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Small-scale farmer innovation systems

A review of the current literature

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Acknowledgements

Many thanks to all those who participated in the two-day expert consultation on small-scale farmer innovation systems, hosted in Geneva by QUNO in May, 2015. The consultation brought together sixteen experts from twelve different countries to discuss drivers of small-scale farmer innovation, how collaborative partnerships can be formed between formal sector scientists and breeders and small-scale farmers, and what policies may be part of an enabling environment for small-scale farmer innovation. The objectives of the meeting were to arrive at common understandings and identify strategic leverage points for mainstreaming the concept of small-scale farmer innovation within national agricultural innovation strategies and relevant international fora. The full consultation report and agenda are available online at:

http://quno.org/resource/2015/10/small-scale-farmer-innovation-systems-report-first-expert-consultation-26-27-may

A draft version of this document was presented leading up to the consultation and experts were invited to critically examine its context, question its underlying assumptions and to affirm, amend and further qualify the knowledge gaps identified. This literature review has benefited immensely from the supplementary materials shared following the consultation. We would particularly like to thank Manuel Ruiz for his work from the earliest stages in shaping and contributing to this work. QUNO will continue to critically engage with this material in it work with small-scale farmer innovation systems moving forward.

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Tables, Boxes & Figures

Acronyms

AIS	Agricultural innovation systems
CGIAR	Consultative Group on International Agricultural Research
CoS (SIS)	Convergence of Sciences (Strengthening agricultural innovation systems)
CSO	Civil society organization
FAO	Food Agriculture Organization of the United Nations
GIAHS	Globally Important Agricultural Heritage Systems
IAR4D	Integrated Agricultural Research for Development
ICT	Information and communication technology
ICT4D	Information and communication technology for development
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
NGO	Non-governmental organization
OECD	Organization for Economic Co-operation and Development
PPB	Participatory plant breeding
R&D	Research and development
SSF	Small-scale farmer
QUNO	Quaker United Nations Office
WFP	World Food Programme

Summary and overview

This document reviews academic literature on small-scale farmer (SSF) innovation systems. Its primary objective is to bring some clarity to what has remained an abstract and elusive concept. SSF innovation systems have been described as fundamentally social phenomena — the result of interactions among social and economic actors participating in formal and informal networks (Engles 1997). Within these networks individuals and communities share and adapt local knowledge and selectively integrate 'scientific' knowledge, and develop new and better ways of managing resources and overcoming local challenges (Sanginga 2009). What this looks like in practice, however, has not been clearly defined or systematically explored. This review draws together published literature on the evolution of the concept, how on-farm innovation systems function in practice, and the roles of outside actors in supporting them.

Before delving into the literature *on* SSF innovation, Section I of this document discusses why it is important to look at SSF innovation in the first place. The majority of experimentation and adaption has taken place on-farm since the beginning of agriculture, and today the global food system continues to rely on farmers' innovation for meeting changing demands and contemporary challenges.

Section II maps out how the concept of SSF innovation systems has evolved out of critiques of the conventional technology transfer model and the limitations of agricultural innovation systems. Section III then draws boundaries (albeit imperfect and inevitably dynamic ones) around SSF innovation systems, distilled from available literature. Drawing these boundaries helps to create common understanding of what SSF innovation systems are. This represents a first step towards mainstreaming the concept within international fora and operationalizing supportive policy frameworks at national levels. Boundaries are defined by looking at:

- Who are the main and supporting actors within SSF innovation systems?
- What constitutes as SSF innovation?
- Why and/or for what ends do SSFs innovate?
- How do SSFs innovate in absence of support, with the help of innovation intermediaries, and/or in innovation platforms?
- Where and when can context-specific innovation be scaled-up and diffused?

Strategies and guiding principles for intervening actors seeking to support SSF innovation systems, without falling into engrained patterns of innovating *on behalf of* farmers, are discussed in Section IV. Intervening actors may:

- Institutionalize support for SSF innovation within their own organizations;
- Increase exposure of SSF innovative capacity.
- Supplement farmers' capacity to innovate where required.
- Provide direct financial resources to farmers for on-farm research.
- Facilitate knowledge sharing among geographically disparate farming communities.
- Conduct research to better understand relationships between national innovation frameworks and SSF innovation systems.

Throughout this document gaps in the literature requiring further research are identified. Most noteworthy of these include the following:

- Most on-farm innovation remains undocumented and invisible to formal sector scientists and academic researchers (Beckford and Baker 2007b). What is documented remains within grey literature or buried in organizations' project reports and internal documents (Wettasinha et al 2014).
- Efforts to measure on-farm innovation are still in their infancy (Läpple et al 2015), and so communicating its value in concrete terms (i.e. its contributions to food security, livelihood improvements and agroecosystem resilience) remains a challenge.
- There has been modest academic inquiry into how formal sector actors can support SSF innovation without falling into the familiar patterns of transferring new technologies to users.
- The dynamics between formal and informal innovation systems have been largely left unexplored, particularly in terms of how polices for stimulating innovation in the formal sector (i.e. intellectual property rights and trade liberalization) affect on-farm innovation.

This document calls for further evidence-based research documenting the contributions of farmer innovation towards achieving global and local food security, livelihood improvements and agroecosystem resilience.[1] Further evidence will help bring attention to the value of SSF innovation and reorientate countries' innovation strategies towards supporting SSFs in their efforts to meet their own needs and respond to emerging challenges and opportunities.

[1] The value of SSF innovation may be framed in terms of its contributions towards meeting the Sustainable Development Goals, particularly goals 1 (ending poverty), 2 (ending hunger and promoting sustainable agriculture), 13 (combating climate change), 14 and 15 (protecting marine and terrestrial ecosystems, respectively, and halting biodiversity loss).

I. Focusing on small-scale farmer innovation

Small-scale farmers (SSFs) produce most of the food that the world consumes (FAO, IFAD and WFP 2015) and are active stewards of majority of the planet's wild and domesticated agricultural biodiversity, or agrobiodiversity[2] (Amend et al 2008; Pimbert 1999), thus contributing to *global* food security now and in the future.[3] The paradox is that SSFs are often resource poor and food insecure themselves (FAO, IFAD and WFP 2015), and are undernourished with a deficient nutrient intake and/or without timely access to food year round (FAO 2014). SSFs occupy the majority of the planet's marginal lands under cultivation without access to productivity-enhancing inputs, lack access to markets and essential infrastructure, do not have secured land rights, and are vulnerable to socio-economic marginalization (FAO 2014). SSFs also tend to be disadvantaged within inequitable food chains and lack the freedom of choice to opt out of dominant food systems or to choose quality inputs (De Schutter 2014).

Overcoming vulnerability and local food insecurity requires more than increasing productive capacity — it requires increasing the capacity of farmers to meet their own needs and respond to local challenges and opportunities, as locally defined. SSFs have intimate knowledge of their natural surroundings, the expertise needed to experiment with new tools and management practices and to observe subtle changes over time, and the capacity to adapt to changing environmental and socio-economic conditions. Supporting SSF innovation means strengthening these capacities, and by extension, contributing to both local and global food security, rural livelihood improvements, and agroecosystem resilience.

> *Overcoming vulnerability and food insecurity requires more than increasing productive capacity — it requires increasing the capacity of farmers to meet their own needs and respond to local challenges and opportunities, as locally defined.*

Conventionally, agricultural innovation has been understood as an invention, output, or concrete return on investment that brings about productivity gain or other concrete, measurable improvement (Berdegué 2005). Innovation policy developed with this definition in mind naturally focuses on increasing investment in agriculture by increasing market access of private firms, securing intellectual property rights over inventions and increasing the adoption of new technologies developed *by* professional scientists *for* the benefit of farmers (see Pray 2008; Rotman 2013). Most countries have strategies for encouraging investment in science and technology,[4] and a substantial amount of investment is put towards research and development and increasing diffusion rates of outputs (OECD 2014).

[2] Agrobiodiversity is understood to include diversity at genetic, species and ecosystem levels. Humans are integral components of agroecosystems and agrobiodiversity depends upon the people who actively maintain and use it. It has both social and biological components. See http://agrobiodiversityplatform.org/.

[3] Food security is defined as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food security includes four pillars: food availability (production), food accessibility (food affordability, physical accessibility and its equitable distribution), food utilization (food safety, adequate nutrition, good health standards required for absorption, access to clean water), and food stability (sustained availability, accessibility and utilization over time) (FAO 2006).

[4] See OECD Science, Technology and Industry e-Outlook tool: http://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/stipolicygovernance/nationalstrategiesforsciencetechnologyandinnovation.htm

A broader understanding of innovation in agriculture inspires a reconsideration of the type of policy measures that are needed to nurture and support it.

More recently, the scope of what is considered agricultural innovation has broadened (Spielman et al 2009; Kraemer-Mbula and Wamae 2010). It has become more widely understood as a *process* that is inherently social in nature. Individuals and communities in specific localities share and adapt local knowledge, selectively integrate 'scientific' knowledge, and develop new and better ways of managing resources, responding to opportunities and overcoming local challenges (Sanginga 2009). A broader understanding of innovation in agriculture inspires a reconsideration of the type of policy measures that are needed to nurture and support it.

The critical role of farmers in innovating to meet growing and changing demands and challenges of the global food system has not yet been widely acknowledged within international fora or institutions and organizations relating to innovation in agriculture, particularly with regards to intellectual property and agricultural trade. While aspects of SSF innovation systems (e.g. Traditional Knowledge, Farmers' Rights and Access and Benefit Sharing) are recognized within international fora relating to agrobiodiversity (i.e. the International Treaty on Plant Genetic Resources for Food and Agriculture and the Convention on Biological Diversity), an appreciation for farmer innovation has not yet been made explicit.

This document represents a first step towards understanding and operationalizing support for SSF innovation systems. This is part of the QUNO Food and Sustainability Program's effort to shift the discourse within international fora to include a broader definition of innovation in agriculture and to support national governments to undertake measures that support SSF innovation.

II. Evolving understandings of innovation in agriculture

This section maps out three ways of understanding innovation in agriculture, as it is discussed in the literature (summarized in Table 1). The first is the conventional technology transfer model, where new technologies are developed within and disseminated by formal institutions to farmers (innovation *for* farmers). The second is the innovation systems perspective, where innovation is viewed as process rather than output, and the result of complex interactions among actors in a particular context. Here knowledge is 'co-produced' by formal institutions and farmers (innovation *with* farmers). The third is the endogenous innovation perspective, where farmers themselves are recognized as having immense capacity to innovate while all other actors play supporting roles (innovation *by* farmers).

Table 1: Three ways of understanding innovation in agriculture

	Conventional agricultural innovation	**Agriculture Innovation System (AIS)**	**SSF innovation system**
Innovation is a(n)…	Output	Process	Process
Primary actors	Formal institutions and organizations	Formal institutions and organizations (while unpredictability limits complete control)	SSFs, supported by other actors
Role of formal sector	Innovate and facilitate technology transfer	Facilitate research process and technology adoption	Provide resources and facilitate knowledge sharing
Role of farmers	Adopt new technologies	Participate in innovation process	Innovate and adapt
Types of innovation	Modern varieties and farm management practices	Modern varieties, farm management practices and alternative ways of organizing	Adaptation of modern varieties and practices, integration of knowledge systems, on-farm experimentation
Major themes in the literature	Investment in R&D, improving technology transfer	Investment in R&D and extension service, multi-stakeholder platforms, participatory research	Innovation as a social learning process, building social capital, roles of supporting actors
	Innovation for SSFs	***Innovation with SSFs***	***Innovation by SSFs***

Views differ in terms of who has capacity to innovate and how innovation in agriculture is best supported. Coudel (2013) reminds us that new agricultural models do not displace old ones, but coexist with them as they are gradually implemented more and more on the ground. The dominant strategy today remains innovating *for* farmers; innovating *with* farmers has become mainstream discourse; and a greater appreciation of innovation *by* farmers is still emerging.

2.1 The technology transfer model

Scholarship in agricultural innovation was born out of a neo-classical economic tradition. This tradition holds that there is a positive and linear relationship between investment in research and development (R&D) and the dissemination of good and services of social value (Hall et al 2001a *in* Berdegué 2005). Simply put, investment spurs innovation, which benefits society. Schumpeter (1934) first wrote that innovation grants an entrepreneur an advantage over his competitors and thus the ability to generate profits. Innovation became synonymous with an invention that had market value; an output in a production system.

The dominant strategy today remains innovating for farmers; innovating with farmers has become mainstream discourse; and a greater appreciation of innovation by farmers is still emerging.

The 'technology gap' theory asserts that technology growth rates have a direct and positive impact on economic growth rates, and thus lagging economies can 'catch-up' by exploiting knowledge already created by more advanced economies and bring themselves up to the technology frontier (Fagerberg, 1987; Abramovitz, 1986). The 'technology gap' is closed when governments invest in R&D to bring about economic development through technological change (Kraemer-Mbula and Wamae 2010). In agriculture, societies throughout the past two centuries have ambitiously created organizations and institutional arrangements in order to increase technological innovation, following this logic (Engel 1997).

Agricultural innovation most often refers to farmers' adoption of new technologies. Rogers' theory on diffusion of innovations (Rogers 1962) is still dominant view of how innovation in agriculture benefits society (Waters-Bayer et al 2009). During the Green Revolution, the focus was put on developing modern varieties with higher yields and disseminating more efficient and productive farming practices (Pingali 2012). Today, the focus is on developing modern varieties with a wider range of desired traits such as improved nutrition and adaptations to new environmental stresses, particularly for withstanding predicted climate change scenarios, and on developing new farm management practices that are less resource-intensive, following the 'sustainable intensification' movement (see Godfray et al 2010). Regardless of how current challenges are framed, the same logic prevails: farmers are required to adopt more productive, profitable and resource-efficient technologies developed within and disseminated by formalized institutions for innovation (see Shiferaw et al 2009; Dogliotti et al 2014; Anandajayasekeram and Gebremedhin 2009).

A large body of literature couched in this paradigm focuses on private firms' incentives to invest in science and technology. Drivers of innovation include growing international markets for agricultural products and inputs, reduced restrictions on trade, growth in demand due to increased income, extension services to help facilitate technology transfer, investment in science and technology, and increased capacity for investors to appropriate gains from investment due to strengthened intellectual property rights (Pray 2008). Investment in science and technology and market liberalization will, it is argued, result in greater food security for SSFs and the broader society and contribute to the gradual alleviation of poverty among poor farmers (Rotman 2013).

The role of the private sector vis-a-vis the public sector in this pursuit is growing. Over the past few decades many countries have changed the way they fund public sector investment and incentivize private sector investment, leading to shifting patterns of spending in R&D in agriculture (Pardey et al 2006; Conway 2012).

A second body of literature focuses on increasing technology transfer by studying the characteristics of 'early adopters' and, more recently, incorporating farmers' needs and preferences into breeding targets. This has inspired interest and investment in participatory plant breeding (PPB) which seeks to make new technology more relevant and applicable to end users (Chambers et al 1989; Scoones et al 1994). Varying degrees of participation — according to the roles of farmers and the stage and degree to which they participate in the process and influence decisions — make farmers more or less passive in this exchange (Sperling et al 2001).

Box 1: Technology transfer remains the dominant strategy

Technology transfer remains the primary vehicle for sharing the benefits arising from the use of plant genetic resources for food and agriculture with farmers in developing countries. The Governing Body of the FAO International Treaty for Plant Genetic Resources for Food and Agriculture (the Treaty) has called upon Contracting Parties and all relevant stakeholders to improve technology transfer (Resolution 4/2011), emphasizing the role of technology and utilization of modern tools for achieving food security. A Platform for the Co-Development and Transfer of Technologies is now being created to help mobilize resources and facilitate technology transfer initiatives and projects that benefit developing countries (ITPGRFA 2013).The Treaty's funding mechanism for in situ conservation — the Benefit-Sharing Fund of the Multilateral System — is also orientated towards technology transfer. The 2014 Third Call for project proposals for the Benefit-Sharing Fund highlights information exchange, technology transfer and capacity-building as the first of three priority funding areas, followed by on-farm conservation and sustainable use of plant genetic resources, respectively. Key expected outputs include the introduction and dissemination of new varieties from public and private breeding programmes and the increased adoption of new varieties through participatory breeding methods with farmers (ITPGRFA 2013).

The conventional understanding of innovation as linear technology diffusion has been criticized for:

- Not reflecting the complexity of agricultural systems in practice (Röling 1992; Engel 1997; Spielman et al 2009; Coudel 2013; Smith et al 2014);
- Bringing limited benefits to farmers (Wettasinha et al 2014; Hounkonnou et al 2012);
- Ignoring the distributional and equity issues relating to innovation (Hall et al 2001a *in* Berdegué 2005); and
- Contributing to current problems relating to the sustainability of agriculture, erosion of traditional and indigenous knowledge including gendered knowledge, biodiversity loss and the degradation of natural resources (Engel 1997; Waters-Bayer et al 2009).

These critiques have gradually moved discussions away from innovation as a driver for economic growth towards a more a more holistic view of innovation as a process of social transformation (Kraemer-Mbula and Wamae 2010).

2.2 Agricultural innovation systems

The agricultural innovation systems (AIS) perspective has caught on rapidly among academics and research organizations. AIS applies complex systems theory to conventional agricultural innovation studies, pioneered by Hall and Clark (1995), Engel (1997) and Hall et al. (2001, 2003). Innovation has since become more widely understood as a social process embedded within complex systems, requiring scholars to study the milieu in which innovation occurs (Spielman et al 2009).

AIS is defined as a system that brings together actors from the public, private and civil sector to bring new products, processes and organizational forms into economic use, together with institutions and policies that affect how actors interaction and how knowledge is used and exchanged (World Bank 2006). The key divergence from the technology transfer approach is that innovation is understood as a process rather than an output, whereby technological developments are combined with new institutional and organizational arrangements (Yang et al 2014). Technology transfer alone does not translate directly to productivity gains or other desired improvements. Improvements are contingent upon constantly changing relationships among actors and evolving ecological, technological, cultural, social, economic and political environments (Spielman et al 2009; Kraemer-Mbula and Wamae 2010).

Managing innovation systems requires understanding of how knowledge is exchanged and how institutional and technological change occurs (Anandajayasekeram and Gebremedhin 2009). No one actor, regardless of how much relative power they have, can exercise complete control over a system. Likewise, policies put in place to manage systems cannot do so with complete certainty (Axelrod 1999 *in* Spielman et al 2009). This represents a substantial epistemological departure from the neo-classical view of innovation as a linear, input-output model of agricultural development.

The scope of innovation is also expanded beyond new technologies and farm management practices to include new ways of organizing (Ton et al 2015). Examples include markets, labour, land tenure and distribution of benefits (Adjei-Nsiah et al 2008; Dormon et al 2004; Pamuk et al 2014). Essential supports for AIS include financial support for formal research, extension services and business development organizations (Hall et al. 2007; Wongtschowski et al. 2010; Ton et al 2014), access to credit and market facilities and improved infrastructure, and increased coordination both within and between groups of actors at the individual, community and institutional levels (FAO 2014).

AIS literature focuses on engagement with farmers as a means of increasing the relevance and applicability of innovation. There is widespread consensus that farmers need to have greater influence over the entire research process supporting innovation (Douthwaite 2002; Klerkx and Leeuwis 2008; Klerkx et al. 2006; Neef and Neubert 2011; Poulton et al. 2010; Ton et al 2015). Organizations are under pressure to more actively engage with SSFs in order to make their research more accessible to farmers and for it to more accurately reflect their needs (Wettasinha et al 2014), and more are adopting AIS language to describe their work (see FAO 2014, World Bank 2006; 2012).

This does not, however, automatically lead to change in practice. There remains a heavy emphasis on the role of institutions and organizations introducing innovation to farmers and facilitating technology adoption (Kraemer-Mbula and Wamae 2010). Technology itself is more broadly understood to include tools, farming practices or methods of organizing, but its transfer remains the most common strategy for pursuing agricultural development in practice. Smith et al (2014) explain that it is difficult for organizations, even those supporting social entrepreneurship,[5] to shed the deeply embedded tradition of developing generic technologies to be applied to context-specific problems. Engrained sets of habits, beliefs and rules within institutions and interactions influence how knowledge flows through innovation systems (North, 1990; Edquist, 1997).

While technology itself is more broadly understood to include tools, farming practices or methods of organizing, its transfer remains the most common strategy for pursuing agricultural development in practice.

Kraemer-Mbula and Wamae (2010) argue that while SSFs have been made the target beneficiaries of investment in science and technology, and investment has been re-orientated towards making production systems more ecologically sustainable, these changes do not represent transformative shifts in perspective. The significance of farmers' role in innovation processes remains largely unacknowledged and the asymmetrical power relationship between formal and informal actors remains unchanged (ibid). Wettasinha et al (2014) point to the divide between "the worlds of formal and informal agricultural research and development" that needs to be bridged in order to arrive at more useful and sustainable outcomes for smallholders (pp.12). In essence, the process of innovation is now practiced *with* farmers, but the direction of the flow of knowledge and expertise has not changed directions. Spielman (2009) adds that few AIS studies examine distributional and poverty-related effects of innovation and very few are focused on technological or institutional change that is explicitly pro-poor.

[5] Social entrepreneurship is understood as a model for business in which the primary goal is social change through the development of *social technologies*, secondary is market sustainability. Community ownership is essential but outside intervention can enhance efforts (Cozzens and Sutz 2012). Social technologies are defined as community-based on grassroots innovations where the main driver is to make life better rather than for profit (Dagnino 2010 *in* Cozzens and Sutz 2012).

Box 2: Agricultural innovation systems have entered into dominant discourse

> *The FAO 2014 report on innovation in family farming comes from an AIS perspective. While family farmers are understood to be integral components of innovation systems, they are the beneficiaries rather than originators of innovation. Synthesized, the supports required for innovation systems to flourish are 1) research and development to develop new technologies; 2) extension and advisory services to increase uptake of new technologies; 3) producer organizations to link farmers with markets and financial services such as credit schemes; and 4) a national-level regulatory framework that encourages public and private sector investment in agriculture and increases links to international markets through trade policies and investing in market-related infrastructure. While these supports are meant to benefit family farmers, this list does not mention farmers' abilities to innovate themselves.*

2.3 Small-scale farmer innovation systems

The SSF innovation systems perspective represents a merger between AIS and development studies. SSF innovation systems are understood as social phenomena in which individuals and communities in a specific locality share and adapt local knowledge, integrate scientific knowledge, and develop better ways of managing resources and overcome local challenges (*adapted from* Sanginga 2009). Fundamental to the concept is that farmers have the capacity to innovate, experiment and adapt, and are viewed primarily as innovators themselves rather than implementers of innovation. Farmers' innovation systems are recognized as fundamentally unique from formal sector innovation systems.[6]

> *Fundamental to the concept is that farmers have the capacity to innovate, experiment and adapt, and are viewed primarily as innovators themselves rather than implementers of innovation.*

SSF innovation systems are understood to be synonymous with:

- Embedded innovation processes (Van Rijn et al 2012);
- Farmer-led innovation systems (Wettasinha et al 2014);
- Local innovation systems (Innovation Africa is this Sanginga 2009?);
- Informal innovation systems (Cozzens 2012);
- Micro-level innovation (Läpple et al 2015);
- Demand-driven innovation (von Hippel, 2005, 2007; Kraemer-Mbula and Wamae 2010); and
- Grassroots or bottom-up innovation systems (Seyfang and Smith, 2007; Smith et al 2014).

[6] The 'formal' sector is understood to include both public and private institutions and organizations with the mandate of improving agriculture through the advancement of science and technology, investment in R&D and extension services. These actors are generally orientated towards scale and efficiency, have greater access to resources and a more dominant presence within policy fora regarding innovation in agriculture.

SSF innovation is conceptually distinct from pro-poor innovation systems (Berdegué 2005) and inclusive innovation systems (Swaans et al 2014), where SSFs are the primary beneficiaries of innovation and incentives are at times used to increase farmer participation in the innovation process.

SSF innovation systems are both a resource for responding to new opportunities and a coping mechanism for responding to the challenges faced by vulnerable populations in absence of outside support. As such we believe they need to be brought to the forefront of discussions regarding sustainable agriculture, poverty alleviation and global food security.

This body of literature emphasizes farmers' immense capacity to innovate. Farmers are active, understand the impacts of their own practices, and are both sources and users of knowledge and information in agriculture (Engel 1997). They are knowledgeable, skilled, motivated and empowered to develop technologies suited to their circumstances and farming objectives (Hounkonnou et al 2012). They experiment continually and are highly capable of innovating to solve problems (Scoones and Thompson 1994; Chambers 1989 1990; Chambers et al. 1989 in Beckford and Baker 2007). Waters-Bayer et al (2009) assert that the most original ideas and successful local adaptations of modern varieties have been done by farmers in the absence of formal research and extension support. Other actors may support SSF innovation systems through a process of 'co-generating' or 'co-producing' knowledge, going through iterative cycles of action and reflection (Waters-Bayer et al 2007).

Over the past three decades the international community has begun to pay attention to farmers' innovation (Wu and Zhang 2013). The concepts of 'social learning', 'co-learning' and the integration of knowledge systems among farming, indigenous and scientific communities entered into agricultural development discourse following the appropriate technology movement in the 1970s, the People's Science Movement in India in the 1980s and the social inclusion movement in Latin America (Seyfang and Smith 2007; Wu and Zhang 2013; Smith et al 2014).

Recent works bring explicit attention to SSF innovation systems. Foremost of these are 'Innovation Africa' (Sanginga 2009), 'Farmer First Revisited' (Scoones and Thompson, 2009), 'Action Research in Partnership' by Faure et al. (2010), and 'Renewing Innovation Systems in Agriculture and Food' (Coudel 2013). These scholars emphasize the need for collaborative partnerships to be made between farmers and the formal sector institutions and organizations in agriculture that go *beyond* a participatory approach to where supporting farmers' innovation becomes the impetus for collaboration.

A handful of studies have attempted to measure innovation at the farm level (Diederen et al 2003; Karafillis and Papanagiotou 2011; Ariza et al 2013; Wu and Zhang 2013; Läpple et al 2015). This work is summarized in Section *4.2.5. Adoption of exogenous innovation*. These scholars recognize that measuring innovation in agriculture by quantifying investment in formal sector R&D and extension services insufficiently captures innovation on the part of farmers. However, the vast majority end up focusing their recommendations on how to increase technology adoption rates among farmers rather than on how to support innovation *by* farmers. As explained by Läpple et al (2015), measuring innovation that goes on outside of formal sector is still in its infancy and there remain challenges to quantifying what remains an elusive concept.

Practical examples of SSF innovation have been documented. Examples include:

- Gupta et al (2003) document the work of the HoneyBee Network in India;
- Smith et al (2014) and Miranda (2011) describe the Social Technology Network (RTS, *Rede de Tecnologia Social*) in Brazil;
- Waters-Bayer et al (2009; n.d working paper) highlight the ongoing work of the Promoting Local Innovation in ecologically oriented agriculture and natural resource management (Prolinnova) initiative;
- Wettasinha et al (2014) study a series of farmer-led research initiatives jointly supported by the CGIAR Research Programs on Aquatic Agricultural Systems (AAS) and on Climate Change, Agriculture and Food Security (CCAFS) and Prolinnova; and
- The World Overview of Conservation Approaches and Technologies (WOCAT) hosts databases and publications on sustainable land management practices and adaptation measures, many of which have their roots in traditional farming practice from around the world.

These studies also provide evidence for how endogenous innovation can co-exist with, and be supported by, existing institutional arrangements in agricultural innovation.

On the whole, however, relatively little attention has been given to farmers' capacities to experiment and adapt to meet their own needs (Waters-Bayer et al 2009). Lorentzen (2010) reports that the majority of research in agricultural innovation focuses on formal organizations rather than on individuals, households and communities as the principle units of analysis. As a result there lacks a systematic research agenda concerning the innovation of the 'bottom billion'. 'Informal' innovation processes are rarely documented in peer-reviewed journals and are thereby difficult to access. Most documentation remains in project reports, civil society organizations' websites and less academic-oriented literature such as magazines (Wettasinha et al 2014).

The majority of research in agricultural innovation continues to focus on formal organizations rather than individuals, households and communities as the principle units of analysis (Lorentzen 2010).

SSF innovation remains largely unrecognized by academics for two reasons. First, farmers do not attach their names to innovations nor apply for patents, write scientific papers on their discoveries or otherwise document their work (Rhoades 1989). This is even more so the case when it comes to traditional roles of women in farming communities (Momsen 2007). Second, farmers are generally viewed as passive recipients rather than originators of technologies (Beckford et al 2007; Chopra 2014; Waters-Bayer et al 2009). This follows a tradition of farmers being depicted as ignorant, resistant to change, bound by tradition and lacking in innovative capacity (Chambers et al 1989; Rhoades 1989; Beckford et al 2007). As a result, farmers themselves often view their role as receivers of technology and instructions rather than having something valuable to offer (De Leener 2001a,b *in* Waters-Bayer et al 2009).

Olwig (2012) adds that it is increasingly difficult to discern what constitutes a local agency to innovate as global organizations play an increasingly visible and powerful role in participatory research (innovation *with* SSFs). Here there is a risk that organizations supporting SSF innovation systems may inadvertently detract from farmers' own perceptions of their abilities, thereby limiting their innovative potential (ibid).

Progress has been slow in terms of integrating SSF innovation into organizational practice. Smith et al (2014) contend that grassroots innovation rarely features in policy discussions within formal scientific, technology and innovation communities, and innovation policies remain focused on rent-seeking firms developing new technologies for increasingly globalized markets. 'Best practice' is considered fostering relations among science and technology institutes and firms and providing incentives for firms to invest in innovation activities (citing OECD 2010), for the ends of closing the age old 'technology gap' (Smith et al 2014).

It is foreseeable that the growing recognition of SSFs' *adaptive capacity* will translate into a wider appreciation for their *innovative capacity* in the coming years. There is considerable overlap between the concepts of innovation and adaptation (see Section 3.2.4 *Adaptation to environmental and market stress).* Particularly within the burgeoning field of agroecology, farmers' adaptive capacity in terms of their ability to experiment with new varieties and management practices to suit changing growing conditions is garnering attention (see for example Tittonell et al 2012). There is also evidence of climate change spurring novel partnerships between farmers and formal sector research and development organizations, an example of institutional innovation (see for example Chhetri et al 2012; Chhetri and Easterling 2010).

III. SSF innovation systems: Identifying system boundaries

Understanding SSF innovation as a ‘system’ requires identifying what such a ‘system’ includes and what is excluded (Engles 1997). This section draws boundaries around SSF innovation systems in order to facilitate shared understanding and move towards operationalizing support for them at national and international levels. Boundaries are imperfect, dynamic and highly context-specific:

- Who main and supporting actors are.
- What constitutes as SSF innovation.
- Why / for what ends SSFs innovate.
- How SSF innovate in absence of support, with the support of innovation intermediaries, and as participants in innovation platforms.
- Where and when context-specific innovation may be scaled-up and diffused.

3.1 Who are the main and supporting actors?

The main actors in SSF innovation systems are farmers themselves, including informal networks among farmers, grassroots farmers’ organizations and cooperatives.

Many SSFs are considered ‘resource-poor’, falling below the minimum requirements for access to credit which in turn limits access to inputs and markets (Wettasinha et al 2014). Wettasinha et al (2014) report that these farmers in particular, with less access to inputs and less well-connected to extension services, innovate using locally-available resources to meet local needs. Women, who make up a disproportionate share of resource-poor farmers, are widely recognized as local and traditional knowledge holders and are particularly active with regards to on-farm experimentation with varieties with post-harvest qualities and nutritional and cultural value (Howard et al 2008). Many SSFs have diversified livelihood strategies combining subsistence and commercial farming with participating in other goods and service industries to protect themselves against low market prices and price volatility (FAO 2014).

Not all SSFs are innovators and there are degrees of participation and involvement of SSFs in local innovation processes (Wettasinha et al 2014). Waters-Bayer et al (2009) point out that the farmers who demonstrate or ‘model’ introduced technologies are more commonly referred to as ‘innovative’, while others may be the more creative problem solvers.

Supporting actors are not primarily innovators but influence the innovation system.[7] They include formal institutions and organizations for agricultural policy, research and development and extension services, whether they are publicly funded programs, private sector investments or academic research initiatives. Stakeholders in related sectors or industries, and those at various points along agri-food value chains are also considered supporting actors.

Civil society organizations (CSOs) and non-governmental organizations (NGOs) may be considered main or supporting actors depending upon specific circumstance, their relationships with farmers and formal

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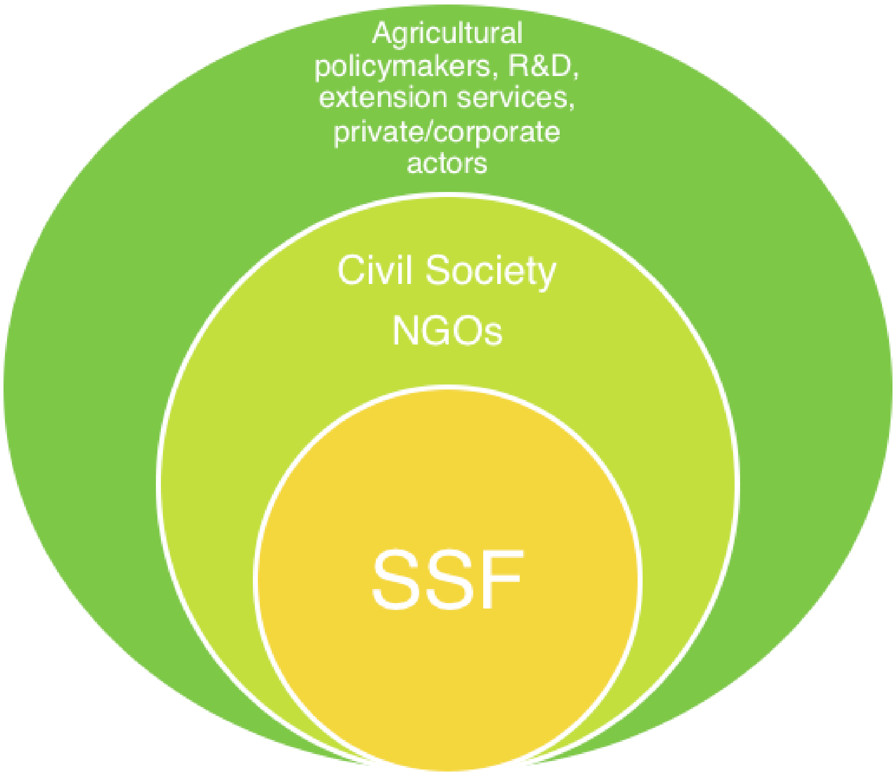
[7] Engles (1997) and Kramer and de Smit (1987) recommend differentiating between inside (main) and outside (supporting) actors in this way in order to understand the functioning of an innovation system.

institutions involved, and internal organizational structure, vision and mandate. The role of CSOs and NGOs as 'innovation intermediaries' facilitating interactions between SSFs and other actors is discussed in Section 3.4.2.

Figure 1: Main and supporting actors in a SSF innovation system



The SSF innovation system perspective narrows-in on innovation at the smallest-scale, recognizing that the ideas and voices of key players operating at this level are often unheard when amalgamated into this much larger whole.

By comparison, the AIS perspective has drawn the widest boundary possible. Every stakeholder, institutional arrangement, process and social and natural phenomenon that influences or is influenced by innovation in agriculture is taken to be part of the whole (see for example, World Bank 2006). Wu and Zhang (2013) warn that differences in values, interests and attitudes between farmers and other stakeholders, as well was communication barriers, are underestimated in multi-stakeholder partnerships focused primarily on knowledge sharing. The SSF innovation system perspective narrows-in on innovation at the smallest-scale, recognizing that the ideas and voices of key players operating at this level are often unheard when amalgamated into this much larger whole. Choosing this scale of analysis does not ignore the broader context in which innovation occurs, but rather brings to the forefront questions surrounding how the broader context affects innovation at the farm level.

Particularly when discussing partnerships between SSFs and formal institutions and organizations, the line between main and supporting actors quickly becomes blurred. The key point from the SSF innovation perspective is that farmers need to be kept in focus when studying innovation in agriculture.

3.2 What is considered SSF innovation?

Wu and Zhuang (2013) define farmer innovation as any technology, invention or improvement made by rural people to cope with the complexity of local resource, ecological, economic and social conditions (citing Chambers et al 1989; Biggs 1990; Wortmann et al 2005). What this looks like in practice is inevitably as diverse as farming systems are themselves. Coudel (2013) emphasizes that innovation systems take different forms depending on what country they are in, whether agriculture is capital intensive and there is high consumption of inputs, and whether farmers have access to these resources.

Broadly defined, the 'what' of SSF innovation includes both tangible **outcomes** (e.g. new techniques and technologies) and **processes** for arriving at tangible outcomes (e.g. new ways of organizing). Table 2 summarizes the types of innovation discussed in this section.

Table 2: What is considered SSF innovation?

4.2.1	Technical and institutional change	Outcome
4.2.2	The application of traditional knowledge to current circumstance	Process
4.2.3	The maintenance, development and use of agrobiodiversity, cultural diversity and the diversity of farm management practices	Outcome and process
4.2.4	Adaptation to climate change and other environmental and socio-economic stresses	Process
4.2.5	The adoption of outside (exogenous) innovation to suit local needs and resource endowments	Process

3.2.1. Technical and institutional change

Innovation refers to both technical and institutional processes of change (Sanginga 2009). Röling (2009) highlights the difference between on-farm *technical* innovation that leads to productivity gains or other measurable impact in terms of sustainability or poverty alleviation, and *institutional* innovation (relationships among actors) that leads to opportunities for increasing the scale of impact by spreading innovations over larger areas and achieving longer term impacts. The two types of innovation are mutually reinforcing — technical innovation can inspire institutional innovation, and institutional innovation can create conducive environments for technical innovation to emerge (ibid).

Using a similar typology, Wettasinha et al (2014) differentiate between "hard" bio-technical innovation that is the focus of most interventions and "soft" socio-institutional innovation that happens on-farm during participatory farmer-led research initiatives. Soft innovation refers to the more subtle inner-workings of social networks and relationships that cannot be ignored in the context of problem solving. SSFs working in groups and networks respond to heterogeneous needs within communities relating to a wide array of topics, while sustaining communication channels after an intervention has ended. Soft innovations are commonly low-cost, low-risk innovations that are not easily recognized by formal research and development actors, but which bring 'early wins' and increased motivation among farmers to experiment and engage in the research process. Supporting soft innovation requires researchers and scientists to spend time with farming communities and engage in "action-reflection-learning-action" processes. They may then witness the socio-institutional change that is inspired by and/or accommodates bio-technical innovation (ibid: 142).

Soft innovation refers to the more subtle inner-workings of social networks and relationships that cannot be ignored in the context of problem solving. SSFs working in groups and networks respond to heterogeneous needs within communities relating to a wide array of topics, while sustaining communication channels after an intervention has ended.

The HoneyBee Network in India has documented more than twenty thousand examples of technical innovation of small farmers, women and artisans across India and beyond, supported by the Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) and the National Innovation Foundation (Gupta et al 2003). Examples include small machinery, herbal pesticides, veterinary medicines, new plant varieties, agronomic practices and many other products (ibid).

Wettasinha et al (2014) cite the development of a platform for handling of resource-use conflicts as one example of soft innovation. Rodima-Taylor et al (2012) study how informal associations for economic cooperation facilitate climate change adaptation among rural communities in Tanzania, an example of socio-institutional innovation. Associations regulate access to cash, manage income diversification and facilitate participation in local governance decisions. The authors assert that they are becoming increasingly important for adaptation across Africa by facilitating collective experimentation and risk management, and contributing to the sustainability of socio-ecological systems by facilitating collaborative resource management.

3.2.2. Application of local knowledge to current circumstance

Local knowledge is here understood as synonymous with traditional knowledge. Knowledge is 'traditional' only in the sense that it is developed outside of formal education systems, is specific to socio-cultural contexts and has tended to be transmitted orally rather than being written down (Beckford and Baker 2007). Local knowledge systems are not a static collections of ways of being and doing, but rather dynamic bodies of know-how, practices and skills used over time that provide framework for decision making among rural peoples (Scoones and Thompson 1994). Put differently, local knowledge systems are entirely contemporary. They facilitate continual adaptation to changing environmental and socio-economic conditions (Chambers et al. 1989; Beckford and Baker 2007; Sanginga 2009; Beckford et al 2007), and allow people to cope with immediate problems and develop pragmatic and contextually-relevant solutions (Smith et al 2014).

Local knowledge includes environmental and ethnobotanical knowledge, a history of what has worked under what conditions, as well as knowledge of how to combine local knowledge with scientific knowledge (Beckford and Baker 2007). It extends beyond 'technical' knowledge to include insights, wisdom, ideas, perceptions and innovative capacities (Thrupp 1989), and is generated through lived experience (Beckford and Baker 2007). Farm management reflects generations of observation within very specific niche environments to suit the nutritional and cultural requirements of local people (Eyzaguirre 2001 *in* Beckford and Baker 2007; Thrupp 1989). Local knowledge informs choices of farming techniques, soil management practices, pest control, crop selections, rotations and crop combination within specific niche environments, and tends to be highly sophisticated in the case of specific crops important to household food security and income (Beckford and Baker 2007).

The presentation of local knowledge as 'pristine' or inherently ecologically sustainable may be problematic if it has the effect of dismissing contributions from conventional science without discretion.

Authors caution against the romanticization of traditional/local knowledge. Briggs (2005) warns that it is unrealistic to expect that it will always provide sustainable solutions to local problems. Thrupp (1989) write that not all resource-poor individuals have the capacity to transfer local knowledge related to environmental and socio-economic conditions, or to innovate based on this knowledge; and local knowledge is not always 'in balance' with natural environments and can become inappropriate in the face of rapid socio-economic or environmental changes. The presentation of local knowledge as 'pristine' or inherently ecologically sustainable may be problematic if it has the effect of dismissing contributions from conventional science without discretion (Briggs 2005). Scientific and local knowledge systems are complementary when applied within specific economic and socio-cultural contexts. The aim is not to romanticize local knowledge, but to give it due credence as a source of appropriate examples that are contextually useful.

3.2.3. Maintenance, development and use of diversity

Diversity in its many forms provides the inputs to further innovation. Agrobiodiversity encompasses biodiversity at the genetic, species and ecosystem levels, as well as cultural diversity including culinary traditions and traditional knowledge systems found within farming communities. The diversity of farm management practices employed by SSFs encompasses both traditional practices that have evolved (and continue to evolve) within particular contexts and the integration of new practices that prove beneficial.

Few scholars explicitly highlight how the active maintenance, use and development of diversity relates to innovation. The conservation of plant genetic resources is widely understood as necessary for future variety development, but historically the role of SSFs as innovators in its development has gone unrecognized. The role of SSFs as managers of dynamic agricultural systems often goes unnoticed (Clapp 2014; Bragdon and Rodgerson 2014; Foresight 2011). The global public goods provided by SSFs in terms of the maintenance of key genetic resources and their contribution to the development of new varieties, food production, soil conservation and sharing of agro-ecological knowledge and practices are also largely unaccounted for.

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There are noteworthy exceptions to this. The FAO Globally Important Agricultural Heritage Systems (GIAHS) Programme (Howard et al 2008) documents ways in which 'traditional peoples' maintain and use biodiversity within landscapes of particular ecological and cultural significance. Farmers, herders, pastoralists, hunters, gatherers and fisherfolk are recognized as innovators who develop complex, locally-adapted management systems generally leading to improved food security, sustainable natural resource management, biodiversity conservation and the preservation of cultural identity. Critical to the GIAHS concept is that humans have immense capacity to understand, learn, manage and innovate to affect their environments. In order to be considered a GIAHS, agricultural systems must host significant ingenuity and adaptive capacity, yielding innovative solutions to critical biophysical and socio-cultural constraints.

Examples of innovative strategies for reducing risk include (Howard et al 2008):

- Diversifying resource base, including crops and varieties, field locations, and food procurement practices including hunting, gathering and options to sell surplus crops, handicrafts, wage labour and forest products.
- Changing varieties and species planted.
- Adjusting the timing of activities such as sowing and harvesting to suit changing conditions.
- Adopting technical innovations in crop improvement, cropping patterns, inputs, infrastructure, landscape modification and social-cultural institutions.
- Changing location of activities, resources or lifestyles.
- Exchanging goods and services through barter, reciprocity or markets.
- Applying of traditional resource techniques to improve the management climate-sensitive resources such as water.

According to Howard et al (2008), innovative solutions tend to be found in environments with major biophysical challenges and where cultures have evolved the specialized knowledge and skills required to manage stresses and fluctuations, such as periodic drought. In these environments technologies such as agrochemical and modern varieties are less effective or ineffective in improving crop yields. Local knowledge, practices and technologies are better suited (ibid).

SSFs innovate using agrobiodiversity in the following ways, discussed in sequence below:

- Cultivation of home gardens.
- Consumption of wild and indigenous foods.
- Food preservation, safety, storage and processing.
- Culinary traditions.
- Development and dissemination of seed through informal seed systems.

Home gardens are recognized for the food security, nutrition and better livelihoods they provide farm families (De Boef et al 2013; Gotor and Martin 2013). Field crops generally provide staple carbohydrates and legumes, while fruits, vegetables and other 'minor' crops are produced in smaller quantities in home gardens (Howard et al 2008). These crops are used in culturally significant dishes and are nutritionally rich and diverse (Chweya and Eyzaguirre 1990). Home gardens provide subsistence throughout the year in tropical areas, insurance during times of shortage and economic downturn, goods that can be exchanged through social networks based on reciprocity, and an important source of income (Howard 2006). They also yield ointments and medicines, fuel, animal feed and building materials (Bastidas and Rueda 2013;

Gotor and Martin 2013). Women's prominent role in cultivating home gardens translates into increased opportunity to generate income (Howard 2008) and social recognition and empowerment within their communities (Gotor and Martin 2013).

Home gardens also provide habitats for wild and domestic agrobiodiversity. Shaded coffee plantations in particular are recognized as important habitats for agrobiodiversity (Perfecto et al 1996). Coffee is described as a keystone species in the Afromontane region of Ethiopia (Feyissa et al 2013) — a centre of origin for many crop species — and the Umbuzeiro region of Brazil (Peroni et al 2013).

Home gardens serve as sites for crop domestication and variety experimentation before successes are transferred to larger field plots (Landauer and Brazil 1990; Eyzaguirre and Linares 2004; Kumar and Nair 2006). Howard et al (2008) report that most communities continually introduce new species into home gardens — one of the primary means by which farmers adapt to change and innovate, and the main source of species richness in agrobiodiverse settings. Researchers document examples of highly productive polycultures and the selection of symbiotic crop combinations in home gardens (kitchen gardens) in the Caribbean (Hills and Iton 1983; Hills 1988; Brierley 1976 1991; Beckford and Baker 2007).

Wild and indigenous foods provide nutritional benefits (including probiotics and nutraceuticals), many have documented medicinal value, and are associated with traditional customs and beliefs. The World Health Organisation estimates that in many developing countries up to 80% of the population relies on biodiversity for primary health care (Herndon and Butler 2010) and the loss of biodiversity has been linked to the increased emergence and transmission of infectious diseases. Innovation occurs where the use of wild and indigenous foods is adapted to suit current needs, or when they contribute to new employment opportunities, household food security, improved diets and cultural reorientation/reclamation (Azam-Ali and Battock 2001 *in* Howard et al 2008).

Innovation includes the knowledge and skills required to develop and maintain **food storage, preservation and processing techniques** (Howard et al 2008). The integrity of post-harvest handling practices is essential to the health and wellbeing of farming communities, food security and culinary traditions. Examples of time-honoured practices include fermentation, sun-drying, smoking and salting that keep foods free from bacteria.

Culinary traditions are one of the most important aspects of cultural identity (Howard et al 2008). There is much research documenting women's selection of crop varieties based on characteristics such as their specific tastes, colours and cooking qualities (Counihan and Kaplan 1998). The role of women in promoting diversified diets comprised of traditional crops is critically important as diets become increasingly homogenous and nutritious, traditional foods are replaced with processed foods and refined carbohydrates and fats (Liniger et al 2011).

Informal seed systems are a cornerstone of on-farm innovation. Farmers maintain and develop new varieties adapted to local conditions and distribute them through informal social and economic networks. Farmers obtain seed fairs, exchanges with neighbouring farmers, community seed banks or from the farmers' own produce (Vernooy and Ruiz 2012). Informal seed systems provide farmers with sufficient access to locally adapted and affordable seed in a timely manner (Louwaars et al 2013) and help to minimize the risks associated with reliance on a given seed provider (Lapeña 2012).

For many SSFs, and depending on the crop, informal seed systems are the only sources of affordable and reliable seed to sustain local farming and food production (Vernooy and Ruiz 2012; Almekinders and Haardon 2006). This is particularly the case for minor food crops where there is insufficient public and private sector investment into developing varieties adapted to specific environments and marginal growing conditions (Louwaars and de Boef 2012; Almekinders and Louwaars 2002). Byerlee et al (2007) estimate that eighty percent of all seed in Africa is produced by farmers and distributed within informal systems, and Louwaars and De Boef (2012) suggest that for minor crops this is closer to a hundred percent. According to the FAO (2010b), this is likely to remain the case for the foreseeable future.

Informal seed systems also contribute to improved nutrition. Up to ninety percent of seed used by SSFs across South Asia and sub-Saharan Africa is produced, selected and saved by women, and it is predominantly women's role to grow and preserve varieties important for healthy diets and local food cultures (De Schutter 2009).

Maintaining the vitality of informal seed systems is important for nurturing SSF innovation. There exists a body of literature discussing how flexible seed policies — developed to suit the unique characteristics of domestic seed sectors and in consultation with farmers — can support rather than impede informal seed systems, and promote synergistic relationships between them and more formalized seed production and distribution systems (see Louwaars and de Boef 2012; Louwaars et al 2013).

Maintaining the vitality of informal seed systems is important for nurturing SSF innovation.

3.2.4 Adaptation to environmental and market stress

Innovation and adaptation are overlapping concepts (Rodima-Taylor et al 2012). Young (2014) suggests that the distinguishing feature between the concepts is that adaptation is more commonly associated with identifying and developing responses to risk (particularly climate related risk) while innovation is more commonly associated with new approaches to meeting emerging or existing needs (particularly new market niches). In the context of agriculture the two may be less distinguishable, as innovations can be understood as human adaptations to changing conditions (Rodima-Taylor et al 2012).[8] Amaru and Chhetri (2013) define adaptation as an ongoing and dynamic process whereby communities continually respond to changing conditions, be they socioeconomic, technological or environmental. Using this definition, incremental change within agricultural systems may be understood as both adaptation and innovation.

Climate change and environmental degradation are significant sources of risk, and as such, are major drivers of on-farm adaptation and innovation.

Climate change and environmental degradation are significant sources of risk, as such, are major drivers of on-farm adaptation and innovation. SSFs have historically relied on local innovation systems based on agrobiodiversity and agroecological practices to minimize and prepare for uncertainty and risk (IPCC 2014;

[8] How this is interpreted may have implications for how intellectual property law applies to farmers' innovation. Small, incremental changes that build upon each other likely yield innovations lacking the 'inventive step' required to meet patent eligibility criteria and, in the context of breeding, would yield varieties considered 'essentially derived' from pre-existing material and be ineligible for plant variety protection (PVP).

De Boef et al 2013). Rodima-Taylor et al (2012) suggest that climate change has the greatest potential to spur innovation in areas where its effects are felt most severely, particularly among the poor living in marginal areas whose livelihoods are dependent on natural resources.

The capacity of farmers to respond to climate change in locally-appropriate ways is increasingly recognized in academic literature (Mikhail et al 2011; Chistoplos et al 2009). UN Special Rapporteur on the Right to Food Olivier de Schutter (2010) provides evidence of farming communities adapting to climate change by adopting new farming practices based on the principles of agroecological production. Tittonell et al (2014) discuss the EU-funded Agroecology-based aggradation-conservation agriculture (ABACO) initiative (2011-2014) that brings scientists, farmers and other relevant stakeholders from across Sub-Saharan Africa together to develop innovative solutions for soil rehabilitation and increased water productivity in semi-arid regions. Chhetri et al (2012) document partnerships in Nepal that bring together different knowledge systems to develop appropriate technologies for climate change adaptation. Distilled, the key message from these authors is that effective responses to climate change will demand both technical and institutional innovation and increased connectivity between informal and formal sector actors (see Tittonell et al 2014; Rodima-Taylor et al 2012).

Effective responses to climate change will demand both technical and institutional innovation and increased connectivity between informal and formal sector actors.

The role of SSF innovation systems in helping farmers adapt to market fluctuations and price volatility is not tackled explicitly within SSF innovation systems literature. However, measures such as income diversification, participation in producers' cooperatives, and on-farm processing and storage, which help farmers' mitigate the impacts of markets, may be construed as examples of technical and institutional innovation.

Rural-urban migration, seasonal jobs demanding temporary migration and remittances are household strategies for dealing with economic instability. While not typically considered innovation, Tacoli (1998) highlights that migrants, often portrayed as victims, are rational decision makers responding to social, political and economic changes at the national and global levels. Seen in this light, migration itself and participation in the urban informal economy are innovative livelihood strategies. De Haas (2010), however, warns that such an optimistic view of migration as "self-help development" may shift attention away from the role of states in ensuring favourable conditions for migrants once they arrive in urban areas. In other words, framing migration as innovation may have the effect of diminishing states' responsibilities to provide social services to migrants.

3.2.5. Adoption of exogenous innovation

SSF innovation encompasses both change that emerges from within farming communities (purely endogenous innovation) and change that is introduced from external sources (exogenous innovation), adapted to suit local needs. Sanginga (2009) considers this a false dichotomy, as farmers continually experiment with goods, services and technologies developed externally to make them more applicable to local contexts — a process that Kraemer-Mbula and Wamae (2010) refer to as 'user innovation'.

Waters-Bayer et al (2009) contend that scientists underestimate how much farmers adapt technical innovations to suit their needs by performing informal field trials, and that more original ideas and successful adaptations come from farmers without the support of formal research or extension services. They argue that exogenous technologies and ideas are most useful when provided in absence of exact specifications so as to grant farmers the space and flexibility to experiment and adapt them to suit local conditions (ibid). Chambers et al (1989) and Thrupp (1989) emphasize the expertise that goes into discriminating among technology options and that exogenous technologies are often not adopted because they are inferior to existing techniques or unsuitable for local needs and environments.

There is a wealth of literature available on innovation developed outside of farming communities to improve small scale farm productivity and ecological sustainability (see Van Rijn et al (2013; Godfray et al 2010; Altieri 2002; Liniger et al 2011). For example, Linger et al (2011) document a vast collection of innovative farm management practices tailored to small scale farms, complete with tools for increasing adoption rates and scaling-up innovations once adopted. Farmer participation is emphasized within each of these works, however the time, energy, resources and expertise that farmers put towards adapting exogenous innovations to suit their specific needs and circumstances is not widely addressed.

The majority of studies on SSFs' adoption of exogenous technology adoption focus on how to increase technology adoption rates (see Diederen et al 2003; Karafillis and Papanagiotou 2011; Ariza et al. 2013; Wu and Zhang 2013). Commonly cited factors correlating with technology adoption rates include:

- Farmers' access to credit and farm size (Feder et al 1985; Läpple et al 2015; Diederen et al 2003 use solvency rate as a proxy for access to finances);
- Land tenure and resource rights (Drechsel et al 2005 *in* Liniger et al 2011);
- Access to information (Drechsel et al 2005 *in* Liniger et al 2011);
- Farmers' personal characteristics including risk preferences, age, education rate, marital status and whether they are engaged in off-farm work (Gardebroek 2006; Läpple et al 2015);
- Short-term productivity gains, short-term establishment times and practices that are 'easy to learn' (Stotz 2009; Liniger et al 2011);
- Appropriateness of technology to specific circumstances (Wu and Zhuang 2013);
- Relationships of trust between farmers and researchers and extension service agents (Wu and Zhuang 2013);
- Favourable conditions and technical and institutional support provided by the government (Wu and Zhuang 2013); and
- The presence of farmer leadership, or the influence of 'early adopters' within farming communities (Wu and Zhuang 2013).

It is noteworthy that while this list sheds light on factors influencing farmers' willingness to use exogenous technologies, these studies do not address farmers' active role in integrating local and scientific knowledge systems and adapting technologies to suit local conditions.

Most recently, Läpple et al (2015) developed a composite index for measuring on-farm innovation adoption, knowledge acquisition and continuous innovation in Ireland, moving beyond using rates of adoption as the sole proxy for on-farm innovation. Knowledge acquisition is assessed by whether or not farmers had consulted advisory services (citing Knickel et al 2009, Spielman and Birner 2008), and continuous innovation is assessed based on whether or not farmers had renewed some machinery during the last year (citing OECD 2013, VanGalen 2009). These additional measures do not capture innovation that goes on in the absence of extension services and in agricultural systems that are not mechanized, while farmers' active role in technology adoption is still not captured. While perhaps useful for increasing the exposure of on-farm innovation in developed countries such as Ireland, this composite index is insufficient for capturing the scale and scope of SSF innovation in other parts of the world. Läpple et al (2015) concede that measuring innovation that goes on outside of formal sector is still in its infancy, and call for further research in this area.

While their composite index may not be universally applicable, Läpple et al (2015) exemplify how policy recommendations for encouraging innovation may emerge from focusing on farmers themselves. They find that younger farmers who have completed agricultural education and manage their holdings more intensively are more likely to innovate, thus policies that encourage earlier inter-generational transfer of land, tuition subsidies, tax exemptions and access to credit targeting a younger demographic may help drive on-farm innovation (ibid).

3.3 Why do SSFs innovate?

Foran et al (2014) ask the fundamental questions of why innovation is required in food systems, and what interventions and innovation are appropriate for combating the underlying causes of food insecurity (as locally defined) and for increasing resilience (as locally understood)? How food insecurity and resilience are defined determines what innovation strategy is deemed to be appropriate.

What drives or motivates farmers to innovate is different from what drives 'formal' innovation systems. Formal sector agricultural innovation is driven by financial incentives and returns on investment, pursued most commonly through intellectual property rights and licensing agreements (Wynberg and Pereira 2013).[9] SSF innovation, in contrast, is often driven by non-monetary benefits and incentives such as climate adaptability, cultural norms and relationships based on reciprocity (ibid). Wynberg and Pereira (2013) suggest that formal innovation systems integrate environmental sustainability, agrobiodiversity, food and nutrition security and social benefit into incentive structures in order for the formal innovation regime to benefit resource-poor farmers.

> *Wynberg and Pereira (2013) conclude that formal innovation systems must integrate environmental sustainability, agrobiodiversity, food and nutrition security and social benefit into incentive structures in order for the formal innovation regime to benefit resource-poor farmers.*

SSFs face price volatility, food safety concerns, intensifying environmental pressures and extreme weather events, malnutrition, lack of access to markets and hard infrastructure such as storage facilities, among a host of other challenges (FAO 2014). Farmers continually innovate to overcome these challenges, or at least mitigating their impacts to the greatest extent possible (Howard et al 2008; Kilelu et al 2013).

Berdegué (2005) explains that resource-poor farmers are largely driven to innovate by 'push' factors: the need to mitigate the impacts of negative stimuli such as soil nutrient depletion, drought, over subsidized agricultural imports driving down local prices and overpopulation in relation to natural resource endowments. In contrast, SSFs with greater access to resources can innovate in response to 'pull' factors: new opportunities such as new markets for high value crops, new rural enterprises, new biotechnologies

[9] The role of intellectual property in encouraging innovation in agriculture, including within the 'formal' innovation system, is the subject of increasing debate. See Spielman and Ma (2015); Gallini and Scotchmer (2002).

and opportunities to participate at points further along in agri-food value chains through processing and marketing (ibid).

The push and pull factors influencing SSFs' behaviour are likely to change according to farmers' current circumstances. Tittonell (2014) presents a typology of farm livelihood strategies in smallholder agriculture across Africa:

1. 'Hanging-in': farmers in situations of poor resource potential and market opportunities who engage in subsistence farming activities.
2. 'Stepping up': farmers in situations of high agricultural potential who invest in assets to expand current production (semi-commercial farming).
3. 'Stepping-out': farmers with accumulated assets and who may engage in non-farm activities.

Farmers who are 'hanging-in' likely innovate in response to push factors while those 'stepping up' and 'out' may respond to new market opportunities. However farms typically fluctuate within two regimes. Smallholders who 'step-out' may only do so temporarily or partially. Smallholders that undergo contractions of their natural, financial and human resources are increasingly vulnerable to system shocks, are forced to liquidate their capital assets, undergo loss of social capital and are forced to reconfigure their livelihood strategies (Tittonell 2014).

Both the active maintenance and use of agrobiodiversity and the adoption of ecologically sustainable farm management practices can be understood as innovative responses to environmental degradation and the uncertainty surrounding the impacts of climate change.

The most widely discussed 'push' factors in the literature are environmental degradation due to unsustainable agricultural practices and climate change. Environmental degradation and climate change are pushing SSFs to adapt to changing growing conditions and contributing to the erosion of agrobiodiversity. The FAO (2015) reports that agricultural systems everywhere are vulnerable to climate change, and that production is particular under threat in areas near the equator. Even the most modest projections of climate change will affect the geographic distributions, migration patterns and the growing cycles of crops faster than they are able to adapt or migrate, even in assisted migration scenarios (FAO 2010b). These changes will necessitate changes in farmers' crop selections, crop rotations and planting times. Soil degradation and water eutrophication and depletion are likewise pushing farmers to adopt more resource-efficient farming practices (Godfrey et al 2010).

Another 'push' factor for SSF innovation is economic instability. Farmers face increasing production costs and decreasing product prices (Dogliotti et al 2014), as well as increasing price volatility in the market. External inputs are often cost-prohibitive (Beckford and Baker 2007; de Schutter 2014). Reconfiguration of livelihood strategies including rural-urban migration and seasonal employment, farm income diversification, and the establishment of farmers' cooperatives to better negotiate with larger actors in the agrifood sector are all innovative responses to economic instability.

Beckford and Baker (2007) argue that SSF innovation is a natural outcome of a general context of neglect. SSFs *need* to improve local varieties and experiment with new practices in the absence of sufficient public sector investment. Public and private sector investment in crop improvement is concentrated in cash crops such as sugarcane and staple food crops such as rice, wheat and maize, while local crops are neglected. Public investment in research and development and extension services has declined in recent decades (Pingali and Traxler, 2002; Pardey et al 2006), exacerbating this trend. Very little research is directed towards developing resistances to pests and diseases or transferring other desirable qualities to neglected species (Beckford and Baker 2007). Crop improvement for these crops is then relegated to the informal sector.

Reij and Waters-Bayer (2014) offer a unique perspective on how environmental degradation may also serve as a 'pull' factor: farmers are motivated to innovate and spread their innovations relating to land rehabilitation and adaptation in order to prove that environmental degradation is not inevitable nor irreversible, and to gain public recognition for their efforts. Public recognition by itself in an important 'pull' factor (ibid), perhaps understated in existing literature that focuses on firms' incentives to innovate (see for example Pray 2008).

Along the same lines, Miranda et al (2011) document that innovators view themselves as part of larger process of social transformation based on solidarity and creativity. Social entrepreneurs are driven to innovate because they self-identify with the process of social transformation (ibid). Smith et al (2014) describe grassroots innovation as a consequence of perceived social injustices.

Box 3: Increasing market access: An insufficient strategy for supporting SSF innovation.

The FAO (2014) recommends increasing access to markets as a means of "giving family farmers incentives to innovate" (pp. 92). Barriers to farmers adopting innovative practices include absence of physical and marketing infrastructure, financial and risk management instruments and secure property rights. This logic is based on the assumption that SSFs are motivated primarily by commercial 'pull' factors, and does not consider that only relatively resource-endowed farmers may be able to respond to new market opportunities. This is not to suggest that increased access to markets and accompanying infrastructure does not support SSF innovation — market opportunities influence smallholders' livelihood strategies and are an important factor determining their capacities to 'step-out' (Tittonell 2014) — however, it is important that this may be an incomplete strategy for supporting SSF innovation. Multiple factors affect farmers' motivations to innovate, and these factors are likely unique from those influencing formal sector innovation systems.

3.4 How do SSFs innovate?

Innovation is now widely recognized as a social phenomenon (Röling 1996, 2002; Douthwaite 2002; World Bank 2006; Hall et al 2001; Engel 1997; Berdegué 2005; Sanginga 2009; Wu and Zhuang 2013). All actors have certain insights, perspectives and context-specific knowledge gained through experience (Engel 1997), and no single actor has sufficient information, resources and competencies to manage resources to his or her satisfaction (Sanginga 2009). *Innovative capacity* is then understood as a function of both the expertise of those involved and their capacity to form relationships of cooperation in order to acquire new relevant information (Engel 1997). Fostering innovative capacity involves creating opportunities for trust-building, mutual learning and knowledge sharing and integration among farmers and between farmers and external actors (Wu and Zhuang 2013).

Fostering innovative capacity involves creating opportunities to share and integrate knowledge though collaborative networks.

SSFs innovate:

1. Through informal networks.
2. With the support of innovation intermediaries.
3. By participating in innovation platforms.

3.4.1 Innovating through informal networks

Informal networks consist of clusters of individuals having informal meetings to discuss farming activities (Coudel 2013). They are built by farmers themselves without any outside intervention or resources (Wu and Zhuang 2013). Farmers working together in informal networks are credited with having done the majority of experimentation, adaptation and innovation in absence of formal sector support throughout history (Darré 1996; Sanginga 2009).

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Informal networks are fundamentally based on social relationships of trust and reciprocity. Trust among farmers can increase cooperation, lower transaction costs and increase bargaining power within the market and allow groups of individuals to share in the risks associated with experimentation and adopting new innovations (van Rijn et al 2012). Adger (2010) suggests that the effectiveness of community action is a major determinant of communities' capacity to adapt to climate. The knowledge exchanged through informal networks comes from traditional, local, gendered, and indigenous knowledge systems (see section 4.2.2. *Application of local knowledge to current circumstance*).

On the other hand, van Rijn et al (2012) report a negative correlation between strong intra-community ties (cognitive social capital) and adoption rates of exogenous innovation. They interpret this result as the "dark side of social capital" (pp: 121), pointing to 'inward-looking modes of behaviour' and social norms as impediments to innovation. This fits with the analysis of Gupta et al (2003), who include the contempt felt in society for those who break the mould in the list of constraints to SSF innovation. Social entrepreneurs are cast as social deviants, which discourages innovative behaviours (ibid).

However, it is important to note that van Rijn et al (2012) focus on exogenous technology adoption rather than SSF innovation. Other scholars contend that SSF innovation is positively correlated with the strength of intra-community relations (Wu and Zhuang 2013). Van Rijn et al (2012) also report that innovative farmers have stronger inter-community ties (bonding capital) relative to ties with formal sector actors (bridging social capital), suggesting that SSFs' capacity to innovate in the absence of formal sector intervention and support is at least somewhat dependent on the strength of informal networks.

3.4.2 Innovating with the support of innovation intermediaries

Many scholars discuss the role of innovation intermediaries: supporting actors that facilitate interaction among disparate or isolated innovation networks, and between farmers and supporting actors such as researchers, policy makers and other industry stakeholders. Intermediaries are identified in the literature as brokers between two or more parties (Howells 2006), 'boundary spanning individuals' forging connections among networks and between them and their environments (Klertz et al (2010), and actors who bridge micro and macro scale of innovation (Westley et al 2011). The exact function of intermediaries depends upon their relations with all relevant actors, their legitimacy in the eyes of each group of actors, and their fund raising and operational capacity (Klerkx and Leeuwis, 2009; Yang et al 2014).

Intermediation encompasses both knowledge and innovation intermediation (Yang et al 2014). Knowledge intermediation includes articulating users' needs and demands, providing information to fill users' needs (i.e. classic extension services), and supporting actors in knowledge co-production (i.e. participatory research). Innovation intermediation implies a wider function, focused more on personal relations among actors than on transferring technical expertise (Christoplos, 2010, 2012; Sulaiman and Davis 2011; Yang et al 2014). It includes building and managing networks, facilitating social learning processes, and creating an overarching vision regarding the scope and nature of the innovation (e.g. its role in societal transformation, poverty alleviation, environmental sustainability) (ibid). Klerkx et al (2010) add that because networks can only partially influence their institutional environments, and because unpredictability is an inherent quality of complex systems, innovators must constantly reflect upon and re-interpret their position vis-a-vis their environment. Intermediaries can help provide perspective and facilitate, monitor and evaluate this type of 'system learning'.

Because networks can only partially influence their institutional environments, and because unpredictability is an inherent quality of complex systems, innovators must constantly reflect upon and re-interpret their position vis-a-vis their environment (Klerkx et al 2010). Intermediaries can help provide perspective and help facilitate, monitor and evaluate this type of 'system learning'.

The majority of literature describing innovation intermediaries comes from an AIS perspective — that is, the role of intermediaries in facilitating more reciprocal relationships between *innovators* and *beneficiaries of innovation.* Intermediation is presented as a formal, professionalized role in development, where intermediaries are hired consultants or internet based platforms for brokering exchange among actors in agri-food systems (see The World Bank 2012; Klerkx and Leeuwis 2009b).

Alternatively, farmers' cooperatives, producers' organizations, NGOs and CSOs, grassroots innovation movements may function as intermediaries. Klerkx et al (2009) emphasize that in the context of developing country agriculture, innovation intermediaries often take a different form than the formal organizations that have situated themselves as 'neutral brokers'. They are often more informal groups, tend to have conflicting interests and face legitimacy concerns. Eriksen and Selboe (2012), studying the social organization of climate change in mountain farming communities in Norway, warn that innovation and adaptation among farmers is potentially limited by growing pressures to formalize informal relations and local collective action. This draws attention to the importance of policy frameworks allowing for flexibility and recognizing and supporting informal innovation intermediaries outside of existing formal structures (Rodima-Taylor et al 2012).

Innovation and adaptation among farmers is potentially limited by growing pressures to formalize informal relations and local collective action, drawing attention to the importance of policy frameworks allowing for flexibility and recognizing and supporting informal innovation intermediaries outside of existing formal structures.

Yang et al (2014) study the roles of farmers' cooperatives as innovation intermediaries within AIS, drawing from experiences in China. Farmers' cooperatives operate at a small scale and are embedded within local contexts, and are thus well-placed to go beyond classic extension services and help develop more contextualized technologies (ibid). Functioning as intermediaries they can help farmers:

- Develop relationships with other relevant actors in order to produce higher quality products;
- Gain access to markets, research organizations and extension services;
- Participate in collective marketing;
- Bring new technologies into farming practices.
- Interpret public standards and develop technical guides with regards to water, pesticide and fertilizer management;
- Build awareness on food safety issues;
- Facilitate transactions within broader AIS
- Handle paper work such as farming records for certification and project funding applications.

The FAO (2014) also identifies producer organizations and cooperatives as important intermediaries. They facilitate farmers' access to market, facilitate closer cooperation between farmers and rural extension and advisory service providers, and give farmers a voice to policy debates to influence national innovation priorities. This report advocates for a supportive regulatory environment for producer organizations and cooperatives.

Wettasinha et al (2014) provide evidence of civil society and non-governmental organizations effectively playing the role of intermediary. NGOs and CSOs can play an important capacity-building role, strengthening both the technical and socio-organizational skills of farmers, and their role in building social capital within informal networks by fostering motivation, trust, networking capacity and ownership is particularly valuable. Their position of working closely with farmers can make these NGOs and CSOs more effective in supporting SSF innovation systems than formal institutions and organizations. NGOs and CSOs are well placed to form geographically wide networks of farmers and bring collective experiences into policy dialogues and participate in farmers' advocacy, provided political conditions allow (ibid).

NGOs and CSOs are well placed to form geographically wide networks of farmers and bring collective experiences into policy dialogues and participate in farmers' advocacy, provided political conditions allow.

Smith et al (2014) discuss how grassroots innovation movements can support local ingenuity and empower local innovators by helping farmers develop their ideas and diffuse their innovations, if desired. The HoneyBee Network in India and the Villagero Network use ICT to connect farmers with investors and bring awareness to farmers' creativity and capacity for experimentation (ibid).

3.4.3 Participating in innovation platforms

Innovation platforms are multi-stakeholder configurations established deliberately to facilitate interaction and partnership formation and to undertake joint activities relating to agricultural innovation at the region, country, sector or value chain level (Kilelu et al 2013: 66). Representatives from government, public sector agricultural research and development organizations, private companies, universities, agri-food industry and related sectors and farmers' organizations may participate in platforms. The concept is synonymous with innovation coalitions (Biggs 1990), innovation networks (Leeuwis and van den Ban 2004) and to a certain extent, public private partnerships (Hall et al 2001; Spielman et al 2010; Kilelu et al 2013).

A word of caution: When studying multi-stakeholder partnerships it is particularly difficult to separate the literature that emerges from an AIS perspective from that which emerges from a SSF innovation system perspective. Most scholars studying these partnerships are focused on increasing the uptake and relevance of new technologies and integrating farmers into global value chains (i.e. innovation *with* SSFs). There has been relatively little inquiry into how innovation platforms can support farmer-led research, experimentation and innovation. As van Rijn et al (2012) concede, critiquing their own work, SSF innovation may not even get captured by academic studies focusing on farmers' involvement in multi-stakeholder innovation platforms.

It is important to note that SSF innovation may not even get captured by academic studies focusing on farmers' involvement in multi-stakeholder innovation platforms.

Engaging key actors from formal sector institutions in innovation platforms and inviting innovation intermediaries to mediate interactions between them and farmers can result in the conditions required for SSF innovation (Hounkonnou et al 2012).

Hounkonnou et al (2012) report that engaging key actors from formal sector institutions in innovation platforms and inviting innovation intermediaries to mediate interactions between them and farmers can result in the conditions required for SSF innovation. 'Formal' and 'informal' may have different connotations depending on the context, and varying degrees of formality exist within different platforms (Nederlof et al 2011). Smith et al (2014) assert that bridges between informal networks and formal institutions and organizations enables the diffusion and scaling-up of social innovations, which Wettasinha et al (2014) argue will lead to more useful and sustainable outcomes for SSFs.

Platforms have been successful in increasing interactions among stakeholders and building social capital (Nederlof et al 2011; Tenywa et al 2011; van Rijn et al 2012; Kilelu et al 2013). Nederlof et al (2011) report successes of platforms across West Africa in terms of SSFs' integration into global value chains and productivity increases. Regeer (2009) and van Mierlo et al (2010) discuss how platforms are useful tools for dealing with complex issues by reconciling results-based management with the need for feedback and greater reflectivity to be built-in to program planning.

Kilelu et al (2013), however, acknowledge three limitations to platforms which arose in the case of the East Africa Dairy Development (EADD) program in Kenya:

1. Less success was achieved in terms of promoting uptake of new technologies.
2. The strategies pursued by each organization represented in the platform reflected the individual mandates of each, which caused tensions that undermined the broader vision of the program.
3. The platform was not be adaptive and responsive enough to new issues that arose, despite the learning component built-in to the program planning.

The third limitation points to the challenge of scale. Larger programs demand clear budgeting and the use of project management tools such as logical frameworks and timelines for the purposes of transparency and implementation. It remains a challenge to adequately institutionalize the flexibility required for social learning processes. Kilelu et al (2013) conclude that funding schemes need to be responsive to unforeseen challenges.

3.5 Where and when can SSF innovation be scaled-up and out?

Scholars debate the extent to which SSF innovation systems should be supported for the ends of scaling-up and diffusing outputs. Diffusion is an essential element of the conventional technology transfer model. Impact is most easily achieved through scaling-up and scaling-out successes, and innovations arising in one place have the potential to benefit others facing similar challenges (Wu and Zhang 2013; van Rijn et al 2012). Liniger et al (2011), for example, suggest that local knowledge and practices should be documented in a standardized and accessible way so that lessons can be shared across the world.

Waters-Bayer et al (2009) warn that an emphasis on scaling-up and diffusing innovation puts greater value on the *invention* part of the equation than on the *process of social interaction* that creates innovation.[10] The goal instead should be to use successes to inspire and stimulate experimentation elsewhere, recognizing that results in one locality can rarely be copied or adopted elsewhere. The following outcomes are more appropriately disseminated than specific technologies or practices:

- Field tested methods for stimulating innovation processes;
- Lessons for supporting personal and institutional growth and change; and
- Best practices for building partnerships and engaging in policy dialogues to create an enabling environment conducive to local innovation (Critchley et al 2006 *in* Waters-Bayer et al (2009).

Local innovations emerge in response to specific conditions and may lose their value once decontextualized (Briggs 2005). Activists in the 'appropriate technology movement' of the 1970s (see Wu and Zhuang 2013) struggled to balance an appreciation for the local specificity of innovation and a desire to diffuse technologies with potential wide-scale relevance to other communities. Smith et al (2014) reports that this remains a challenge for organizations today interested in supporting endogenous innovation, given the emphasis on achieving results and measuring project impact.

Smith et al (2014) assert that the strategy of developing standard technologies which are widely-applicable is at odds with developing 'socio-technical configurations' (technologies) appropriate to the local values, aspirations, capabilities, resources available and political and economic realities, and take into account the functional requirements of the technologies involved. Grassroots innovations may only have wider relevance when information about how knowledge systems were integrated and which aspects of the innovation are most heavily embedded within local contexts is transferred along with SSF innovations (ibid). This will inform what elements of technologies may be applicable elsewhere and help inform wider social entrepreneurship (Gupta et al., 2003; London and Hart, 2011; Smith et al 2014).

[10] Waters-Bayer et al (2009) distinguish between *innovations* and *innovation*, referring to products and processes respectively

IV. The role of supporting institutions and organizations

There is a long academic tradition of wrestling with the role of outside intervention in small-scale farming systems, particularly from the development practitioner perspective (see Reijntjes et al 1992; Engel 1997). The role of supporting actors in the context of innovation systems is just as ambiguous.

This section highlights six strategies for supporting SSF innovation discussed in the literature:

1. Institutionalize support for SSF innovation;
2. Increase exposure of SSF innovative capacity;
3. Supplement farmers' capacity to innovate where required;
4. Provide direct financial resources to farmers for on-farm research;
5. Facilitate knowledge sharing among geographically disparate farming communities;
6. Conduct research to better understand relationships between national innovation frameworks and SSF innovation systems.

These strategies are mutually supportive. For example, using ICT to facilitate knowledge sharing among disparate networks of farmers may also serve to increase exposure among policy makers, which may in turn promote institutional change at the systems level. Providing farmers with direct financial support, along with control over budgets, allows them to hire outside expertise where required in order to supplement existing capacity.

4.1 Institutionalize support for SSF innovation

The first strategy is to institutionalize the concept of SSF innovation within outside/supporting institutions and organizations. Leeuwis and van den Ban (2004) define innovation as an alignment of hardware (technology), software (ways of thinking and learning and adapting), and 'orgware' (new institutional arrangements among actors, or the "rules of the game" [citing North 1990] that structure interactions). SSFs in general lack agency to influence institutional arrangements and change norms, laws and procedures that are manipulable at higher levels (Hounkonnou et al 2012). Instead, forward thinking organizations that recognize the innovative capacity of SSFs must seek to change the 'rules of the game'.

SSFs in general lack agency to influence institutional arrangements and change norms, laws and procedures that are manipulable at higher levels (Hounkonnou et al 2012). Changing the 'rules to the game' must be taken on instead by forward thinking organizations that recognize the innovative capacity of SSFs.

The most common barrier to institutional change cited in the literature is the engrained sets of patterns of interactions among farmers, researchers, scientists and policy makers, many of which still largely (and by default) follow a conventional model of technology transfer, at best incorporating SSFs into the research process. The Ouagadougou Declaration (2015) calls for formal sector researchers to recognize farmers as innovators rather than solely recipients of research results, and for investment in capacity building for formal sector researchers to support farmer-led research, and changes in attitudes towards farming communities.

According to Waters-Bayer et al (2007), many extension workers lack the confidence, facilitation skills and openness required to work through iterative cycles of joint action and reflection with farmer innovators. Extension workers may need to first be trained to recognize farmer innovation processes that happen 'below the radar', requiring open conversations with farmers about what innovation is. Trained extension workers can then become effective intermediaries between farmer innovators and external experts (such as specialists, breeders, researchers and academics), and help authenticate the results of farmer-led research and experimentation (ibid).

Thrupp (1989) identifies a host of strategies for initiating 'institutional adjustments', while noting that on their own they may be insufficient for bringing about true reform:

- Hiring people who emphasize people-centred approaches
- Training for professionals
- Providing incentives and rewards to those who achieve success with innovative approaches
- Demonstrating participatory experiences
- Establishing systematic monitoring for the above efforts
- Increasing funding for projects supporting local knowledge (citing Chambers et al 1989; others).

True reform requires helping researchers, scientists and policy makers understand not only what *farmers want, but* why *they use particular practices or varieties and the principles and knowledge systems that underpin the outcomes of innovation processes (Thrupp 1989).*

Going further, true reform requires helping researchers, scientists and policy makers understand not only *what* farmers want, but *why* they use particular practices or varieties and the principles and knowledge systems that underpin the outcomes of innovation processes. Grassroots organization and farmers' active participation in decision-making processes are essential to this end (Thrupp 1989). The Ouagadougou Declaration (2015) likewise calls for space for representation for smallholder farmers in governing bodies of research institutions.

Wettasinha et al (2014) report that progress towards institutionalizing farmer-led research within research and development organizations has been slow. In the case studies no significant changes in organizational structure or budget allocations were reported among participating organizations, although some changes in mindset were observed among the researchers involved. NGOs and farmers' organizations were more open to integrating farmer-led research approaches into their work (ibid).

Hounkonnou et al (2012) study the role of institutional change in increasing productivity of small scale farms in Sub-Saharan Africa, focusing on two large-scale programs.[11] An impact study on the original investment (CoS Program, see Röling 2010) concluded that institutional change is required beyond innovation at the farm level, as the adoption of some technologies depended on conditions over which farmers had no control and thus did not continue after the program ended (Van Huis et al 2007, *in* Hounkonnou et al 2012). In short, technological innovation reaches a ceiling when institutional innovation does not keep pace (CoS 2013). The subsequent investment is explicitly focused on creating institutional

[11] Their findings are based on two large-scale interventions: the US$26 million 2006–2010/12 Sub-Saharan Africa Challenge Programme (SSA-CP) supporting 32 multi-stakeholder Platforms in eight countries; and the €4.5 million 2008–2013 Convergence of Sciences: Strengthening Innovation Systems (CoS-SIS) research program supporting nine platforms in Mali, Benin, and Ghana.

arrangements that create space for farmers' voices in project planning and larger policy debates (Hounkonnou et al 2012).

The education system, which sets the standard for organizational behaviour, is largely based on an outdated technology-transfer approach to innovation (Sanginga 2009). Sanginga (2009) reports that efforts to re-think agricultural education in universities are scattered and isolated. New curricula and learning processes need to become embedded within the formal education system, and these changes must be sustained longer than externally funded projects (Hounkonnou et al 2012). The CoS-SIS Program also focuses on informing decision makers in national, regional and African agricultural research organizations, universities, NGOs and other stakeholders about ways to encourage SSF innovation. The program seeks to influence university curricula, research institute programmes, government policies and the structure of value chains (CoS 2013).

Gupta et al (2003) warn that without institutionalizing SSF innovation, formal scientific institutions and educational systems weaken the momentum of grassroots innovations by failing to build upon them and/or ignoring them altogether. The result is a generation of young people lacking confidence in their innovative capacity, believing that solutions to their problems will come from outside actors, generally from the west. "The defeatist mentality and pervasive cynicism add to the problem" (Gupta et al 2003: 982). Thrupp (1985; 1988) contributes evidence that pressure to adopt exogenous technologies through advertisements and extension services can make farmers embarrassed and uncertain over their practices and detracts from the legitimacy of local knowledge in their own eyes.

Pressure to adopt exogenous technologies through advertisements and extension services can make farmers embarrassed and uncertain over their practices and detracts from the legitimacy of local knowledge in their own eyes.

4.2. Increase exposure of SSF innovative capacity

Events that facilitate exposure to local innovations such as farmer innovation fairs, workshops, agricultural exhibitions and conferences may encourage SSF innovation by increasing their exposure (Waters-Bayer et al 2009). Farmer innovation fairs, for example, bring together farming communities with policy makers and government representatives, formal research institutions, academia, NGOs, private sector stakeholders to learn about farmer innovation processes and identify areas for future collaboration. They lend legitimacy to SSF innovation, present opportunities for public recognition and publication in academic journals, and defends the intellectual property of farmer innovators by putting innovation into the public domain. Publication of innovations in catalogues and radio may also be beneficial, particularly if farmers receive support in documenting their own innovations (Wettasinha et al 2006).

Public exposure of farmers' innovation, particularly among farmers from outside the region, can act as a major incentive for innovation (Reij and Waters-Bayer 2014). Innovative farmers gain social recognition for their efforts, visiting farmers gain inspiration and knowledge which they can then experiment with and adapt to their specific conditions, and the public at large gains appreciation for the capacity of farmers to innovate (ibid).

Public exposure can also increase the legitimacy of SSF innovation in the eyes of farmers themselves. Reij and Waters-Bayer (2014) document cases of farmers who would not otherwise present their innovations as such. This is particularly the case for women farmers, who often do not perceive themselves as innovators due to traditional beliefs and attitudes regarding their roles in society, lack of formal education and less mobility and access to external sources of information than men (ibid). Women may require additional encouragement to take advantage of opportunities to showcase and present their innovations (Critchley et al 1999; Reij and Waters-Bayer 2014).

Exposure facilitates mutual learning and creates opportunities for innovations to be disseminated to a wider audience (Veldhuizen et al 1997; Waters-Bayer et al 2009), and may help change the dominant discourse which depicts farmers are recipients rather than originators of innovation:

> "When the researchers and development agents start to bring examples of what they think are local innovations, and when farmers start showing what they regard as innovations - then everyone becomes involved in discussions about what is traditional and what is innovative; what is an invention and what is innovation; is it something that is new here or new everywhere in the world; can an innovation here be a tradition there; what is exogenous; and does it makes a difference in the end where the idea comes from if local people can make something useful out of it? This discussion is necessary." (Waters-Bayer et al 2009: 248).

The Honeybee Network is a horizontal (farmer-to-farmer) network documenting innovations of small farmers, women and artisans across India and beyond and disseminates results from farmer field trials in newsletters in six languages[12] (Gupta et al 2003). The Social Technology Network (RTS, *Rede de Tecnologia Social)* aims to create more vertical connections between grassroots innovators and large investors in Brazil (Smith et al 2014). Technologies in the areas of agroecology, recycling, sustainable energy, housing and infrastructure and rainwater harvesting is showcased in electronic newsletters.[13] Other actors are able to support the innovation process while the network of social entrepreneurs themselves integrate scientific and local knowledge systems Miranda et al (2011).

4.3. Supplement farmers' capacities

Greater access to formal scientific institutions can help grassroots innovators optimize their solutions and bring their innovations to their logical conclusions (Gupta et al 2003). Examples of ways in which supporting actors can supplement farmers' innovative capacity include:

- Offering alternatives to current practices. Engineers or designers can contribute to grassroots innovation processes with ideas and expertise otherwise shaping the overall innovation process (Smith et al 2014).
- Improving farmers' experimental design and exploring more systematic methods of experimentation (Waters-Bayer et al 2009), and helping farmers to isolate the factors contributing to something working or not working (Wettasinha et al 2014). Farmer-led experimentation can be facilitated by post-doc students, as in the case of the CoS-SIS program (CoS 2013).
- Providing information on phenomena that cannot be observed (Veldhuizen et al 1997; Waters-Bayer et al 2009). Supporting actors can finance diagnostic studies (Röling et al 2004).

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[12] See http://www.sristi.org
[13] See http://rts.ibict.br/

- Documenting farmers' work in order to a) share experiences widely and scale-out the farmer-led research process, and b) communicate farmer innovation in scientific terms in order to increased their credibility within the formal sector research and development sector (Wettasinha et al 2014). Thrupp (1989), however, warns against the need to validate or 'prove' the usefulness of local knowledge in ways that conform to formal research requirements. Local knowledge (and its manifestations, i.e. SSF innovation) should be recognized as legitimate and valuable in its own terms; the "sciences of many cultures" (pp. 22) have varying values and purposes.
- Facilitating the creation of multi-stakeholder innovation platforms that focus on creating the enabling conditions required for SSF innovation at the institutional level (CoS 2013).
- Facilitating the creation of self-help groups among poor producers to overcome transaction risks, increase social capital and help link groups with service providers such as banks, marketing boards or supermarkets (Ashby et al 2009).

Ashby et al (2009) assert that capacity building is necessary for farmers to overcome the wealth differential and gain equitable access to product markets. The public sector is called upon to invest in 'pre-enterprise skill acquisition' to make these five capabilities, in combination, available to farmer entrepreneurs:

- Basic group management skills (e.g. problem solving, visioning, knowledge-sharing)
- Financial management skills (e.g. saving, equitable lending)
- Basic marketing skills (e.g. identifying profitable opportunities, group production, accessing market information, negotiating with buyers and sellers)
- Experimentation and innovation skills (e.g. comparing technologies, keeping records of experiments, sharing results)
- Sustainable production and natural resource management skills (understanding interdependencies among wider landscape, rehabilitation and conservation, developing collective rules, negotiating with other stakeholders)

Ashby et al (2009) emphasize that markets do not work for the poor in the early stages of development, contrary to the popular slogan of national development efforts to achieve the millennium development goals (citing Barrett et al 2001; Krishna 2004). Markets are insufficient for eliminating poverty and inherently ineffective at supplying poor farmers with complementary measures such as support for small agro-enterprise development, rural credit systems, physical infrastructure, communications and human capital. The public sector's role is to fill in capacity gaps and help farmers become 'market ready.' "Pro-poor market-based growth can take off only if sufficient coordination mechanisms develop to create a virtuous cycle of increased investment in all the necessary interventions beyond a threshold level" (pp. 132).

4.4 Provide direct financial support

Gupta et al (2003) identify the lack of micro venture capital available to grassroots innovators as both a reason why innovation does not lead to enterprises, and as evidence of a lack of appreciation for the potential of grassroots innovations on behalf of national and global policy institutions. Gupta (2003) argues that the lack of venture capital and research funds constrains the pace of SSF innovation. However, there is a lack of evidence that microfinance programs have positive impacts on the poor (Duvendack et al 2011).

Wettasinha et al (2014) recommend that agricultural and development organizations create budgets to support farmers' on-farm experimentation, as well as CSO and NGO-facilitated farmer-led research. This will encourage farmer-led research to become integrated into the current education and training for innovation in agriculture. In most of the cases studied, CSO and NGO innovation intermediaries received funding from outside organizations. External funding for long-term research projects is particularly important for building capacity among farmers and strengthening networks. The researchers highlight that most external funding is orientated towards project cycle management rather than long-term funding, which may constrain the innovation process by limiting the flexibility and creativity required. Longer-term funding commitments, rather than higher levels of funding, are required (ibid). The Ouagadougou Declaration (2015) similarly calls for long term funding to be made available to initiatives in participatory innovation development (PID) and farmer-led research.

Alternative funding mechanisms have been established on a pilot basis to promote local innovation in eight countries in Africa and Asia (Cambodia, Ethiopia, Ghana, Kenya, Nepal, South Africa, Tanzania and Uganda). Funds are managed by farmer-led steering committees that call for proposals and grant funds to applicants based on a set of criteria developed by the community (Waters-Bayer et al 2007). These funds enable SSFs to contract research support where required that fits within the local agenda for innovation (see Prolinnova 2012). In India, the National Innovation Foundation (www.nifindia.org) was established in 2000 to develop a national register of innovations and provide innovators access to rewards, recognition, exhibitions, mentoring, in situ incubation of grassroots technologies, financial support and investment and enterprise opportunities (Gupta et al 2003).

Smith et al (2014) highlight the significant support for social technologies coming from organizations engaged in corporate social responsibility and that have an interest in fostering social enterprise. Large corporations, banks and science and technology ministries within governments represent significant sources of financial support for endogenous innovation. RTS started as annual prize awarded to social entrepreneurs organized by *Fundação Banco do Brasil* in 2001, and has since grown into a catalogue of innovation in the areas of agroecology, recycling, sustainable energy, housing and infrastructure and rainwater harvesting. Entrepreneurs and small-scale cooperative enterprises gain access to financial resources, training programs and marketing support through the network (Smith et al 2014). Miranda et al (2011) report that between 2005 and 2009, public and private organizations in invested US$175 million of social technology activities.

Cho (2006) questions the inherent 'social' value of social entrepreneurship. Entrepreneurs are driven and ambitious, have a vision, are independent and focused on achieving ends. The concept assumes that entrepreneurs pursue financial objectives consistent with substantive values and social welfare objectives. However, referencing the ecotourism industry, entrepreneurship may have negative environmental and social consequences resulting form land privatization, forcible exclusion of indigenous peoples, cultural appropriation and the concentration of benefits in the hands of few (ibid).

4.5 Facilitate knowledge sharing through ICT

Information and communication technologies (ICT) can facilitate knowledge sharing among drastically extended networks and provide farmers access to free and transparent information (CoS 2013).

The FAO (2014) underscores the positive effect that ICT infrastructure can have on innovation by reducing transaction costs associated with obtaining information on new techniques and practices, improving advisory services and strengthening the bargaining power of producers organizations. Mobile phones and the internet support rural entrepreneurs by informing them about weather conditions, input availability, dealers, financial services, market prices and consumer demand. Asenso-Okyere and Mekonnen (2012), in review of studies on the use of ICT for agricultural development in Africa and Asia, report that some studies found significant improvements in market access, farmers' income, farm productivity, crop diversification and environmental stewardship (cited in FAO 2014).

ICT for development (ICT4D) gained popularity in the 1990s, characterized by internet-connected computers delivering information and services to rural communities in developing countries. Projects during this period achieved little success due to the cost of personal commuters and the lack of telecommunications infrastructure (Heeks 2008). ICT4D 2.0 (coined by Heeks 2008) efforts since 2000 have involved the rapid expansion of wireless communications and mobile devices which have achieved much high adoption rates across developing countries (Steinfield and Wyche 2013). Many ICT4D projects target SSFs, providing extension and advisory services and market information (World Bank 2011).

Access, however, remains an issue. The 'digital divide' refers to the gap between those with access and skills required to use ICT and those without (see DiMaggio et al 2004; Steinfield et al 2015). Use of ICT is constrained by regular access to electricity, quality of internet access (broadband vs. dial-up) and the price of internet relative to the monthly incomes of users (Steinfield and Wyche 2013). The expansion of ICT may exacerbate existing inequalities both within communities and between rural and urban populations (DiMaggio et al 2004). ICT is often particularly inaccessible to women due to cultural barriers and low literacy rates, and will therefore likely not achieve promised improvements in gender equality and women's empowerment (Mackey 2012).

Antonio and Tuffley (2014) provide a recent review of initiatives to mitigate the 'gender digital divide' in developing countries. Yates et al (2013), studying the impacts of national ICT policies in 150 countries, conclude that technology adoption rates are most improved where governments invest in mobile broadband infrastructure and ensure competition in the provision of telecommunication services. The impact of ICT investment on SSF innovation is not considered.

The 2016 World Bank World Development Report (WDR) is focused on Digital Development. The report, yet to be released, will document how the internet promotes development by expanding markets and promoting greater inclusion within them, raising the efficiency of economic and social interactions, and creating economies of scale and opportunities for crowdsourcing which will have positive outcomes for consumer welfare, citizen engagement and government accountability.[14] The report's concept note highlights how poor farmers will benefit from increased access to credit as banks can access information

[14] See http://go.worldbank.org/ON8XMECNW0

on them to gauge their 'creditworthiness' (The World Bank 2014). Support for SSF innovation is not discussed.

Chomitz, Senior Advisor in the Independent Evaluation Group of the World Bank and a coauthor of the 2016 WDR, writes that storing and sharing information is constrained by the large geographical areas and numbers of farmers agricultural extension agents are assigned.[15] The logistical challenge of carrying 'flip charts' across large areas can be overcome using digital technology. Chomitz endorses the work of Digital Green, a not-for-profit international development organization that uses videocameras, pico projectors and the internet to diffuse SSF innovation across South Asia and Sub-Saharan Africa.[16] Digital Green helps women farmers document their innovations and pools videos online where extension agents can download and share them with groups of women in other areas. Information on where videos are watched and which ones inspired uptake automatically feeds into a database,[17] which may become a valuable monitoring tool for future research on SSF innovation systems.

Gupta et al (2003) describe how the Honeybee Network is experimenting with ICT and multi-media databases accessible through touch-screen kiosks to facilitate knowledge sharing among innovators. The lack of infrastructure is cited as a barrier for impact. The lack of social networking among innovators is also cited as a barrier to collaborative learning and access to moral support in times of failure, which ICT can facilitate. Gupta et al (2003) add that a lack of media support prevents horizontal networking among innovators and the creation of demand for their products.

[15] http://blogs.worldbank.org/developmenttalk/information-intervention-visit-digital-green
[16] http://www.digitalgreen.org/
[17] http://www.digitalgreen.org/analytics/overview_module

V. Concluding thoughts

This document has synthesized academic literature on SSF innovation systems for the purpose of creating a common understanding of what these systems look like in practice, and identifying ways in which other actors may support them. The objective is to establish a starting place for discussions on what policies may be part of an enabling environment for SSF innovation systems, and to contribute towards the mainstreaming of the concept within international fora relating to agricultural innovation.

It is noteworthy that as SSF innovation systems in a relatively novel concept in academia, the literature is quite small and self-referential. Impact reviews are sometimes carried out by the same organization responsible for the intervention. Efforts to promote the institutionalization of SSF innovation systems within formal institutions and organizations and mainstream the concept within international fora will benefit from a widened evidence base and a separation of practitioner/impact assessor.

There remain challenges to operationalizing the concept of SSF innovation systems. Very modest progress has been reported with regards to institutionalizing support for on-farm innovation within agricultural research and development organizations due to engrained patterns of interactions between farmers, researchers, scientists and policy makers. A broader definition of agricultural innovation — one that understands innovation as including, among other things, the maintenance, use and development of local knowledge systems, agrobiodiversity and traditional farm management practices, and the deliberate adaption of technologies developed elsewhere to suit local contexts — is understandably more difficult to operationalize from a public policy perspective. This is especially the case given the sheer diversity of farming systems around the world.

Moving forward, supportive policies must not only be context specific, but reflect *what, how* and *why* farmers choose to innovate. We must think critically about how existing policies in place for encouraging innovation in agriculture support and/or impede SSF innovation systems. As highlighted in this document, interactions between formal and informal innovation systems have yet to be studied systematically (Kraemer-Mbula and Wamae 2010; Lorentzen 2010; Wynberg and Pereira 2013). The list of support measures discussed by academics coming from a SSF innovation perspective (e.g. providing financial support for on-farm research and experimentation) diverges from conventional strategies for spurring innovation (e.g. increasing access to markets, strengthening intellectual property rights and investing in extension services in order to increase technology uptake among farmers).

Further exploration is needed into:

- How international and national frameworks for promoting innovation in agriculture support and/or inadvertently impede SSF innovation, particularly the foundations such as biodiversity upon which the innovation is based;
- What policies may better serve the ends of fostering SSF innovation, and
- What is needed to support SSF innovation that contributes to food security and resilience both locally and globally.

The work of QUNO's Food and Sustainability Program is now to contribute towards filling these research gaps, informed by this literature review and the expert consultation on SSF innovation systems held in May, 2015.[18]

[18] For the full report on this event, see: http://quno.org/resource/2015/10/small-scale-farmer-innovation-systems-report-first-expert-consultation-26-27-may

References

Abramovitz, M. (1986). Catching up, forging ahead, and falling behind. *The Journal of Economic History*, 46 (2): 385-406.

Adger, W.N. (2010). Social capital, collective action, and adaptation to climate change. *In* Der Klimawandel (pp. 327-345). VS Verlag für Sozialwissenschaften.

Adjei-Nsiah, S., Kuyper, T.W., Leeuwis, C., Abekoe, M.K., Cobbinah, J., Sakyi-Dawson, O. and Giller, K.E. (2008). Farmers' agronomic and social evaluation of productivity, yield and N2-fixation in different cowpea varieties and their subsequent residual N effects on a succeeding maize crop. *Nutrient Cycling in Agroecosystems*, 80(3): 199-209.

Almekinders C. and Haardon, J. (eds.) (2006). *Bringing Farmers Back into Breeding. Experiences with Participatory Plant Breeding and Challenges for Institutionalization*. Agromisa Special 5, Agromisa, Wageningen, The Netherlands.

Almekinders, C. J., & Louwaars, N. P. (2002). The importance of the farmers' seed systems in a functional national seed sector. Journal of New Seeds, 4(1-2), 15-33.

Altieri, M.A. (1989). Agroecology: A new research and development paradigm for world agriculture. Agriculture, Ecosystems & Environment, 27: 37–46.

Altieri, M.A. (2002). Agroecology: The science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment, 93: 1–24.

Amaru, S. and Chhetri, N.B. (2013). Climate adaptation: Institutional response to environmental constraints, and the need for increased flexibility, participation, and integration of approaches. *Applied Geography*, 39: 128–139.

Amend, T., Brown, J., Kothari, A., Phillips, A. and Stolton, S (eds.) (2008). *Protected Landscapes and Agrobiodiversity Values*. Volume 1 in the Series. Protected Landscapes and Seascapes. IUCN & GTZ. Kaspareg Verlag, Heidelberg, Available at <cmsdata.iucn.org/downloads/agrobiodiv.pdf>

Anandajayasekeram, P. and Gebremedhin, B. (2009). Integrating innovation systems perspective and value chain analysis in agricultural research for development: Implications and challenges. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project Working Paper 16. ILRI (International Livestock Research Institute), Nairobi, Kenya (16): 67.

Antonio, A. and Tuffley, D. (2014). The Gender Digital Divide in Developing Countries. *Future Internet*, 6(4), 673-687.

Ariza, C., Rugeles, L., Saavedra, D. and Guaitero, B. (2013). Measuring innovation in agricultural firms: a methodological approach. *Electr. J. Kn. Manage*, 11: 185– 198.

Asenso-Okyere, K. and Davis, K. (2009). Knowledge and Innovation for Agricultural Development. IFPRI Policy Brief 11, 11(March), 4. Available at <http://www.ifpri.org/sites/default/files/publications/bp011.pdf>

Ashby, J., Heinrich, G., Burpee, G., Remington, T., Wilson, K., Quiros, C. A., ...Ferris, S. (2009). What farmers want: collective capacity for sustainable entrepreneurship. *International Journal of Agricultural Sustainability*, 7(2): 130-146.

Axelrod, R. and Cohen, M.D. (1999). *Harnessing complexity. Organizational implications of a scientific frontier.* New York: Free Press.

Ayele, S., Duncan, A., Larbi, A. and Khanh, T.T. (2012). Enhancing innovation in livestock value chains through networks: lessons from fodder innovation case studies in developing countries. *Sci. Publ. Policy* 39: 333–346.

Bastidas, C.G.T. and Carrera Rueda, H.F.C. (2013). "Practices that contribute to promoting and appreciating Andean crops and identity in Cotacachi, Ecuador" In de Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., and O'Keeffe, E. (Eds.). (2013). Community Biodiversity Management: promoting resilience and the conservation of plant genetic resources. Routledge. pp. 77-82.

Batterink, M.H., Wubben, E.F.M., Klerkx, L. and Omta, S.W.F. (2010). Orchestrating innovation networks: the case of innovation brokers in the agri-food sector. *Entepreneurship Reg. Dev*. 22: 47–76

Beckford, C. and Barker, D. (2007). The role and value of local knowledge in Jamaican agriculture: Adaptation and change in small-scale farming. *Geographical Journal*, 173(2): 118–128.

Beckford, C., Barker, D., and Bailey, S. (2007). Adaptation, innovation and domestic food production in Jamaica: Some examples of survival strategies of small-scale farmers. *Singapore Journal of Tropical Geography*, 28: 273–286.

Berdegué, J.A. (2005). Pro-Poor Innovation Systems. Background paper 49. IFAD.

Brierley, J.S. (1976). Kitchen gardens in the West Indies, with a contemporary study from Grenada. *Journal of Tropical Geography*, (43): 30–40.

Brierley, J.S. (1991). Kitchen gardens in the Caribbean, past, and present: their role in small farm development. *Caribbean Geography,* (3): 15–28.

Biggs, S.D. (1990). A multiple source of innovation model of agricultural research and technology promotion. *World Development,* 18(11): 148–1499.

Briggs, J. (2005). The use of indigenous knowledge in development: Problems and challenges. *Progress in Development Studies,* 5: 99–114.

De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M. and O´Keeffe (eds.) (2013). *Community Biodiversity Management. Promoting Resilience and the Conservation of Plant Genetic Resources*. Routledge, London, New York.

Bragdon, S. and Rodgerson, C. *Informal Report and Understandings. Emerging from the Second Experts Consultation on QUNO´s New Framework for Trade and Investment in Agriculture (NFTIA)*, May 22-23, 2014. QUNO, November 2014. Available at http://quno.org/resource/2014/12/informal-report-and-understandings-emerging-second-expert-consultation-qunos-new

Brody, B.A. (2010). Traditional knowledge and intellectual property. Kennedy Institute of Ethics journal (20).

Byerlee, D., A. de Janvry, E. Sadoulet, R. Townsend, and I. Klytchnikova (2007). *World development report, 2008. Agriculture for development*. Washington, DC: World Bank.

Chambers, R., Pacey, A. and Thrupp, L .A. (eds) (1989). *Farmer first: farmer innovation and agricultural research.* Intermediate Technology Publications, London.

Chhetri, N., Chaudhary, P., Tiwari, P.R. and Yadaw, R.B. (2012). Institutional and technological innovation: Understanding agricultural adaptation to climate change in Nepal. *Applied Geography*, 33: 142-150.

Chhetri, N.B. and Easterling, W.E. (2010). Adapting to climate change: retrospective analysis of climate technology interaction in the rice-based farming system of Nepal. *Annals of the Association of American Geographers*, 100(5): 1156-1176.

Chewya J. and Eyzaguirre, P. (eds.) (1999). The Biodiversity of Traditional Leafy Vegetables. Rome: International Plant Genetic Resources Institute (IPGRI).

Cho, A.H. (2006). Politics, values and social entrepreneurship: A critical appraisal. *Social entrepreneurship*, 280: 34-56.

Chopra. T. (2014). “Persistent narratives, persistent failures: Why GM crops do not - and will not - feed the world,” *Mapping the state of play on the global food landscape*, Waterloo, September 26-27, 2014.

Christoplos, I. (2010). Mobilizing the potential of rural and agricultural extension. Global Forum on Rural Advisory Services (G-FRAS), Zürich, Switzerland.

Christoplos, I. (2012). Climate advice and extension practice. *Geogr. Tidsskrift- Danish J. Geogr.* 112: 183–193.

Clapp, J. *Trade Liberalization and Food Security: Examining the Linkages.* Quakers United Nations Office, June 2014, Available at
<http://quno.org/sites/default/files/resources/QUNO_Food%20Security_Clapp.pdf>

Conway, G. (2012). One billion hungry: can we feed the world?. Cornell University Press.

CoS (2013). Convergence of the Sciences: Strengthening agricultural innovation systems in Benin, Ghana and Mali) (2013). New Pathways for Innovation: Creating conditions in which West African smallholders can capture opportunity. Available at: <http://www.cos-sis.org/pdf/CoS-SIS%20Brochure%20EN_FINAL_LR.pdf>

Coudel, E. (ed.) (2013) *Renewing innovation systems in agriculture and food: How to go towards more sustainability?* Wageningen Academic Publishers.

Counihan, C. and Kaplan, S.L. (eds.) (1998). Food and gender: Identity and power (Vol. 1). Taylor & Francis.

Cozzens, S. and Sutz, J. (2012). Innovation in Informal Settings : A Research Agenda. Ottawa: IDRC: 1–53.

Critchley, W., Verburg, M. and van Veldguizen, L. (2006). *Facilitating multistakeholder partnerships.* IIRP, Silang/Prolinnova International Secretariat, Leusden, The Netherlands.

Dagnino, R. (ed.) (2010). Tecnologia Social: Ferramenta para construir outra sociedade. Campinas, Brazil, Komedi.

Darré, J.P. (1996). L'intervention des practiques dans l'agriculture. Karthala, Paris, France.

De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., and O'Keeffe, E. (Eds.). (2013). Community Biodiversity Management: promoting resilience and the conservation of plant genetic resources. Routledge.

De Haas, H. (2010). Migration and development: a theoretical perspective. *International migration review*, 44(1): 227-264.

De Schutter, O. (2009). Seed policies and the right to food: enhancing agrobiodiversity and encouraging innovation. A/64/170

De Schutter, O. (2014). Final report: The transformative potential of the right to food United Nations Human Rights Council, A/HRC/25/57

DiMaggio, P., Hargittai, E., & Celeste, C. S. Shafer (2004). Digital Inequality: From Unequal Access to Differentiated Use. Russell Sage Foundation, New York, 355-400.

Drechsel, P., Olaleye, A. Adeoti, A., Thiombiano, L., Barry, B. and Vohland, K. (2005). Adoption driver and constraints of resource conservation technologies in Sub-Saharan Africa. Available at http://www.iwmi.cgiar.org/africa/west_africa/projects/AdoptionTechnology/AdoptionConstraints-Overview.pdf

Diederen, P., van Meijl, H., Wolters, A. and Bijak, K. (2003). Innovation adoption in agriculture: innovators, early adopters and laggards. *Cah. Econ. Sociologie Rurales,* 67: 30–50.

Dogliotti, S., García, M.C., Peluffo, S., Dieste, J.P., Pedemonte, A.J., Bacigalupe, G.F., Rossing, W.A.H. (2014). Co-innovation of family farm systems: A systems approach to sustainable agriculture. *Agricultural Systems* (126): 76–86.

Dormon, E.N.A., Van Huis, A., Leeuwis, C., Obeng-Ofori, D. and Sakyi-Dawson, O. (2004). Causes of low productivity of cocoa in Ghana: farmers' perspectives and insights from research and the socio-political establishment. *NJAS-Wageningen journal of life sciences*, 52(3): 237-259.

Douthwaite, B. (2002). *Enabling innovation: a practical guide to understanding and fostering technological change,* ZED Books: London.

Duvendack, M., Palmer-Jones, R., Copestake, J.G., Hooper, L., Loke, Y. and Rao, N. (2011). *What is the evidence of the impact of microfinance on the well-being of poor people?* London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Edquist, C. (1997). Systems of Innovation Approaches – Their Emergence and Characteristics. *In* C. Edquist (ed.), *Systems of Innovation: Technologies, Institutions and Organisations*, Pinter/Cassell: London.

Engel, P.G.H. (1997). The social organization of innovation: A focus on stakeholder interaction. Royal Tropical Institute, Amsterdam.

Eriksen, S. and Selboe, E. (2012). The social organisation of adaptation to climate variability and global change: The case of a mountain farming community in Norway. *Applied Geography*, 33: 159-167.

Eyzaguirre, P.B. (2001). Global recognition of indigenous knowledge: Is this the latest phase in globalization? Indigenous Knowledge and Development Monitor 9.

Eyzaguirre, P.B. and Linares, O.F. (2004). Home gardens and agrobiodiversity.

Gupta, A.K., Sinha, R., Koradia, D., Patel, R., Parmar, M., Rohit, P., ... & Vivekanandan, P. (2003). Mobilizing grassroots' technological innovations and traditional knowledge, values and institutions: articulating social and ethical capital. *Futures*, 35(9): 975-987.

FAO (2006). "Food Security" FAO Food and Economics Division. Available at: ftp://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf

FAO (2013). *The State of Food and Agriculture. Foods Systems for Better Nutrition*. Food Agriculture Organization of the United Nations, Rome.

FAO (2010). *The State of Food Insecurity in the World 2010: Addressing Food Insecurity in Protracted Crises.* Food Agriculture Organization of the United Nations, Rome.

FAO (2010b). *Second report on the state of the world's plant genetic resources for food and agriculture*. Rome, Italy: Commission on Genetic Resources for Food and Agriculture.

FAO (2014). *The State of Food and Agriculture. Innovation in Family Farming*. Food Agriculture Organization of the United Nations, Rome.

FAO 2015. *Climate change and food systems: global assessments and implications for food security and trade.* Food Agriculture Organization of the United Nations, Rome.

FAO, IFAD and WFP (2015). *The State of Food Insecurity in the World 2015: Meeting the 2015 international hunger targets: taking stock of uneven progress.* Food Agriculture Organization of the United Nations, Rome.

Fagerberg, J. (1987). A technology gap approach to why growth rates differ. *Research policy*, 16(2): 87-99.

Feygassa, F., Gezu, G., Tsegaye, B. and Tesfaye, K. (2013) "Community management of forest coffee landscapes in Ethiopia" In de Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., and O'Keeffe, E. (Eds.). (2013). Community Biodiversity Management: promoting resilience and the conservation of plant genetic resources. Routledge. pp. 156-162.

Fonseca, R.R. and Serafim, M. (2009). A tecnologia social e seus arranjos institucionnais. *In* Dagnino, R. (ed.), *Tecnologia social: ferramenta para construir outra sociadade*. Instituto de Geociencias de UNICAMP, Campinas.

Foran, T., Butler, J.R., Williams, L.J., Wanjura, W.J., Hall, A., Carter, L. and Carberry, P.S. (2014). Taking complexity in food systems seriously: an interdisciplinary analysis. *World Development*, 61: 85-101.

Foresight: The Future of Food and Farming (2011). The Government Office for Science Final Project Report, London. Available at <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/288329/11-546-future-of-food-and-farming-report.pdf>

Gallini, N. and Scotchmer, S. (2002). Intellectual property: when is it the best incentive system?. *In Innovation Policy and the Economy*, Volume 2 (pp. 51-78). MIT Press.

Gardebroek, C. (2006). Comparing risk attitudes of organic and non-organic farmers with a Bayesian random coefficient model. *Eur. Rev. Agric. Econ,* (33): 485–510.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., ... & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science*, 327(5967): 812-818.

Gotor E. and Martin, W. (2013). Home Gardens in Nepal. Bioversity International series of Impact Assessment Briefs, no. 10. Bioversity International.

Hall, A. and Clark, N. (1995). Coping with change, complexity and diversity in agriculture—the case of rhizobium inoculants in Thailand. *World Development*, 23(9): 1601-1614.

Hall, A., Bockett, G., Taylor, S., Sivamohan, M.V.K., and Clark, N. (2001). Why research partnerships really matter: innovation theory, institutional arrangements and implications for developing new technologies for the poor. *World Development,* 29 (5): 783-797.

Hall, A., Sulaiman, R., Clark, N., Sivamohan, M.V.K., and Yoganand, B. (2002). Public-private sector interaction in the Indian agricultural research systems: An innovation systems perspective of institutional reform. *In:* Byerleee, D., and Echeverria, R.G. (Eds.). *Agricultural Research Policy in an Era of Privatization*. Wallingford: CABI Publishing: 155-176.

Hall, A., Sulaiman, R., Clark, N. and Yoganand, B. (2003). From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. *Agricultural Systems*, 78: 213–41.

Hall, A., Clark, N. and Naik, G. (2007). Technology supply chain or innovation capacity?: Contrasting experiences of promoting small scale irrigation technology in South Asia. *Technology,* 014.

Herndon, C.N. and Butler, R.A. (2010). Significance of biodiversity to health. *Biotropica*, 42(5): 558-560.

Hills, T.L. (1988). The Caribbean food forests: ecological artistry or random chaos. *In* Brierley, J.S. and Rubenstein, H. (eds.) *Small farming and peasant resources in the Caribbean,* pp. 1–28.

Hills, T.L. and Iton, S. (1983). A reassessment of the 'traditional' in Caribbean small-scale agriculture. *Caribbean Geography,* (1): 24–35

Hippel, E. von (2005). *Democratizing Innovation.* MIT Press, Cambridge MA.

Hippel, E. von (2007). Horizontal Networks – by and for Users. *Industrial and Corporate Change*, 16(2): 293-315.

Hounkonnou, D., Kossou, D., Kuyper, T.W., Leeuwis, C., Nederlof, E.S., Röling, N., … van Huis, A. (2012). An innovation systems approach to institutional change: Smallholder development in West Africa. *Agricultural Systems*, 108: 74–83.

Howard, P. (2006). Gender and social dynamics in swidden and homegardens in Latin America. *In* Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry. Kumar, B. and Nair, P. (eds). pp. 159-84. Dordrecht (NL): Springer.

Howard, P., Puri, R., Smith, L. and Altieri, M. (2008). A Scientific Conceptual Framework and Strategic Principles for the Globally Important Agricultural Heritage Systems Programme from a Social-ecological Systems Perspective. Rome: Food and Agriculture Organization of the United Nations.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Res. Policy,* 35: 715–728.

IPCC (International Panel on Climate Change) (2014). *Synthesis Report. Summary for Policy Makers*. Available at http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr1.pdf

ITPGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture) (2013). "Reports of meetings on the establishment of a platform for the co-development and transfer of technology." Muscat, Oman, 24-28 September 2013. Fifth session of the Governing Body. IT/GB-5/13/Inf.16

Karafillis, C. and Papanagiotou, E. (2011). Innovation and total factor productivity in organic farming. *Applied Economics,* 43: 3075–3087.

Kilelu, C.W., Klerkx, L. and Leeuwis, C. (2013). Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. *Agricultural Systems*, 118, 65–77.

Klerkx, L. and Leeuwis, C. (2008). Institutionalizing end-user demand steering in agricultural R&D: Farmer levy funding of R&D in The Netherlands. *Research Policy*, 37(3): 460-472.

Klerkx, L. and Leeuwis, C. (2009). Shaping collective functions in privatized agricultural knowledge and information systems: the positioning and embedding of a network broker in the dutch dairy sector. *J. Agric. Educ. Ext.* 15: 81–105.

Klerkx, L. and Leeuwis, C. (2009b). Establishment and embedding of innovation brokers at different innovation system levels: insights from the Dutch agricultural sector. T*echnol. Forecast. Soc. Chang.* 76: 849–860.

Klerkx, L., De Grip, K. and Leeuwis, C. (2006). Hands off but strings attached: the contradictions of policy-induced demand-driven agricultural extension. *Agriculture and Human Values*, 23(2): 189-204.

Klerkx, L., Hall, A. and Leeuwis, C. (2009). Strengthening agricultural innovation capacity: are innovation brokers the answer? *Int. J. Agric. Resour. Gov. Ecol*. 8: 409–438.

Klerkx, L., Aarts, N. and Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems*, 103(6): 390–400.

Knickel, K., Tisenkopfs, T. and Peter, S. (2009). Innovation processes in agriculture and rural development: results of a cross-national analysis of the situation in seven countries, research gaps and recommendations. IN-SIGHT: Strengthening Innovation Processes for Growth and Development. Available at <http://www.insightproject.net/files/IN-SIGHT_final_report.pd>

Kraemer-Mbula, E. and Wamae, W. (2010). Innovation and the Development Agenda. OECD/IDRC.

Kramer, N.J.T.A. and Smit, J.D. (1987). *Systeemdenken: inleiding tot de begrippen en concepten*. Leiden: Stenfert Kroese.

Kumar, B.M. and Nair, P.K.R. (2006). Tropical homegardens (p. 377). Dordrecht: Springer.

Landauer, K. and Brazil, M. (1990). Tropical home gardens. Selected papers from an international workshop held at the Institute of Ecology, Padjadjaran University, Bandung, Indonesia, 2-9 December 1985. United Nations University Press.

Lapeña I. (2012). *La Propiedad Intelectual sobre Semillas y sus Implicancias para la Agricultura Familiar en el Perú*. Serie de Política y Derecho Ambiental. No. 25, Lima, Perú.

Läpple, D., Renwick, A. and Thorne, F. (2015). Measuring and understanding the drivers of agricultural innovation: Evidence from Ireland. *Food Policy*, 51: 1–8.

De Leener (2001a). “From technology-based to people-oriented synergies.” IFAD technical workshop on methodologies, organistion and management of Global Partnership Programmes.

De Leener (2001b). “Towards an evolving conceptual framework to effectively capture the complexity of collaborative research.” IFAD.

Leeuwis, C. and van den Ban, A.W. (eds.) (2004). *Communication for rural innovation rethinking agricultural extension.* Oxford: Blackwell, Science.

Liniger, H.P., Mekdaschi Studer, R., Hauert, C. and Gurtner, M. (2011). Sustainable Land Management in Practice – Guidelines and Best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO).

Lobell, D.B., Schlenker, W. and Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, 333(6042): 616-620.

London, T. and Hart, S.L. (2011). Next Generation Business Strategies for the Base of the Pyramid: New Approaches for Building Mutual Value. FT Press, New Jersey.

Lorentzen, J. (2013). Low-income countries and innovation studies: A review of recent literature. *Challenges of African Transformation: Exploring Through Innovation Approach:* 80–107.

Louwaars, N.P., de Boef, W.S., Edeme, J. (2013). Integrated Seed Sector Development in Africa: A Basis for Seed Policy and Law. Journal of Crop Improvement, 27: 186–214.

Louwaars, N.P., de Boef, W.S. (2012). Integrated Seed Sector Development in Africa: A Conceptual Framework for Creating Coherence Between Practices, Programs, and Policies. *Journal of Crop Improvement*, 26: 39–59.

Lowder, S.K., Skoet, J., Singh, S. *What do we Really Know about the Number and Distribution of Farms and Family Farms in the World* ? Background paper for The State of Food and Agriculture 2014 ESA Working Paper No. 14-02 April 2014 Agricultural Development Economics Division Food and Agriculture Organization of the United Nations. Available at <http://www.fao.org/docrep/019/i3729e/i3729e.pdf?utm_source=twitter&utm_medium=social+media&utm_campaign=faoknowledge>

Mackey, K.A. (2012). "Mobile Phones and Gender Inequality: Can We Hear Her Now?." Thesis, Georgia State University.

Maffi, L. and Woodley, E. (2010). *Biocultural Diversity Conservation: A Global Sourcebook*. Routledge.

Mikhail, M., Fencl, A., Naruchaikusol, S. and Kemp-Benedict, E. (2011). Innovation and diffusion of sustainable agricultural water resource management in a changing climate: Case Study in Northeast Thailand.

Miranda, I., Lopez, M. and Soares, M.C.C. (2011). Social technology network: paths for sustainability. *Innovation and Development*, 1: 151-152.

Momsen, J.H. (ed) (2007). Special issue on 'Gender and agrobiodiversity'. *Singapore Journal of Tropical Geography,* 28 (1): 1–106.

Moser, S.C. and Ekstrom, J.A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*, 107(51): 22026-22031.

Nederlof, S., Wongtschowski, M. and van der Lee, F. (2011). Putting heads together: agricultural innovation platforms in practice. *Development, Policy & Practice*. Bulletin 396. KIT Publishers.

Neef, A. and Neubert, D. (2011). Stakeholder participation in agricultural research projects: a conceptual framework for reflection and decision-making. *Agriculture and Human Values*, 28(2): 179-194.

North, D. (1990). *Institutions, Institutional Change and Economics Performance.* Cambridge University Press, Cambridge.

OECD, 2013. Agricultural Innovation Systems: A Framework for Analyzing the Role of the Government. OECD Publishing. Available at <http://dx.doi.org/10.1787/9789264200593-en>

Olwig, M.F. (2012). Multi-sited resilience: The mutual construction of "local" and "global" understandings and practices of adaptation and innovation. *Applied Geography*, 33: 112–118.

Ouagadougou Declaration (2015). "Francophone Workshop on Approaches to Farmer-Led Research and Development" (12–14 May 2015, Ouagadougou, Burkina Faso). Available at: http://www.etc-international.org/blog/wp-content/uploads/2015/05/Ouagadougou-Declaration-FIPAO-English-final.pdf

Oyelaran-Oyeyinka, B. (2005). Systems of innovation and underdevelopment: an institutional perspective. UNI-INTECH Discussion Paper No. 2005-1. Maastricht: United Nations University, Institute for New Technologies.

Pamuk, H., Bulte, E. and Adekunle, A.A. (2014). Do decentralized innovation systems promote agricultural technology adoption? Experimental evidence from Africa. *Food Policy*, 44: 227-236.

Pardey, P.G., Beintema, N.M., Dehmer, S. and Wood, S. (2006). Agricultural Research: A growing global divide? (Vol. 17). IFPRI.

Perfecto, I., Rice, R.A., Greenberg, R. and Van der Voort, M.E. (1996). Shade coffee: A disappearing refuge for biodiversity. *BioScience,* 598-608.

Peroni, N., De Alguqueque, U.P., De Assis, A.L. and De Freitas Lins Neto, E.M. (2013). “The domestication of landscapes and cultural keystone species in a context of community biodiversity management in Brazil” In de Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., and O'Keeffe, E. (Eds.). (2013). Community Biodiversity Management: promoting resilience and the conservation of plant genetic resources. Routledge. pp 145-150.

Pimbert, M (1999) *Sustaining the Multiple Functions of Agricultural Biodiversity*. Gatekeeper Series No. 88. IIED: London.

Pingali, P.L. (2012). Green Revolution: Impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences*, 109(31): 12302–12308.

Pingali, P.L. and Traxler, G. (2002). Changing locus of agricultural research: will the poor benefit from biotechnology and privatization trends?. *Food Policy*, 27(3): 223-238.

Poulton, C., Dorward, A. and Kydd, J. (2010). The future of small farms: New directions for services, institutions, and intermediation. *World Development,* 38(10): 1413-1428.

Prolinnova (2012). “Farmer access to innovation resources: Findings and lessons learnt on facilitating Local Innovation Support Funds.” Leusden: PROLINNOVA International Secretariat, ETC Foundation. Available at: www.prolinnova.net/sites/default/files/documents/thematic_pages/piloting_lisf/farmer_access_to_innovation_resources_for_web.pdf

Regeer, B. (2009). Making the Invisible Visible: Analysing the Development of Strategies and Changes in Knowledge Production to Deal with Persistent Problems in Sustainable Development. Boxpress, Oisterwijk.

Reij, C. and Waters-Bayer, A. (Eds.). (2014). Farmer innovation in Africa: A source of inspiration for agricultural development. Routledge.

Reijntjes, C., Haverkort, B. and Waters Bayer, A. (1992). *Farming for the future: an introduction to low-external-input and sustainable agriculture.* Macmillan.

Rhoades, R (1989). The role of farmers in the creation and continuing development of agricultural technology and systems. *In* Chambers, R., Pacey, A. and Thrupp, L. (eds.) *Farmer First: Farmer Innovation and Agricultural Research*, 3–9. ITDG, London.

Rodima-Taylor, D. (2012). Social innovation and climate adaptation: Local collective action in diversifying Tanzania. *Applied Geography*, 33: 128–134.

Rodima-Taylor, D., Olwig, M.F., and Chhetri, N. (2012). Adaptation as innovation, innovation as adaptation: An institutional approach to climate change. *Applied Geography*, 33: 107–111.

Roep, D., Van Der Ploeg, J.D. and Wiskerke, J.S.C. (2003). Managing technical-institutional design processes: some strategic lessons from environmental co-operatives in the Netherlands. *NJAS-Wageningen J. Life Sci*. 51: 195–217.

Rogers, E.M. 1962. *Diffusion of innovation*. New York: Free Press.

Röling, N. (1992). The emergence of knowledge systems thinking: a changing perception of relationships among innovation, knowledge process and configuration. *Knowledge and policy*, 5(1): 42-64.

Röling (1996). Towards an interactive agricultural science. *European journal of agricultural education and extension*, 2(4): 35-48.

Röling, N. (2009). Pathways for impact: scientists' different perspectives on agricultural innovation. *International journal of agricultural sustainability*, 7(2): 83-94.

Rotman, D. (2013). "Why we will Need Genetically Modified Foods." MIT Technology Review. Available online at <http://www.technologyreview.com/featuredstory/522596/why-we-will-need-genetically-modified-foods/>

Sanginga, P.C. (Ed.). (2009). *Innovation Africa: enriching farmers' livelihoods*. Earthscan.

Santilli, J. (2012). *Agrobiodivesity and the Law. Regulating Genetic resources, Food Security and Cultural Diversity*. Earthscan. USA, Canada.

Schumpeter, J.A. (1934). The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle (Vol. 55). Transaction publishers.

de Schutter, O. (2010). Report submitted by the Special Rapporteur on the right to food. United Nations Human Rights Council: Geneva. A/HRC/16/49.

de Schutter, O. (2014). Final report: The transformative potential of the right to food. United Nations Human Rights Council: Geneva. A/HRC/25/57.

Scoones, I. and Thompson, J. (1994). Knowledge, power, and agriculture: Towards a theoretical understanding. *In: Beyond farmer first: Rural people's knowledge, agricultural research, and extension Practice*. I. Scoones, and Thompson. J. (Eds.), 16–31. London: Intermediate Technology Publication.

Scoones, I. and Thompson, J. (2009). Farmer first revisited: Innovation for agricultural research and development (No. E14 193). Institute of Development Studies.

Seyfang, G. and Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental politics*, 16(4): 584-603.

Shiferaw, B.A., Okello, J., and Reddy, R.V. (2009). Adoption and adaptation of natural resource management innovations in smallholder agriculture: Reflections on key lessons and best practices. *Environment, Development and Sustainability*, 11: 601–619.

Smith, A., Fressoli, M., & Thomas, H. (2014). Grassroots innovation movements: Challenges and contributions. *Journal of Cleaner Production*, 63: 114–124.

Sperling, L., Ashby, J.A., Smith, M.E., Weltzien, E., and McGuire, S. (2001). A framework for analyzing participatory plant breeding approaches and results. *Euphytica*, 122(3): 439-450.

Spielman, D. and Birner, R. (2008). How innovative is your agriculture? Using innovation indicators and benchmarks to strengthen national agricultural innovation systems. Agriculture and Rural Development Discussion Paper 41. The World Bank.

Spielman, D.J., Ekboir, J., Davis, K. and Ochieng, C.M.O. (2008). An innovation systems perspective on strengthening agricultural education and training in sub-Saharan Africa. *Agricultural Systems*, 98: 1–9.

Spielman, D.J., Ekboir, J., and Davis, K. (2009). The art and science of innovation systems inquiry: Applications to Sub-Saharan African agriculture. *Technology in Society*, 31(4): 399–405.

Spielman, D.J., Hartwich, F. and Grebmer, K. (2010). Public–private partnerships and developing-country agriculture: evidence from the international agricultural research system. *Public Admin. Dev*. 30: 261–276.

Spielmann. D.J. and Ma, X. 2015). Private Sector Incentives and the Diffusion of Agricultural Technology: Evidence from Developing Countries. The Journal of Development Studies. DOI: 10.1080/00220388.2015.1081171.

Steinberg, M.K. (1998). Neotropical Kitchen Gardens as a Potential Research Landscape for Conservation Biologists. *Conservation Biology*, 12(5): 1150–1152.

Steinfield, C. and Wyche, S. (2013). Asessing the role of information and communication technologies to enhance food systems in developing countries: A Focus on Eastern and Southern Africa. Technical report. MSU.

Steinfield, C., Wyche, S., Cai, T., and Chiwasa, H. (2015). The mobile divide revisited: mobile phone use by smallholder farmers in Malawi. In Proceedings of the Seventh International Conference on Information and Communication Technologies and Development (p. 8). ACM.

Stotz, S. (2009). Identification of SLM best bet practices in Sub-Saharan Africa and an analysis of the upscaling potential of different technologies. Bachelor study 03-907-185. University of Bern, Switzerland.

Sulaiman, V.R. and Davis, K. (2011). The ‘‘New Extensionist’’: Roles, Strategies, and Capacities to Strenghen Extension and Advisory Services. *Global Forum for Rural Advisory Services* (G-FRAS), Zürich, Switzerland.

Swaans, K., Boogaard, B., Bendapudi, R., Taye, H., Hendrickx, S., and Klerkx, L. (2014). Operationalizing inclusive innovation: lessons from innovation platforms in livestock value chains in India and Mozambique. *Innovation and Development*, 4(2): 239-257.

Tacoli, C. (1998). Rural-urban interactions; a guide to the literature. *Environment and Urbanization*, 10: 147-166.

Tapia, M. and Tobin, B (2013). Guardians of the Seed. *In* Kamau, E.C and Winter, G (eds.) *Common Pools of Genetic Resources: Equity and Innovation in International Biodiversity Law*, Routledge, Oxon.

Tenywa, M.M., Rao, K., Tukahirwa, J.B., Buruchara, R., Adekunle, A., Mugabe, J., Wanjiku, C., Mutabazi, S., Fungo, B., Kashaija, N.I., Pali, P., Mapatano, S., Ngaboyisonga, C., Farrow, A., Njuki, J. and Abenakyo, A. (2011). Agricultural innovation platform as a tool for development oriented research: lessons and challenges in the formation and operationalization. *J. Agric. Environ. Stud*. 2: 117–146.

Thrupp, L.A. (1989). Legitimizing Local Knowledge: From Displacement to Empowerment for Third World People. *Agricultural and Human Values* (Summer): 13-24.

Tittonell, P. (2014). Livelihood strategies, resilience and transformability in African agroecosystems. *Agricultural Systems*, 126: 3–14.

Tittonell, P., Scopel, E., Andrieu, N., Posthumus, H., Mapfumo, P., Corbeels, M., … Mkomwa, S. (2012). Agroecology-based aggradation-conservation agriculture (ABACO): Targeting innovations to combat soil degradation and food insecurity in semi-arid Africa. *Field Crops Research*, 132: 168–174.

Ton, G., Klerkx, L., Grip, K. and Rau, M. (2015). Innovation grants to smallholder farmers: Revisiting the key assumptions in the impact pathways. *Journal of Food Policy*, 51: 9–23.

UNCTAD (2010). *Technology and Innovation Report 2010: Enhancing Food Security in Africa through Science, Technology and Innovation*. UNCTAD. Sales No. E.09.II.D.22

VanGalen, M. (2009). Innovatiemonitor 2008 vernieuwing in de land en tuinbouw ontcijferd. Working Paper. University of Wageningen.

Van Huis, A., Jiggins, J., Kossou, D., Leeuwis, C., Röling, N., Sakyi-Dawson, O., Struik, P. and Tossou, R. (2007). Agricultural research to reduce rural poverty: Can convergence of sciences support innovation by resource-poor farmers in Benin and Ghana? Special Issue of International Journal of Agricultural Sustainability (IJAS) 5 (2–3): 91–108.

van Mierlo, B., Regeer, B., Amstel, M.v., Arkesteijn, M.C.M., Beekman, V., Bunders, J.F.G., Cock Buning, T.D., Elzen, B., Hoes, A.C. and Leeuwis, C. (2010). Reflexive Monitoring in Action: A Guide for Monitoring System Innovation Projects. Boxpress Oisterwijk.

van Rijn, F., Bulte, E. and Adekunle, A. (2012). Social capital and agricultural innovation in Sub-Saharan Africa. *Agricultural Systems*, 108: 112–122.

Vandermeer, J. H. and Perfecto, I. (2012). Syndromes of production in agriculture: Prospects for social-ecological regime change. *Ecology and Society*, 17(4).

Veldhuizen et al (1997) *Developing Technology with Farmers: A trainer's guide for participatory learning.* Zed books.

Vernooy, R. and Ruiz, M (eds.) (2012).*The Custodians of Biodiversity: Sharing Access to and Benefits of Genetic Resources*. Earthscan. USA and Canada.

Vivas-Eugui, D. and Anamika, I.P.A. (2012). Bridging the gap on intellectual property and genetic resources in WIPO's Intergovernmental Committee (IGC). ICTSD's Programme on Innovation, Technology and Intellectual Property.

Von Hippel, E. (2005). Democratizing innovation: The evolving phenomenon of user innovation. *Journal für Betriebswirtschaft,* 55(1): 63-78.

Waters-Bayer, A., Wettasinha, C. and van Veldhuizen, L. (2007). Prolinnova: building partnerships to enhance local innovation processes. Working Paper 16.

Waters-Bayer, A., Wettasinha, C., Assefa, A., Kamau, G., Araya, H., Righa, M. and van Veldhuizen, L. (n.d.). Facilitating extensionists to learn by doing in promoting local innovation.

Waters-Bayer, A., van Veldhuizen, L., Wongtschowski, M. and Wettasinha, C. (2009). Recognising and enhancing processes of local innovation. *In* Sanginga, P.C. (ed.).*Innovation Africa: enriching farmers' livelihoods*. Earthscan: 239-254.

Waters-Bayer, A., Krisjanson, P., Wettasinha, C., van Veldhuizen, L., Quiroga, G., Swaans, K., Douthwaite, B. (2015). Exploring the impact of farmer-led research supported by civil society organisations. *Agriculture & Food Security,* 4*:* 1-4.

Westley, F. and Antadze, N. (2011). Making a Difference: Strategies for Scaling Social Innovation for Greater Benefit. *The Public Sector Innovation Journal,* 15(2). Available at <sig.uwaterloo.ca/sites/default/files/documents/MAKING_A_DIFFERENCE_SiG_Format.pdf>

Wettasinha, C., Wongtschowski, M. and Waters-Bayer, A. (2006). Recognising local innovation: experiences of PROLINNOVA partners. C. Wettasinha (ed.). International Institute of Rural Reconstruction (IIRR).

Wettasinha, C., Waters-Bayer, A., van Veldhuizen, L., Quiroga, G. and Swaans, K. (2014). Study on impacts of farmer-led research supported by civil society organizations. Penang, Malaysia: CGIAR Research Program on Aquatic Agricultural Systems. Working Paper: AAS- 2014-40.

Wongtschowski, M., Triomphe, B., Krone, A., Waters-Bayer, A. and van Veldhuizen, L. (2010). Towards a Farmer-Governed Approach to Agricultural Research for Development: Lessons from International Experiences with Local Innovation Support Funds. pp. 11.

The World Bank (2006). Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems. Washington, DC, USA: The World Bank.

The World Bank (2012). *Agricultural Innovation Systems: An Investment Sourcebook.* World Bank.

The World Bank (2014). *Internet for Developent. World Development Report 2016: Concept note*. Report No. 91877.

Wortmann, C.S., Christiansen, A.P., Glewen, K.L., Hejny, T.A., Mulliken, J., Peterson, J.M., Varner, D.L., Wortmann, S. and Zoubek, G.L. (2005). Farmer research: Conventional experiences and guidelines for alternative agriculture and multi-functional agro-ecosystems. *Renewable Agriculture and Food Systems,* 20(4): 243–251.

Wu, B. and Zhang, L. (2013). Farmer innovation diffusion via network building: A case of winter greenhouse diffusion in China. *Agriculture and Human Values*, 30: 641–651.

Wynberg, R. and Pereira, L. (2013). "Whose innovation counts? Exploring the interface between informal and formal innovation in seed development in South Africa." The Business School of Environmental Innovation Graduate School of Business, Cape Town.

Yang, H., Klerkx, L. and Leeuwis, C. (2014). Functions and limitations of farmer cooperatives as innovation intermediaries: Findings from China. *Agricultural Systems*, 127: 115–125

Yates, D.J., Gulati, G.J.J. and Weiss, J.W. (2013). Understanding the impact of policy, regulation and governance on mobile broadband diffusion. In System Sciences (HICSS), 2013 46th Hawaii International Conference on (pp. 2852-2861). IEEE.

Young, C. (2014). The problem solution framework: process guidance for adaptation practitioners. VISES Climate Change Working Paper No. 19, Victoria Institute of Strategic Economic Studies, Victoria University, Melbourne.