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Sustainable Food Security: An Emerging Research and Policy Agenda

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Abstract. As a response to emerging calls for the adoption of a systemic approach to food security, in this article we identify and discuss inextricably linked barriers to 'sustainable food security'. Based on an extensive analysis of recent academic and policy literatures on the economic, social and ecological effects of global environmental change at different stages of the food system, we highlight a series of cross-cutting issues and areas of disconnection between food production and consumption that call for a renovated focus on the different nodal points of the food system. As we suggest, a *sustainable food security framework* should move away from the conventional focus on individual components of the food system (e.g., supply and demand) and address more holistically the complex relationships between its different stages and actors.

Introduction

For decades, food security and sustainability were treated as separate governance concerns. In essence, food security was confined to the challenge of tackling hunger in the Global South, whereas sustainability was addressed in relation to food safety and the environmental impacts of agriculture in the North.

Today, the emergence of a 'new food equation' (Morgan and Sonnino, 2010) is redefining the meanings of food security and sustainability – as well as their interrelationship. Since the spikes in fuel, food and energy prices of 2007–2008, the prevailing perception of a world of food surplus has shifted to one of food deficit. At the same time, the rapid growth of obesity and malnutrition in both developed and developing countries is redefining the geography of food insecurity, especially in the expanding urban areas (Ashe and Sonnino, 2013). To further complicate this scenario, the last years have also witnessed a financial crisis, the depletion of global food stocks as vast productive areas have been utilized to produce biofuels rather

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than foods (Mol, 2007), and the proliferation of 'land grabbing' activities in the Global South.

In this context of urgency and uncertainty, the debate on food security has been enriched by different scenario analysis exercises that depict a range of plausible futures. Although they are highly heterogeneous in terms of scale, accounting methods and underlying conceptual frameworks and core questions (see Reilly and Willenbockel, 2010), these scenarios all suffer from two fundamental weaknesses in their conceptualizations of food security. First, they confine their analyses to the production side of the food system (i.e. yield and land use) and to market transactions (i.e. demand and supply) that translate into indicators such as food prices and calorie availability. In so doing, they address only two dimensions of food security: availability (i.e. the amount, type and quality of food that a certain unit has at its disposal) and access (i.e. the ability of a unit to obtain access to the type, quality and quantity of food that it requires) (Ericksen, 2008, p.238). Food utilization (i.e. the capacity to consume and benefit from food, which depends on its safety and nutritional value as well as on socio-cultural aspects of consumption) is neglected in these exercises. Second, these scenarios have explored inadequately the economic, ecological and political dimensions of sustainability (Swart et al., 2004; Reilly and Willenbockel, 2010) or, as Ericksen et al. (2009, p.376) state, 'the wider issues that underpin food security and the environmental consequences of different adaptation options'.

These weaknesses reflect an unwarranted polarization of the academic and policy debate, which has been dominated by a tension between two narratives: the first conceptualizes food security as a production issue, which should be addressed through intervention at the supply end of the food chain (e.g. by increasing the amount of food produced); the other, in contrast, consider it as a consumption matter, which calls into question the accessibility of nutritious food. By failing to extend their views and values beyond the two ends of the food system, these narratives have constrained the interpretation of (and policy intervention on) global food security.

Based on an extensive analysis of recent academic and policy literatures, this article responds to emerging calls for the adoption of a more systemic approach to food security that takes into account sustainability concerns (Lang and Barling, 2012) and bridges the gap between production-based and consumption-based narratives. By focusing on the multiplicity of economic, social and ecological outcomes of global environmental change at different stages of the food system, the article identifies the tangible (and often inextricably linked) barriers to 'sustainable food security' – a concept based on the fundamental assumption that the long-term capacity of the food system to provide an adequate amount of nutritious food will depend on its ability to respond to the environmental and socio-economic challenges that threaten its resilience and to minimize its impacts on human and environmental health. By joining the security and sustainability lenses, our sustainable food security framework proposes a long-term theoretical and policy approach that, as Carolan (2013, p. 7) convincingly argues, is becoming increasingly necessary to address a wide range of large ecological footprints that are threatening the resilience of the global food system.

Sustainability and Food Security: Two Competing Narratives

The origins of the 'productivist' approach can be traced back to early FAO conceptualizations of food security, which 'focused on increasing food production, particularly in the developing countries, stabilizing food supplies, using the food surpluses of developed countries constructively and creatively, creating world and national food reserves, stimulating world agricultural trade [and] negotiating international commodity agreements' (Shaw, 2007, p. 283). Under this approach, food is reduced to the quantity produced and it is valued according to the efficiency of the production process (Rosin, 2013). Today, central to this narrative is the concern over feeding nine billion people in a context of growing competition over land and other resources, which, for the proponents of this approach, requires an increase in food production and, by implication, a support for the status quo. For this reason, the productivist view of food insecurity tends to be supported by the most powerful actors in the food system – including the World Bank, the WTO and FAO (Mooney and Hunt, 2009; Holt Giménez and Shattuck, 2011).

Demand-led approaches, by contrast, view food insecurity as essentially a matter of lack of (physical, financial and cultural) access to food. As Sage (2013) summarizes, these approaches move three central criticisms to productivism. First, the emphasis on the supply side overrides questions of distribution and the ecological costs of production systems (Feldman and Biggs, 2012). Second, an approach that emphasizes agricultural output tends to regard food, feed and fuels as a set of tradable commodities for international markets, rather than as foundational elements for national food security. Third, a concern with food output alone neglects nutritional security – in other words, it assumes the continued expansion of the 'nutrition transition', an expression that refers to the increase in the amount of food consumed brought about by an increase in income (UNEP, 2012).

There are two main differences in the ways in which these two narratives interpret the relationship between food security and sustainability. First, productivism emphasizes the role of global governance through an emphasis on large-scale programmes to improve agricultural productivity, manage environmental resources and develop markets for small farmers (Jarosz, 2011). In this perspective, trade liberalization (as opposed to a drive towards self-sufficiency) is considered crucial to sustain food security (e.g. DEFRA, 2002). By contrast, demand-led approaches start from the assumption that, since the global food system is unlikely to be able to cope with long-term stress arising from climate change, the vital task is to enhance the adaptive capacity (i.e. resilience) of local and regional food systems (Marsden, 2012; Sage, 2013). Second, productivists emphasize the need for scientific and technological innovation to grow more productive or resilient food crops. In the UK, for example, a report by the Royal Society (2009) examined the potential range of technologies to enhance production (advanced biotechnology, improved conventional practices, low-input methods), concluding that there is a need for 'scientific solutions to mitigate potential food shortages' (p. 47). Proponents of demand-led approaches to food security criticize this tendency to privilege 'technological solutions over more place-based technologies and knowledge systems' (Marsden, 2012, p. 142; see also Hinrichs, 2013). The IAASTD's report on agricultural knowledge, science and technology (McIntyre et al., 2009), for example, advocates policies that support the revitalization of traditional knowledge and the democratization of technology (Kneafsey et al., 2013). This approach recognizes that precision agriculture, genetic engineering and nanotechnology have roles to play in the development of the food system (Beddington and Beddington, 2010; Gebbers and Adamchuk, 2010; Scrinis and Lyons, 2010). However, it is also emphasized that some technologies may not address the needs of some users and may not necessarily enhance the human right to adequate food (De Schutter, 2011b; Sage, 2013).

In synthesis, then, the two approaches differ in the identification of the primary target for food security and sustainability policies. Productivists propose an economic-based (i.e. 'weak') interpretation of sustainability, which prioritizes the global food market. The underlying assumption here is that, once we manage to produce enough food, the global market itself will solve the distribution problem. In their view, wealthier countries need to produce more food not just for domestic consumption but also for supply through trade and aid to poorer countries. This ideology is very strong in countries such as Australia (Dibden et al., 2013), New Zealand (Rosin, 2013) and in the UK, where the government has suggested that 'one of the most important contributions that the UK can make to global, and our own, food security is having a thriving and productive agriculture sector' (DEFRA, 2008, p. 28) – that is, exploiting natural advantages in domestic food production to meet rising demand elsewhere. Access-based approaches, by contrast, criticize the emphasis on the economic dimension of sustainable development at the neglect of its social and environmental objectives (Yngve et al., 2009; Lang, 2010). Through notions of 'right-to-food' (MacMillan and Dowler, 2012) and 'food and nutrition security' (SCN, 2004), these approaches propose a 'strong' version of sustainability that embraces the entire ecology of the food system –or, as Lang (2010, p. 95) states, all 'factor[s] in all diet-related ill-health, not just hunger'. Implicit in this argument is the assumption that once we have addressed the distribution challenge, food producers and the industry will adjust to changes in demand. In the next sections, we will test the arguments (and proposed solutions) of these two main narratives against the tangible barriers to sustainable food security at different stages of the food system.

Sustainable Food Security: The Challenges for Food Production

On the supply side, there are four main threats to sustainable food security: the degradation and loss of agricultural land; the loss of biodiversity; the pressure of agriculture on water resources; pollution and resource depletion – all issues that impact on, and at the same time are impacted by, the dynamics of climate change, which are bound to change the global geography of food production, as many have been arguing. Land degradation processes, which are related to inadequate use of soil conservation techniques (including slope and cover management, fallow, reincorporation and recycling of manure and crop residues into the soil), deforestation, pollution and overgrazing (Stocking and Murnaghan, 2001), are estimated to affect 16–40% of the land area (Chappell and LaValle, 2011) and a total of 1.5 billion people, especially in sub-Saharan Africa (where 13% of the degraded land is located) and South East Asia (6% of the degrading area) (UNEP, 2012). In recent years, the problem of soil degradation has been exacerbated by the emergence of competing pressures on land, linked to the search for alternative forms of energy (biofuels), urban expansion and the loss of biodiversity.

According to Aarnink et al. (1998), during the twentieth century 75% of the genetic diversity of agricultural crops went lost as a result of the Green Revolution, which has changed the pattern of intraspecific diversity in the fields. As stated in the Millennium Ecosystem Assessment (2005, p. 5), the problem (which has only partially been offset by the creation of seed banks) is one of resilience; indeed, the loss of genetic diversity 'reduces overall fitness and adaptive potential, and it limits the prospects for recovery of species whose populations are reduced to low levels'. In 2008, for example, 81% of the marine fisheries were fully or over exploited, and a further 4% were depleted or recovering from depletion (FAO, 2010a). The loss of off-farm biodiversity also has negative impacts on the food system, since it implies losing 'services' (such as pollination by insects) provided by organisms that ensure a form of natural control on crop pests and diseases.

Irrigation for agriculture utilizes 70% of total water resources (FAO, 2011), and this figure is predicted to increase. By 2050, domestic water demand in sub-Saharan Africa will have doubled against the levels of 1997, whereas in Asia it will have increased by 20–90% (Millennium Ecosystem Assessment, 2005). In practice, this means that 90% of the three billion people who will add to the global population by 2050 will be located in water-stressed regions (WWAP, 2012). As a result, the competition between agriculture, industries and households for the available water resources will intensify.

More generally, it has been calculated that agriculture contributes by 92% to the human water footprint. Oil crops alone account for 43% of the global virtual water flow – i.e. the water footprint embedded in traded commodities (Hoekstra and Mekonnen, 2012). More than half of this amount relates to trade in cotton products; about one-fifth relates to trade in soybean. Other crops that have a large share in the global virtual water flow include cereals (17%), industrial foods (12%), coffee, tea and cocoa (8%) and beef (7%). When considering the rising demand for meat and cereals (Collette et al., 2011) and the fact that environmental externalities are not included in the price of water, it is easy to predict that water availability will become a major issue, especially in the regions affected by desertification processes.

Intensive agriculture's heavy reliance on fertilizers and pesticides has also had serious consequences for ecosystem health, especially in the Global North and in the emerging economies of the South. In some regions, fertilizers and pesticides have disrupted the natural nutrient cycle, causing eutrophication of surface water and contamination of groundwater. Fertilizers utilize non-renewable resources (especially phosphors), which continue to being depleted (Cordell et al., 2009). The same applies to fossil fuels, which have significant impacts in terms of climate change; it has been estimated that agricultural CH_4 and N_2O emissions have increased by nearly 17% between 1990 and 2005 and that agriculture alone accounts for 10–12% of the total anthropogenic emissions of greenhouse gases (Smith et al., 2007).

Environmental degradation can displace people (Myers, 2002) and increase disparities between farming communities. Indeed, access to constantly depleting resources (land, fossil fuel, phosphors, water) is likely to become even more difficult for low-income smallholder farmers, who produce 80% of the food supply in developing countries (Collette et al., 2011). According to UNEP (2012), the declining quality of land and water resources has already resulted in global net losses of cropland productivity averaging 0.2% per year. In this context, 'climate smart' agriculture is gaining momentum as a tool to address the two main challenges that have emerged here – i.e. lowering the amount of emissions that agriculture produces while at the same time enhancing its resilience to climate change.

Addressing Food Production Challenges: Sustainable Intensification

A growing awareness of the environmental impacts of food production and of the competing pressures over land has fuelled the emergence of sustainable intensification (SI) as one of the most powerful productivist discourses in the food security debate. The main underlining principle of SI is that capacities for change should be harnessed through technological and scientific innovation (from improving the efficiencies of agro-ecological methods of food production to the experimentation in the utilization of modern genetics). Practically, as defined by the FAO (Collette et al., 2011), SI means producing more from the same area of land while reducing negative environmental impacts and increasing contributions to natural capital and the flow of environmental services (see also Pretty et al., 2011). Originally developed in the context of sub-Saharan Africa as a response to low yields and high environmental degradation (Reardon et al., 1995; Pretty, 1997), this concept has been popularized by the UK's Royal Society (2009) and Foresight reports (2011). The latter, in particular, stated: 'The global food supply will need to increase without the use of substantially more land and with diminishing impact on the environment: sustainable intensification is a necessity' (Foresight, 2011, p. 31).

There are three key elements that shape the SI agenda. First, SI promotes a systemic approach to natural resource management that uses inputs such as land, water, seeds and fertilizers to complement the natural processes that support plant growth (including pollination, natural predation for pest control, and the action of soil biota that allows plants to access nutrients) (FAO, 2010b). The basic features of this approach include improved soil and water management; an emphasis on soil fertility through the harnessing of agro-ecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism; a moderate use of external inputs; the use of crop varieties and livestock breeds that are resistant to stress (e.g. drought, salinity, disease) and have a high productivity rate in response to the use of externally derived inputs, a reduced use of technologies and practices that have adverse impacts on the environment and human health, a productive use of human and social capital (in the form of knowledge and capacity for innovation), and the minimization of environmental externalities (Collette et al., 2011; IFAD, 2011; Pretty et al., 2011). These agro-ecological principles, which inform many of the existing examples of SI (Pretty and Hine, 2001), have the potential to address many of the environmental problems that affect food production, especially in relation to biodiversity conservation (Gibson et al., 2007) and the natural life cycle (De Backer et al., 2009), while also ensuring an adequate level of productivity (Badgley et al., 2007), especially for poor smallholders (McIntyre et al., 2009; De Schutter, 2011a).

The second key principle of SI raises the need to connect different types of knowledge to bridge the gap between agro-industrial/biotech and agro-ecological propositions (Dibden et al., 2013). As Jules Pretty, a member of the UK Foresight project's expert group, said, SI facilitates 'a move away from the "binary opposition" between high-tech and low-tech approaches' that often does not reflect the reality of contemporary agriculture, which mostly lies somewhere between conventional and agro-ecological practices (Tscharntke et al., 2012). In theory, then, SI promotes a new way of producing food (Godfray et al., 2010b) that can offer significant benefits to small farmers by enhancing their productivity, reducing costs, building resilience and strengthening their capacity to manage risk (Collette et al., 2011).

The importance of engaging with traditional and local knowledges is the third key principle of SI (Garnett and Godfray, 2012). As Pretty et al. (2011, p. 10) state, 'successful projects of sustainable intensification by definition fit solutions to local needs and contexts'. By acknowledging the uniqueness of different environmental and socio-economic conditions (e.g. different labour requirements and different access to inputs and technologies), SI emphasizes the importance of involving local farmers in the process of innovation.

Despite the recognized potential of SI as a food security strategy, there are important criticisms of this concept. Garnett and Godfray (2012) have highlighted the tendency to associate SI with the goal of increasing the amount of food produced, rather than with the fundamental objective of increasing productivity while reducing the environmental impacts of production. For them, the main problem is that many have downplayed the original aspirational nature of this concept and use it to describe a certain type of agriculture – i.e. how food production should change now, as opposed to what different modes of food production can respond to the challenges raised by a resource-constrained world.

Other criticisms of SI call into question its one-dimensional focus on the supply side and on the environmental dimension of the food system, at the neglect of important ethical and political issues – especially the trade-offs that must be made in the decision-making process to ensure an equitable distribution of the burdens and benefits of SI in terms of market competition (FAO, 2004; Freibauer et al., 2011). For SI to realize its potential in terms of sustainable food security, it is crucial to overcome the limits imposed by specific production discourses and expand its argument to other stages of the food system.

Sustainable Food Security: The Consumption Challenges

On the demand side of the food system, SI, like other productivist approaches, is criticized for neglecting issues related to the quality and nature of the food needed to sustain food security – as well as its accessibility. From this perspective, one of the phenomena that impinge mostly upon sustainable food security is the nutrition transition, which has been responsible for a dramatic global spread of diet-related diseases (Kearney, 2010). For example, in the USA the health-care costs of illnesses related to obesity and overweight are estimated to double each decade up to 2030, when they will reach a total of $ 860–956 billion (Wang et al., 2008). There are important social justice issues to be considered. Indeed, higher-quality diets are more costly per kilocalorie and tend to be adopted by consumers of higher educational level (Monsivais and Drewnowski, 2009); as Mullie et al. (2010) have argued, citizens of lower socio-economic status tend to consume less fruit and vegetables.

Globally, there are many interrelated factors that hinder sustainable food security at the demand end of the food system. These include: a rise in global per capita income, which translates into increased consumption of animal-based and processed foods – hence, higher-fat diets; trade liberalization, which has reduced the price of unhealthy foods and increased their availability (Thow and Hawkes, 2009); and urbanization, which has caused negative changes in our dietary behaviour – linked to the wider availability of (often unhealthy) food choices, combined with lower-energy expenditure in urban jobs (Kearney, 2010). In sum, research shows that sustainable food security is seriously constrained by a widespread lack of access to healthy and nutritious food, which is affecting in particular urban residents (Sonnino, 2009). Significantly, it is also in cities that some of the environmental impacts of food production (such as water pollution and waste) are concentrated, with important implications for food safety. It has been reported that diarrhea contracted from consuming contaminated food and water causes 1.8 million deaths a year (Millstone and Lang, 2008). Clearly, urban food systems are emerging as important (but still under-researched) units of analysis for sustainable food security.

Another barrier to sustainability that is widely discussed in the literature on food consumption has to do with the high levels of food losses (at the production, post-harvest and processing stages) and food waste (at the retail and consumption stages), which all together amount to 1.3 billion tonnes per year – that is, at least one third of the total amount of food produced (Gustavsson et al., 2011). In general, post-harvest losses are greatest in developing countries (where they have reached 16–49%) due to lack of agricultural technologies and infrastructure (Parfitt et al., 2010). Food waste, which is linked to over-purchasing and consumer / retailer behaviour, is especially a problem in the North: American consumers throw away 25% of the food they purchase; British consumers one third (UNEP, 2012). The magnitude of this problem, and its implications for the environment (i.e. wasting food means using resources such as energy and water in vain and producing additional GHG emissions), has led to widespread discussions about possible solutions and policy interventions (see, for example, Sonnino and McWilliam, 2011), which have been recently framed around the notion of sustainable diets (SDs).

Addressing Consumption Challenges: The Concept of Sustainable Diets

As described by the FAO and Biodiversity International (2010), SDs are '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' (p. 1). In practice, SDs are based on five key principles: reduced consumption of meat and dairy products and of food and drinks with low nutritional value; increased consumption of fruit and vegetables; respect for the variability and seasonality of food supply; and an emphasis on the purchasing of environmentally friendly products (UNEP, 2012). The literature on SDs is still in its infancy, and suffers from the limitations imposed by a largely behavioral approach that does not account for important structural issues such as fairness across different stages of the food system. Moreover, not much has been said about specific strategies that can support their development and implementation. Across a range of disparate literatures, there are two policy instruments that require attention in the light of their potential to promote SDs. First, the planning system can play a major role in preventing the loss of agricultural land in peri-urban areas (which, especially in developing countries, play an important role in terms of food security – see Lerner and Eakin, 2011), protecting healthy food retailers (Dixon et al., 2007; Morgan, 2009), and supporting urban agriculture, which lowers the ecological impacts of food production by eliminating transportation and reducing waste (Redwood, 2009). Second, innovative public procurement policies can create important markets for small producers, as happened in Brazil (Rocha et al., 2012), and improve consumer attitudes towards food (Morgan and Sonnino, 2008).

In sum, the focus on the supply and the demand sides of the food system has uncovered a range of significant barriers and threats to sustainable food security. Concepts such as SI and SDs are important attempts to devise solutions to the problems, but they both suffer from a fundamental inability to provide a comprehensive perspective on food security. In simple terms, the literature on SDs does not deal with key questions about production – i.e. the methods and measures needed to deliver low-impact and healthy diets (Garnett, 2013). Research on SI, on its part, rarely accounts for rising concerns about global food demand – i.e. how to increase the accessibility of nutritious food and, at the same time, avoid overconsumption patterns that may further degrade the environment. When looking at the relationship between the two ends of the food system, it becomes clear that there are multiple and complex connections and disconnections between production and consumption that raise additional questions regarding the scope for achieving sustainable food security.

Sustainable Food Security at the Post-production Stages: Uncovering the 'Missing Links'

Sustainability analyses at the post-production stages of the food system have been largely neglected in the literature, which has tended to focus on a number of isolated issues, often neglecting the interconnections (or lack thereof) between different stages. Most research has focused on GHG emissions, which tend to be much more significant in high-income countries (Vermeulen et al., 2012) such as the UK, where post-production emissions make up around 50% of total food system emissions (Garnett, 2011). GHG emissions also vary significantly depending on the level of processing, the method utilized and the technology adopted – factors that influence the energy inputs required for the life cycle of different food items (Carlsson-Kanyama et al., 2003). For example, in the USA the energy used by the processing industry for cooking, cooling and freezing contributes an average share of 15–20% of total food system energy use (Cuéllar and Webber, 2010).

Refrigeration along the different stages of the food chain has an important contribution to make to sustainable food security, given its role in preventing food losses. However, refrigeration, especially in developed countries, also constitutes a major source of emissions (Pelletier et al., 2011). Coulomb (2008) estimates that 15% of the electricity consumed worldwide is used for refrigeration, but with changes in ambient temperature its use is likely to increase globally (James and James, 2010). In this kind of assessment, it is crucial to consider also the issue of embedded energy; for instance, it has been estimated that in the UK 2.4% of total GHG emissions are due to food refrigeration, but 'embedded' refrigeration of imported foods increases this figure to 3–3.5% (Garnett, 2007).

Transportation is the post-production stage that has received most scientific and media attention, especially through the concept of food miles. Despite its usefulness for uncovering the convoluted nature of the global food system, food miles is an imperfect sustainability measurement tool, on various grounds: it does not account for the emissions produced at the manufacturing and packaging stages of the food chain, which are actually higher (12% vs 19%); it neglects issues related to the volume of the food transported as well as to the way in which consumers travel to purchase their food (Mariola, 2008); and it does not account for the environmental damage produced by foods that have been grown locally in glasshouses (Garnett, 2011). Clearly, a focus on transportation alone offers a very partial and limited assessment of the sustainability of a food supply chain.

Transportation and refrigeration of food, which are closely connected practices, bring to the forefront the debate on trade globalization, which raises a number of additional challenges for sustainable food security. Globally, food production can be affected negatively by market intervention of developed countries, which can afford to subsidize their national agriculture and 'dump' its surplus products on developing countries, thereby displacing local producers (Friedmann, 1993; Herman et al., 2003). Second, trade globalization marginalizes poor farm households, which often lack appropriate transport routes and other market access mechanisms (Godfray et al., 2010a). This power imbalance has been widely acknowledged in discussions about the WTO negotiations (Pechlaner and Otero, 2010) and the recent food crisis, which has uncovered the vulnerability of food-import dependent countries at a time when 29 countries have already limited or banned food exports (Bradsher and Martin, 2008). Third, trade globalization has significant impact on biodiversity; according to Lenzen et al. (2012), 30% of global species are threatened by international trade, which always causes waste and losses. Indeed, when the food produced in a region is exported, the region loses the resources that have been utilized in the production process but still has to bear the costs of the waste produced during the production cycle. Research in this area has tried to capture the problem through the development of concepts such as 'virtual water trade' (Chapagain and Hoekstra, 2008).

Trade globalization, coupled with an improvement in logistics and the transportation system, has also facilitated a process of vertical and horizontal concentration at different stages of the food system – especially retailing (Hendrickson and Heffernan, 2002; Oosterver and Sonnenfeld, 2012). Supermarkets' share of food markets in developing countries has experienced a particularly steady increase – from 5–10% in 1990 to 50–60% in 2007 in South America and South Africa, and to 20–50% in Mexico, Central America and South East Asia (Reardon and Timmer, 2007). Although they play an important role in delivering good food at affordable prices (Lawrence and Burch, 2007), supermarkets often externalize the social, economic and environmental costs of the food system (Hattersley and Dixon, 2012) and resort to highly polluting practices such as packaging, an important but under-researched area that requires special attention from a sustainable food security perspective (Vermeulen et al., 2012). The most commonly used plastics in the packaging industry utilize petrochemical products that present risks for human and ecosystem health. These neither totally recyclable nor biodegradable products also increase the consumption of fossil fuels (over 99% of plastics are of fossil fuel origin), create environmental pollution, promote landfill depletion, require high energy levels for their manufacturing and contribute to the spread of polymers and additives (Mahalik and Nambiar, 2010). At the same time, however, packaging can have an important role to play in reducing food losses, especially in developing countries.

The concept of 'short food supply chains' (SFSCs) has emerged as a response to the different sustainability concerns that impinge upon food security at the post-production stages. Despite a widespread tendency in the literature to conflate them with local food chains (see Sonnino, 2010), SFSCs do not necessarily entail relocalization. The term refers, more broadly, to 'simplified' modes of food provisioning that reconnect producers and consumers around sustainability values and objectives (see Hinrichs, 2000; Renting et al., 2003; Kanemasu and Sonnino, 2009). From an economic perspective, SFSCs redistribute value along the supply chain and articulate new forms of market governance (Moragues-Faus and Sonnino, 2012). Socially, they aim to establish more just relationships across the food chain and revalue the cultural attributes of food (Sonnino and Griggs-Trevarthen, 2013). Ecologically, they promote environmentally friendly practices through reduced packaging, waste and food miles. In this sense, short supply chains can become an important conceptual tool to address the tension between the dynamics of the global 'space of flows' and the local 'space of places' – a tension that, as Oosterver and Sonnenfeld (2012, p. 13) argue, is responsible for the environmental problems related to food provisioning.

More generally, as a normative concept, short supply chains can become an important platform for an innovative research agenda that focuses on the scope for creating new connections between different stages and actors in the food system through, for example, better planning of logistic facilities ('food hubs') and the preservation of peri-urban agriculture (Mundler and Rumpus, 2012). To deliver sustainable food security goals, this agenda needs to consider also the role of global markets in feeding areas that are physically unable to produce enough food.

Reconnecting Food Producers and Consumers for Sustainable Food Security: Some Conclusions

Traditional approaches to food security, we have argued, fall short on two accounts: first, they neglect the real and potential connections and disconnections that exist between the two ends of the food system; second, and as a result, they tend to ignore a wide range of sustainability issues that threaten the resilience of the food system, especially at post-production stages. Recent debates on SI and SDs are creating a promising ground for rethinking food security in sustainability terms – that is, for progressing a research and policy agenda that accounts for the 'deeply inter-locking nature of economic, social and environmental systems' (Misselhorn et al., 2012, p. 10). As Garnett and Godfray (2012, p. 49) state, 'a system of food production that is socially, economically or ethically unacceptable to a large fraction of the population will lack "continuability", or resilience, however ecologically attuned it may be.' The same applies, we can add, to any socially just and acceptable food system that is rooted in processes of environmental degradation and resource depletion.

Our sustainable food security framework is an attempt to contribute to the development of a more systemic research and policy agenda that goes beyond the conventional focus on individual components of the food system (i.e. supply and demand) to address more holistically the complex relationships between its different stages and actors (see Figure 1). For instance, this framework challenges technological solutions to engage with their long-term socio-economic and environmental implications for different actors in the food system. At the same time, it has the potential to critically assess recommendations on changing consumer behaviour by taking into consideration wider structural and justice issues. More importantly perhaps, it offers a long-term perspective that responds to recent requests for a dynamic perspective that envisions food security as a process, rather than as an end in itself (Carolan, 2013).

The use of this kind of framework in our critical review of the available literature has identified two main research areas that may constitute the first steps in the development of the new agenda. First, it has uncovered the centrality of cross-cutting issues that affect the capacity of the food system to foster positive and synergistic connections between producers and consumers. There is a need for systemic research and intervention on the relationships between food and trade, energy and water use, among other issues, at different stages of the supply chains. Second, our approach has given prominence to other specific areas of disconnection between production and consumption ('the missing links') that emerge as an important fo-

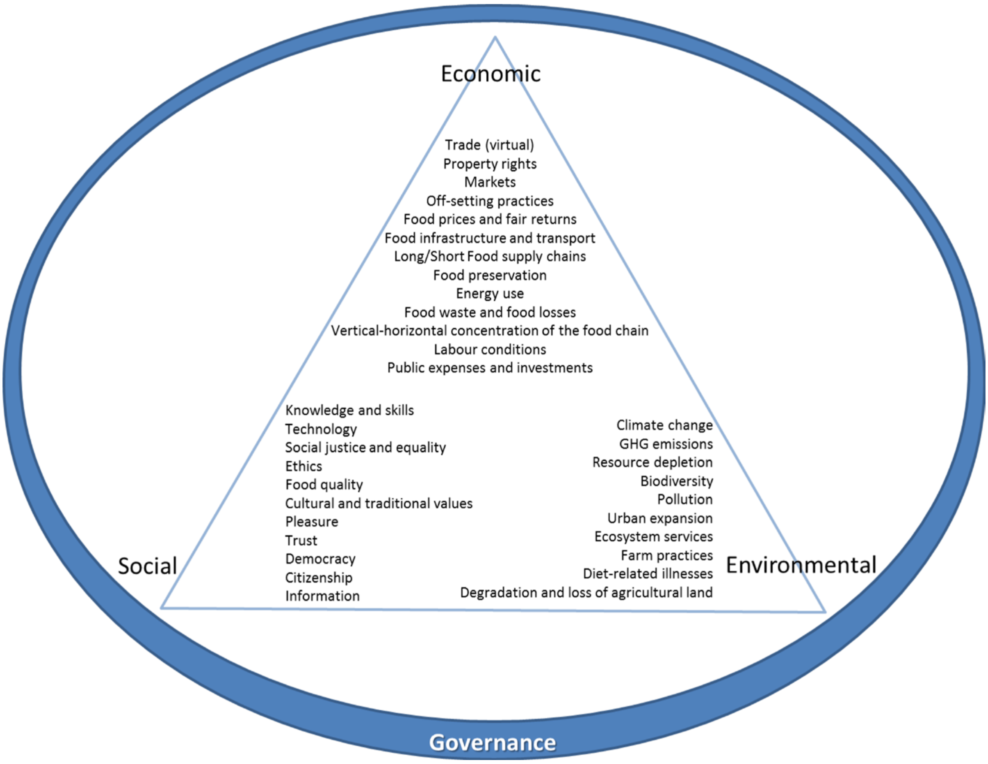

Figure 1. Sustainability food security: key issues for a future research agenda.

cus for research that aims to overcome polarized narratives in the academic and policy domains. Appropriate forms of land-use planning, the creation of logistic facilities and the use of new policy instruments such as public procurement are areas that need much more scholarly attention as potentially powerful tools to reconnect producers and consumers around food security and sustainability values and outcomes. In more general terms, at a time when a 'new food equation' is creating a renewed responsibility for science to support food policy formation (Ericksen et al., 2009), a research agenda that joins the security and sustainability lenses has added benefits for its capacity to capture and tackle, in both theory and practice, the failures, vulnerabilities and potentialities that emerge at different nodal points of the food system.

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