



Transition heuristic frameworks in research on agro-food sustainability transitions

Hamid El Bilali¹

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Abstract

The agro-food system needs a genuine sustainability transition to achieve sustainable food and nutrition security in the face of climate change, population growth, ecosystem degradation and increasing resource scarcity. Agro-food sustainability transitions refer to transformation processes needed to move towards sustainable agriculture and food systems. There is a broad range of theoretical and conceptual frameworks that have been used to understand and promote transition towards sustainability. These include the multi-level perspective (MLP) on socio-technical transitions, transition management (TM), strategic niche management (SNM), technological innovation system (TIS) and social practice approach (SPA). The paper analyses the use of these heuristic frameworks in research on agro-food sustainability transitions. A search carried out in March 2018 on Scopus yielded 791 documents, and 127 research articles underwent a systematic review. Results show that more than three-fifths of research papers dealing with sustainability transitions in agriculture, food processing, distribution and consumption use at least one of the five heuristic frameworks (MLP, TM, SNM, TIS and SPA). The MLP is the most prominent framework in research on agro-food sustainability transitions, followed by TM, SPA, SNM and then TIS. Nevertheless, MLP is increasingly complemented with frameworks that focus on human-related and social factors (SPA), management and governance (TM, SNM) or agency and interactions between actors (TIS) in sustainability transitions processes. Therefore, the paper makes the case for more integration of transition frameworks in order to better nurture and foster transitions towards sustainable agro-food systems.

Keywords Sustainability transitions · Agriculture · Food · Multi-level perspective · Transition management · Strategic niche management · Social practice theory · Technological innovation systems

✉ Hamid El Bilali
hamid.elbilali@boku.ac.at

¹ Centre for Development Research, University of Natural Resources and Life Sciences (BOKU), Peter Jordan Strasse 76, 1190 Vienna, Austria

1 Introduction

Contemporary environmental problems (e.g. climate change, resource depletion, biodiversity loss) present formidable societal challenges that can be addressed only by radical, structural changes (Elzen et al. 2004; Foxon 2008; Grin 2010). These grand challenges relate to unsustainable consumption and production patterns in systems such as energy and agro-food (STRN 2017). Therefore, transition studies have received increasing attention in both the academic literature (Markard et al. 2012; Lachman 2013; Falcone 2014; Loorbach et al. 2017) and policy arena (European Environment Agency 2016, 2018; OECD 2011; UNEP 2011). The field has diversified in terms of journals and grown in terms of the numbers of publications (STRN 2017). A great strength of transitions research is that it addresses systemic changes (Sustainability Transitions Research Network 2010). The notion of “sustainability transition” refers to transition towards sustainable systems (Geels 2018; Lachman 2013). Grin et al. (2010) considered sustainability transition as a “radical transformation towards a sustainable society in response to a number of persistent problems confronting contemporary modern societies”. Markard et al. (2012) defined 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).

The Sustainability Transitions Research Network (STRN 2017) argues that sustainability transition is a broad and interdisciplinary research field. In fact, sustainability transitions have several features that make them a special topic in sustainability scholarship: *multi-dimensionality and co-evolution* (transitions are co-evolutionary processes, involving changes in different dimensions of socio-technical systems); *multi-actor process* (transitions are enacted by a range of stakeholders/actors); *stability and change* (dialectic relationship between stability and change is central in sustainability transition research); *long-term process* (transitions may take decades to unfold); *open-endedness and uncertainty* (sustainability journeys are open-ended as there are multiple transition pathways, which implies uncertainty); *values, contestation, disagreement* (sustainability notion is highly contested, so different actors tend to disagree about sustainability transitions pathways); *public policy* (public policy plays a central role in shaping transitions towards sustainability).

Since the publication by the Sustainability Transitions Research Network (STRN) of its first research agenda in July 2010 (Sustainability Transitions Research Network 2010), sustainability transition scholarship has deepened intellectually, broadened empirically and extended geographically. Nevertheless, sustainability transitions research field tended to overlooked agro-food systems. In fact, work on sustainability transitions tended to focus on energy and mobility systems (Hinrichs 2014; Markard et al. 2012; Sustainability Transitions Research Network 2018; Truffer and Markard 2017). Nevertheless, the agro-food system—which lies at the centre of a global nexus of environmental, social and economic problems—is in need of a genuine sustainability transition as humanity faces the grand challenge of achieving sustainable food security in the face of climate change, population growth, ecosystem degradation and increasing resource scarcity (El Bilali et al. 2018; Freibauer et al. 2011; Garnett 2014; Garnett et al. 2013; Gladek et al. 2016; Godfray et al. 2010b; IPES-Food 2015; Lang 2009; Searchinger et al. 2013; WWW-UK 2013). Furthermore, environmental, social and economic challenges facing the agro-food system are interconnected and magnify one another (Hinrichs 2014). This is exacerbated by an unprecedented confluence of pressures on modern agro-food systems (e.g. poverty, land degradation, hunger and malnutrition, inadequate diets, water scarcity, social inequalities,

biodiversity loss, climate change) (FAO 2014). Moreover, modern agro-food systems failed to address the issues of food insecurity and malnutrition (Foresight 2011; Godfray et al. 2010a, b; WWW-UK 2013).

There is a broad range of theoretical and conceptual frameworks that have been used to conceptualise, understand and promote transition towards sustainability (Falcone 2014; Geels 2005a; Grin et al. 2010; Lachman 2013; Markard et al. 2012; Sovacool and Hess 2017; STRN 2017). For instance, Sovacool and Hess (2017) identified 96 theories and conceptual approaches spanning 22 identified disciplines that are useful at explaining socio-technical changes; among these, fourteen theories¹ were deemed most useful and relevant, e.g. socio-technical transitions, social practice theory, actor-network theory (Callon 1999; Latour 2013; Paredis 2011). Lachman (2013) provided a review of the more notable transition frameworks: the multi-level perspective (e.g. Geels 2002, 2011), strategic niche management (e.g. Raven and Geels 2010; Schot and Geels 2008), transition management (e.g. Loorbach and Rotmans 2006; Loorbach et al. 2008; Loorbach 2010), technological innovation systems (e.g. Bergek et al. 2008; Hekkert et al. 2007), Techno-Economic Paradigm (TEP) shifts (e.g. Freeman and Perez 1988; Van den Bergh and Oosterhuis 2008; Geels 2011) and Socio-Metabolic Transitions (e.g. Fischer-Kowalski and Rotmans 2009; Siefeler 2010; Fischer-Kowalski 2011). Likewise, Falcone (2014) carried out a survey of the main transition frameworks, namely the multi-level perspective (Geels 2002; Geels and Schot 2007; Smith et al. 2010), strategic niche management (Kemp et al. 1998; Smith 2007; Raven and Geels 2010), transition management (Loorbach 2010; Kern 2012) and technological innovation systems (Bergek et al. 2008; Hekkert et al. 2007). According to Hinrichs (2014), there are two main orientations in transitions research and scientific approaches: the MLP on transitions, which investigates pathways of sustainability innovation, and Social Practices Approach (SPA), which considers how people's ordinary practices and routines can present openings for more sustainable shifts. Sustainability transition frameworks differ in terms of epistemological styles, ontological assumptions or methodological commitments (Geels 2011).

There was until recently a lack of research on agro-food systems in sustainability transitions scholarship, but it is now rapidly emerging. Moreover, there is so far no comprehensive analysis of the use in—and consequently suitability to—agro-food systems of heuristics proposed to study transitions in energy and mobility systems. To address these gaps in the present literature, this paper provides a critical, systematic overview on the use of five prominent heuristic frameworks (multi-level perspective, strategic niche management, transition management, technological innovation systems, social practices approach) in research on agro-food sustainability transitions. The paper also helps in demonstrating the specificity of agro-food transitions research, thus enriching the sustainability transitions research field.

¹ These are: sociotechnical transitions, social practice theory, Discourse Theory, Domestication Theory, Large Technical Systems, Social Construction of Technology, Sociotechnical Imaginaries, actor-network theory, Social Justice Theory, Sociology of Expectations, Sustainable Development, Values Beliefs Norms Theory, Lifestyle Theory, and the Unified Theory of Acceptance and Use of Technology (Sovacool and Hess 2017: 703).

2 Transition frameworks: an overview

Innovation system (IS) theory suggests that innovation occurs in the context of an entire system and not only through entrepreneurs (Twomey and Gaziulusoy 2014; Weber and Truffer 2017). It accounts for change beyond technical and economic spheres (Hekkert et al. 2007; Lachman 2013; Sartorius 2006). A Technological Innovation System (TIS) is defined as “a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilisation of a technology” (Carlsson and Stankiewicz 1991). The main purpose of the TIS approach is to consider all the activities that contribute to the development, diffusion and use of innovations as system functions. In the TIS approach, the development of a new technology results from the positive fulfilment of seven functions: entrepreneurial activities, knowledge development, knowledge diffusion, search guidance, market formation, resource mobilisation, and advocacy and legitimacy creation (Bergek et al. 2008; Hekkert et al. 2007). More recently, Markard (2018) introduced a TIS life-cycle framework that distinguishes between four stages of development, i.e. formation, growth, maturity and decline. The major contribution of IS perspectives was to introduce a systemic perspective (e.g. a focus on weak networks, institutional failures, infrastructure failures) replacing narrow market concepts (Jacobsson and Bergek 2011).

The multi-level perspective (Rip and Kemp 1998; Geels 2002, 2005a, b, 2010, 2011; Smith et al. 2005, 2010; Schot and Geels 2008) posits that transitions come about through interaction processes within and between three analytical levels: *niches* (micro level; locus of radical innovations); *socio-technical regimes* (meso-level; locus of established practices and associated formal, normative and cognitive rules); and an exogenous *socio-technical landscape* (macro level). Niches are spaces (e.g. research and development laboratories, small market niches, demonstration projects) where innovative activity takes place and where protection is offered against dominant rules (Smith et al. 2010; Geels 2011). The socio-technical *regime* comprises the network of actors and social groups, the formal and informal rules they maintain to run a dominant socio-technical system, and related material and technical elements (Geels 2011). Regimes tend to change only incrementally and rarely undergo transformation or reconfiguration (Lachman 2013). The overarching level, and backdrop to the regime and niche levels, is the socio-technical *landscape*. It cannot be changed easily and in the short run (Geels 2002; Geels and Schot 2007; Rip and Kemp 1998) and includes trends and global events such as demographic trends, macroeconomic trends, political ideologies and developments, deep societal and cultural values, and climate change (Lachman 2013). Landscape changes can constitute a source of pressures for regime change and/or generate opportunities for niches (Smith et al. 2010). In MLP, transitions are defined as shifts from one regime to another and they result from the interaction between processes at niche–regime–landscape levels; niche innovations build up internal momentum, changes at the landscape level create destabilising pressure on the regime, and regime destabilisation creates windows of opportunity for radical niche innovations that gather momentum to take centre stage within the system (Geels 2006, 2011; Grin et al. 2010; Markard and Truffer 2008). MLP emphasises that processes at niche, regime and landscape levels should be aligned for a transition to be successful (Geels 2011).

Socio-technical transitions are an umbrella term that includes, besides the MLP, a family of approaches such as and Multi-Phase Model, strategic niche management and transition management. Strategic niche management (SNM) and transition management (TM) emerged from the aspiration to support radical innovation and system transformation

(Twomey and Gaziulusoy 2014). SNM aims to bridge the gap between niche development and market exploitation. Therefore, SNM scholars focus on the early adoption of innovations, the processes that determine successful niche development as well as niche–regime interactions. SNM promotes reflexive management of niche experiments and initiatives to create momentum for niches to breakthrough (Schot and Geels 2008). The core idea behind SNM is learning (experiential, social, etc.) (Raven and Geels 2010). Transition management (TM) shares many features with SNM, focusing on the key processes in establishing a niche (e.g. promoting learning based on experiments, developing rules, stabilising networks). It emphasises the importance of creating visions in so-called transition arenas before starting niche experiments (Rotmans et al. 2001; Kemp et al. 2007; Loorbach 2007; Schot and Geels 2008). The TM approach is useful to understand the role of such “transition arenas”, where niche players and change-inclined regime actors can form new coalitions (Rotmans and Loorbach 2009). In doing so, TM concentrates on alternative visions to influence the cognitive frames of regime actors (Schot and Geels 2008). It follows a cyclical path consisting of problem structuring and envisioning (strategic level), agenda building and networking (tactical level), experimenting and diffusing (operational level) and evaluating and adjusting (cf. reflexive governance) (Loorbach 2007, 2010; Loorbach et al. 2008).

The Social Practices Approach (SPA) bridges individual lifestyles and socio-technical systems (Hargreaves 2011; Moore 2015). The theory of social practices investigates the social relations between producers and consumers, embedded in infrastructures (Hargreaves et al. 2013; Reckwitz 2002; Shove and Walker 2010; Southerton et al. 2004; Spaargaren and van Vliet 2000; Warde 2005). Shove and Pantzar (2005) and Pantzar and Shove (2010) saw practices as made of skills (knowhow, competence forms), images (meaning, symbols) and materials that are recursively and actively integrated through everyday life. Changing social practices in an innovation process is seen as a collective accomplishment, which questions boundaries around regimes and systems (Pantzar and Shove 2010). Change of social practices, according to Warde (2005), would occur when their continuous replication is disrupted. Regarding change, SPA further distinguishes between practices that are routinely reproduced, and new practices that are more unstable and fluid (Shove and Walker 2010).

3 Materials and methods

The paper is based on a systematic review of documents indexed in Scopus database (Table 1). An important step of the process was the selection of the peer-reviewed scientific literature dealing with agro-food sustainability transitions. For that, a literature search was carried out on 3 March 2018, using the *Title-Abs-Key* search string: (*transition AND sustainability*) AND (*agri* OR agro OR food*).

The search on Scopus yielded 791 papers. Further 56 documents were added from the quarterly newsletter of the Sustainability Transitions Research Network (STRN). In order to be included in the systematic review, research articles had to satisfy two requirements, namely to deal with both sustainability transitions and agro-food (agriculture and/or food). In some cases, a scrutiny of full papers was necessary. In fact, 54 records underwent an eligibility check based on full papers. Following screening, scrutiny and eligibility checks, only 127 research articles were included in the systematic review (Table 2).

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

| Systematic review step | Number of selected records | Step description |
|--|----------------------------|--|
| Identification of records (Scopus and STRN newsletter) | 847 | 791 records identified through Scopus database searching 56 papers from STRN's newsletter |
| Removing duplicates | 799 | 48 duplicates removed |
| Selection of research articles | 726 | 73 review articles excluded as the paper focuses only on research regarding agro-food sustainability transitions |
| Screening of records based on titles | 618 | 108 records excluded Records that refer to transitions (political, economic), land use change or forestry without any reference to agro-food were excluded |
| Scrutiny of abstracts and full-text articles for eligibility | 127 | 491 records excluded 465 records were excluded based on scrutiny of abstracts as they do not deal with sustainability transitions and/or with agro-food |
| Inclusion of research articles in the systematic review | 127 | 26 records were excluded based on assessment of full texts as they deal only with sustainability (and sustainability assessment) in agro-food, not with agro-food sustainability transitions |

Table 2 Research articles on agro-food sustainability transitions included in the systematic review

| Year | Number of papers | References |
|------|------------------|---|
| 2018 | 11 | Davies and Legg (2018), Gorissen et al. (2018), Hassink et al. (2018), Ingram (2018), Järnberg et al. (2018), Long et al. (2018), Marco et al. (2018), Maye (2018), Nygaard and Bolwig (2018), Sautier et al. (2018) and Sixt et al. (2018) |
| 2017 | 30 | 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), Kuhnonen (2017), Kuokkanen et al. (2017), Loconto and Barbier (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) and Wonneck and Hobson (2017) |
| 2016 | 25 | Bui et al. (2016), Chiffolleau 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) and Vankeerberghen and Stassart (2016) |
| 2015 | 18 | 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), Mylan et al. (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) and 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) and Vinnari and Vinnari (2014) |
| 2013 | 11 | 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), Kirwan et al. (2013), Lutz and Schachinger (2013), Marsden (2013) and Van Mierlo et al. (2013) |

Table 2 (continued)

| Year | Number of papers | References |
|------|------------------|---|
| 2012 | 5 | das Chagas Oliveira et al. (2012), Grin (2012), Lawhon and Murphy (2012), Manuel-Navarrete and Gallopín (2012) and Zwartkruis et al. (2012) |
| 2011 | 4 | Elzen et al. (2011), Jehlička and Smith (2011), Levkoe (2011) and Quist et al. (2011) |
| 2010 | 1 | Beers et al. (2010) |
| 2009 | 2 | Negi et al. (2009) and Schandl et al. (2009) |
| 2008 | 2 | Lebel et al. (2008) and Wilson (2008) |
| 2007 | 1 | Smith and Jehlička (2007) |
| 2006 | 1 | Smith (2006) |
| 2003 | 1 | Wiskerke (2003) |

Based on the discussion in Sects. 1 and 2, five transition frameworks were selected for empirical analysis: IS/TIS, MLP, TM, SNM and SPA. For each heuristic framework, a search string was elaborated: multi-level perspective (search string: {multi-level perspective} OR {multilevel perspective} OR MLP OR niche), transition management (search query: {transition management}), strategic niche management (search query: {niche management}), technological innovation systems (search query: {innovation system}), social practice approach (search string: {social practice} OR “practice theory”). Search was performed on Scopus in the list of 127 selected research articles dealing with agro-food sustainability transitions.

The following topics were addressed for each framework: agriculture sub-sectors (crop production, animal production, fisheries/aquaculture) and stage of the food chain (production, processing, distribution, consumption); niches; interactions with other regimes/sectors (e.g. energy); geography of author affiliations and countries where case studies were performed; main focus of the framework (e.g. niches–regimes interactions, emergence and development of niches, roles of actors in the transition process); weaknesses/critiques to the framework.

4 Results and discussion

The results of the systematic review show that all five heuristic frameworks are used in research on agro-food sustainability transitions (Table 3). Moreover, 68.5% of the selected research papers dealing with agro-food sustainability transitions use at least one transition framework. The multi-level perspective (MLP) is by far the most prominent transition framework followed by transition management (TM), social practice approach (SPA), strategic niche management (SNM) and then innovation systems. It should be pointed out that many papers use different transition frameworks. For instance, Crivits and Paredis (2013) used MLP and SPA, while van den Heiligenberg et al. (2017) integrated insights from the TM literature with innovation systems approach. MLP, TM, SPA, SNM and IS are the dominant transition frameworks, but some authors refer to other approaches such as Socio-Metabolic Transitions (Marco et al. 2018; Schandl et al. 2009).

There are some differences with the use of heuristic frameworks in the mother field of sustainability transitions (Truffer and Markard 2017). In fact, Truffer and Markard (2017) showed that TM is the most prominent transition framework in sustainability transitions field followed by MLP, TIS and then SNM. The authors did not consider SPA in their analysis. This clearly shows that SPA, which focuses on consumption, is mainly used in agro-food research.

The analysis of the trend in the use of transition frameworks in research on agro-food sustainability transitions (Table 4) shows that the use of SPA is rather recent. Meanwhile, SNM was among the first frameworks to be used in research on agro-food sustainability transitions, but it kept marginal in the research field. Likewise, the innovation systems approach is still marginal in the field.

The use of each transition heuristic framework in agro-food sustainability transitions research field is analysed in the following paper subsections. Papers using more than one framework were analysed in a separate subsection (see Sect. 4.6).

Table 3 Use of transition frameworks in research articles dealing with agro-food sustainability transitions

| Transition framework | Searched documents ^a | Selected documents ^b | Selected documents ^c (%) | References |
|----------------------|---------------------------------|---------------------------------|-------------------------------------|--|
| MLP | 70 | 45 | 35.4 | Audet et al. (2017), Beers et al. (2010), Bui et al. (2016), Bush and Marschke (2014), Crivits and Paredis (2013), Davidson et al. (2016), Duru et al. (2014), Elizen et al. (2011), Hargreaves et al. (2013), Hassink et al. (2014, 2018, 2013), Hauser and Lindtner (2017), Hinrichs (2014), Immink et al. (2013), Ingram (2015, 2018), Ingram et al. (2015), Isgren and Ness (2017), Jacobs et al. (2017), Järnberg et al. (2018), Jurgilevich et al. (2016), Konefal (2015), Lawhon and Murphy (2012), Levidow et al. (2014), Loconto and Barbier (2017), Lutz and Schachinger (2013), Marsden (2013), Maru et al. (2016), Meynard et al. (2017), Moragues-Faus and Morgan (2015), Morrissey et al. (2014), Nygaard and Bolwig (2018), Pant (2016), Papachristos and Adamides (2016), Pitt and Jones (2016), Santhanam-Martin et al. (2015), Schut et al. (2016), Slingerland and Schut (2014), Stahlbrand (2016), Sutherland et al. (2015), Vankeerberghen and Stassart (2016), Vivero-Pol (2017), Vlahos et al. (2017) and Wiskerke (2003) |
| TM | 54 | 18 | 14.2 | Beers et al. (2014), Crivits et al. (2017), Davies (2014), Davies and Doyle (2015), de Olde et al. (2017), Gorissen et al. (2018), Grin (2012), Halbe et al. (2015), Hansen and Bjørkhaug (2017), Hoppe et al. (2016), Kuhlmonen (2017), Long et al. (2018), Pant et al. (2014), Rosin et al. (2017), van den Heiligenberg et al. (2017), van Gameren et al. (2015), Vinnari and Vinnari (2014) and Vittersø and Tangeland (2015) |
| SPA | 96 | 14 | 11.0 | Crivits and Paredis (2013), Hargreaves et al. (2013), Davies (2014), Hinrichs (2014), Cohen and Ilieva (2015), Davies and Doyle (2015), Twine (2015), Ely et al. (2016), Langendahl et al. (2016), Liu et al. (2016), Mylän et al. (2016), Huttunen and Oosterveer (2017), Paddock (2017) and Wonneck and Hobson (2017) |
| SNM | 43 | 9 | 7.1 | Wiskerke (2003), Smith (2006), Bhattarai and Pant (2013), Hermans et al. (2013), Kirwan et al. (2013), Raman and Mohr (2014), Pitt and Jones (2016), Rossi (2017) and Maye (2018) |
| IS | 19 | 8 | 6.3 | Van Mierlo et al. (2013), Pant (2014), Long et al. (2016), Prasad (2016), van den Heiligenberg et al. (2017), Randelli and Rocchi (2017), Turner et al. (2017) and Sixt et al. (2018) |

^aNumber of documents mentioning the transition framework found through the search carried out using the search string (N.B. "Searched documents" add up to 282 as many documents mention different transition frameworks)

^bNumber of documents using the transition framework selected after scrutiny of abstracts (N.B. "Selected documents" add up to 94 as many papers dealing with agro-food sustainability transitions do not use any of the five transition frameworks)

^cPercentage of selected documents using each transition framework out of 127 records dealing with agro-food sustainability transitions

Table 4 Trend in the use of transition frameworks in research on agro-food sustainability transitions

| | MLP | TM | SNM | SPA | IS |
|------|-----|----|-----|-----|----|
| 2003 | | | 1 | | |
| 2006 | | | 1 | | |
| 2010 | 1 | | 0 | | |
| 2011 | 1 | | 0 | | |
| 2012 | 1 | 1 | 0 | | |
| 2013 | 6 | 0 | 3 | 2 | 1 |
| 2014 | 7 | 4 | 1 | 2 | 1 |
| 2015 | 6 | 4 | 0 | 3 | 0 |
| 2016 | 10 | 1 | 1 | 4 | 2 |
| 2017 | 8 | 6 | 1 | 3 | 3 |

4.1 Multi-level perspective

Most of the selected papers focus on crop production; other agriculture sub-sectors such as animal production (Davidson et al. 2016; Elzen et al. 2011; Immink et al. 2013) and fisheries/aquaculture (Bush and Marschke 2014) remain largely underserved. However, some papers address both crop production and animal husbandry. For instance, Santhanam-Martin et al. (2015) analysed relation between livestock and natural landscape. As for the stages of the food chain, the main focus is on the production one. Also distribution, sourcing/procurement and catering (Audet et al. 2017; Bui et al. 2016; Stahlbrand 2016) are fairly addressed. Processing stage is underrepresented in research on agro-food sustainability transitions using MLP. In general, MLP is rarely used as a standalone framework to analyse transition in consumption patterns. Some papers adopt a food system approach and address simultaneously different stages of the food chain, such as production and consumption (Jurgilevich et al. 2016; Lutz and Schachinger 2013; Meynard et al. 2017; Morrissey et al. 2014). Other papers deal with different regimes and address the interface between agriculture and energy (Slingerland and Schut 2014; Sutherland et al. 2015; Nygaard and Bolwig 2018) or health care (Hassink et al. 2013, 2014, 2018).

Considering its recognised potential in understanding transitions, many scholars applied MLP to a multitude of cases in the agro-food sector. According to Darnhofer (2015), niches may take the form of “new technologies and practices, new configurations of actor groups, new beliefs and values, new networks, new policies”. Niches considered in the selected papers include agro-ecology (Duru et al. 2014; Isgren and Ness 2017; Levidow et al. 2014; Pant 2016), organic agriculture (Hauser and Lindtner 2017), permaculture (Ingram 2018), conservation agriculture (Vankeerberghen and Stassart 2016), integrated farming (Vlahos et al. 2017) and alternative food networks (Audet et al. 2017; Bui et al. 2016; Lutz and Schachinger 2013) (Table 5).

There is a north–south divide in both the affiliations of authors and where case studies on agro-food sustainability transitions are performed. In fact, affiliations are dominated by the UK and the Netherlands. Although also location of case studies on agro-food sustainability transitions is north-biased, distribution is more balanced in this case (Table 5) because, inter alia, northern researchers increasingly perform research also in the Global South (e.g. Ethiopia, Ghana, Mozambique, Uganda).

In MLP, the interactions across niches, regimes and landscapes shape sustainability transitions (Geels 2002, 2011). In general, the focus of papers using MLP is on the

Table 5 Use of the multi-level perspective in research on agro-food sustainability transitions

| References | Case study | Country |
|-----------------------------|--|-----------------------------|
| Audet et al. (2017) | Montreal seasonal food markets | Canada |
| Beers et al. (2010) | Agriculture | The Netherlands |
| Bui et al. (2016) | Alternative food networks | France |
| Bush and Marschke (2014) | Aquaculture | Undefined |
| Davidson et al. (2016) | Effect of mad cow disease on alternative beef production | Canada |
| Duru et al. (2014) | Agroecology | France |
| Elzen et al. (2011) | Pig husbandry | The Netherlands |
| Hassink et al. (2013) | Care farming | The Netherlands |
| Hassink et al. (2018) | Care farming | The Netherlands |
| Hassink et al. (2014) | Care farming | The Netherlands |
| Hauser and Lindtner (2017) | Organic agriculture | Uganda |
| Imminck et al. (2013) | Livestock sector | The Netherlands |
| Ingram (2018) | Permaculture | UK (England) |
| Ingram (2015) | Sustainable agriculture | Multi-country/Europe |
| Ingram et al. (2015) | Sustainable agriculture | Multi-country/Europe |
| Isgren and Ness (2017) | Agroecology | Uganda |
| Jacobs et al. (2017) | Phosphorus use | Multi-country/North America |
| Järnberg et al. (2018) | Agricultural development | Ethiopia |
| Jurgilevich et al. (2016) | Circular economy in the food system | Undefined |
| Konefal (2015) | Sustainability metrics and standards in agriculture | USA |
| Lawhon and Murphy (2012) | Genetically modified organisms (GMOs) in food production | Undefined |
| Levidow et al. (2014) | Agro-ecological research | Multi-country/Europe |
| Loconto and Barbier (2017) | Agriculture sustainability standards | Undefined |
| Lutz and Schachinger (2013) | Local food networks | Austria |
| Marsden (2013) | Agri-food sector | UK |

Table 5 (continued)

| References | Case study | Country |
|------------------------------------|--|---|
| Maru et al. (2016) | Integrated agricultural research for development (IAR4D) | Multi-country/East and West Africa |
| Meynard et al. (2017) | Agri-food sector | Multi-country |
| Moragues-Faus and Morgan (2015) | Urban food policy | Multi-country/UK and Sweden |
| Morrissey et al. (2014) | Agri-food sector | Multi-country |
| Nygaard and Bolwig (2018) | Jatropha biofuel | Ghana |
| Pant (2016) | Agroecology | Multi-country |
| Papachristos and Adamides (2016) | Functional foods | Undefined |
| Santhanam-Martin et al. (2015) | Landscape and dairy farming | Australia |
| Schut et al. (2016) | Innovation platforms | Multi-country/Africa |
| Slingerland and Schut (2014) | Jatropha biofuel | Mozambique |
| Stahlbrand (2016) | Soil Association's Food For Life catering mark | UK (England) |
| Sutherland et al. (2015) | Renewable energy | Multi-country/Germany, Czech Republic, UK |
| Vankeerberghen and Stassart (2016) | Conservation agriculture | Belgium |
| Vivero-Pol (2017) | Food | Multi-country |
| Vlahos et al. (2017) | Integrated peach farming | Greece |

dialectic relations between the emerging niches and established regimes and how their interactions shape transition towards sustainability. In this respect, MLP is similar to the strategic niche management framework. Such papers focus on how niches influence regimes or a component of them, e.g. agricultural knowledge system (Ingram 2018), agricultural research (Levidow et al. 2014; Maru et al. 2016; Schut et al. 2016). Nevertheless, some papers analyse also internal dynamics within niches or regimes as well as transition pathways. For instance, Bui et al. (2016) investigated both niche development trajectories and niche–regime interactions. Isgren and Ness (2017) focused in their analysis on regime dimensions (culture, guiding principles, knowledge, policy, practices/technologies, market relations). Jacobs et al. (2017) drew on MLP to develop transition pathways in North American phosphorus system. Vlahos et al. (2017) pointed out that very often various transition paths unfold simultaneously rather than a single transition pathway.

Although MLP is by far the most prominent transition framework also in agro-food sustainability transitions research field, some scholars highlight its inadequacy for understanding and nurturing agro-food sustainability transitions in some specific contexts. For instance, Audet et al. (2017) pointed out that while MLP anticipates that sustainability transition would depend on the protection of niches that face the agro-food regime, the Montreal seasonal food markets do not fit in this portrait as they evolve at the intersection of the regime and niches. Bui et al. (2016) highlighted that MLP does not allow elucidating the mechanisms of niches contribution to regime reconfiguration. According to Hassink et al. (2018), “several aspects need more attention like agency, interactions across system boundaries and multi-regime interactions” (p. 186). Transition in MLP is considered as a regime change, but Ingram et al. (2015) pointed out that “the transition to sustainable agriculture might be understood as a complex of interactive processes leading to a series of adaptive changes, rather than as regime change” (p. 55). Likewise, Vlahos et al. (2017) questioned “clear-cut analytical separation between the three levels of the multi-level perspective, as well as the relevance of a bottom-up procedure as a prerequisite for niche emergence vis-à-vis policy induced change” (p. 43). Lawhon and Murphy (2012) formulated four critiques to MLP related to the way it addresses social and political relations, participation, geography and power. Agency seems one of the main weaknesses of MLP. Isgren and Ness (2017), Stahlbrand (2016) and Vivero-Pol (2017) called for more room of agency within MLP. Isgren and Ness (2017) and Stahlbrand (2016) highlighted the important role of civil society collective action in agro-food sustainability transitions. This is in line with the critique formulated by Hargreaves et al. (2011) who argue that MLP tends to focus on market actors while neglecting civil society ones. Stahlbrand (2016) also pinpointed the essential contribution of public institutions. Konefal (2015) pointed out that MLP under-theorises governance role in sustainability transitions by highlighting the role played by multi-stakeholder initiatives in agricultural regime change in the USA.

4.2 Transition management

Transition management (TM) approach emerged from the aspiration to develop management tools and instruments to support system transformation. The focus of papers using TM is, generally, broader than in the case of MLP. In fact, papers focus on building visions for sustainable agro-food systems and actions needed to move towards such an envisioned system. Selected papers address transition in production (Beers et al. 2014; de Olde et al. 2017; Grin 2012; Hoppe et al. 2016; Pant et al. 2014), processing (Long et al. 2018; Rosin et al. 2017), consumption (Vinnari and Vinnari 2014; Vittersø and Tangeland 2015) or in

Table 6 Transition management in research on agro-food sustainability transitions

| References | Case study | Country |
|-------------------------------|---|---|
| Beers et al. (2014) | Mixed farming | The Netherlands |
| Crivits et al. (2017) | Agro-food governance network | Belgium |
| de Olde et al. (2017) | Pig farming | The Netherlands |
| Gorissen et al. (2018) | Urban food system | Belgium |
| Grin (2012) | Dutch agriculture in the post-World War II | The Netherlands |
| Halbe et al. (2015) | Water–energy–food nexus | Cyprus |
| Hansen and Bjørkhaug (2017) | Bioeconomy | Norway |
| Hoppe et al. (2016) | Phosphorus and nitrogen management | Multi-country (The Netherlands and Finland) |
| Kuhmonen (2017) | Potential of futures images in food system transition | Finland |
| Long et al. (2018) | Food and beverage industry | The Netherlands |
| Pant et al. (2014) | Transformation in subsistence farming | Nepal |
| Rosin et al. (2017) | Sustainable wine production | New Zealand |
| van Gameren et al. (2015) | Local food systems | Belgium |
| Vinnari and Vinnari (2014) | Plant-based diets | Undefined |
| Vittersø and Tangeland (2015) | Organic food | Norway |

the whole food system (Crivits et al. 2017; Gorissen et al. 2018; Kuhmonen 2017; van Gameren et al. 2015). Other papers adopt a wider approach and deal with bioeconomy (Hansen and Bjørkhaug 2017) or water–energy–food nexus (Halbe et al. 2015). As in the case of MLP, affiliations of scholars as well location of case studies are north-biased (Table 6). TM approach was particularly used by Dutch researchers.

The main difference between papers using MLP and those referring to TM or SNM is that while the former focus on interactions between niches and regimes, the latter are more concerned with actors' capacity of triggering institutional transformation. TM emphasises the importance of creating shared visions in “transition arenas” before starting transition experiments (Rotmans et al. 2001; Kemp et al. 2007; Loorbach 2007; Schot and Geels 2008). A “transition arena” is a space where there is interaction between niche actors and change-inclined regime stakeholders (Rotmans and Loorbach 2009). De Olde et al. (2017) emphasised the role of collaborations between different involved stakeholders (e.g. farmers, policy-makers and researchers) in the success of transitions. Partnering is one of the mechanisms identified by Gorissen et al. (2018) to accelerate sustainability transitions in urban food systems. They also show that acceleration dynamics in the food domain are fuelled via multi-actor collaborations, in which coordination and reflexive governance play a crucial role. Long et al. (2018) found that collaboration with firm external actors (e.g. suppliers, government, customers) is crucial in determining the success of transition towards business models for sustainability in the Dutch food and beverage industry.

Crivits et al. (2017) showed that political representation in transition arenas affects the success of transition governance and management. Likewise, Grin (2012) pointed out that politics (see powering, legitimisation) may interfere with the governance of sustainability transition. Van Gameren et al. (2015) highlighted that socio-political configurations, institutional contexts and governance arrangements influence the nascent local food systems in Belgium and, consequently, sustainable food consumption transitions. Therefore, they put

governance, politics and institutions at the centre of the debate on sustainable consumption. Hoppe et al. (2016) addressed resource politics in their critical analysis of the governance of phosphorus and nitrogen systems in Finland and the Netherlands. They show the crucial role played by policies in determining both merits and failures of system transition. Besides market failures, policy failures (e.g. lack of policy coordination) can prevent sustainability transitions.

The notions of experimentation and social learning (Wals 2007) are central in the literature on TM and SNM. Beers et al. (2014) pointed out that learning in transition experiments should not be limited to niche-internal learning processes as also social learning about the environment of transition experiments is crucial to effectively meet societal demands. Therefore, social learning can determine the success (or failure) of transition experiments. Linking social learning to societal environment and context can allow for an effective management of transition experiments and projects. Likewise, de Olde et al. (2017) highlighted the need for knowledge exchange between farmers, researchers and policy-makers to foster transition towards sustainable agriculture. Grin (2012) emphasised the need for learning during all transition phases. Learning requirements are different not only along the phases of transition but also for the various actors. Addressing actors' specific learning requirements is vital to achieve sustainability transition (Halbe et al. 2015).

Transition management approach also concentrates on alternative visions to influence the reference frames of regime actors (Schot and Geels 2008). Hansen and Bjørkhaug (2017) analysed the dialectic relation between visions and actor expectations. They highlight the importance of developing common visions, which represent the synthesis of the expectations of the different sectors (aquaculture, agriculture, fishery, biotechnology, forestry), to foster transition towards bioeconomy in Norway. Having a clear narrative and vision was identified by Long et al. (2018) as one of the factors that determine the success of transition towards sustainability by Dutch SMEs in the food and beverage sector.

Beers et al. (2014) argued that the transition management literature provides a limited elaboration on the processes of learning involved in transition experiments and journeys. Therefore, they recommend relating transition theory to Senge's Field of Change (Senge et al. 1994) in order to provide a more comprehensive approach to learning processes in transitions. Vittersø and Tangeland (2015) related the TM and ecological modernisation theories to analyse transition towards sustainable consumption in the food system. Likewise, Pant et al. (2014) recommended to integrate transition management (cf. management of change) and adaptive management (cf. adaptation to change) in an "adaptive transition management" approach to foster agro-ecological transition in the Nepalese Karnali mountains. Vinnari and Vinnari (2014) argued that TM approach needs further development to suit the food consumption context; they build on transition management and its cyclical path (strategic, tactical, operational levels), to develop a transition management framework to elucidate transition to plant-based diets. Kuhmonen (2017) pointed out that transition management efforts should pay more attention to agency and structures in the food system. Likewise, Rosin et al. (2017) called for considering also non-human agency (e.g. sustainability standards and metrics) in agro-food transition management.

4.3 Social practice approach

There have been calls for more attention to demand and consumption at the individual, household and community level (Schot and Geels 2008). The Social Practices Approach (SPA) puts demand and consumption at the centre of stage in food sustainability transitions.

Table 7 Social practice approach in research on agro-food sustainability transitions

| References | Case study | Country |
|--------------------------------|--------------------------------------|---------|
| Cohen and Ilieva (2015) | Shopping at farmers' markets | USA |
| Ely et al. (2016) | Maize production and consumption | China |
| Huttunen and Oosterveer (2017) | Agricultural fertilisation practices | Finland |
| Langendahl et al. (2016) | Food processing | UK |
| Liu et al. (2016) | Sustainable food consumption | China |
| Mylan et al. (2016) | Domestic food provisioning | UK |
| Paddock (2017) | Household food consumption | UK |
| Twine (2015) | Snacking | UK |
| Wonneck and Hobson (2017) | Food and yard waste recycling | Canada |

Most of papers using the social practice theory focus on consumption stage. In general, also food provisioning and procurement are analysed in relation to consumption (Cohen and Ilieva 2015; Mylan et al. 2016). In fact, one strength of SPA is that it combines human agency (see consumers) and social structures (see provision systems) to analyse sustainable consumption (Liu et al. 2016). Nevertheless, there are some exceptions to the focus of SPA on consumption. For instance, Huttunen and Oosterveer (2017) use the practice theory to investigate agricultural fertilisation practices among Finnish farmers. Some papers address both consumption and production (Ely et al. 2016) (Table 7). As the framework deals mainly with consumption patterns, there is no clear-cut distinction between the different agriculture sub-sectors (crop production, animal production, fisheries/aquaculture).

Many papers focus on changing food practices in cities. Cohen and Ilieva (2015) highlighted the relation between socio-technical systems, such as food systems, and everyday practices. Doing so, they show the importance of changing shopping practices in transition towards a more sustainable food system in New York City. Their analysis also highlights that practices, as social constructs, are context specific and geographically distinct. Therefore, cities can foster sustainability transition by creating an enabling food environment. In fact, according to Cohen and Ilieva (2015), "Cities shape, support and normalize food practices, and in the process play an important role in transitioning the wider food system" (p. 199). Mylan et al. (2016) investigated domestic consumption–circular economy nexus by analysing the linkages between food provisioning, eating practices and household waste generation in three British cities (Bristol, London, Preston). They show that dynamics of domestic food consumption practices are central in waste production; therefore, they should be taken into consideration in the design and implementation of strategies for the reduction of waste by consumers. Mylan et al. (2016) suggested to "[...] shift from imagining consumers as 'users' of particular products or services, to conceptualisation as 'doers' of everyday activities". Also Paddock (2017) suggested a shift in the way of viewing consumers. In particular, she unpacks the notion of consumers acting as autonomous choice agents and highlights that food consumption practices are shaped by complex social, material and cultural factors. The author suggests to focus not only on the single practices themselves, but also on the relationships and interconnections between them. In this respect, changes in food practices can be an entry point for a broader transition towards more sustainable lifestyles. Paddock (2017) put that "It is in thinking about the nexus of practices that we might come to more novel and dynamic policy interventions for sustainable consumption" (p. 135). This resonates well with "practice-based spillover effects" of Wonneck and Hobson

(2017). The authors show that a food and yard waste recycling pilot program in Calgary (Canada) had positive spillover effects on food shopping. This shows the connectedness of practices, which means that changes in one practice can have implications (either negative or positive) also on others. Targeting the shared elements of these “mutually evolving practices” (Wonneck and Hobson 2017) can bring about more significant benefits in terms of sustainability transitions in cities.

Instead of domestic household consumption, Twine (2015) focused on out of home food consumption and analyses snacking through the lens of practice theory. The author calls for moving beyond individualistic assumptions of consumers’ behavioural change and “situate snacking as an eating practice with health implications that has emerged within the social, temporal, economic and cultural organisation of everyday life” (p. 1270). This shows once again that eating practices, as well as changes in eating practices, are affected by the social environment and context.

Ely et al. (2016) focused on the linkages between consumption and production in China. They discuss political, sociocultural and technological factors shaping transition as well as pathways of changes in maize consumption and production practices. Their analysis shows the increasingly central role of consumers in shaping production and consumption patterns. Also Liu et al. (2016) emphasised linkages between provision systems and sustainable consumption practices. The authors argue that “neither an ‘individualist’ nor a system- or structural perspective alone is sufficient for understanding and analysing the transition towards sustainable consumption” (p. 13) and apply SPA that combines human agency (cf. individualist perspective) and social structures (cf. system/structural perspective). They show that research on sustainable consumption in China focused in the last decades on increase in production efficiency, while it paid almost no attention to changes in consumers’ behaviour.

While the majority of papers using SPA focus on consumption, Huttunen and Oosterveer (2017) dealt with production and Langendahl et al. (2016) dealt with food processing. Huttunen and Oosterveer (2017) showed the applicability of the practice theory also in analysing changes in production practices. They deal with agricultural fertilisation practices. By focusing on the meanings, competences and material constituents of the fertilisation practice, they analyse paths change and differentiation. The analysis shows that changes in fertilisation practices are affected by their performance. The authors point out that nudging changes in meaning is a good strategy to effect real changes in practices. Langendahl et al. (2016) drew on the practice theory to conceptualise as practices, sustainable innovation activities of a British firm operating in food processing. They highlight that one “[...] can usefully treat a firm as a flow of practices that either resist or otherwise accommodate new practices deemed more sustainable” (p. 105). That is to say that firm’s practices (e.g. strategy making, procurement, production, marketing, sales, transport, estate management) can either present windows of opportunity or constitute obstacles to transition towards sustainability.

4.4 Strategic niche management

Strategic niche management (SNM) is still a marginal framework in research on agro-food sustainability transitions. SNM approach considers networking with actors beyond the niche and learning (both internal learning and social learning) crucial facets of successful niche development. In fact, articulation of expectations and visions, building of social networks, and learning at multiple levels are central processes in SNM approach (Roep and

Table 8 Strategic niche management in research on agro-food sustainability transitions

| References | Case study | Country |
|------------------------------|-------------------------------------|-----------------|
| Bhattacharai and Pant (2013) | Gender mainstreaming in rural areas | Nepal |
| Hermans et al. (2013) | Environmental cooperatives | The Netherlands |
| Kirwan et al. (2013) | Big Lottery Local Food programme | UK (England) |
| Maye (2018) | Permaculture community | UK (England) |
| Raman and Mohr (2014) | Biofuels | Undefined |
| Rossi (2017) | Grassroots food innovations | Italy |
| Smith (2006) | Organic food | UK |

Wiskerke 2004; Schot and Geels 2008). The focus of papers using SNM is on processes of early adoption of innovations and factors that determine successful niche development. SNM scholars also address the relation between radical niche innovations and socio-technical regimes that they aim to change. Selected papers deal mainly with crop production. They address different stages of the food chain. Some papers address other topics such as gender mainstreaming in rural areas (Bhattacharai and Pant 2013) or biofuels (Raman and Mohr 2014). Both affiliations and study areas are dominated by the UK (Table 8).

Strategic niche management approach was used to investigate different types of niches and protected innovation spaces. Bhattacharai and Pant (2013) integrated SNM with patriarchal bargains theory to highlight the importance of creating protected niches for gender mainstreaming in securing the rights of rural women in western Nepal. Hermans et al. (2013) used SNM to explain network dynamics of the environmental cooperatives of the Northern Frisian Woodlands (The Netherlands). They highlight the interaction between niche processes (e.g. vision building, experimentation) and network dynamics. The authors show that niche vision, its projects and experiments as well as structural characteristics of the niche network evolve over time. Successful niche experiments increase not only niche network size but also its connectedness. Nevertheless, network size is also affected by external factors such as government financial support.

Grassroots innovations are a recurring theme in research papers using SNM. Kirwan et al. (2013) used the example of the Big Lottery Local Food programme, promoting local food networks, to investigate the spread of grassroots and social niche innovations and their impacts in terms of strengthening the resilience of local communities in England. Also Maye (2018) focused on grassroots niches. He combines SNM and Communities of Practice theory to examine the development dynamics of the permaculture community as well as its attempts to influence the mainstream agro-food regime in general and its knowledge system in particular. He shows that while permaculture community has been rather successful in replicating and scaling up permaculture, permaculture translation into the agro-food regime resulted very challenging. The challenge arises from both the internal characteristics of the niche (see difficulty to explain and apply permaculture concept) as well as the resistance of the mainstream. Also Rossi (2017) focused on the transformative potential of grassroots food innovations in Italy. She shows that grassroots initiatives, as examples of bottom-up and inclusive social innovation, have had a significant contribution in shaping the Italian food culture and consumption practices. The success of these food-related niches can be explained by their dynamism, continuous innovation and networking efforts.

Articulation of expectations and visions is crucial in SNM approach as it provides direction for niche development and legitimates niche protection. Raman and Mohr (2014)

Table 9 Innovation systems in research on agro-food sustainability transitions

| References | Case study | Country |
|----------------------------|--------------------------------------|--|
| Long et al. (2016) | Climate-smart agriculture | Multi-country (The Netherlands, France, Switzerland and Italy) |
| Pant (2014) | Food security strategies | Multi-country (Nepal, India) |
| Prasad (2016) | System of Rice Intensification (SRI) | India |
| Randelli and Rocchi (2017) | Food industry | Italy |
| Sixt et al. (2018) | Rainfed agriculture | Jordan |
| Turner et al. (2017) | Community for change in agriculture | New Zealand |
| Van Mierlo et al. (2013) | Poultry | The Netherlands |

analysed how networks, visions and learning about biofuels have been shaped over time. For instance, the food versus fuel conflict has not been envisioned by promoters of biofuels in the aftermath of the 1970s oil shocks. The authors also highlight that it is important to also consider space and geography in order to better comprehend of dynamics of niche development.

Like the other frameworks, SNM has been critically discussed. Lachman (2013) questioned the effectiveness of SNM tools in managing sustainability transitions. Smith (2006) focused on the dialectical relation between niches and socio-technical regimes taking as an example that of organic food in the UK. In particular, he addresses the issue of niche–regime compatibility and its effect on the successful diffusion of niche innovations. In fact, the SNM literature points out that the success of a niche in transforming the regime is higher in case of good compatibility with the regime, while such a compatibility would mean a low transformative potential of the niche.

4.5 Innovation systems

The use of innovation systems approach in research on agro-food sustainability transitions is rather limited. Technological innovation system (Randelli and Rocchi 2017; Sixt et al. 2018) is the most prominent framework in innovations systems family, but some papers refer also to agricultural innovations systems (Turner et al. 2017) or regional innovations systems (van den Heiligenberg et al. 2017).

The focus of selected papers is on weaknesses in innovation networks, institutional failures and infrastructure failures that explain the limited dissemination and adoption of niche innovations as well as how these mechanisms are affected by interactions among actors. In particular, they analyse interaction among different actors in sustainability transitions journeys and institutional contexts and environments under which interaction takes place (Klerkx et al. 2010). The selected papers deal mainly with production (Long et al. 2016; Prasad 2016; Sixt et al. 2018) and processing (Randelli and Rocchi 2017) stages of the food chain (Table 9).

Long et al. (2016) explored socio-economic barriers and bottlenecks to diffusion and adoption of climate-smart agriculture (CSA) in France, Italy, Switzerland and the Netherlands. They show that barriers exist on demand (users) and supply (technology providers) sides of the technological innovation chain, which implies that policy-makers should collaborate with both CSA technological innovations producers and potential end users (e.g.

farmers). While Long et al. (2016) focused on the diffusion of technological innovations (see CSA), Pant (2014) criticised the focus on technological innovation in food security strategies. By analysing the cases of Nepal and India, he argues that “The competence challenges of developing countries to make use of available agricultural resources are ecological, technological and learning-oriented in nature” (p. 340); therefore, “Technological innovation is necessary but not sufficient to achieve food security” (p. 336). The author concludes that developing countries cannot succeed in achieving food security unless technological competences are complemented by learning and agro-ecological competences. Prasad (2016) highlighted the importance of social innovation in agricultural sustainability transitions. He analyses the example of the System of Rice Intensification (SRI) in India and points out that social agro-ecological innovation networks can help creating possibilities for change from outside the mainstream. The author argues that heterogeneous networks (including civil society organisations, farmers, researchers) provide opportunities for the articulation of an inclusive and participative sustainability transition within agriculture.

System failures and blocking mechanisms are a recurring theme in the literature on innovation systems. Sixt et al. (2018) analysed systemic problems for transitions in water harvesting and rainfed agricultural production in Jordan. They show that the main interlocking blocking mechanisms in the water harvesting TIS are related to financing, planning and institutional structure, and highlight the need for integrated policy interventions to address them. Turner et al. (2017) explored a multi-actor, iterative and reflexive process to develop a common understanding of problems hampering system innovation in an agricultural innovation system (AIS) in New Zealand. The process fostered engagement among actors and led them to identify actions to stimulate system innovation and challenge dominant practices and institutional logics. The authors highlight that collective system analyses and involvement of multiple actors from AIS are beneficial in triggering agriculture transition. Also Van Mierlo et al. (2013) highlighted the relevance of collective and multi-actor analyses of structural and systemic barriers to system innovation towards sustainability, but they also underline the crucial role of system learning in sustainability transition in the Dutch poultry sector. They point out that “The innovation system perspective broadens the scope of the system and helps to distinguish the structures underlying current unsustainable practices” (p. 29).

Randelli and Rocchi (2017) applied the TIS approach to food industry in Italy and argued for explicitly considering “[...] consumers and producers as interacting and then co-evolving actors” (p. 94) in alternative food networks, which act as innovative systems in sustainability transitions journeys. Consumers are active agents that are central in shaping new paths towards sustainability. As in the case of Long et al. (2016), their analyses highlight the importance of considering both demand and supply elements in the innovation system.

4.6 Integration of transition frameworks

Many authors highlighted the need for integration of transition frameworks in order to better understand and nurture sustainability transitions (Markard and Truffer 2008; Meelen and Farla 2013; Shove 2003). For instance, the analytical framework proposed by El Bilali and Probst (2017) to map sustainability transitions in agro-food systems plugs in MLP elements of TM, SNM and innovation systems. Synthesising transition approaches would allow benefiting from their different strengths in the study of transitions.

Table 10 Integration of transition frameworks in research on agro-food sustainability transitions

| Frameworks combined | References | Case study | Country |
|---------------------|------------------------------------|-----------------------------------|----------------------|
| MLP and SPA | Crivits and Paredis (2013) | Local food systems (food teams) | Belgium |
| | Hargreaves et al. (2013) | Organic agriculture | UK |
| | Hinrichs (2014) | Food systems | Undefined |
| MLP and SNM | Pitt and Jones (2016) | Food for Life (FFL) catering mark | UK |
| | Wiskerke (2003) | Wheat and bread | The Netherlands |
| TM and SPA | Davies (2014) | Eating practices | Ireland |
| | Davies and Doyle (2015) | Household food consumption | Ireland |
| TM and IS | van den Heiligenberg et al. (2017) | Food | Multi-country/Europe |

Different combinations of transition frameworks are present in the selected research papers: MLP and SNM (Wiskerke 2003; Pitt and Jones 2016), MLP and SPA (Crivits and Paredis 2013; Hargreaves et al. 2013; Hinrichs 2014), TM and IS (van den Heiligenberg et al. 2017), TM and SPA (Davies 2014; Davies and Doyle 2015) (Table 10). It is noteworthy that MLP is the framework that was more widely combined with other transition heuristics. This might be due not only to the fact that MLP is by far the most prominent framework in agro-food sustainability transition studies but also that it has been at the centre of the ongoing debate and controversies in the research field (e.g. Geels 2011). In fact, MLP is transversal in the research field and has many similarities, as well as complementarities, with TM and SNM. Moreover, the increasing use of SPA in agro-food transition research was somehow a critical response to the “verticality” of MLP.

It is widely recognised that social practices are fundamentally intertwined with socio-technical systems. Therefore, MLP is increasingly complemented with approaches that give more importance to human-related and social factors in sustainability transitions such as SPA. According to Geels (2011), the concepts of “regimes” in MLP and “routinised practices” in SPA are similar. However, while the MLP privileges a vertical analytical lens, SPA considers a more horizontal perspective by analysing continuities and possible ruptures in everyday practices (Hinrichs 2014). Crivits and Paredis (2013) developed an “applied practice approach” that combines the concept of “practice” (cf. SPA) with that of “niche/regime” (cf. MLP) and argued that “This re-combination adds to the field of applied consumption research and describes consumption beyond the boundaries of individualist and structuralist models, as well as integrates a conceptualization of the a-linear reproduction of aligning and competing consumer practices” (p. 306). Hinrichs (2014) identified MLP and SPA as the main approaches in the research field of sustainability transitions and argued that “Taken together, these approaches offer different and useful ways to think about the dynamics, durability and significance of innovations in food and agriculture, and the part they play in transitions to sustainability” (p. 143). Likewise, Hargreaves et al. (2013) identified many intersection points and crossovers between regimes (cf. MLP) and practices (cf. SPA) and recommended integrating both approaches to better comprehend transition processes. According to the authors, the flat ontology of SPA makes it a fruitful complementary to MLP; MLP is primarily concerned with transitions in socio-technical regimes and SPA is concerned with transition in practices. Therefore, the authors connect

regimes (cf. MLP) and practices (cf. SPA) to address transition towards food and nutrition security.

Pitt and Jones (2016) and Wiskerke (2003) referred to both MLP and SNM in their sustainability transitions studies. Pitt and Jones (2016) analysed processes of scaling up and out as a form of policy transfer that is crucial in food sustainability transitions and pointed out that “Policy decisions are significant to transition because policy convergence might create pressure for regime change or facilitate strategic niche management” (p. 4). Wiskerke (2003) analysed the development and stabilisation of the Dutch wheat regime (cf. inspection service, wheat breeders’ legal rights, binding list of recommended wheat varieties) and the dynamics of emergence of a promising alternative, sustainable baking wheat cultivation system (Zeeuwse Vlegel in Zeeland province). The analysis shows the effects of changing European agriculture landscape on both regime and niche as well as dialectic interactions between niche and regime.

Besides integration with MLP, social practice theory was also combined with TM approach by Davies (2014) and Davies and Doyle (2015). Davies (2014) drew on “... insights from a participatory backcasting process that adopted a practice orientation within an overarching transitions framework” (p. 181) in her analysis of the role of interaction between citizen–consumer and technology (in particular ICTs) in shaping and co-creating future eating practices. Doing so, she situates eating practices at the heart of transition management processes. Also Davies and Doyle (2015) referred to a “practice-oriented participatory (POP) backcasting process”—allowing interdisciplinary interaction, creative innovation and collaborative learning—to give more value to governance and everyday consumption practices in transition planning and visions about sustainable food futures. POP backcasting method combines practice thinking and transition approach.

Some researchers have made efforts to integrate innovation systems and socio-technical transition approaches (MLP, TM, SNM) to better conceptualise linkages between emerging innovations and established regimes (Markard and Truffer 2008; Meelen and Farla 2013). Van den Heiligenberg et al. (2017) combined insights from the TM and regional innovation systems literature to analyse factors that determine the success (or failure) of innovation upscaling processes in inducing sustainability transitions and regime change. They conclude that success factors are related to the transition experiments themselves as well as to contexts/habitats in which they take place, but the involvement of users in the innovation experiments is the most important factor. The authors highlight the importance of the active collaboration between innovators/entrepreneurs, users and governments to foster sustainability transitions.

5 Conclusions

Scholars agree that there is not one right way to investigate transitions as socio-technical transitions are a complex and multi-faceted research topic. The diversity of transition frameworks accommodates the diversity of transition pathways and the plural form of “sustainability transitions” as well as the different perspectives, scopes and levels of sustainability transitions analyses. This paper reviewed the main transition frameworks that are used to understand and foster sustainability transitions in agro-food systems. Reviewed frameworks include the multi-level perspective (MLP), transition management (TM), strategic niche management (SNM), innovation systems (IS) and the Social Practices Approach (SPA). These sustainability transitions frameworks differ in terms

Table 11 Transition frameworks: focus, strengths and weaknesses

| TF | Focus | Strengths | Weaknesses |
|-----|--|--|--|
| MLP | Alignment processes, multidimensional struggles and dialectic relations within and between niche innovations, regimes, and socio-technical landscape | <p>Systemic and holistic approach to transitions</p> <p>Multi-scale perspective (from niche innovations to local projects, to sector-level regimes and broader societal contexts)</p> <p>Integration/bridging of different "classic" disciplines</p> <p>Accommodating stability and change in transition pathways</p> <p>Explaining past transitions in different sectors and contexts</p> | <p>Operationalisation of concepts (niche, regime, landscape)</p> <p>Conceptualisation of agency, politics, governance and power</p> <p>Bias towards bottom-up change</p> <p>Internal niche dynamics</p> <p>Ethics, normativity and politics of transitions</p> <p>Role of social innovations in transitions</p> <p>Bias towards production</p> <p>Mechanisms of niche contribution to regime reconfiguration</p> |
| TM | Management and governance of sectoral transition processes | <p>Cyclical path (problem structuring and envisioning, agenda building and networking, experimenting, and evaluating and adjusting)</p> <p>Set of management principles and tools for reflexive governance of transitions</p> <p>Creating space for niche development (transition arenas)</p> <p>Prescriptive approach highlighting policy implications of transitions</p> <p>Alternative visions to influence reference frames of regime actors</p> | <p>Elaboration on processes of learning involved in transition experiments and journeys</p> <p>Suitability for food consumption</p> <p>Agency and structures</p> |
| SNM | Governance and management of internal niche dynamics | <p>Strategies to nurture niches and protect them from full market competition</p> <p>Empowering niches across transition phases</p> <p>Social learning in niche experiments</p> <p>Articulation of expectations of actors and building of social networks</p> | <p>Overreliance on niche experiments</p> <p>Taking for granted participation of actors in niche experiments</p> <p>Underestimating the effects of external factors/environment on niche development</p> <p>Bias towards bottom-up technological change</p> |

Table 11 (continued)

| TF | Focus | Strengths | Weaknesses |
|-----|---|---|--|
| TIS | Drivers and barriers/blocking mechanisms for new technologies/innovations | <p>Systemic perspective on innovation</p> <p>Explaining success and failure of novel technologies/innovations</p> <p>Interactions and relations among actors in the transition process</p> <p>Policy advice of how to support new, innovative technologies</p> <p>Agency (role of actors, institutions, networks)</p> | <p>Bias towards technical innovations and production</p> <p>Geography and system boundary (local vs. global)</p> <p>Relation between innovation and transition (how emerging innovations struggle against existing systems)</p> <p>Politics, power and normative issues</p> |
| SPA | Disruption of replication and changes in social practices | <p>Attention to demand and consumption</p> <p>Combining human agency and social structures</p> <p>Bridging individual lifestyles and socio-technical systems</p> <p>Relations between provision systems and consumption practices</p> <p>Social, material and cultural factors shaping consumption practices</p> | <p>Instability and inconsistency of practices</p> <p>Focus on single practices</p> <p>Emphasis on everyday practices versus changes at larger scales (cf. transition)</p> <p>Context specificity and geographical distinctness of practices</p> <p>Bias towards provisioning and consumption</p> |

TF Transition Framework

of epistemologies, assumptions or methodologies, but alert to the interconnections and complexities in promoting and nurturing any shift towards greater sustainability in the agro-food system. Furthermore, they offer useful ways to think about innovation dynamics in the agro-food arena as well as the role that innovation plays in agro-food sustainability transitions. The MLP is now the leading framework in the agro-food sustainability transition research field, but it is increasingly complemented with other approaches. The literature does not provide consensus on the best approach, and each of the reviewed frameworks has its strengths as well as its critics (Table 11). Therefore, the paper makes the case for more integration of these frameworks and approaches in order to better nurture and foster transitions towards sustainable agro-food systems. Integrating the frameworks outlined in this paper and developing an integrated heuristic framework, that is more adapted to the agro-food system, would represent a substantial contribution to and a significant breakthrough in agro-food sustainability transitions research field.

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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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