

# RELATION BETWEEN INNOVATION AND SUSTAINABILITY IN THE AGRO-FOOD SYSTEM

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## ABSTRACT

This review paper explores the complexity of relation between innovation and sustainability and relates it to the agro-food arena. Many scholars argue that meeting the Sustainable Development Goals (SDGs) requires major transformation in modes of innovation. As for the agro-food system, relationship between innovation and sustainability is far from straightforward. Innovation (especially technical one) provides a fertile ground for alternative agro-food movements to criticize the over-industrialization of the food system. However, it seems that it is not about questioning innovation *tout court*, but about what type of innovation (see, sustainable innovation) should be promoted to foster transition towards sustainable food systems.

*Keywords:* social innovation, sustainability transitions, sustainable agriculture, sustainable food systems, sustainable innovation, technical innovation

## 1. INTRODUCTION

Innovation is rather an ambivalent term and that may explain the existence of different understandings of what innovation means. In fact, innovation has been defined in many different ways to the point that there is somehow a 'lack of definitional clarity' (SHAVER, 2016). OECD and EUROSTAT (2005) describe innovation as *"the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations"*. Innovation refers to a complex phenomenon, involving the production, diffusion and translation of scientific or technical knowledge into new products, techniques, services (MENRAD and FEIGL, 2007). According to STERRENBURG *et al.* (2013:62), *"Innovation is the creation of better or more effective products, processes, services, technologies, or ideas that are accepted by markets, governments, and society. Innovation differs from invention in that innovation refers to the use of a new idea or method, whereas invention refers more directly to the creation of the idea or method itself"*. This definition clearly shows that there are different types of innovation, with different degrees of application in the agro-food sector.

There are also broader understandings of innovation. According to STEPS CENTRE (2010:1), innovation means *"new ways of doing things. This includes not only science and technology, but – crucially – the related array of new ideas, institutions, practices, behaviours and social relations that shape scientific and technological patterns, purposes, applications and outcomes"*. Innovation concept is strongly linked to that of knowledge, which is fundamental to move towards sustainable practices (GRIN *et al.*, 2010). Knowledge plays an important role in transitions to sustainable food systems. Therefore, it is important to pay attention to the different types of knowledge (information, skills, judgment and wisdom) that are needed in different situations (LOCONTO, 2016). However, knowledge, as well as innovation, needed to make transition is often contested and inconclusive (BATIE, 2008; LEVIN *et al.*, 2012; PETERS and PIERRE, 2014).

The literature contains many categorisations of innovation along many different dimensions. According to STUMMER *et al.* (2010), innovations can be categorized according to innovation type (product, service, process, market), dimension (objective or subjective), scope of change (radical, incremental, reapplied), or how innovation was created (closed or open). The OECD and EUROSTAT (2005) distinguish product, process, marketing and organisational innovations. Agricultural innovation as well as innovation in agri-food can be classified using the same categories (AVERMAETE *et al.*, 2004; AVOLIO *et al.*, 2014).

SCHUMPETER (1934, 1942) is often identified as the first to feature innovation as a central driver of the economy and to reject neoclassical economics' idea of a static equilibrium. His idea that the process of innovation *"incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a new one"* (SCHUMPETER, 1942:83) continues to be influential to this day. However, Schumpeter and his followers employed the so-called 'linear model' in which innovation begins with an invention, is developed into a commercially viable technology in a firm, and is then diffused into the market place (TWOMEY and GAZIULUSOY, 2014). A consequence of this model was a strong prioritisation of research and development (R&D) and the entrepreneur as the driver of innovation. This is sometimes referred to as the technology- or supply-push perspective of innovation. An alternative perspective put forward in the 1950s and 60s, but still within the linear model approach, was that demand for products and services is more important in stimulating innovation activity and is known as the demand-pull perspective (SCHMOOKLER, 1966).

In the last decades there has been a shift from an innovation concept centred on research to innovation as a result of interactions among several actors that establish diverse

networks and linkages (WORLD BANK, 2006) in an innovation system. In fact, over the last fifty years, a more nuanced and richer picture of the innovation has emerged, with a wider set of implications for those hoping to assist, shape or direct innovation process. Modern innovation theory has moved towards the recognition that innovation is a joint activity involving a large number of actors with different interests, perceptions, capabilities and roles (TWOMEY and GAZIULUSOY, 2014). It also reshaped the relation between innovation and science (TYFIELD, 2011). An interesting further development was the recognition of the importance of users (firms and individual consumers) in the innovation process (VON HIPPEL, 2005; BOGERS *et al.*, 2010).

According to OSBURG (2013), innovation theory has seen constant change of its focus over the last decades: concept of newness (1950s), management theory (1960s), demand side (1970s), process innovation (1980s), service innovations (1990s), and, more recently, open innovation (CHESBROUGH, 2003a) and social innovation (VAN DE VEN *et al.*, 2008).

Appreciation of the importance of actor networks is a key idea in modern innovation field. In the mid-1980s the concept of 'innovation systems' (FREEMAN, 1995; HEKKERT *et al.*, 2007; JACOBSSON and BERGEK, 2010) was introduced. Innovation systems (IS) theory is a heuristic framework that starts from the basis that innovation occurs in the context of an entire system. Furthermore, there have been efforts towards integrating innovation systems approach and the socio-technical transitions (MARKARD and TRUFFER, 2008). The socio-technical transition approach (KEMP, 1994; GEELS, 2005; ROTMANS *et al.*, 2000) is an umbrella term that includes, among others, the Multi-Level Perspective on socio-technical transitions (MLP). The MLP approach differs in focus and scope from the IS approach; MLP is conceived in a societal context that is broader than the innovation systems approach (GEELS, 2005). A central theme of MLP is the recognition of the co-evolutionary development of technologies, institutions and social and economic subsystems. MLP is particularly powerful in understanding the complex interplay of different forces at the macro-, meso- and micro-level in creating disruptive change (GEELS, 2010; GEELS, 2011).

The modern theory of innovation provides a number of concepts and insights similar to that of transition (TWOMEY and GAZIULUSOY, 2014; TYFIELD, 2011). The common term 'transition' is often used interchangeably with the term 'systems innovation', either at the technology system or society-wide level. KEMP and ROTMANS (2005), however, argue that *"For the purposes of managing change processes to sustainability it is useful to use the concept of a 'transition' rather than system innovation"* since it brings into focus the new state, the path towards the end state, the transition problems and the wide range of internal and external developments which shape the outcome.

The concept of "transitions" was first coined by Alex de Tocqueville in the 19<sup>th</sup> century (COENEN-HUTHER, 1996). The term was also utilized in other research areas, such as evolutionary biology, demography, and studies on power relations (MARODY, 1996). In the 1990s, the 'transition' concept was introduced within socio-technical research. In the latter, 'transitions' initially referred to large-scale transformations within society or important subsystems, during which the structure of the societal system fundamentally changes (ROTMANS *et al.*, 2001). More recently, the definition has been refined in such a way by LOORBACH and ROTMANS (2010) that the concept now stands for *"a fundamental change in structure (e.g. organizations, institutions), culture (e.g. norms, behaviour) and practices (e.g. routines, skills)"*. According to STERRENBERG *et al.* (2013:9), radical systems innovations or transitions involve *"innovations that are directed to redesigning entire systems of practices and provisions, instead of individual products or processes"*. Transitions efforts have often borrowed from different strands of research and disciplines, resulting in a myriad of approaches towards understanding and exercising transitions (LACHMAN,

2013). Overviews of transition theories and approaches can be found in GEELS (2005), OLSTHOORN and WIECZOREK (2006), GRIN *et al.* (2010), and MARKARD *et al.* (2012).

The momentum generated by the diffusion of the term 'sustainable development' (WCED, 1987) spurred an interest in research on transitions towards sustainable futures (MARKARD *et al.*, 2012; LACHMAN, 2013; FALCONE, 2014). Ambiguity, complexity, interconnectedness and multidimensionality of sustainability problems imply that incremental changes are no more sufficient and there is a need for transformative change at the systems level (STRN, 2010). Embracing the goal of transition towards sustainable systems, the notion of 'sustainability transition' was coined (GEELS, 2011; KEMP and VAN LENTE, 2011; LACHMAN, 2013). MARKARD *et al.* (2012:956) 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*". Sustainability transitions are needed also in the agro-food arena to move towards sustainable food systems.

According to the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2014), "*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*". This definition clearly shows the strong linkage between food system sustainability and long-term food security. The International Panel of Experts on Sustainable Food Systems (IPES-FOOD, 2015) pointed out that a multi-directional flow of knowledge between the worlds of science, policy and practice is needed to foster a genuine transformation of food systems, which is necessary to make transition towards sustainability. This is urgently required, among others, because food systems are complex 'social-ecological' systems that require different sources of knowledge to be combined. Therefore, there is a need for a real food-related knowledge revolution to overcome persistent lock-ins and path dependencies. Transition will most likely not depend on one or even a small number of technological innovations, but is likely to arise from a constellation of mutually interacting systems of innovations (TWOMEY and GAZIULUSOY, 2014). This is particularly true in the case of food system where social innovations seem also important. According to HINRICHS (2014), social and organizational innovations are as central to sustainability transitions in food systems as any particular innovative technology. Social innovation will likely play an important role in transitions to sustainability in agriculture and food sector that may not be primarily technology-driven (DARNHOFER, 2015) and the transition to sustainable food systems requires complex and holistic change processes in which social innovation plays as big a role as technological innovation (IPES-FOOD, 2015).

The review paper aims to analyse innovation narratives in sustainability literature. In particular, the paper explores the complexity of relation between innovation and sustainability with a particular focus on agro-food systems.

The paper is structured as follows. In section 2, I explore the complex relation between innovation and sustainability (cf. sustainable development) by analysing, among others, references to innovation in the outcomes of the main conferences on sustainable development as well as in the Sustainable Development Goals (SDGs). This section also introduces the concept of Sustainability-Oriented Innovation (SOI) with particular reference to sustainable innovation and eco-innovation as a way to combine innovation and sustainability. In section 3, I analyse the relation between innovation and sustainability in the agro-food arena and I highlight harmony and conflict areas. Sustainable intensification is taken as an example to show diversity of perspectives, agendas and visions regarding sustainable agriculture. The section also analyses attitude of some alternative agro-food movements (e.g. organic agriculture, agro-ecology, food sovereignty, Slow Food) towards innovation.

## 2. INNOVATION AND SUSTAINABILITY: EXPLORING MULTIFACETED LINKAGES

The relation between innovation and sustainability can be analysed at least in two different ways: innovation as a driver of sustainability (role of innovation in achieving sustainable development) or sustainability as a driver of innovation (sustainability as a new paradigm and guiding concept for innovation).

Innovation, science and technology have essential roles to play in meeting the interlinked global environmental, social, and economic challenges of environmental sustainability, poverty reduction, social justice and climate change (STEPS CENTRE, 2010; UN, 2012). In fact, innovation is seen as a route to economic growth and competitive economy as well as to propose effective solutions to real problems such as poverty and environmental challenges (STEPS CENTRE, 2010). The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009) highlights that knowledge, science and technology (AKST) is crucial to address different sustainable development issues such as food insecurity and poverty. It sheds also light on the fact that the scope of agricultural knowledge goes beyond the narrow confines of science and technology (S&T) and encompasses other types of relevant knowledge that is held by agricultural producers, consumers and end-users.

The contribution of innovation to sustainability is highlighted in many strategic and policy documents dealing with sustainable development such as the outcomes of the recent world conferences of Rio, Johannesburg and Rio+20 (Box 1).

Innovation was also addressed recently in the context of the 2030 Agenda for Sustainable Development and Sustainable Development Goals (SDGs) (Box 2). According to LEACH *et al.* (2012:2), delivering SDGs requires a radically new approach to innovation. They add that *“What is now needed is nothing short of major transformation—not only in our policies and technologies, but in our modes of innovation themselves—to enable us to navigate turbulence and meet SDGs that respect the safe operating space”*.

Sustainability is considered nowadays a driver for innovation especially in the private sector (e.g. NIDUMOLU *et al.*, 2009). Many companies are seizing the strategic opportunities in innovation for sustainability. In fact, sustainability, environmentalism, and corporate social responsibility (CSR) have become during the last decades buzzwords among multinational corporations, agribusinesses included, with a risk of ‘green-washing’ (e.g. MUNSHI and KURIAN, 2005). Many private firms see nowadays sustainability as a key factor for their competitiveness and understand that innovation will be crucial factor in developing sustainability. Sustainability is often understood as the voluntary integration of environmental, economic and social concerns in firm operations (VILANOVA and DETTONI, 2011). KASKINEN *et al.* (2013) suggest that there are fundamentally three ways of incorporating sustainability into companies; risk aversion strategy (use of certificates and standards as a reaction to an external critique), cost-effectiveness strategy (cost savings through a smart and effective use of resources), and differentiation strategy (using sustainability to distinguish company’s offering on the market). As put by DEARING (2000:2), the operational and commercial challenges for companies are *“[...] to learn to treat sustainable development as a framework for innovation and to use and extend established management principles to make this framework operational and effective”*.

**Box 1.** Innovation in the outcome documents of world conferences on sustainable development.

In *'Our Common Future'*, the final report of the World Commission on Environment and Development (WCED, 1987) – that, among others, mainstreamed the concept of sustainable development – there is quite a number of references to innovation. The document is rather critical towards innovation and calls for reorienting technology and managing risk by enhancing capacity for technological innovation in developing countries and adapting recent innovations to their needs. It also calls for broadening the scope of innovation beyond product and process innovations. *Our Common Future* emphasizes the need to blend traditional and modern technologies and to promote collaborative learning in agriculture: “*Researchers must learn from and develop the innovations of farmers and not just the reverse*” (p. 116). This is a clear stance against linear innovation model. It should be highlighted that much of the focus of *Our Common Future* is on technological innovation, whereas there is no reference to social innovation; the document even reports that traditional social systems and community control over agricultural practices “*may have limited the acceptance and diffusion of technical innovations*” (p. 44).

Interestingly, the first reference to innovation in *Agenda 21*, the Rio Declaration on Environment and Development (UN, 1992), was in its chapter on *Changing Consumption Patterns* where it highlighted the multiple sources of innovation “*Peoples’ organizations, women’s groups and non-governmental organizations are important sources of innovation*” (p. 15). This broader scope of innovation is confirmed in chapter on conservation of biological diversity that calls for promoting “*the wider application of the knowledge, innovations and practices of indigenous and local communities*” (p. 150). Besides ‘technological innovation’, there is also a clear reference to ‘social innovation’ (p. 129) as well as ‘informal innovations’ (p. 156), and ‘indigenous innovations’ (p. 319). Innovation is considered as important to prevent pollution and control environmental degradation. However, *Agenda 21* also highlighted the importance of assessing the relationship between innovation and development as well as effects of innovation. There is also an entire chapter dedicated to science for sustainable development.

In the Plan of Implementation of the World Summit on Sustainable Development 2002 (UN, 2002) as well as in the report of the Summit (UN, 2002a) there is only one reference to innovation in relation to recognition of the rights of local and indigenous communities as holders of traditional knowledge, innovations and practices regarding biodiversity.

The *Future We Want*, outcome document of the United Nations Conference on Sustainable Development 2012 (UN, 2012a), includes also a few references to innovation. In its preamble, it calls for continued and strengthened international cooperation in the area of innovation to achieve sustainable development. It also recognizes the critical role of promoting innovation especially in developing countries and invites governments to create enabling frameworks that foster environmentally sound innovation, including in support of green economy. In its *Framework for action*, it emphasizes the importance of investments in scientific and technological innovation in job creation. Once again, the traditional knowledge and innovations of indigenous peoples in relation to biodiversity are recognized. Further references to innovation are in the context of education and finance.

**Box 2.** Innovation in the 2030 Agenda for Development Sustainable and SDGs.

The General Assembly of the United Nations adopted on September 25<sup>th</sup>, 2015, a set of 17 goals (and 169 targets) as part of the 2030 Agenda for Sustainable Development (UN, 2015). The only SDG where innovation is explicitly mentioned is SDG9 '*Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*'. There are only few references to innovation in the adopted Agenda. Innovation is considered in the Agenda preamble especially regarding its potential in medicine and energy sectors as well as in sustainable urban development; interestingly no reference to agriculture here. Moreover, there was no reference to innovation either in relation to the targets of SDG2 '*End hunger, achieve food security and improved nutrition, and promote sustainable agriculture*'. Only in the case of SDG8 '*Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*', technological upgrading and innovation are considered essential to achieve higher levels of economic productivity and there is a call to promote development-oriented policies that support, *inter alia*, creativity and innovation. Innovation is further mentioned two times in targets of SDG9 in reference to upgrading technological capabilities of industrial sectors by, *inter alia*, encouraging innovation especially in developing countries. Nevertheless, the part of the document that abounds with references to innovation is that related to SDG17 "*Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development*" especially in sections dealing with technology (see, access to science, technology and innovation; innovation capacity-building mechanism for least developed countries), and means of implementation and the global partnership (see, Addis Ababa Action Agenda, which addresses also systemic issues in science, technology and innovation, and established a Technology Facilitation Mechanism - TFM; private business activity, investment and innovation). It seems, anyway, that there is a recognition of, and maybe also concerns about, the role of technology and innovation in sustainable development and that may explain the establishment of many mechanisms for follow-up of this issue during the implementation of the 2030 Agenda. In fact, TFM - that involves representatives of Member States, civil society, the private sector and the scientific community – is composed of a United Nations inter-agency task team on science, technology and innovation for the SDGs; a collaborative multi-stakeholder forum on science, technology and innovation for the SDGs; and an online platform to share information on existing science, technology and innovation initiatives.

According to SZEKELY and STREBEL (2012), 'strategic innovation for sustainability' – which focuses on the use of innovation to improve performance in environmental, economic and social dimensions of sustainable development - entails improvements that are not only technological/technical but also in business models, thinking, operating procedures and practices, processes, and systems. They consider that types of innovation for sustainability ranges from incremental innovations in products and services or eco-design (e.g. innovations that focus on improvement in eco-efficiency through reduction in resource inputs such as energy, materials, wastes and emissions), to radical innovations in value chains and processes, to 'game-changing systemic innovation'. Radical transformation of supply chains aims to take more account of the impacts of a company's products and operations, including environmental (e.g. raw materials sourcing, end-of-life), economic (e.g. competitiveness) and social (e.g. labour conditions) issues. Examples of 'game-changing innovation' include collaborative consumption (e.g. car sharing and sharing economy in general), that has been enabled by information technology, as well as social entrepreneurship (e.g. micro-credit to the poor). This reminds of the concept of

'open innovation' (e.g. CHESBROUGH, 2003; CHRISTENSEN *et al.*, 2005) that calls for a more open approach towards knowledge management and dissemination to assure a wider access to, and consequently use of, knowledge and innovation. Open innovation concept stresses innovation and knowledge as public goods (e.g. STIGLITZ, 2007) to which a wide range of stakeholders should have access. Open innovation is the opposite of closed innovation. Processes of closed innovation focus on in-house development of innovation before their dissemination to external stakeholders. On the contrary, open innovation focuses on "[...] *the use of purposive inflows and outflows of knowledge to accelerate Innovation*" (CHESBROUGH, 2003). However, finding a balance between reward (for innovation and creativity) and accessibility remains one of the fundamental challenges in science, technology and innovation ecosystems.

There is a growing emphasis on the concepts of 'responsible', 'sustainable', 'social' and 'ecological' innovation (Table 1).

**Table 1.** Some definitions of concepts of sustainable innovation, eco-innovation and social innovation.

Concept	Definition	Source
Sustainable innovation	Sustainable innovation is a process where sustainability considerations (environmental, social, financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialisation. This applies to products, services and technologies, as well as new business and organisation models.	CHARTER and CLARK, 2007
	Creating new or improved products, services, technologies, processes and management techniques that produce environmental or social benefits along with economic value.	CHONKOVA, 2015
Sustainability-driven innovation	The creation of new market space, products and services or processes driven by social, environmental or sustainability issues.	KEEBLE <i>et al.</i> , 2005
Eco-innovation	The process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact.	FUSSLER and JAMES, 1996
	Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives.	KEMP and PEARSON, 2008
	The production, assimilation or exploitation of a novelty in products, production processes, services or in management and business methods, which aims, throughout its lifecycle, to prevent or substantially reduce environmental risk, pollution and other negative impacts of resource use (including energy).	EC 2008 in CARRILLO-HERMOSILLA <i>et al.</i> , 2010
Social innovation	Social innovations 'are new solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and better use of assets and resources.	CAULIER-GRICE <i>et al.</i> , 2012
	Social innovations are new ideas that meet social needs, create social relationships and form new collaborations. These innovations can be products, services or models addressing unmet needs more effectively.	EC, 2017
	Innovative activities and services that are motivated by the goal of meeting a social need and are predominantly developed and diffused through organizations whose primary purposes are social.	MULGAN <i>et al.</i> , 2007



Responsible innovations (RI) address so-called 'grand challenges' of our time, such as climate change (EC, 2013), but they are also associated with a range of socio-ethical issues. The NETWORK FOR BUSINESS SUSTAINABILITY (2012) identified multiple definitions relating to 'Sustainability-Oriented Innovation' (SOI): eco-innovation, ecological innovation, environmental innovation, frugal innovation, green innovation, green product innovation, inclusive innovation and social innovation. Sustainable innovation means paying attention to ecological integrity along social values diversity, promoting fairer and wider distribution of innovation benefits, encouraging plural innovation pathways, fostering inclusive and participatory governance of innovation processes (STEPS CENTRE, 2010). SOI is differentiated from conventional innovation in its purpose and direction as it adds environmental and social consideration to economic profit (BOS-BROUWERS, 2010). Key drivers of sustainable innovation include environmental and resource risks, sustainable consumption and production (SCP) policies, product environmental regulation and other product policy initiatives as well as market and financial drivers (CHARTER and CLARK, 2007). Also for CHONKOVA (2015), drivers of sustainable innovation include compliance with existing regulation or anticipating future regulations, cost savings by improving resource efficiency as well as social and supply chain pressures. Meanwhile, according to NIDUMOLU *et al.* (2009) to become sustainable, companies should go through five distinct stages of change: viewing compliance as opportunity, making value chains sustainable, designing sustainable products and services, developing new business models and creating next-practice platforms.

Sustainable innovation is widely recognised as a critical dimension of sustainable development as well as sustainable consumption and production (SCP), sustainable food systems included. In fact, the crucial importance of sustainable innovation in these contexts has been recognised since the 1980s and was reinforced since the 1990s not only by United Nations (UN) but also in the European Union (EU). However, sustainable innovation has remained mainly peripheral. Nevertheless, the subject is now rapidly moving to centre stage to meet sustainable development challenges of a growing population. In fact, the urgency of adopting sustainable innovation is nowadays recognised as a fundamental step towards a sustainable future (CHARTER and CLARK, 2007). For instance, the European Commission (EC) issued in 2016 two strategic notes dealing with innovation and sustainability namely '*Opportunity Now: Europe's mission to innovate*' (EPSC, 2016) and '*Sustainability Now! A European Vision for Sustainability*' (EPSC, 2016a).

GERHARDT and HUBBERT (2009) distinguish between conventional innovation (characterised by low sustainability, both environmental and social), green innovation (based on natural resources use and with positive or neutral environmental impact), social innovation (that contributes to social well-being and is accessible by consumers in emerging and developing countries) and sustainable innovation, that's to say addresses the triple bottom line (ELKINGTON, 1997) i.e. is environmentally, socially and economically sustainable. Sustainable innovation covers the spectrum of levels of innovation from incremental to radical. STEVELS (1997) defined four levels of innovation in the context of environmental improvement; from incremental, re-design or green limits, functional or product alternatives, to systems design. According to the NETWORK FOR BUSINESS SUSTAINABILITY (2012, 2012a), firms can adopt different pathways to become sustainable. These range from 'Operational Optimization' (small incremental changes to improve eco-efficiency) to 'Systems Building' (radical and disruptive changes that have a positive societal impact) through 'Organizational Transformation' (new products, services or business models).

A concept similar to green innovation, and to a certain extent also sustainable innovation, is that of eco-innovation (e.g. KEMP and FOXON, 2007; CHARTER and CLARK, 2007;

REID and MIEDZINSKI, 2008; CARRILLO-HERMOSILLA *et al.*, 2010). However, CHARTER and CLARK (2007) pointed out that although the two terms, sustainable innovation and eco-innovation, are often used interchangeably, sustainable innovation embraces all dimensions of sustainability (environmental, economic, social/ethical) while eco-innovation addresses mainly environmental and economic dimensions. ANDERSEN (2005) distinguishes the following five categories of eco-innovations: add-on innovations, integrated innovations, eco-efficient technological system innovations, eco-efficient organizational system innovations, and general purpose eco-efficient innovations. Eco-innovation can be analysed in terms of its target (product, process, marketing method, organisation, institution), mechanism (modification, re-design, alternatives, creation) and impact (effect on the environment). Systemic changes, such as creation and alternatives, generally generate higher environmental benefits (OECD, 2009). The drivers for eco-innovation include cost reduction, increasing market share, pressure from regulation or communities, improving technical efficiency, green ethos, profits from commercialisation, and improving the company image (KEMP and FOXON, 2007).

Many companies as well as a number of governments use eco-innovation to describe their contributions to sustainable development. For instance, eco-innovation is considered to support the Lisbon Strategy for competitiveness and economic growth in the European Union (EU) while preventing or substantially reducing negative impacts on the environment, pollution and improving resource efficiency (OECD, 2009; EC, 2012). The Lisbon Strategy called for focusing on innovation and sustainable development and was, thus, a clear example of focus on sustainable innovation. This tendency to focus on sustainable innovation in the EU was reaffirmed in the declaration on the '*Strategy for smart, sustainable and inclusive growth*' that should drive the EU until 2020. Other key international organisms (e.g. OECD), UN agencies (e.g. ILO, WTO) as well as the World Economic Forum advocated similar approaches (VILANOVA and DETTONI, 2011). In fact, according to OECD (2008), eco-innovation is considered to have promise for improving environmental conditions without compromising economic growth. While eco-innovation has focused mainly on environmental technologies, there is a tendency to broaden the concept scope in order to accommodate more societal concerns (RENNINGS, 2000; METI, 2007). Therefore, the overarching concept of eco-innovation is seen as providing vision for pursuing sustainable development.

A further concept related to sustainable innovation is that of social innovation (e.g. NICHOLLS and MURDOCK, 2012; CAULIER-GRICE *et al.*, 2012; OSBURG and SCHMIDPETER, 2013), that deals with the integration of environmental and social issues. As put by OSBURG (2013), social innovation is about adding the social element to innovation or the applied theory of innovation with addition of a relevant and significant social component. According to CHONKOVA (2015), social innovation can be both business oriented (product, process, organisational, marketing) and/or socially oriented (i.e. social innovation). Social innovations are considered good not only for the economy but also for society (CAULIER-GRICE *et al.*, 2012) as they engage with social problems in a way that is more efficient, just, effective or sustainable than existing solutions (PHILLS *et al.*, 2008). Nevertheless, social innovations are not value neutral but rather socially and politically constructed, and context dependent (CAULIER-GRICE *et al.*, 2012). According to OSBURG (2013), open innovation is a must for social innovation, that cannot work with closed innovation processes, as solving current problems in today's societies requires a constant collaboration across sectors and between different categories of stakeholders. CAULIER-GRICE *et al.* (2012) identified eight common features of social innovation: cross-sectoral, open and collaborative, grassroots and bottom-up, *pro-sumption* (see, production-consumption) and co-production, mutualism, creating new roles and relationships, better use of assets and resources, and developing assets and capabilities.

In a Manifesto on innovation, sustainability, development, STEPS CENTRE (2010) called for a radical shift in how we think about and perform innovation towards a greater respect for and integration of cultural variety, democratic accountability and regional diversity. Moving towards innovation for sustainability and sustainable development means nothing less than a radical change in the whole innovation process including agenda setting, capacity building, governance, monitoring, evaluation accountability as well as funding. For that, three arrays of questions related to direction, distribution and diversity, should be addressed (Table 2). These three issues are interrelated. For instance, direction matters also because it shapes innovation benefits, risks and costs distribution. Meanwhile, the appraisal of innovation directions needs to take into account also benefits distribution and to address social equity and justice issues. Furthermore, taking seriously direction and distribution questions, means pursuing deliberately a diversity of innovation pathways to accommodate different needs and aspirations including those of marginalised and poor groups such as small-scale farmers. This, in turn, implies paying attention not only to technical dimension of innovation but also social and organisational ones (STEPS CENTRE, 2010). These questions are not only still actual but also particularly relevant in agro-food systems.

**Table 2.** Arrays of questions regarding innovation for sustainable development.

Issue	Questions to be addressed
Technical, social and political directions for change	What is innovation for? Which kinds of innovation, along which pathways? And towards what goals?
Distribution	Who is innovation for? Whose innovation counts? Who gains and who loses?
Diversity	What - and how many - kinds of innovation do we need to address any particular challenge?

Source: STEPS CENTRE (2010:9).

### 3. COMPLEX AND MULTIFACETED RELATION BETWEEN INNOVATION AND AGRO-FOOD SUSTAINABILITY

Innovation has become a key issue in the discussion about the relation between agriculture and sustainability (e.g. FAO, 2012; EIP-AGRI, 2013; FAO, 2013; IPES-FOOD, 2015; GLOBAL HARVEST INITIATIVE, 2016). In general, there is a broad consensus on the critical role of innovation to make agriculture not only more competitive but also sustainable. In fact, agricultural innovation is considered vital for meeting the challenges of agriculture development, adapting to climate change and achieving food security (IAASTD, 2009; IICA, 2014; EC, 2016; UNCTAD, 2017). Innovations and modern techniques can strengthen food system resilience, improve resource efficiency in agriculture, and secure social equity thus contributing to the achievement of sustainable food security (HLPE, 2017). The European Union has placed emphasis upon innovation as a key element in achieving transformation towards sustainable agriculture (HERMANS *et al.*, 2010; DWYER, 2013).

Agricultural research and development (R&D) has been shown to very profitable (ALSTON *et al.*, 2000; RAO *et al.*, 2012) and to improve agricultural development, economic growth, and poverty reduction (IAASTD, 2009). However, assessing innovation

in agriculture only through investment in agricultural R&D shows clearly that the linear model of innovation is still dominant in official arenas and, especially, when it comes to innovation statistics. Nevertheless, IAASTD (2009) highlights that *“There is ample evidence available from the literature that AKST investments have contributed significantly to organizational and institutional innovations in the form of methods, tools development, capacity strengthening, and understanding how institutes interact with each other in achieving developmental goals”* (p. 516).

The High Level Panel of Experts on Food Security and Nutrition (HLPE, 2017) identified in a recent note knowledge and technology as critical emerging issues for food security and nutrition. As there are diverging views on the suitability of different innovations and technologies to improve food security in a sustainable way in different contexts and for different kinds of users – for instance, in the context of small-scale agriculture and agri-food supply chains (e.g. PEANO *et al.*, 2015; WETTASINHA, 2016), HLPE (2017) recommended to assess all innovations and technologies against their long-term environmental, economic and social impacts. Such an assessment should take into consideration not only technical sustainability and economic profitability but also environmental friendliness and social justice in each use context (e.g. DUNMADE, 2002; KRIESEMER and VIRCHOW, 2012).

The relation between innovation and sustainability (including sustainability transitions) in agro-food system is more complicated than in other systems and sectors. Although more recent sustainability transitions research has stressed that important sustainability innovations can be social rather than technological (SEYFANG and SMITH, 2007; KIRWAN *et al.*, 2013), research on food systems change has long favoured a different vocabulary of civic initiatives, community development projects and social movements to reference what sustainability transitions researchers present as manifestations of ‘grassroots innovations’ for sustainable development (HINRICHS, 2014). It is widely admitted nowadays that to meet sustainability challenges, more attention should be paid to social innovations, grassroots innovation actors and processes (LEACH *et al.*, 2012; MOULAERT, 2013; SMITH and SEYFANG, 2013; LOCONTO *et al.*, 2017). Similarly, IAASTD (2009), suggests that future agricultural innovation needs to address not only simple technological and technical issues but also social ones and to innovate in scales of thinking and action in order to contribute more effectively in addressing pressing challenges such as climate change and food security. Likewise, innovation in rural development is widely understood, especially in the European Union, in terms of social innovation (i.e. encouraging collective learning cultures, networks, interactions) and cultural innovation (i.e. improving rural context) rather than in the narrow sense of technological innovation (DARGAN and SHUCKSMITH, 2008; DWYER *et al.*, 2012; HERMANS *et al.*, 2010). This broader understanding of innovation in agriculture is nowadays widespread predominantly in developed countries such as those of the European Union, as clearly stated by its Standing Committee on Agricultural Research (SCAR): *“Innovation is not restricted to a technical or technological dimension. It increasingly concerns strategy, marketing, organization, management and design”* (SCAR-EU, 2012).

Innovations imply different directions of development, not all of which are sustainable, and which should be subject to democratic debate (STRN, 2010). Critically inclined research on agricultural and food systems change has generally viewed capital-intensive technologies as contributing to the vast restructuring of food and agriculture and ‘sustaining the unsustainable’ (BUTTEL, 2006), especially referring to genetically modified (GM) crops. Because some technologies have abetted industrialization, consolidation, and global neo-liberalization of food and agriculture, technology may be categorically dismissed by some scholars and food system actors as a potentially productive analytical entry point for work on sustainability transitions in food and agriculture (HINRICHS,

2014). In fact, innovation and technology in agriculture may also negatively affect the environment and rural livelihoods and that may explain increasing mistrust in certain institutionalized forms and fields of science (MILLSTONE and van ZWANENBERG, 2000) such as genetics. Management of collective rights and intellectual property rights - IPR (cf. fields of big data and genetics) is particularly problematic and challenging in the agricultural sector (HLPE, 2017). In this regard, biotechnologies raise many ethical concerns as highlighted by the European Group on Ethics in Science and New Technologies (EGE, 2008:59): *“The current IPR system (for plant varieties and GM crops) could pave the way for market predominance where a few companies control much of agricultural production, with an impact on innovation and the growth of local economies in developing countries”*.

The three perspectives on sustainable food security and food system sustainability analysed by GARNETT (2014) – namely efficiency, demand restraint, food system transformation – also reflect different values and ideologies on the role of technology and innovation in the agro-food arena. For the efficiency perspective, the boundaries of environmental limits can be expanded or overcome by using technology to accommodate humanity. The vision underlying the efficiency perspective is that technology can be used to deliver development goals (e.g. food security, well-being) with less environmental impact. Therefore, it can be assumed that advocates of this perspective have a positive attitude towards new technologies and innovation. Meanwhile, for the demand restraint perspective, technology is sometimes problematic and can be used by humans to further damage the environment and nature.

Nevertheless, innovation has always occurred in agriculture as farmers have adapted agricultural practices to changing climate and environment conditions. However, many scholars dealing with agro-food system do not feel comfortable with the current narrow definition of innovation meaning technological and commercialised innovation (LEVIDOW, 2015). This narrow ‘technological-deterministic’ understanding of innovation dates back to the early 20<sup>th</sup> century, when innovation was considered as synonymous of adoption of commercial technological inventions. This innovation model, that emphasises capital-intensive technology, has become profoundly entrenched in research and policy frameworks. The model ignores existing farmers’ knowledge and marginalises their cooperative exchange and learning networks and undervalue their capacity to innovate while favouring a linear knowledge transfer (MOSCHITZ *et al.*, 2015) based on the Transfer of Technology (ToT) model (LIONBERGER, 1960; HAVELOCK, 1969; CHAMBERS and JIGGINS, 1987). ToT model stimulates farmers to capture economies of scale and encourages externalization of significant environmental and social costs (e.g. LAL *et al.*, 2005; MUKHERJEE and KATHURIA, 2006; IAASTD, 2009).

According to IAASTD (2009) report, in general, no recognition is given to farmers’ local and traditional knowledge and their innovation in official systems of agricultural knowledge and science. In fact, the *“role of traditional, indigenous knowledge is already being undermined as a result of the growing disconnection with ongoing research activity”* (SCAR-FEG, 2007:11). The linear innovation model has privileged laboratory-based and scientific knowledge in research agendas at the expense of farmers’ agro-ecological knowledge (VANLOQUEREN and BARET, 2009). This process was seen as causing profound social or cultural changes (GODIN, 2008, 2015), that are not always positive on farming and rural communities. Moreover, inequitable power relationships in agricultural knowledge and information system create barriers to farmers’ innovation (SILICI, 2014). Therefore, in order to contribute more effectively to achieving sustainable food and nutrition security, agricultural research in particular and food-related research in general should adopt a ‘food system approach’ and address at the same time profitability, productivity and

sustainability in agricultural and food systems (GLOBAL PANEL ON AGRICULTURE AND FOOD SYSTEMS FOR NUTRITION, 2016).

Multinationals and consulting firms in the agro-food sector seem nowadays more aware about concerns regarding technology and innovation in agriculture. However, they stress the importance of classical technologies (fertilizers, crop protection products) in meeting food security challenge through increase in productivity. For them, the slowing down or plateauing of crop yields, especially cereals, is a big threat to future global food security that requires new breakthrough innovations for the 'sustainable' intensification of production. The latter include digital innovation (e.g. soil sensors, drones), biotech innovations (e.g. genetically engineered plants and animals) and process innovation (e.g. vertical farming, hydroponics, aquaponics). However, acceptance of these innovations and technologies is still a problem in agriculture sector: "*While these technological innovations have the potential to make a positive impact on agribusiness, the challenge is to find common ground between the significant social, political, and environmental concerns and the business interests surrounding these disruptive changes*" (ATKEARNEY, 2016:3). In order to gain such an acceptance, the advantages of such technologies for smallholder farmers in developing countries as well as relevance of these breakthrough innovations in reducing the carbon footprint of agriculture and its contribution to climate change are often highlighted. Further moves include global transfer of knowledge, also to developing countries, transparency and the democratization of data and better collaboration between agribusiness, government and the civil society (ATKEARNEY, 2016).

Many agro-food companies, including multinationals, are paying more attention to sustainability issues. A clear example of that is publication of periodical sustainability reports (e.g. MONSANTO, 2017) or dedicating a section of annual reports to sustainability (e.g. BAYER, 2017; BASF, 2017). In its Sustainability Report, Monsanto makes even a clear reference to SDGs and states that its key principles are: *act ethically and responsibly, advocate for biodiversity, advance product stewardship, create a great work environment, drive modern agricultural innovation, engage communities and society, foster collaboration and transparency, improve global food and nutrition security, reduce our environmental impact* (MONSANTO, 2017:5). Therefore, there is a clear intention to connect agricultural innovation and technology with societal challenges such as food security, environmental protection, biodiversity as well as ethical concerns. This move of agri-multinationals is often considered as an example of incremental change or even, worse, of 'greenwashing' (e.g. SCANLAN, 2013). However, for instance, SZEKELY and STREBEL (2012) consider the Unilever's transformation of its tea supply chain for its Lipton brand to certified sustainable tea as an example of 'radical innovation'. In fact, Unilever entered into a partnership with the Rainforest Alliance (RfA) to certify tea supplies focusing on the areas of environmental protection, employee welfare and farm management. This shows clearly the divergences in opinions regarding sustainability transitions in the agro-food arena. In fact, there are several contending paradigms and narratives about sustainable agriculture and way to achieve it (VAN DER PLOEG, 2009; LEVIDOW, 2011; ELZEN *et al.*, 2017). A clear example of these contending agendas about agricultural innovation are the '*life sciences & global value chains*' (see, knowledge-based bio-economy) and '*agroecology & agro-food-energy relocalisation*' in the EU (LEVIDOW, 2011).

Sustainable intensification (e.g. GARNETT *et al.*, 2013) is a good example to show diversity of visions, agendas and perspectives regarding sustainable agriculture. It clearly shows trade-offs not only between productivity and sustainability aspirations but also between innovation (that ideally should help improving, simultaneously, both productivity and sustainability) and sustainability. Sustainable intensification agendas promote a 'toolkit' of various options and techniques for reconciling higher productivity with environmental sustainability. The orthodox consensus on 'technological intensification' has been

challenged by a variety of concerns such as environmental protection, animal welfare, and food quality and safety (LOEBER and VERMEULEN, 2012). Nevertheless, some agri-companies have seized the 'sustainable intensification' momentum to rebrand their products as sustainable intensification tools (CONSTANCE *et al.*, 2016). In fact, the *neoproductivist* agenda (e.g. ALMÁS and CAMPBELL, 2012) has been widely articulated under a sustainable intensification approach that encompasses various agroecological but also even biotechnological methods to increase yield, while also lowering the burdens on the environment (GARNETT and GODFRAY, 2012). In some contexts, the sustainable intensification toolkit is reduced to only biotechnological solutions such as GM crops (YOUNG, 2013). Meanwhile, counter-hegemonic global food movements embrace agroecology and community-based food systems. They promote a concept of 'eco-functional intensification' (NIGGLI *et al.*, 2008). However, there are also some attempts to reconcile these two opposed agendas. For instance, a report from the Rural Investment Support for Europe (RISE) mentioned six systems to achieve sustainable intensification (BUCKWELL *et al.*, 2014): agroecology, biodynamic, organic, integrated, precision farming and conservation agriculture. Similarly, in the European Union, where mainly capital-intensive technological innovation is emphasized, agroecology has been promoted as a different kind of practice that combines know-how, organizational, social and technological innovation (IFOAM EU GROUP *et al.*, 2012). Disagreement about model of agriculture that allows reconciling productivity (cf. innovation) and sustainability (especially environmental one) was evident during the setting up of the European Innovation Partnership (EIP) for Agricultural Productivity and Sustainability (EIP-AGRI). In the end, the Strategic Implementation Plan of EIP-AGRI encompassed different approaches such as sustainable intensification, organic farming, low-external input systems (EIP-AGRI, 2013).

The attempt to show at least an apparent compatibility and harmony between productivity (see, technological innovation) and sustainability in agriculture is somehow exported to other world regions such as Sub-Saharan Africa. For instance, four different pathways to sustainable intensification of agri-food systems in Africa were identified in the PROIntensAfrica project (a Horizon 2020 coordination and support action): conventional agriculture pathway, eco-technical pathway, agroecology pathway, and organic agriculture pathway (PROIntensAfrica, 2017).

Generally speaking, some alternative agro-food movements (e.g. food sovereignty, Slow Food, agroecology) have a critical attitude towards innovation (especially technical/technological one) while others (e.g. organic agriculture) have evolved towards a more accommodating position. In the manifesto *'Food Sovereignty: A Future Without Hunger'*, presented by Via Campesina at the 1996 World Food Summit (VÍA CAMPESINA, 1996), there is no reference to innovation. This clearly shows a critical attitude towards innovation of this peasant movement. However, access to technology by peasant families, especially women, is stressed. In the Declaration of Nyéléni (NYÉLÉNI, 2007), food sovereignty movement did again no reference to innovation, be it technical or social. However, it made it clear that it is fighting against "*Technologies and practices that undercut our future food producing capacities, damage the environment and put our health at risk. Those include transgenic crops and animals, terminator technology, industrial aquaculture and destructive fishing practices, the so-called white revolution of industrial dairy practices, the so-called 'old' and 'new' Green Revolutions, and the "Green Deserts" of industrial bio-fuel monocultures and other plantations*" (p. 3). Slow Food movement pays a particular attention to the ecological, economic, social and cultural sustainability of the local agro-food systems (e.g. SLOW FOOD, 2013; PEANO *et al.*, 2014). It can be argued that the movement has a critical stance with respect to innovation and technology. In fact, references to innovation can be hardly found in the declarations of the movement (e.g. SLOW FOOD,

2008; Slow Food, 2009). The term innovation has also no place in Slow Food terminology (SLOW FOOD, 2015). The organic agriculture movement seems to have nowadays, as it was not always the case, a more accommodating attitude towards innovation. In fact, innovation is even part of the official definition of organic: *“Organic Agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved”* (IFOAM, 2010).

One of agro-food alternatives is agroecology that has been coined by scientists with the intention to open up scientific preoccupations and to contest technocratic governance of agricultural innovation, oriented towards commercial benefits, agricultural intensification and expansion of global trade (ELZEN *et al.*, 2017). Agroecology is not against innovation in general but certain types of innovation. In fact, as the Institute for Agriculture and Trade Policy (IATP, 2013) points out agroecology *“is by definition an innovative, creative process of interactions among small-scale producers and their natural environments”*. However, agroecology faces the task of challenging the dominant models of innovation in agriculture. Beside technological-scientific innovation, it embraces also know-how, social and organisational innovation forms (IFOAM EU GROUP *et al.*, 2012). Agroecology promotes social and organisational innovation as an alternative strategy across the whole agro-food chain with the aim of strengthening connection between agro-ecological farmers and consumers that support their agro-ecological innovations. These agro-ecological initiatives are variously known as short food supply chains (SFSCs) or alternative agro-food networks and they are clear examples of social innovation (GALLI and BRUNORI, 2013). Such new agro-ecologically-inspired local networks and citizen-community alliances can counterweight the dominant agri-food system (FERNANDEZ *et al.*, 2013) provided that they professionalise their skills, maintain consumer loyalty, constantly learn and continuously innovate (KARNER, 2012) thus developing genuine and sustainable local food systems.

Agro-ecological innovation is key to the transition towards sustainability in the current agro-food system (LEVIDOW, 2015). Thanks to many social and grassroots movements (e.g. La Via Campesina), the Latin American agroecology agenda (e.g. National Plan of Agroecological and Organic Production, PLANAPO, in Brazil), inspired transformational strategies elsewhere such as in Europe. Indeed, according to the EU's Standing Committee on Agricultural Research (SCAR-FEG, 2009), agro-ecological principles should be given priority in agriculture research agendas in the European Union. In this context, the European organic sector promotes agro-ecological research with the concept of 'eco-functional intensification' linking farmers' knowledge and innovation with scientific research (NIGGLI *et al.*, 2008). This new understanding of 'agro-ecological innovation' is promoted by a European alliance involving civil society organisations and farmers (ARC2020 and FRIENDS OF THE EARTH EUROPE, 2015).

Nevertheless, agro-ecological methods, but not necessarily agro-ecological principles, were adopted also by some conventional agriculture actors, such as agrochemical companies and some governments, that incorporated agro-ecological methods into 'sustainable intensification' agendas. Such a move and process was criticized by many farmers' organisations, NGOs and social movements (LEVIDOW *et al.*, 2014; ARC2020 and FRIENDS OF THE EARTH EUROPE, 2015; LEVIDOW, 2015a).

LEVIDOW (2011) explained very nicely the complicated relation between innovation and sustainable agriculture: *“Nowadays most innovations are promoted under the banner of 'sustainable development', but there are different accounts of what is to be sustained. Likewise sustainable agriculture has different accounts, so it has become an ambiguous concept – even a*



*contentious one*". Accounts of what is to be sustained include agriculture growth, natural resources, current production patterns, livelihoods, ecosystem services, communities, etc. This adds to tensions between and multiple interpretations of environmental, social and economic sustainability in agriculture.

#### 4. CONCLUSIONS

This paper argues that a better understanding of the complex and multifaceted relation between innovation and sustainability in the agro-food arena is crucial to make more effective transition towards sustainable food systems as perception towards innovation in agro-food can be an obstacle to or a lever for the deep and radical change that is needed.

It is clear nowadays that innovation is needed to foster sustainability transitions in food system from production to processing, distribution and consumption. While technical innovations are widely used and advocated for a sustainable intensification of food production, social and organisational innovations seem more relevant in the other stages of the food system as they allow improving food chain functioning and governance. However, although innovation and technological progress have had significant benefits in terms of achieving food security, relationship between innovation and sustainability is far from straightforward. In fact, the food system is for sure a contested arena where different worldviews and narratives are confronted and this applies also to innovation. Moreover, it should be highlighted that food has also a strong cultural connotation and, for that, all changes in agro-food arena are carefully scrutinised. Simply put, while many food system actors emphasize the positive role of innovation and technology in driving progress toward sustainable food systems; innovation (especially technical one) provides fertile ground for alternative agro-food movements (e.g. organic agriculture, Slow Food, agro-ecology, food sovereignty) to criticize the over-industrialization of food system. These movements seem more benign towards social innovations, especially grassroots ones, that are seen as a means to bring about the transition towards more sustainable, inclusive and equitable food systems.

Ultimately, it seems that the issue is not about questioning innovation *tout court*, but about what type of innovation should be promoted. In other words, it is not about being pro- or anti-innovation, but about addressing real, essential questions of innovation politics related to direction of change pathways in agro-food systems, distribution and equity, and diversity of options. While moving towards 'sustainable' or 'sustainability-oriented' innovation seems to be a good compromise and a step in the right direction, thus making transition towards sustainable food systems smoother and more effective, there is no doubt that this does not represent a panacea *per se* as even the concept of 'sustainability' is contested. In fact, one can always ask, a sustainable innovation for whom (as there are winners and losers in any transition or change), where (as sustainability is place- and context-specific), etc. Therefore, it can be assumed that innovation approaches need an increased dose of ethics, rules and values when they are applied to food systems and that is also true for all discourses and paradigms regarding sustainability transitions.

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