



Research on agro-food sustainability transitions: where are food security and nutrition?

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Abstract

The main outcome of sustainable agro-food systems is food and nutrition security. Nevertheless, about half of the global population is affected by food insecurity and malnutrition, a symptom of the dysfunctions of the current food system. This paper provides a review of the state of research on the sustainability of agro-food transitions, and the extent to which and in what ways such research examines food and nutrition security. A search carried out on Scopus in January 2018 yielded 771 documents; 120 of these were included in the systematic review. Agro-food represents a small share of the sustainability transitions research field. Most of the available research focuses on crops and the production stage. In general, it is assumed that a transition to sustainability in the agro-food arena would lead to increased food availability, improved food access, better food utilisation and increased food system stability and resilience. However, scholars also point out that the quest for food security (especially through intensification) may undermine transition towards sustainable agriculture and food systems. Likewise, it is assumed that a transition towards sustainable food systems implies changes in dietary patterns and nutrition habits. Nevertheless, food security and nutrition are still marginal topics in the literature on agro-food sustainability transitions. Furthermore, transformation of food systems, which should guide agro-food sustainability transitions, is the exception rather than the rule in the research field. This systematic review represents a useful contribution to research on transitions towards sustainability in agriculture and food sectors, and provides insights into how such research can contribute to addressing the grand challenges of food insecurity and malnutrition. The paper suggests the need to move beyond silos by fostering cross-sectoral collaboration and the integration of the agro-food sustainability transitions and food security research fields.

Keywords Sustainability transitions · Food security · Nutrition · Food system · Agriculture

1 Introduction

Food security has an important history and represents a key concept for policymakers (Bureau and Swinnen 2018; Candel and Biesbroek 2018; Lang and Barling 2012). The food security concept has evolved and expanded over recent decades (Du and King 2018; Committee on World Food Security 2012; Gross et al. 2000; Lang and Barling 2012; McMichael 2014). The 1996 World Food Summit definition of food security (Table 1) is still widely used (FAO 1996); such a definition represented a change of focus from increasing food

production to improving food access in order to address food insecurity (Ingram 2011a). It was officially reaffirmed in the 2009 Declaration of the World Summit on Food Security (FAO 2009a, b), with the addition of social access to food. Food security is built on four pillars (Committee on World Food Security 2012; Ericksen 2008; FAO et al. 2013; United Nations System High Level Task Force on Global Food Security 2011): *food availability* (i.e. sufficient quantities of food available on a consistent basis); *food access* (i.e. having sufficient resources to obtain appropriate and nutritious foods); *food use/utilisation* (i.e. appropriate use, based on knowledge of basic nutrition and care); and *stability* in food availability, access and utilization. While food security has been mainly discussed from the angle of agriculture and markets, malnutrition has been predominantly considered as a health problem. Nutrition security (Table 1) focusses on individual/household food consumption and on how food is utilised by the body (Committee on World Food Security

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Table 1 Definitions of some concepts relating to food security and nutrition

Concept	Definition	Reference
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
	Food security exists when all people, at all times, have physical, <i>social</i> and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life	FAO 2009a
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 <i>in</i> 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 <i>in</i> 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 <i>in</i> 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 2011 <i>in</i> Committee on World Food Security 2012

2012). Food security and nutrition security have generally been combined in two different ways, i.e. food security and nutrition, or food and nutrition security (Table 1). Both terms acknowledge the importance of addressing key nutritional concerns for achieving food security and emphasise the need for greater integration of nutrition into food security programmes and policies (Committee on World Food Security 2012). Until recently, most food-related policies and interventions, especially those related to agriculture, were rarely designed with nutrition as their primary objective or their primary concern (Allen and de Brauw 2018; FAO 2013; Poole et al. 2018; UNSCN 2016; Thow et al. 2018). Nevertheless, food security is essential to ensuring adequate nutrition, and the two concepts—food security and nutrition security—are interlinked and overlap (FAO 2013, 2017).

It is increasingly understood that attaining food security is more complicated than just producing more food, as the fundamental issue concerns access to nutritious and safe food (Dumont and Rosier 1969; George 1976; OECD 2013; Prosekov and Ivanova 2018; Sen 1981). Therefore, attention has turned to food systems and their functioning, governance and sustainability (Delaney et al. 2018; El Bilali 2018a; Ingram 2011a, b; Marsden et al. 2018). In fact, the dimensions of food security are highly influenced by food system activities (Beddington et al. 2012; Foresight 2011; Garnett 2014; Godfray et al. 2010; HLPE 2014a). The importance of a systems approach for the achievement of food and nutrition security (FNS) was stressed by the High Level Panel of Experts on Food Security and Nutrition (HLPE) in its note on critical and emerging issues for food security and nutrition (HLPE 2014b). In July 2014, the Panel provided the following definition of a sustainable food system (HLPE 2014a): “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” (p. 31), where “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” (HLPE 2014a:29). According to FAO (2014), there is an unprecedented confluence of pressures on modern agriculture and food systems. In fact, the current food systems lie at the centre of a global nexus of environmental, social and economic problems, as the world faces the challenge of achieving sustainable food security in the face of resource scarcity, ecosystem degradation, human population growth, and climate change (FAO 2014; Foresight 2011; Garnett 2014; Gladek et al. 2016; Godfray et al. 2010b; IPES-Food 2015; Lang 2009; Searchinger et al. 2013; Vermeulen et al. 2012; World Bank 2015; WWW-UK 2013). Moreover, modern agro-food systems have failed in addressing the issues of food insecurity and malnutrition (FAO et al. 2015, 2017; Foresight 2011; Godfray et al. 2010a; WWW-UK 2013).

Agriculture, food security, nutrition and sustainability are increasingly discussed in the same context (e.g. Allen and de Brauw 2018; Fanzo et al. 2018; Lang 2009; Willett et al. 2019; Yates et al. 2018). In fact, recent global processes and debates have emphasised the importance of food security as part of sustainability, and vice versa (Berry et al. 2015; Prospero et al. 2014). The definition of a sustainable food system provided by HLPE (2014a) clearly shows the strong linkage between

food security and food sustainability; food systems unsustainability is a key driver of food insecurity and malnutrition. The definition also highlights the importance of addressing environmental, economic and social dimensions of sustainability simultaneously, at every stage of a food system. Likewise, there has been increasing agreement among scholars and practitioners that sustainability is very relevant to food security (Garnett et al. 2013; Hanson 2013; Lang and Barling 2013; Pinstrup-Andersen and Herforth 2008; Richardson 2010; Smith and Gregory 2013; UNEP 2012). Environmental, economic and social sustainability are, indeed, preconditions for long-term food security (Berry et al. 2015) and are applicable across all dimensions of sustainability (Gitz 2015). However, the relationships between food security and food sustainability are reciprocal, as food security is increasingly also considered a condition for sustainability (Berry et al. 2015). That's why Garnett (2014) considers both food system sustainability and sustainable food security, and identifies three prominent perspectives on how to achieve them (cf. efficiency, demand restraint, food system transformation). Similarly, the 'New nutrition science' (Anonymous 2005; Leitzmann and Cannon 2005) incorporates a more comprehensive understanding of the relation between food systems sustainability and good nutrition. In fact, in *The Giessen Declaration* (Anonymous 2005), "Nutrition science is defined as the study of food systems, foods and drinks, and their nutrients and other constituents; and of their interactions within and between all relevant biological, social and environmental systems" (p. 786). Sustainability of food systems is also considered a prerequisite for achieving improved nutrition, as in the Rome Declaration on Nutrition (FAO and WHO 2014) and the Framework for Action of the Second International Conference on Nutrition (ICN2) (UNSCN 2017). Linkages between good nutrition and sustainable food systems are also highlighted in the HLPE report entitled 'Nutrition and food systems' (HLPE 2017).

Over the last decades, there has been an increasing focus on the conceptual development and identification of trajectories that move societies toward sustainability. Therefore, the concept of 'transition' (Gazheli et al. 2012; Loorbach and Rotmans 2010), as well as the field of transition studies, has recently received increasing attention both in the policy arena and in academic literature (European Environment Agency 2016; Falcone 2014; Lachman 2013; Markard et al. 2012; STRN 2017). In this context, the notion of 'transition' gained wider recognition in research on agriculture (e.g. Elzen et al. 2017) and food systems (e.g. Hinrichs 2014) over the past decade. The characteristics of sustainability problems imply that incremental changes are no longer sufficient, and there is a need for transformative change at the systems level (STRN 2010). Therefore, the notion of 'sustainability transition' (Markard et al. 2012) was coined to embrace the goal of transition to sustainable systems (Lachman 2013), including food

systems. Markard et al. (2012) define sustainability transitions as "long-term, multi-dimensional and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (p. 956). Different frameworks are used in transition studies; Lachman (2013) provides a review of the more prominent ones, i.e. Multi-Level Perspective (Geels 2002, 2011), Strategic Niche Management (Raven and Geels 2010; Schot and Geels 2008), Transition Management (Loorbach and Rotmans 2006; Loorbach et al. 2008; Loorbach 2010) and Technological Innovation Systems (Bergek et al. 2008; Hekkert et al. 2007). El Bilali (2018b) reviews the use of the most prominent transition frameworks (Multi-Level Perspective, Transition Management, Strategic Niche Management, Technological Innovation Systems, Social Practice Approach) in research on agro-food sustainability transitions.

Earlier work on sustainability transitions tended to focus on energy and mobility systems while overlooking agro-food systems (Hinrichs 2014; Markard et al. 2012; Sustainability Transitions Research Network 2018; Truffer and Markard 2017). Agro-food sustainability transitions, i.e. sustainability transitions in agro-food systems, refer to long-lasting socio-technical transformation processes that guide food practices towards sustainability (Costa 2013). According to Spaargaren et al. (2013), food transitions refer to structural change processes that give rise to new production and consumption modes and to practices that are more sustainable. Agro-food sustainability transitions are processes of change in established patterns of agro-food production, processing, distribution and consumption.

Although food system sustainability, and food security and nutrition are strongly linked, scientific discussion on food system sustainability often stayed separated from the discourse on food security (e.g. Capone et al. 2014). Transition to sustainable agro-food systems is the objective of many initiatives in the agro-food arena (e.g. UNEP 2018) and a focus of a growing body of literature on agro-food sustainability transitions (Maye and Duncan 2017; Spaargaren et al. 2013). However, it is unclear whether such a literature pays due attention to the linkages between sustainable food systems, and food security and nutrition. Therefore, the present paper analyses the approach to food security and nutrition in research on agro-food sustainability transitions.

The paper is structured as follows: section 2 describes the methodology used; section 3 presents the metrics of research on agro-food sustainability transitions; and section 4 analyses whether and how research on agro-food sustainability transitions addresses food security and nutrition. Section 4 also sheds light on the perspectives (efficiency, demand-restraint, food system transformation) that guide approaches to food security in the literature on agro-food sustainability transitions.

2 Material and methods

The paper draws upon a systematic review of documents indexed in the Scopus database (Fig. 1). The methodology used for the selection of documents included in the systematic review is similar to that adopted by El Bilali (2018b). The literature search was carried out on January 22nd, 2018, using the *Title-Abs-Key* search query: *(transition AND sustainability) AND (agri* OR food)*. The search yielded 771 documents. To these were added 56 records dealing with agriculture and/or food from the publications announcement section of the trimestral newsletter of the Sustainability Transitions Research Network (STRN). The total number of records after duplicates (44 records) were removed was 783.

Following the review of titles, a further 118 documents were excluded, as they did not deal with sustainability transitions and/or with agro-food. In case of doubt, records were kept for further analysis.

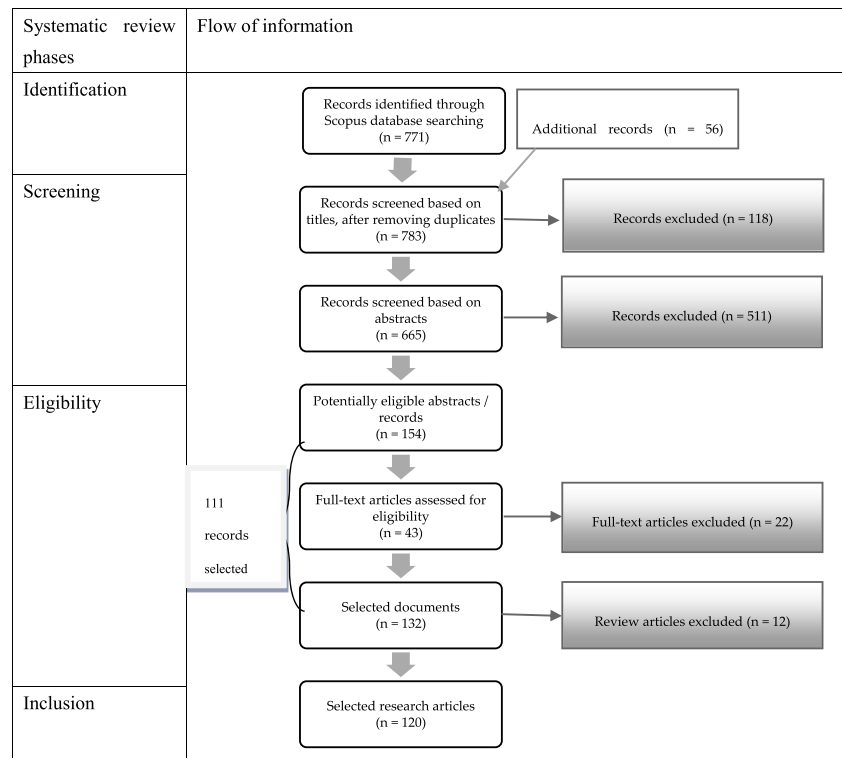
An additional 511 records were excluded following a screening of abstracts. Particular attention was paid to how the search query words (i.e. transition, sustainability, agri, food) were used in abstracts. Records referring to political or economic transitions (especially in Eastern Europe and the former Soviet Union) without any particular focus on agro-food were excluded. Records excluded at this stage included conference announcements in some journals (e.g. *Proceedings of the Nutrition Society*, *International Journal of Life Cycle Assessment*, *Journal of Environmental Radioactivity*), records with no other name available (e.g.

proceedings) and book chapters. At this point, 111 documents dealing with agri-food were directly added to “Selected documents” list as they referred explicitly to the use of a transition framework. Documents addressing changes in forest management or land use, without any direct link to agriculture and/or food, were excluded. In some cases, it was clear that the paper addressed sustainability transitions but not clear whether it dealt with agro-food; in these cases, scrutiny of full papers was necessary.

A further step in the systematic review was the analysis of 43 full papers to make sure that they addressed agro-food sustainability transitions. At this stage, an additional 22 documents were excluded because they dealt only with sustainability (and sustainability assessment) in agro-food as opposed to the element that distinguishes sustainability transitions research from other sustainability research areas, namely its focus on the dynamics of system change, which includes radical innovation in its various forms, associated struggles and wide sectoral transformations. At this step (i.e. scrutiny of 43 full papers), citation of at least one of 20 core papers on transitions identified by Markard et al. (2012) was adopted as a further selection criterion.

Only original research papers were considered; 12 reviews (Cumming et al. 2014; Dentoni et al. 2017; Ferguson and Lovell 2014; Fischer et al. 2012; Gaziulusoy 2015; Kovács 2011; Libert 1997; Pereira et al. 2015; Termeer and Dewulf 2012; Wigboldus et al. 2016), as well as an editorial for a special issue of *Sociologia Ruralis* titled “Understanding Sustainable Food System Transitions: Practice, Assessment

Fig. 1 Systematic review process. Source: Adapted from Moher et al. (2009)



and Governance” (Maye and Duncan 2017) and an assessment (Friedmann 2017), were not included in further analysis.

Therefore, only 120 research articles (Table 2) were included in the systematic review and underwent metrical and other analyses.

The selected research papers, were first analysed for any reference to ‘*food security*’ (search string: {*food security*} OR “*food availability*” OR “*food supply*” OR “*food access*” OR “*food utilization*” OR “*food use*”) or ‘*nutrition*’ (search string: *nutrition* OR *diet* OR “*food utilization*” OR “*food use*” OR {*consumption pattern*}) in the title, abstract and/or keywords, and then for the ways in which food security and/or nutrition were addressed in the paper body, if any. In the case of papers dealing with food security, the dimensions of food security (i.e. availability, access, utilization, stability) addressed and the perspective adopted were analysed. According to Garnett (2014), three broad perspectives on how to achieve sustainable food security and food system sustainability are emerging (Table 3).

The selected records were interrogated to see which perspective identified by Garnett (2014) guided their approaches to food security (Table 4).

3 Metrics of research on agro-food sustainability transitions

3.1 Agro-food in the sustainability transitions research field

It is important to note that research on agro-food sustainability transitions is rather recent; the first paper that can be considered as an entry in that field was published in 2003 (Wiskerke 2003). In December 2016, the 22nd newsletter of the Sustainability Transitions Research Network (STRN 2016) highlighted that—using the search method of Markard et al. (2012)—there are currently about 250 new papers on sustainability transitions every year. The total is now close to 2000. The present systematic review confirms the marginality of research on agro-food sustainability transitions in the sustainability transitions field. In fact, the maximum annual number of papers on agro-food sustainability transitions is 31 (2017), which represents only 12.4% of the papers on sustainability transitions published yearly. Nevertheless, this figure is much higher than that reported by Markard et al. (2012) who found that, as of early 2012, only 3% of papers on sustainability

Table 2 Selected research articles dealing with agro-food sustainability transitions

Year	Records number	References
2018	7	Goissen et al. 2018; Hassink et al. 2018; Järnberg et al. 2018; Long et al. 2018; Maye 2018 ; Nygaard and Bolwig 2018 ; Sixt et al. 2018
2017	31	Alrøe et al. 2017; Audet et al. 2017; Bonomi et al. 2017; Crivits et al. 2017; Cross and Ampt 2017; de Olde et al. 2017; Dedeurwaerdere et al. 2017; Fauchald et al. 2017; Hansen and Bjørkhaug 2017; Hauser and Lindtner 2017; Hubeau et al. 2017; Huttunen and Oosterveer 2017; Isgren and Ness 2017; Jacobs et al. 2017; Kuhmonen 2017; Kuokkanen et al. 2017; Loconto and Barbier 2017; Marco et al. 2017; Meynard et al. 2017; Miles et al. 2017; Paddock 2017; Partzsch 2017; Randelli and Rocchi 2017; Rodríguez Morales and Rodríguez López 2017; Rosin et al. 2017; Rossi 2017; Turner et al. 2017; van den Heiligenberg et al. 2017; Vivero-Pol 2017; Vlahos et al. 2017; Wonneck and Hobson 2017
2016	25	Bui et al. 2016; Clear et al. 2016; Davidson et al. 2016; Ely et al. 2016; Elzen and Bos 2016; Ferguson 2016; Hammond Wagner et al. 2016; Hermans et al. 2016; Hoppe et al. 2016; Jurgilevich et al. 2016; Langendahl et al. 2016; Liu et al. 2016; Long et al. 2016; Maru et al. 2016; Meek 2016; Moraine et al. 2016; Mylan et al. 2016; Pant 2016; Papachristos and Adamides 2016; Pitt and Jones 2016; Prasad 2016; Schut et al. 2016; Stahlbrand 2016; Vankeerberghen and Stassart 2016; Chiffolleau et al. 2016
2015	17	Cohen and Ilieva 2015; Davies and Doyle 2015; Ghaffari et al. 2015; Gilioli et al. 2015; Halbe et al. 2015; Ingram 2015; Ingram et al. 2015; Konefal 2015; Levidow 2015; Moragues-Faus and Morgan 2015; O'Rourke and Lollo 2015; Santhanam-Martin et al. 2015; Sutherland et al. 2015; Twine 2015; Tyfield et al. 2015; van Gameren et al. 2015; Vittersø and Tangeland 2015
2014	15	Beers et al. 2014; Bush and Marschke 2014; Davies 2014; Duru et al. 2014; Hassink et al. 2014; Hinrichs 2014; Levidow et al. 2014; Minh et al. 2014; Morrissey et al. 2014; Pant 2014; Pant et al. 2014; Raman and Mohr 2014; Sherwood and Paredes 2014; Slingerland and Schut 2014; Vinnari and Vinnari 2014
2013	10	Bhattarai and Pant 2013; Crivits and Paredis 2013; Gonzalez de Molina 2013; Hargreaves et al. 2013; Hassink et al. 2013; Hermans et al. 2013; Immink et al. 2013; Lutz and Schachinger 2013; Marsden 2013; Van Mierlo et al. 2013
2012	5	das Chagas Oliveira et al. 2012; Grin 2012; Lawhon and Murphy 2012; Manuel-Navarrete and Gallopín 2012; Zwartkruis et al. 2012
2011	4	Elzen et al. 2011; Jehlička and Smith 2011; Levkoe 2011; Quist et al. 2011
2010	1	Beers et al. 2010
2009	2	Negi et al. 2009; Schandl et al. 2009
2008	1	Lebel et al. 2008
2007	1	Smith and Jehlička 2007
2003	1	Wiskerke 2003

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
Rationale	This perspective focuses on changing patterns of production. In 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. From the demand restraint perspective, the problem lies with the consumer and with the companies that 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.
Food security	Food security problem is a supply side (availability) challenge	There is enough food to feed everyone. The challenges are resource-intensive consumption patterns and diets.	All four food security dimensions are considered

Source: Adapted from Garnett (2014)

transitions indexed in the Scopus database dealt with food, far behind energy (36% of all papers), transportation (8%), and water and sanitation (7%). In 2016, a large share of the 250 papers on sustainability transitions were published in journals dealing mainly with energy (STRN 2016), whilst during the 8th International Sustainability Transitions Conference (18–21 June 2017; Gothenburg, Sweden), there was no track or session devoted to food. All these findings confirm the marginality of research on transitions towards sustainability in the agro-food arena. Nevertheless, there is a general trend towards an increase in contributions on agro-food sustainability transitions (from one paper per year before 2010 to 31 in 2017). Given the upward trend observed, the number of papers on agro-food sustainability transitions published in 2018 may be even higher than in 2017.

3.2 Topical focus of research on agro-food sustainability transitions

Many of the selected papers deal with sustainability transitions in crop production. In fact, the majority deals with the production of crops, but an increasing number of documents also focus on animal production (Davidson et al. 2016; de Olde et al. 2017; Elzen et al. 2011; Elzen and Bos 2016; Immink et al. 2013; Van Mierlo et al. 2013) or fisheries/aquaculture (Bush and Marschke 2014; Lebel et al. 2008). However, the two last agriculture sub-sectors (animal production and fisheries/aquaculture) are largely underserved. Some

papers analyse sustainability transitions in the context of crop-livestock integration (Moraine et al. 2016). In the case of crop production, transitions towards organic agriculture (Ghaffari et al. 2015; Hauser and Lindtner 2017; Vittersø and Tangeland 2015) and agroecology (Cross and Ampt 2017; Duru et al. 2014; Gonzalez de Molina 2013; Isgren and Ness 2017; Levidow 2015; Levidow et al. 2014; Meek 2016; Miles et al. 2017; Pant 2016) are prominent case studies. Interestingly, there are also some papers that deal with urban/peri-urban agriculture (Gilioli et al. 2015) and urban food systems (Chiffolleau et al. 2016; Cohen and Ilieva 2015; Gorissen et al. 2018; Moragues-Faus and Morgan 2015).

Similarly, production (generally referring to crop production) is the most-addressed stage of the food chain, but there are some papers that deal with processing (Long et al. 2018; Wiskerke 2003), distribution and food procurement (Audet et al. 2017; Randelli and Rocchi 2017; Stahlbrand 2016), consumption (Clear et al. 2015, 2016; Davies 2014; Davies and Doyle 2015; Dedeurwaerdere et al. 2017; Liu et al. 2016; O'Rourke and Lollo 2015; Twine 2015) and food waste (Wonneck and Hobson 2017). Other papers adopt a 'food system' approach and address different stages of the food chain simultaneously (Alrøe et al. 2017; Bui et al. 2016; Ely et al. 2016; Hinrichs 2014; Hubeau et al. 2017; van Gameren et al. 2015; Zwartkruis et al. 2012).

Some papers deal with the intersection between agriculture and energy (Hansen and Bjørkhaug 2017; Nygaard and

Table 4 Search queries used in analysing perspectives on food security in the agro-food sustainability transitions literature

Perspective	Search query
Efficiency	<i>(produc* OR agri*) AND (efficien* OR intensification OR productiv*)</i>
Demand-restraint	<i>(consum* OR diet OR nutrition) AND (demand OR waste OR obesity)</i>
Food system transformation	<i>(produc* OR agri*) AND (consum* OR diet OR nutrition) AND ("food system" OR governance OR power OR sovereignty OR justice OR equity OR agroecology)</i>

Bolwig 2018; Partzsch 2017; Raman and Mohr 2014; Rodríguez Morales and Rodríguez López 2017; Sutherland et al. 2015) or water (Sixt et al. 2018), as well as the water–energy–food nexus (Halbe et al. 2015). In other cases, the focus is on transitions in the use of some agricultural inputs, such as fertilisers (Hoppe et al. 2016; Huttunen and Oosterveer 2017; Jacobs et al. 2017) and pesticides (Hammond Wagner et al., 2016; Sherwood and Paredes 2014).

3.3 Metrics of agro-food sustainability transitions research field

Metrics (sources/journals, subject areas, authors, affiliation institutions, affiliation countries, citations) for research dealing with agro-food sustainability transitions are presented in Table 5.

Sustainability (12 papers) is by far the most prominent journal when it comes to scholarly publications on agro-food sustainability transitions. It is followed by the *Journal of Cleaner Production* (nine papers), *Journal of Rural Studies* (six papers) and *Technological Forecasting and Social Change* (six papers). This shows that so far, no journal has specialised in publishing papers on agro-food sustainability transitions. When one looks into the number of articles published, there are some differences with respect to the prominence of journals in the overall field of

sustainability transitions. In the case of the sustainability transitions research field, the most prominent journals are the *Journal of Cleaner Production*, *Environmental Innovation and Societal Transitions*, *Renewable and Sustainable Energy Reviews*, *Energy Research and Social Science* and *Futures* (STRN 2016). Agro-food sustainability research is conducted largely in the domains of the social sciences (69 papers), environmental science (56 papers) and, naturally, agricultural and biological sciences (33 papers). However, the area of energy research (33 papers) also figures prominently; that might be due to the fact that many papers address the interface between agriculture and energy (e.g. biofuels). Selected papers can be categorized in many subject areas (these include even psychology, the humanities, computer science, biochemistry and medicine), which may explain the difficulty of grasping the field of agro-food sustainability transitions, as such research is rather multidisciplinary.

The authors that contributed the most to the development of agro-food sustainability transitions research field are John Grin (four papers) and Frans Hermans (four papers). Meanwhile, the most influential publications in the field, in terms of citations, are ‘*Socio-technical regimes and sustainability transitions: Insights from political ecology*’ (Lawhon and Murphy 2012), with 116 citations; ‘*From post-productionism to reflexive governance: Contested transitions in securing more sustainable food futures*’ (Marsden 2013), with 59 citations; and

Table 5 Metrics of research on agro-food sustainability transitions: top-ten journals, subject areas, authors, affiliations, countries and papers (in terms of citation numbers)

Journals (a)	<i>Sustainability</i> Switzerland (12); <i>Journal of Cleaner Production</i> (9); <i>Journal of Rural Studies</i> (6); <i>Technological Forecasting and Social Change</i> (6); <i>Agroecology and Sustainable Food Systems</i> (5); <i>Agricultural Systems</i> (4); <i>Ecological Economics</i> (4); <i>Environment and Planning</i> (4); <i>Sociologia Ruralis</i> (4)
Subject areas (b)	Social sciences (69); environmental science (56); agricultural and biological sciences (33); energy (33); business, management and accounting (25); engineering (12); economics, econometrics and finance (11); psychology (8); decision sciences (4)
Authors (c)	John Grin (4); Frans Hermans (4); Jan Hassink (3); Wim Hulsink (3); Laurens Klerkx (3); Laxmi Prasad Pant (3)
Affiliations (d)	WUR (22); Erasmus University Rotterdam (6); Open University (5); Cardiff University (5); University of Amsterdam (4); University of Guelph (4); University of Twente (4)
Affiliation Countries (e)	Netherlands (27); United Kingdom (24); United States (12); Canada (11); Belgium (9); France (7); Finland (6); Germany (6); Australia (5); Italy (5); New Zealand (5)
Citations (f)	Lawhon and Murphy 2012: <i>Socio-technical regimes and sustainability transitions: Insights from political ecology</i> (116) Marsden 2013: <i>From post-productionism to reflexive governance: Contested transitions in securing more sustainable food futures</i> (59) Elzen et al. 2011: <i>Normative contestation in transitions ‘in the making’: Animal welfare concerns and system innovation in pig husbandry</i> (57) Quist et al. 2011: <i>The impact and spin-off of participatory backcasting: From vision to niche</i> (51) Levkoe 2011: <i>Towards a transformative food politics</i> (49) Hargreaves et al. 2013: <i>Up, down, round and round: Connecting regimes and practices in innovation for sustainability</i> (46) Wiskerke 2003: <i>On promising niches and constraining sociotechnical regimes: The case of Dutch wheat and bread</i> (44) Smith and Jehlička 2007: <i>Stories around food, politics and change in Poland and the Czech Republic</i> (34) Gonzalez de Molina 2013: <i>Agroecology and politics. How to get sustainability? About the necessity for a political agroecology</i> (30) Hinrichs 2014: <i>Transitions to sustainability: A change in thinking about food systems change?</i> (29)

Legend: Figures in brackets refer to number of documents by journal (a), subject area (b), author (c), affiliation (d), country (e); or number of citations per paper (f), as of February 22, 2018

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'Normative contestation in transitions "in the making": Animal welfare concerns and system innovation in pig husbandry' (Elzen et al. 2011), with 57 citations.

The analysis of author affiliations suggests that research on agro-food sustainability transitions is performed mainly in European institutions and research centres, especially Dutch and British ones. The Wageningen University and Research Centre - WUR (22 papers), Erasmus University Rotterdam (six papers), Open University (five papers) and Cardiff University (five papers) are major contributors. It should be noted that almost 20% of papers dealing with this topic have at least one author affiliated with WUR, which can be considered a leader in this research field. It comes as no surprise that the list of affiliation countries is dominated by the Netherlands (27 papers) and the United Kingdom (24 papers). North America (United States – 12 papers; Canada – 11 papers) is also highly placed on the list of top-ten countries. Unfortunately, although such a list also features some countries from the Global South (e.g. Argentina, Brazil, Burundi, China, Ecuador, Ethiopia, India, Nepal, Nigeria, Peru, Thailand, Vietnam), it confirms the North-South gap in sustainability transitions research. In fact, sustainability transition studies are still largely flavoured by the context in which they were conceived, i.e. in so-called developed countries (Lachman 2013; Wieczorek 2018).

4 Food security and nutrition in research on agro-food sustainability transitions

Food security and nutrition are still marginal topics in research on agro-food sustainability transitions. In fact, only 21.7% and 13.3% of papers on agro-food sustainability transitions address food security and nutrition, respectively. Meanwhile, only nine out of the 120 selected research papers address both food security and nutrition (Table 6).

How the literature on agro-food sustainability transitions addresses, qualitatively, food security, nutrition, and food security and nutrition is analysed hereafter.

4.1 Food security

Most of the papers examined in the initial screening refer to 'food security' in their introductions, but do so only to

highlight the need for sustainability transitions, and do not analyse any of the impacts of agro-food sustainability transitions in terms of food security. Only a few papers address the relation between agro-food sustainability transitions (and agro-food sustainability in general) and food security. Their perspectives, which are not mutually exclusive, can be related to the four dimensions of food security. In general, it is assumed that transition towards sustainability in the agro-food arena would affect food availability (e.g. Ely et al. 2016; Jurgilevich et al. 2016; Kuokkanen et al. 2017; Levidow 2015; Pant 2014; Pant 2016), food access (e.g. Audet et al. 2017; Kuokkanen et al. 2017), food utilisation (e.g. Davies 2014; Ely et al. 2016; Jurgilevich et al. 2016) or stability (e.g. Marsden 2013) either positively or negatively. While most of the papers focus on the implications of sustainability transitions for food security (i.e. how transition towards sustainability affects food security and its dimensions), some papers adopt a reverse approach and highlight how the quest for food security (especially through agricultural production intensification) may undermine efforts to make transitions toward sustainable agriculture and food systems (e.g. Audet et al. 2017). Therefore, discussion of the relation between food security and food system sustainability often implies an analysis of the role of innovation (both technical/technological and social) and/or of alternative forms of agriculture, such as agroecology (e.g. Pant 2014). Efforts to tackle food insecurity issues may also trigger transitions to or introductions of more environmentally-friendly forms of agriculture, such as organic farming (e.g. Hauser and Lindtner 2017). What all the selected papers highlight is the interconnection between food security and food system sustainability. Furthermore, transitions in the wider economy—the circular economy or the bio-economy, for example—(e.g. Jurgilevich et al. 2016; Levidow 2015) as well as in other sectors such as energy (e.g. Raman and Mohr 2014) have food security implications.

Audet et al. (2017) analysed the contribution of the Montreal seasonal food markets to food security and food system sustainability. They note that seasonal markets sell fresh fruits and vegetables directly to consumers in areas where food security is considered a problem, and connect transitions to sustainability in urban food systems to food security outcomes. They also highlight a tension between food security and ecological agriculture (e.g. organic agriculture) in the seasonal markets model—that is to say, the challenge of

Table 6 Food security and nutrition in research on agro-food sustainability transitions

Topic	Records identified through the search	Records selected after eligibility check	Percentage of selected records out of research articles dealing with agro-food sustainability transitions
Food security	55	26	21.7%
Nutrition	34	16	13.3%
Both (food security & nutrition)	22	9	7.5%

balancing agro-food availability and affordability with sustaining local agriculture. Ely et al. (2016) discuss the effects of transition in practices and politics on the sustainability of maize production and consumption patterns in China. In particular, they compare the agricultural intensification pathway with another pathway focusing on agro-ecological approaches and green food chains. According to them, the latter pathway offers the potential of low carbon and climate-resilient food security while also enabling the retention of control of agri-food systems at the community level (cf. food sovereignty). Hauser and Lindtner (2017) relate the emergence of organic agriculture in post-war Uganda, inter alia, to food insecurity; food insecurity was one of the drivers of organic agriculture development after two decades of civil war ending in 1986. Organic agriculture—based on low-cost, resource-conserving technologies and agronomic practices—was a response to and a ‘coping strategy’ for the multiple crises (including food insecurity) faced by rural Ugandan households in the post-war period.

Pant (2014) provides a critical examination of food security strategies in India and Nepal that aim to enable transitions towards agricultural sustainability by transforming traditional subsistence agriculture in the two countries. He notes that both strategies rely, to a large extent, on technological innovations, and fail to valorise agro-ecological resources and natural resource-based competitive advantages. According to Pant (2014) this confirms that technological innovation (see also transition processes that are based only on a constellation of technological innovations) is not sufficient to achieve sustainable food security. In another paper, the same author (Pant 2016) analyses the paradox of mainstreaming agroecology for food security in developing countries. While the paradox is more about the impact of the mainstreaming process on the very nature and values of agroecology (see, agro-ecological niche innovations in water and soil conservation, crop intensification and improvement, and market differentiation), the paper also explores the effects of agro-ecological transitions on food security, especially in rural areas.

While many of the selected papers address the availability, access and utilisation dimensions of food security, Marsden (2013) is perhaps the only one who relates agro-food sustainability transitions in the UK to the stability pillar of food security (see, prices volatility). In fact, he applies a transition perspective to critically assess the turbulent period in agro-food markets since the food price spikes in 2007–8. The analysis shows that food insecurity is also an actual issue in the foodscape of a developed country such as the UK, although “*Food security seems a singularly odd term to be employed in a nation beset by health-related problems of the over-consumption of food*” (p. 126).

Other papers address the relation between transitions in the economy or other sectors (e.g. energy) and food security. For instance, Jurgilevich et al. (2016) provide a useful analysis of the effects of the transition toward a circular economy on food

system sustainability, as well as of its implications in terms of food security. What makes their analysis interesting is that they also adopt a ‘food system’ approach, so they discuss challenges and potential solutions along the food chain, from production to consumption, as well as food wastage. Kuokkanen et al. (2017) also use an integrated approach in their analysis of the food system lock-in in the Finnish context. They examine the impacts of the ‘irreversible’ transformation of food system induced by the introduction of synthetic nitrogen and phosphorus fertilizers, among others, to the Finnish food system. They also consider the positive and negative implications of the created system lock-in for long-term food security. Systematic resistance towards sustainability transition is analysed in interdependent production, policy and institutional, and supply chain processes. Levidow (2015) uses the ‘bioeconomy’ and ‘sustainable intensification’ (neoproduktivism) agendas to illustrate a nascent ‘corporate-environmental food regime’ and relates these two agendas to agroecology. In the process, he also discusses how these two agendas operate in relation to achieving sustainable food security in Europe. Likewise, Raman and Mohr (2014) work at the intersection of food and energy regimes. They analyse the controversy regarding the development of biofuels (and bioenergy in general) and its implications for food security. While biofuels were envisioned to solve problems faced by the energy regime, they generated food security-related concerns. The authors show that food-versus-fuel conflict is a symptom of linkages between globalised industrial agricultural systems and biofuels.

Three perspectives on achieving food security: efficiency, demand restraint and food system transformation

In general, papers that focus on eating practices and consumption patterns use a demand-restraint perspective. However, it should be pointed out that the three perspectives are not mutually exclusive; they are sometimes used in the same context and, consequently, discussed in the same papers. For instance, Pant (2016) analyses the paradox of mainstreaming agroecology (cf. food system transformation perspective) for crop intensification (cf. efficiency perspective). Likewise, Ely et al. (2016) compare agricultural intensification (cf. efficiency perspective) with agroecology (cf. food system transformation perspective) and relate both pathways to changes in maize consumption patterns (cf. demand-restraint perspective). In addition, Levidow (2015) highlights tensions between agroecology and the ‘sustainable intensification’ neo-productivist narrative in Europe. Davies (2014) relates the ‘productivist’ paradigm (see, use of technology, in particular ICT) to food-eating practices in urban settings, and points out that technological advances in production (cf. efficiency perspective) alone are unlikely to generate the radical transformation required to move toward more sustainable urban foodscapes. Similarly, the example of biofuels (Raman and Mohr 2014) shows clearly that improving production

efficiency does not automatically yield improvements in terms of food system sustainability and food security, as the production is not destined for human consumption. Liu et al. (2016) show that efficient production technology (cf. efficiency perspective) is used in China as an entry point to move towards sustainable food consumption (cf. demand-restraint perspective). Other scholars (Kuokkanen et al. 2017; Randelli and Rocchi 2017) highlight the importance of connecting consumption and production, and point out that only an interactive and balanced relation between consumers and producers can foster the needed agro-food sustainability transition. In doing so, they implicitly highlight the need for a food system approach.

Only a few papers adopt a ‘food system’ approach (Chiffolleau et al. 2016; Ely et al. 2016; Jurgilevich et al. 2016; Kuokkanen et al. 2017; Marsden 2013; van Gameren et al. 2015; Vittersø and Tangeland 2015), that can be related to the ‘food system transformation’ perspective, although many scholars refer to the ‘food system’ concept (Audet et al. 2017; Chiffolleau et al. 2016; Cohen and Ilieva 2015; Crivits and Paredis 2013; Dedeurwaerdere et al. 2017; Ely et al. 2016; Jehlička and Smith 2011; Jurgilevich et al. 2016; Kuokkanen et al. 2017; Lutz and Schachinger 2013; Rossi 2017; van Gameren et al. 2015; Vittersø and Tangeland 2015). Different alternative forms of agriculture (e.g. organic agriculture, urban agriculture, permaculture) adopt more systemic approaches and promote synergetic connections between system components (e.g. soils, crops, livestock, humans). Such alternative food systems/networks adopt a holistic approach to food production and strive to connect consumption and production (Cerrada-Serra et al. 2018; Jarosz 2008) by, among others, promoting short food supply chains (Chiffolleau et al. 2016). These alternative approaches include food sovereignty and agroecology (Levidow 2015; Lutz and Schachinger 2013). In fact, the transformative potential of agroecology is increasingly recognised (FAO 2015; IAASTD 2008; IPES-Food 2016), and is promoted as a way of transforming and redesigning food systems, from the farm to the fork (Gliessman 2015, 2016). Instead of the earlier focus on and critique of intensive production and agriculture industrialisation, the current agro-ecological thinking criticises the whole agro-food regime (Elzen et al. 2017; Gliessman and Engles 2015; Holt-Giménez and Altieri 2013).

4.2 Nutrition

Generally speaking, all papers that address aspects of food consumption deal with nutrition (Chiffolleau et al. 2016; Clear et al. 2016; Cohen and Ilieva 2015; Dedeurwaerdere et al. 2017; Liu et al. 2016; Mylan et al. 2016; Rossi 2017; Stahlbrand 2016). Interestingly, there is also a correspondence between focus on nutrition and reference analytical framework. In fact, almost all these papers refer to the Social

Practice Theory/Approach (SPT/SPA) (e.g. Shove 2003; Southerton et al. 2004; Warde 2005). As well, papers that adopt a ‘food system’ approach (Jurgilevich et al. 2016; Kuokkanen et al. 2017) address issues related to food consumption and nutrition. In general, it is assumed that transitions toward sustainable food systems imply changes in food consumption patterns and dietary habits (e.g. Twine 2015). Some scholars argue that health/nutrition-related concerns (e.g. food safety, obesity) may represent a good entry point to bringing about a deep and genuine food transformation that puts sustainability at the forefront (Davidson et al. 2016).

Davidson et al. (2016) analyse linkages between food safety risks (cf. bovine spongiform encephalopathy or mad cow disease) and sustainability transition in beef production in the province of Alberta (Canada). In so doing, they show that not only consumers’ perceptions and attitude towards sustainability, but also their nutrition concerns, can be drivers of sustainability transition journeys, especially in relation to alternative food networks/systems. Ferguson (2016) uses the example of the Australian baking industry to show that while sustainability transitions in the baking sector may bring about health and nutritional benefits (small-scale artisan bakers produce more nutritious products), they may also lead to an overall decline in productivity across the whole sector. This example clearly shows trade-offs between the different dimensions of food sustainability (environment, economy, society-culture, health-nutrition) (e.g. Dernini et al. 2013) during the transition process. Twine (2015) contributes to sociological thinking on eating practices and their reproduction by providing an analysis of snacking through a practice theory lens. He situates snacking as an eating practice with health implications that has emerged within the organization of everyday life. In fact, ‘*A snack has typically been seen as less nutritionally adequate than a meal*’ (p. 1275) and consistently snacking at mealtimes goes against prevailing nutritional norms and common eating practices. Vinnari and Vinnari (2014) develop a transition management framework and apply it to the case of plant-based diets, which are considered as sustainable diets. They also highlight the main obstacles to a transition towards plant-based diets, which have social, economic, environmental, cultural and animal (cf. animal welfare/rights) dimensions.

4.3 Food security and nutrition

Only a few papers address food security and nutrition security aspects at the same time. These are mainly the ones that address issues regarding the whole food system (see, ‘food system approach’) as well as those that deal with food consumption patterns and practices (Chiffolleau et al. 2016; Clear et al. 2016; Cohen and Ilieva 2015; Dedeurwaerdere et al. 2017; Jurgilevich et al. 2016; Kuokkanen et al. 2017; Liu et al. 2016; Mylan et al. 2016; Rossi 2017; Stahlbrand 2016). In

fact, all papers that deal with food utilisation/use pillar of food security also address aspects of food consumption and, consequently, nutrition (Chiffolleau et al. 2016; Clear et al. 2016; Cohen and Ilieva 2015; Dedeurwaerdere et al. 2017; Liu et al. 2016; Mylan et al. 2016; Rossi 2017; Stahlbrand 2016). For instance, Liu et al. (2016) propose applying the social practices approach (SPA), which combines both human agency ('individualist' perspective) and social structures (system or structural perspective), to better understand transitions toward the sustainability of food consumption patterns in China. The analysis shows that the focus is still on improving the efficiency of production technology, while little or no attention is paid to consumers' behaviour and consumption patterns. In other words, production is used as an entry point to improving food system sustainability. Therefore, the authors propose placing more emphasis on the link between food production/provision and sustainable consumption. This is a common denominator of all papers that address food security and nutrition simultaneously.

4.4 Study limitations

As in any systematic review, the results were affected by the search process. First, the choice of the Scopus database means that some important pieces of research in the field that are not scholarly in nature, and/or that are not indexed in Scopus (e.g. papers abstracted only in the Web of Science, book chapters, reports), were not considered. Second, the choice of search terms also affects the results, and this systematic review was no exception in this regard, although an effort was made to use different synonyms in order to broaden the initial screening basis before proceeding to a meticulous scrutiny of screened documents.

Furthermore, the research field of agro-food sustainability transitions has not reached maturity and is largely ill-defined (at least with respect to other sectors such as energy). Therefore, any endeavour to grasp it implies a certain dose of subjectivity and approximation; more research is needed in order to better delineate the contours of this nascent field. That said, the merit of this work is that it is the first of its kind and sets a baseline for future studies on agro-food sustainability transitions.

While the present study engages mainly with literature using the transition theory repertoire (especially transition frameworks such as the Multi-Level Perspective, Transition Management and Strategic Niche Management), the scholarship on agro-food sustainability is much broader and more variegated; the contribution of other theoretical approaches and research strands (e.g. political economy, ecological modernisation, economic geography, governance, resilience, socio-ecological transformation) to agro-food sustainability transitions research should be acknowledged.

Last but not least, the present paper focuses only on the analysis of whether and how transitions research on agro-food sustainability addresses food security. For a more comprehensive analysis of the multifaceted and multidimensional relation between food security and agro-food sustainability transitions, it is also necessary to investigate whether the literature on food security addresses agro-food sustainability transitions.

5 Conclusions

To the best of my knowledge, this is the first systematic review-based paper that delineates the contours of research on agro-food sustainability transitions and analyses how it addresses food security and nutrition. The paper confirms the marginality of agro-food in the sustainability transitions field. Most of the research to date focuses on crops and the production stage (other agriculture subsectors such as animal production and fisheries, as well as the food processing and distribution stages, are underrepresented). Furthermore, food security and nutrition are still marginal topics in papers dealing with agro-food sustainability transitions. Generally speaking, the case study approach that characterises sustainability transitions research, means that even papers that address the implications of transition in terms of food security and/or nutrition do so on a local scale, for a small number of people or a specific category of food chain actors (e.g. farmers, consumers). There is almost a complete lack of studies that address broader implications. The disconnect between food security and nutrition scholarship, on the one hand, and agro-food sustainability transitions literature, on the other hand, might be due, *inter alia*, to the fact that while food security and nutrition are better assessed at household and individual level, respectively, research on agro-food sustainability transitions focuses on systemic change at larger scales. This disconnect may be further explained by the limited role of agency (i.e. the role of agents) in the sustainability transitions field, while food security and nutrition concepts are, by definition, 'people-centred'. Although scholars agree that a 'food system transformation' perspective should frame and guide agro-food sustainability transitions, such a perspective is the exception rather than the rule in the field. All in all, it seems that agro-food sustainability transitions research focuses more on the 'transition' component of 'sustainability transitions', thus overlooking sustainability outcomes and impacts such as food and nutrition security.

The 2030 Agenda for Sustainable Development clearly shows that transition towards sustainable food systems is crucial to achieving sustainable development. Such a transition is also vital to achieving sustainable food and nutrition security for present and future generations. A better understanding of the linkages between agro-food system sustainability (and consequently agro-food sustainability transitions) and food

security is necessary to achieve the second Sustainable Development Goal (SDG 2), ‘Zero Hunger’ (*End hunger, achieve food security and improved nutrition and promote sustainable agriculture*) in the context of the 2030 Agenda. Any transition in food systems—i.e. moving beyond efficiency-oriented and demand restraint narratives towards a genuine food system transformation perspective—should have as a main goal the achievement of sustainable food security and improved nutrition for all. New tools and approaches, as well as a ‘thinking transition’ and different thinking about agro-food sustainability transitions, are clearly needed to ensure both food security and food sustainability. Therefore, research on agro-food sustainability transitions has a vital role to play by paying more attention to food security and nutrition and addressing interrelations between agricultural production and food consumption.

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Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

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