially those targets related to nutrition. Sustainable food systems for healthy diets are one of the six pillars for nutrition action included in the Decade work plan (World Health Organization, 2017) based on the commitments of the Rome Declaration on Nutrition and recommendations included in its FFA.

technological innovations over social ones (IPES-Food, 2015).

Despite the changes in the conceptualization of food security, the term is still mainly used to argue for expanding food production (Foley et al., 2011; Garnett et al., 2013; Gregory et al., 2002; Ingram, 2011). Indeed, FAO projections to 2050 indicate that a considerable intensification of production may be needed in the coming decades to meet increasing global food demand (Bruinsma, 2011; FAO, 2012c). While this is one likely scenario, it is not necessarily a desirable one as this intensification may increase pressure on natural resources (land, water, biodiversity) and cause negative impacts on the environment (Foley et al., 2011). Despite the successes in increasing output through intensification, recent trends have renewed concerns about the continuity of global food supply in the coming decades (Gladek et al., 2016). Satisfying increasing global food demand poses huge challenges for both food production sustainability and ecosystems (terrestrial and aquatic) integrity (Tilman, Cassman, Matson, Naylor, & Polasky, 2002). The planetary boundaries and input availability limitations are hard limits to the food systems' further expansion—a majority of biological resource extraction can be attributed to food systems, making them the primary contributor to the transgression of planetary boundaries (Rockström et al., 2009; Steffen et al., 2015). The depletion of nonrenewable or slowly renewable resources, such as fossil fuels and wild fish stocks, is the second limit to expansion and intensification (Gladek et al., 2016). This underlines the need to insist on the "sustainable" in "sustainable intensification," as negative environmental impacts of agriculture, animal husbandry, and fisheries, such as water pollution, soil degradation, loss of biodiversity, and greenhouse gas emissions become an ever more pressing concern (Foresight, 2011; Gregory & Ingram, 2000; Nemecek et al., 2012; Williams, Audsley, & Sandars, 2006). Accordingly, some agronomic research has turned its main focus on use efficiency of inputs (especially water and nitrogen) and reducing negative externalities (Gregory et al., 2002; Van Ittersum & Rabbinge, 1997).

Pretty, Toulmin, and Williams (2011) defined agricultural intensification as follows: "Traditionally agricultural intensification has been defined in three different ways: increasing yields per hectare, increasing cropping intensity (i.e. two or more crops) per unit of land or other inputs (water), and changing land use from low value crops or commodities to those that receive higher market prices." The search for paradigms to underpin new models of agricultural intensification has led to the appearance of different qualifiers such as sustainable intensification (SI), but also "eco-functional intensification" (Niggli, Slabe, Schmid, Halberg, & Schlüter, 2008) and "ecological intensification" (Chevassus-au-louis & Griffon, 2008).

Sustainable intensification was defined as "[…] producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services" (Pretty et al., 2011). In addition to

TABLE 3 Three perspectives on how to achieve food system sustainability and sustainable food security

Perspective	Efficiency	Demand restraint	Food system transformation
Focus	Changes in production	Changes in consumption	Changes in food system functioning and governance
Target actor(s)	Producers	Consumers and food industry	All food system actors
Advocates	Governments and food industry actors (e.g., farming unions, agricultural input businesses, agro-food processors, and retailers)	Consumer associations, most international NGOs, and intergovernmental organizations	Organic movement and food sovereignty movements (e.g., La Via Campesina)
Food security	Food security problem is a supply-side (availability) challenge	There is enough food to feed everyone. Challenge is resource-intensive consumption patterns and diets	All four food security dimensions are considered
Nutrition	Considered somewhat separately from food security	Good nutrition and food security are related	Relationship between food security and nutrition
Rationale	This perspective focuses on changing patterns of production. For the efficiency mindset, the onus is on producers to develop appropriate techniques and strategies to reduce environmental impacts while increasing productivity	This perspective focuses on reducing excessive consumption. For the demand restraint perspective, the problem lies with the consumer and with the companies who promote unsustainable consumption patterns. Excessive consumption is considered the leading cause of environmental crisis	This perspective considers both consumption and production in terms of the relationships among food system actors, interpreting the problem as one of imbalance, social injustice, or inequality
Example analyzed	Sustainable intensification	Sustainable diets	Agro-food transition

Source: Adapted from Garnett (2014).

agricultural production factors (land, water, and labor), SI emphasizes the use of other factors, for example, knowledge, innovations, ecosystem services and ecological processes, and human capital (CIRAD, 2016). SI is a process that combines both conservation and protection of natural resources and ecosystems while providing smallholders with improved livelihoods and increasing their resilience to shocks (FAO, 2014b). In a recent publication, FAO (2017b) related intensification to diversification of agricultural production: "Sustainable intensification refers to strategies aimed at

simultaneously improving productivity and environmental sustainability, which can be achieved through increasing species diversity in cropping systems or ecosystem-based strategies" (p. 15).

Considering its open character, the term SI has accommodated different kinds of development agendas: capital building, improved resilience to climate change and ecological shocks, stakeholder participation, capacity building, improved livelihoods, and increased food and nutrition security (Cafer & Qin, 2017; Carney, 1998; Luloff, Krannich, Theodori, Trentelman, & Williams, 2004; Marshall, Fenton, Marshall, & Sutton, 2007; Rockström et al., 2017; The Montpellier Panel, 2013). FAO (2014b) related SI to the situation of family farmers, indigenous populations, and women.

An edition of the Food Ethics Council (2012) noted a lack of meaningful dialogue about what exactly SI is and, more importantly, its effectiveness as an agricultural development tool. One of the few concrete frameworks was published by the Montpellier Panel (2013) in its report "Sustainable Intensification: A New Paradigm for African Agriculture." The framework outlines very concrete aspects of four major domains of sustainable agricultural intensification namely sustainable measures, inputs, intensification processes, and outputs.

In Sub-Saharan Africa (SSA), one of the regions most affected by food insecurity, SI is presented as a strategy to address population growth, food insecurity, yield gaps, unemployment, pressure on land, and climate change. The diversity of soil, climatic, economic, social, and political conditions results in a broad spectrum of pathways to ensure sustainable intensification (CIRAD, 2016). The PROIntensAfrica project (Pathways to sustainable intensification of the agri-food system in Africa) identified four different pathways to sustainable intensification of the agri-food systems in Africa (Table 4).

Reduction in food losses and waste (FLW) is also presented as a strategy of sustainable intensification along the food chain. FLW reduction constitutes a significant lever to achieve food security and improves food chain efficiency (FAO, 2011; Waste & Resources Action Programme, 2011). Reducing food wastage would ease the pressure on agro-ecological systems to meet the growing food demand, thus

TABLE 4 Pathways leading to sustainable agricultural intensification in Sub-Saharan Africa

Intensification pathway	Pathway characterization within PROIntensAfrica project
Conventional Agriculture Pathway	This pathway is dominated by high use of external inputs (such as improved varieties and breeds of crops and livestock, GMOs, pesticides and mineral fertilizers) and extensive use of irrigation and mechanization. This pathway is a continuity of the green revolution and engages the use of high-tech, provided that it will improve productivity. Its short term goals predominantly refer to maximizing production
Eco-Technical Pathway	The "eco-technical" pathway seeks to integrate indigenous knowledge and ecological services to ensure a sustainable intensive agriculture. It primarily seeks intensification through rational use of biotechnology, modest external inputs, irrigation and mechanization in such a way that the ecological cycles are maintained
Agroecology Pathway	The agroecology pathway is based on convergence of agronomy and ecology. Maximization of productivity or production is not the main goal of this pathway, rather the optimization of outputs while the farm systems are retained in a healthy state. Intensification in this sense is subordinated to social and economic development and autonomy of the production systems and of the farm
Organic Agriculture Pathway	The organic agriculture pathway refrains from the use of pesticides and mineral fertilizers and emulates ecological systems and cycles. Its main objective is not intensification but to shift to better quality and certification for better valorization

Source: PROIntensAfrica (2017).

improving food systems sustainability and ensuring food security and nutrition. In fact, wasting food means losing not only life-supporting nutrition but also precious resources such as water, land, and energy. Indeed, food loss and wastage amount to significant squandering of resources, including water, land, energy, labor, and capital, and contribute to climate change (FAO, 2013a, 2015b). According to FAO (2012b), minimizing waste can also reduce water demand. Reducing waste across the whole food chain would also improve input use efficiency by increasing the amount of available food for a given level of inputs (Ingram, 2011).

4.2 | Demand restraint pathway—sustainable diets

Sustainable food systems require a transition in multiple dimensions, including the dietary level (IPES-Food, 2015). Sustainable diets are key to nutritional well-being and health while ensuring food system sustainability for future food security (Berry et al., 2015).

Dietary patterns are shifting, due to rising income, urbanization, and urban aspirations toward higher consumption of animal products and processed foods, with consequently, high resource demand (Lundqvist, Fraiture, & Molden, 2008). These changes in diets have considerable health and environmental impacts (WWW-UK, 2013). Dietary patterns with high meat consumption require a high amount of energy, water, and land resources (Gerbens-Leenes & Nonhebel, 2005; Pimentel & Pimentel, 2003). Further global increase in animal-based production will require greater land and resource use (FAO, 2006; McAlpine, Etter, Fearnside, Seabrook, & Laurance, 2009; Pelletier & Tyedmers, 2010; Stehfest et al., 2009; Tukker et al., 2006; Weber & Matthews, 2008), while animal-based diets are associated with the rise of obesity and other diet-related diseases (Friends of the Earth, 2010; Pan et al., 2012; Popkin & Gordon-Larsen, 2004; Sinha, Cross, Graubard, Leitzmann, & Schatzkin, 2009). For the world's poor, however, there are clear nutritional advantages to consuming small amounts of high-quality animal foods: They are rich in protein and essential amino acids, and essential micronutrients important for physical and cognitive development (Smith et al., 2013). The challenge is how to manage complex trade-offs to enable livestock's positive impacts to be realized while minimizing unsustainable impacts (HLPE, 2016).

To achieve a fairer distribution of food-related environmental impact, White (White, 2000) suggests to transition from high-calorie diets to low-calorie ones and to move from high resource-intensive meat-based diets to plant-based ones. This is what the Union of Concerned Scientists (2012) refers to as "Plant the plate" approach. According to WWF (2016), "a dietary shift in high-income countries – through consuming less animal protein – and reducing waste along the food chain could contribute significantly to producing enough food within the boundaries of one planet" (p. 14). Shifting to more sustainable dietary patterns would sustain future production as it would slow down climate change, the depletion of resources—such as energy, water, land use, and biodiversity—and contribute to the fair distribution of wealth. It would also yield benefits regarding noncommunicable diseases (Aleksandrowicz, Green, Joy, Smith, & Haines, 2016).

Sustainable diets concepts started to be explored in the early 1980s, to recommend diets healthier for consumers as well as for the environment (Gussow & Clancy, 1986), but the concept was then mostly ignored for many years. In 2006, the Conference of the Parties of the Convention on Biological Diversity acknowledged the crosscutting character of biodiversity and food and nutrition (Toledo & Burlingame, 2006). By 2010, this initiative was merged with the work on sustainable diets (Burlingame & Dernini, 2012). In 2010, FAO and Bioversity International organized an international scientific symposium on "Biodiversity and sustainable diets." As one of the major outcomes of the symposium, a consensus position was reached on a definition of sustainable diets (Burlingame & Dernini, 2012; FAO, & Bioversity International, 2010).

The interest in sustainable diets has continued to grow in academia and UN agencies (American Dietetic Association, American Nurse Association, American Planning Association, & American Health Association, 2010; American Public Health Association, 2007; Burlingame & Dernini, 2012; DEFRA, 2009, 2011; FAO, 2012a; UNEP, 2012a,b, 2017; United Nations Standing Committee on Nutrition, 2012; WWF, 2016). Sustainable diets are considered as an essential element for a shift toward sustainable food consumption patterns (Esnouf, Russel, & Bricas, 2011; Guyomard et al., 2012; Macdiarmid, Kyle, Horgan, & Loe, 2011; Pluimers & Blonk, 2011; Sustainable Development Commission, 2009, 2011; Tukker et al., 2009).

Despite the broad agreement that a shift toward sustainable diets is needed, it is far less clear how such a shift could be accomplished as it intersects with many adjacent societal challenges (e.g., fair trade, animal welfare, sustainable agriculture, social acceptance, and everyday adoptability; Dibb, 2013). The impact of sustainable diet policy measures has not been sufficiently explored (Jones et al., 2016; Lang & Barling, 2012). Moreover, the composition of individual diets will depend on individual needs, food preferences, dietary customs, geo-climatic, and cultural context as well as locally available foods (Allen, de Benoist, Dary, & Hurrell, 2006). Therefore, there might be different pathways of transition to regionally and culturally adjusted sustainable diets (e.g., Mediterranean diet and New Nordic Diet). Although many models, metrics, and indicators have been developed, a coherent framework is still missing, as well as a move from informal to formal processes of policy creation (Lang, 2014).

BOX 3 Alternative food systems

Consumers, through their choices but also perceptions and attitudes, can be considered political actors (Micheletti, 2003). Food is increasingly becoming a contested arena that reflects changes in societal values and norms (Wright & Middendorf, 2007). Sustainability concerns are directly related to food systems (Harwood, 1990; Helms, 2004) and provide strong impetus to alternative food systems (AFS). AFS initiatives have also been triggered by the many problems associated with "industrial" food (Freidberg & Goldstein, 2011). AFS fall outside of the scope of the conventional and industrial agro-food arena, and some have attempted to go into opposition against the vertically integrated, highly organized industrial food system (Abrahams, 2007; Terragni, Torjusen, & Vitterso, 2009). AFS are supposed to be more sustainable (Nousiainen, Pylkkänen, Saunders, Seppänen, & Vesala, 2009) and explicitly integrate the idea of "transition" as process or outcome. Jarosz (2008) proposed a set of characteristics that many AFS have in common: small farming scale or a holistic food production approach; short producers–consumers distances; alternative institutions such as food cooperatives, farmers' markets, and community-supported agriculture. AFS initiatives have often sought to establish smaller, if possible, local food systems (LFS; Renting, Marsden, & Banks, 2003). LFS aim to reduce the distance between producer and consumer, relying on fewer intermediaries, reducing the need for transport and using direct marketing strategies. Examples of LFS include community agriculture, farmers' markets, farm food outlets, box schemes, and farm-to-school programs. Food sovereignty is a common theme of initiatives that aim to transform food systems towards social justice (NGO/CSO Forum for Food Sovereignty, 2002). Nevertheless, AFS have largely been a phenomenon of the global North; in the global South, AFS have mainly focused on export markets and were largely development-oriented (Freidberg & Goldstein, 2011). However, there are also some initiatives to develop urban agriculture in the Global South (e.g., de Bon, Parrot, & Moustier, 2010; Zezza & Tasciotti, 2010).

4.3 | Food system transformation pathway or agro-food transition

The food system transformation perspective is the most political among the three discussed by Garnett (2014). It claims that the architecture of food systems must change, including the dynamic interactions among social, economic, and environmental components of food systems over time and space. From this perspective, achieving food security will require challenging the power relations in the food world in the context of less government-driven and more market-driven food systems (Lang & Barling, 2012; Lang, Barling, & Caraher, 2009). The transformation approach is good at describing food system complexity, but has difficulties in developing specific recommendations for the way forward (Garnett, 2014). Alternative food systems and networks (Box 3) are considered one of the more concrete examples of how sustainability transitions in agro-food systems could look like. However, while there is broad agreement that the food system is in need of a significant transformation if it is to feed the growing population in a sustainable, equitable, and adaptive manner (Elzen et al., 2017; Gladek et al., 2016), the diversity of perspectives that the different food system actors have on the food sustainability problem makes it difficult to reach a common understanding and genuine agreement on ways forward (Garnett, 2014; Garnett & Godfray, 2012; Hulme, 2009).

The food system transformation perspective recognizes the need for decoupling human development from environmental degradation and social exclusion. Such a transition requires fundamental changes in the global food system (WWF, 2016). Various structures within the current industrialized global food system reinforce the status quo, that is, agricultural subsidies, governmental research programs, and metrics that do not adequately include the environmental, social, ethical, and cultural impacts (Gladek et al., 2016; WWF, 2016). Food system sustainability transitions may thus be in opposition to institutional structures (Matson, 2009). WWF (2016) proposed different strategies to facilitate change: promoting healthy and sustainable consumption patterns, scaling up existing niche innovations, optimizing yield, promoting agro-ecological practices, diversifying farms and farming landscapes, and promoting landscape approaches in supply chains. The International Panel of Experts on Sustainable Food Systems (IPES-Food, 2015) suggested ten principles to guide the transition to sustainable food systems; five principles regard types of knowledge and analysis needed to support the transition (holistic & systemic, power-sensitive, transdisciplinary, critically engaged, and independent), while the remaining principles concern values that should be at the heart of sustainable food systems (sustainable in all dimensions, diverse and resilient, democratic and empowering, socially and technologically innovative, and adequately measured).

Similar to the sustainable intensification discourse, the food system sustainability discourse struggles with agreeing on the meaning of the term (Gladek et al., 2016)—it remains contested given the diversity of food system actors' visions and narratives (El Bilali, 2018; Sonnino, Marsden, & Moragues-Faus, 2016). As Lang and Barling (2012) put

it: "While there is growing awareness of food systems' capacities being under stress, there is as yet less recognition of how extensive change must be before food systems are sustainable" (p. 322). An option to overcome this impasse seems to refer to performance or outcome-oriented features (e.g., adequate food supply for all people) rather than describing the specific mechanisms or approaches that should be used to produce those outcomes (e.g., conventional vs. organic practices; Gladek et al., 2016). Food system transitions thus do not have one easy, obvious, or uncontested pathway but will be characterized by a diversity of options, approaches, places, voices, and historical contexts (El Bilali, 2018; Shove & Walker, 2007; STRN, 2010).

A leading voice in the food system transition discourse has been the agroecology movement—agroecology is promoted as a way of transforming and redesigning food systems, from the farm to the fork, with the goal of achieving environmental, economic, and social sustainability (Gliessman, 2015, 2016). Current agro-ecological thinking criticizes the whole agro-food regime rather than just the production level (Elzen et al., 2017; Gliessman & Engles, 2015; Holt-Giménez & Altieri, 2013). The transformative potential of agroecology (including organic farming) is increasingly recognized not only by organic agriculture movements but also by international organizations and expert panels (FAO, 2015a; IAASTD, 2008; IPES-Food, 2016).

At a more fundamental level, de Schutter (2014) claimed that what is needed is the democratization of food systems—with the opportunity for communities to choose which food systems to depend on and how to reshape those systems. He further elaborates: "Change can be expected neither from government action, nor from business initiatives alone, and grassroots innovations led by ordinary people have a limited impact. Only by connecting these different pathways for reform by food democracy can lasting food systems reform be achieved" (De Schutter, 2017).

5 | CONCLUSIONS

About a half of the world's population is affected by food insecurity, obesity/overweight, or micronutrient deficiencies—showing the need for a reform of the current food system. At the same time, food systems are affected by and causing resource scarcity, ecosystem degradation, and climate change.

We believe that connecting the discourses of food and nutrition security and food system sustainability will be necessary to create a coherent narrative for the necessary sustainability transition. By reviewing the linkages between the two concepts, we show that long-term food and nutrition security—in its availability, access, utilization, and stability dimensions—is a central outcome of sustainable food systems.

To deliver food and nutrition security for present and future generations, all system components need to be sustainable, resilient, and efficient. This will require a transformation of food systems at household, local, national, and global level. While this need is widely recognized, the different strategies to foster sustainability transitions in food systems continue to be debated. Focusing on production efficiency is central to the sustainable intensification pathway; proponents of sustainable diets suggest that the demand for resource-intensive diets needs to be restrained; and alternative food system activists question food system governance and structures from farm to fork.

We conclude that a transition to sustainable food systems will require moving from an agriculture-centered to a food systems policy and research framework. How to make meaning of the complexity of food systems in a way that allows for democratic action is part of the future research agenda.

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