Interrogating agricultural innovation system from small farmers' perspective: China, India and implications for theory and Policy

Joseph, K J (1); Zhang, Liyan (2)

1: Centre for Development Studies, India; 2: Centre for Innovation and Enterprenuership, Tianjin University of Finance and Economics

Abstract

There is a growing consensus that for the agrarian economies in the 21st century, agriculture remains fundamental for poverty reduction, livelihood security, economic growth and environmental sustainability wherein innovation plays a key role. However, the paradigm governing the agricultural R&D and innovation has been evolving over time. The new paradigm, Agricultural Innovation System (AIS), drawing insights from the National System of Innovation (NSI), perceives that in agriculture innovations emerge from interaction and knowledge flows between research and entrepreneurial organizations in the public and private sectors engaged in the agricultural value chain. This is in contrast to the earlier view that research organizations produced new knowledge that the farmers blindly adopted. It has also been argued that since more than nine out of ten farms in the world are small farms, their innovation capability is crucial for achieving food security and sustainable rural development A newly emerging literature on small-scale farmer (SSF) innovation articulates small farmers as innovators themselves rather than mere implementers of innovations as often viewed. In this context this paper explores how small farmers are integrated with the AIS and how conducive are the institutions for enhancing and harnessing their innovation capabilities for addressing varied issues pertaining to agricultural development. The paper examines this issue by taking case studies from China and India with a view to draw lessons for informed policy making. It is argued that that the small farmers, like small firms, are confronted with numerous challenges and have an inherent capacity to innovate. Yet, within the AIS perspective, small farmers' innovation capability is yet to receive the attention that it deserves. The study makes the case for promoting and harnessing small farmers' innovation capability to evolve a more inclusive AIS towards addressing the pressing needs of food safely, rural employment, livelihood and environmental sustainability.

Introduction

There is a growing consensus that agriculture remains fundamental for poverty reduction, livelihood security, economic growth and environmental sustainability in the agrarian economies of the 21st century (World Bank (2007). The role of science, technology and innovation in enabling agriculture to ccomplish the above has been recognized in the literature and practice. The scientific paradigm governing science, technology and innovation for agricultural development, however, has been evolving overtime. In general the paradigm evolved from the top down linear approach of adoption and diffusion perspective (Rogers 1962) as manifested in the National Agricultural Research Systems (NARS) to National Agricultural Knowledge Systems (NAKS) and finally to the Agricultural Innovation System (AIS) perspective (Roling 1990; Klerkx et al 2012; Hall et al 2004). By now AIS perspective, with its analytical foundations drawn from the National Innovation System perspective has emerged as the most popular approach in understanding the innovation and development process in agriculture. Unlike the earlier perspectives, AIS is often considered as more inclusive as it takes into account of a broader spectrum of activities and actors involved in addressing the current challenges of agricultural sector in developed and developing countries.

FAO (2014) argues that about 500 family farms, representing more than nine out of ten farms in the world, are at the center of the solution for achieving food security and sustainable rural development (see also Lowder et al 2016). FAO further makes the case for promoting capacity to innovate at multiple levels; the individual level, the organizational level, policy level and calls for enabling the small-scale farmers to collectively act and innovate. A newly emerging literature on small-scale farmer (SSF) innovation (QUNO 2015) articulates farmers as innovators themselves rather than mere implementers of innovations as often viewed. Farmers' innovation systems are recognized as fundamentally unique from formal sector innovation systems. Hence the small farmers, like small firms in the industrial sector that are known for their innovations, confronted with numerous challenges in their survival also undertake innovative activities which often go unnoticed. Small farmer innovations therefore have the potential to contribute towards addressing the pressing needs of food safely, rural employment, livelihood and environmental sustainability. However, unlike the small firms in the industrial sector, there is neither a recognition of the innovation capacity of small firms nor a proper understanding of the process of innovation by them.

In this context the present study is an attempt at exploring how small farmers are integrated with the AIS and how conducive are the institutions for fostering and harnessing their innovation capabilities for addressing varied issues pertaining to agricultural development. We explore this issue by taking the case of China and India with a view to and draw lessons for informed policy making. The selection of these two countries could be justified on different grounds. With a mean holding size of 0.5 hectares in China in 2006 (Lowder et. al. 2016) and 1.15 hectares in India in 2011 (Government of India 2014) both are known for small farmer domination and agriculture continues to be a major source of employment and income notwithstanding the significant structural change overtime. Further, with the reform process starting with the rural and agrarian sectors China's performance with respect to agricultural growth and poverty reduction was remarkable in comparison with India where in reform process started with the industrial and trade sector (Gulati et al 2008). Finally, both China and India are characterized by diverse agro climatic zones cultivating numerous crops that sets limits for the outreach of the formal sector research and leave room for small farmer innovations.

The remainder of this article is organized as follows. Section 2 explores the analytical foundations of AIS and the role of small farmers therein. Section 3 examines the institutional architecture for integrating small farmer innovations in India and China. The last section presents the concluding observations that draw inference for policy for AIS perspective in general and highlight a few lessons of relevance for India and other developing countries.

2. Agricultural innovation system and small farmer innovations

Throughout the past two centuries agricultural societies have ambitiously created organizations and institutional arrangements with a view to increase technological innovation (Engel 1997) giving rise to different paradigms for harnessing innovation for agrarian transformation. Perhaps the earliest approach was the National Agricultural Research Institutes (NARS) framework, established at the instance of colonial powers, with a view to promote export-oriented cash crop production as in case of planation sector in India. Later this approach got extended to food production with considerable success in the early period and it prevailed for decades. The agricultural production process that emerged turned to be highly chemical-intensive, fossil fuel-dependent, organized in large mono -crop farms and a major contributor to climate change, bio diversity loss and the degradation of land and freshwater ecosystems (Foley et al 2011).

The disenchantment with the top-down linear approach gave way to National Agricultural Knowledge Systems (NAKS) defined as a group of scientific organizations involved in the creation of scientific and technological knowledge related to agriculture

(Hall et al 2004). The NAKS, therefore included the National Agricultural Research Systems (NARS), the National Agricultural Extension System (NAES), and the National Agricultural Education and Training System (NAETS). This line of thinking continued to include the other actors involved in agricultural R&D and resulted in a number of other concepts such as Agricultural Knowledge and Information System (AKIS), the Technology Development and Transfer system (TDT) (Hall et al 2004; Anandajayasekeram and Gebremedhin 2009).

Agricultural development, however, involves a multitude of actors in the agricultural value chain engaged in growing, processing, packaging, distributing, and consuming or otherwise using agricultural products. These actors represent quite disparate perspectives and skills, such as metrology, safety standards, molecular genetics, intellectual property, food chemistry, resource economics, logistics, slash-and-burn farming, land rights to list a few. Innovations occur in all the stages of the value chain as a result of the interactions among these diverse stakeholders harnessing their diverse knowledge (World Bank 2012) Hence, innovation for broad based development, requires a much more interactive, dynamic, and ultimately flexible and evolving process in which the actors deal simultaneously with many conditions and complementary activities that go beyond the traditional domains of R&D and extension for farmers. Taking these aspects into consideration, the latest development, drawing from the National System of Innovation perspective (NSI)[1], is the Agricultural Innovation Systems (AIS) paradigm. This takes into account the failure of earlier paradigms to recognize the multiple sources of innovation and the limits to the linear, top down approach implicit in them. There are two approaches within NIS (Lundvall 2007); one of them, often referred to as STI (Science Technology and Innovation) mode, in tune with the analyses of national science systems and national technology policies (Nelson, 1993, Mowery and Oxley, 1995), aimed at mapping indicators of national specialization and performance with

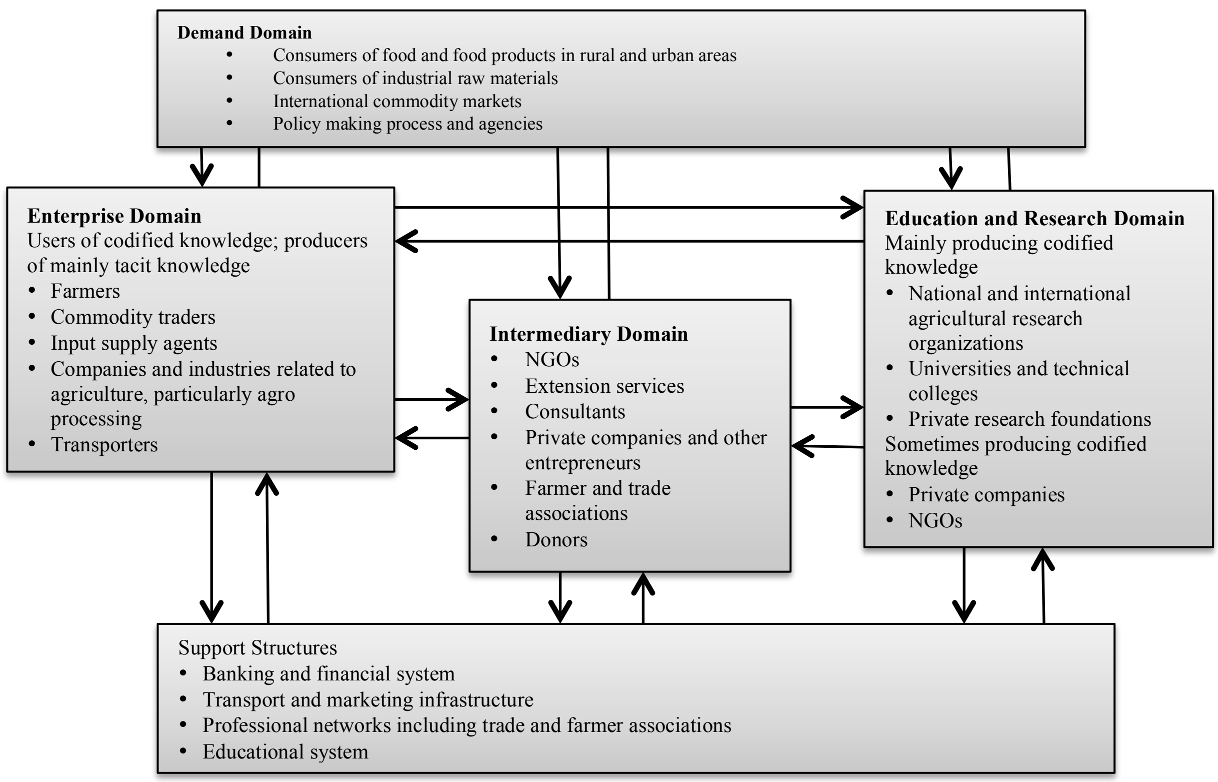
[1] NSI perspective, by now the most popular approach in innovation studies (Fagerberg and Sapprasert (2011(emerged from the pioneering contributions made by Lundvall (1985; 1992) Freeman (1987), Nelson (1993), Equist 1996) as an alternative approach to the linear approach to innovation. This has also been adopted as a tool for policy making by the international organizations like OECD, the European Commission, The World Bank and UNCTAD (Cassiolato et al 2014).

respect to research and development efforts and interaction among science and technology organizations. The policy issues raised were almost exclusively in the realm of explicit S&T policy focusing on R&D. The second approach, often referred to as DUI (Doing Using and Interacting) mode or the experience based learning (Jensen et al., 2007) takes into account user producer interactions, social institutions, macroeconomic regulations, financial systems, education and communication infrastructures as far as these have impact on learning and competence building process (Gu and Lundvall, 2006).

Though the NSI perspective originated in the context of developed countries, it provides a unique lens for exploring interactive learning, innovation and competence building of actors in developing countries (Lundvall et al 2009) including in the context of agriculture (Clark 2002). Exploiting this characteristics of NIS for understanding innovation as a dynamic process of interactive learning among all the actors involved within the changing institutional context, scholars searching for alternatives to the prevailing paradigm in agricultural research and development and pioneered by Hall and Clark (1995), Engel (1997) and Hall et al. (2001, 2003), Ekboir and Parellada 2001; Clark 2002) evolved the Agricultural Innovation System perspective. Such an inquiry was induced by a host of factors. It was widely held that the constraints faced by many agricultural research organizations and systems around the world are institutional in nature (Byerlee and Alex 1998). In a study on the participation of resource poor farmers in research programmes in NARS Biggs (1989) evolved a typology of four modes of participation (contractual, consultative, collaborative, and collegial) to differentiate the ways in which resource-poor farmers participate in research programs and highlighted the role of institutions in shaping the nature and pattern of their participation. It was also observed that source of innovation is not just confined to those who are designated as 'researchers' but it is also contributed by 'practitioners' in numerous settings throughout the research, extension, and production systems. These may include farmers, research practitioners, administrative practitioners, NGOs, private firms and others (Biggs and Clay 1981; Biggs 1990; Clark et al. 2003). Since the linear model was found not fit to understand the actual process of innovation in a world wherein the policy agenda of agricultural research has broadened to include poverty reduction and environmental sustainability (Hall et al. 2004), the multiple source model as articulated by AIS is found to be a more appropriate perspective.

It is evident from figure 1 that AIS considers all the relevant domains, which in turn could influence innovation and development of agricultural sector. This includes not only those engaged in the generation and diffusion of knowledge but also those in the demand domain, enterprise domain, intermediary domain, and support structures

Fig 1: Domains and actors in Agricultural Innovation System



Source: Rajalahti et al (2008)

AIS scholars argued that in agriculture, innovation emerges from interaction and knowledge flows between research and entrepreneurial organizations in the public and private sectors engaged in the different stages of agricultural value chain. This is in contrast to the generally held view that research organizations produced new knowledge that the farmers blindly adopted. Instead, innovation involves an interactive learning process involving a wide variety of scientific and socio-economic agents. This implies that innovation could have multiple sources, not confined to formal research organizations but other actors like civil society organizations, farmers and others. Further, technical and institutional changes were often interdependent and coevolve. (references)

Table 1 presents characteristics of AIS as distinct from NARS and NAKS. It is evident that with respect to the actors and outcomes, AIS is more broadbased as compared to NARS or NAKS and it recognizes the relevance of learning, innovation and competence building of different actors involved. It is also evident that while NARS and NAKS focuses only on scientific agencies as generators of innovations and farmers as adopters, AIS takes into account the role of a wide spectrum of actors involved in the different stages of value chain. Similarly, while the earlier paradigms focused on technology transfer, technology adoption and technological innovation, AIS considers other types of innovations along with the technological innovations. In a sense, while the earlier paradigms focused mainly on the STI mode of innovation, AIS approach is in sync with the DUI mode which is capable of taking into account varied issues confronted by the agricultural sector and facilitating development based on agriculture.

Table 1: Characterizing NARS, NAKIS and NIS

Defining Feature	National agricultural research systems	Agricultural knowledge and Information systems	Agricultural Innovation systems
Actors	Research organizations	Farmer, research, extension, and education	Wide spectrum of actors in the value chain
Outcome	Technology Invention and transfer	Technology adoption and innovation	Different types of Innovation
Organizing principle	Using science to create new technologies	Accessing agricultural knowledge	New uses of knowledge for social and economic change
Mechanism for Innovation	Technology transfer	Knowledge and information exchange	Interaction and Innovation among stakeholders
Role of Policy	Resource allocation, priority setting	Linking research, extension, and education	Enabling Innovation

Nature of capacity strengthening	Strengthening infrastructure and human resources	Strengthening communication between actors in rural areas	Strengthening Interactions between all actors, creating an enabling environment

Source: World Bank 2007

With respect to translating insights from academic research to policy formulation, there are not many parallels for the extent to which AIS perspective has been incorporated into policy action, wherein the role of The World Bank has been remarkable. By bringing together a large number of scholars and drawing from numerous case studies across world the Word Bank (2012) provides the guidelines for all the actors involved in the AIS. With much appreciation that it richly deserves, it is important to highlight certain limits with its implications especially on the small farmers.

Whither Small Farmer Innovations

For the purpose of the present discussion the key issue of relevance relates to the role assigned to the small-scale farmers in AIS. Perhaps, the major point of departure of AIS from the earlier approaches to innovation in agriculture is its emphasis on interactive learning among all the actors involved and the role of institutions there in. Especially notable is the role assigned to farmers with a widespread consensus that farmers need to have greater influence in the innovation process (Klerkx and Leeuwis 2008; Klerkx et al. 2006; Neef and Neubert 2011; Poulton et al. 2010; Ton et al 2015). Thus the farmers are at the centre stage of AIS. But the AIS perspective fails to duly acknowledge the fact that farmers are a heterogeneous category in the developing countries. Moreover, there is evidence to suggest that on account of the capability deficits and entitlement failures along with barriers to interactive learning the small farmers are confronted with multiple spaces of exclusion (Joseph 2014; Raina et al 2013) as articulated by Sen (2000). History also teaches us that wherever agricultural innovations/schemes were introduced without recognizing this heterogeneity, the rich farmers cornered all the returns as has happened in the case of India's green revolution (Rao 1994). FAO (2014) makes it unambiguous when it states "analysis and general policy recommendations are unlikely to be relevant for the entire category, whether they relate to innovation or other domains" (p 26).

NIS perspective derived from the experience of developed countries considers that firms – the basic units in an industry that transforms inputs into output- are the major source of innovations and users of innovations. Hence the NIS perspective makes the case for national/regional governments, both in the developing and developed countries, to have institutional interventions to promote the innovation capability of firms. In the AIS perspective farms, similar to their counterparts in industry, are not explicitly recognized for their ability to innovate but are seen simply as participants and users of innovations.

However, it needs to be noted that AIS did recognize the importance of small farms and the need for empowering them. It is also recognized that innovations having greater interest to the poor are often neglected. It has been argued that this exclusion will not be resolved by establishing partnerships among the poor. Closed networks of poor people rarely yield useful and sustainable innovations (Rajalahti et al 2008). The suggested approach is to link them with private sector and Civil Society Organization (CSOs). Thus viewed, within the AIS perspective the small farmers will have to wait until the private sector finds it a profitable venture to associate with small farmers or until the CSOs are adequately altruistic.

This represents an unrealistic understanding on the process of innovation in the rural setting and farmers' capability to innovate to address many of the issues confronted by them. NIS perspective, the analytical framework of AIS duly acknowledges the capability of small firms in the innovation process both by STI mode and DUI mode. There is a growing evidence indicating that the resource poor, small-scale farmers are innovative by themselves[2]. With an intimate knowledge of their natural landscapes, farmers continually

[2] A small farmer stated during one of my field visits "my day starts in early morning with the milching of the cow and then I proceed for tapping rubber trees. There after I keeps doing other works like plaughing, planting weeding, irrigating, fertilizing, harvesting and feeding the cattle ……so on almost until I go to the bed". Thus the time that a small farmer spends within the farm is much more that of a large farmer, or a scientist. Unlike the larger farmers, small farmers undertake farming for survival. In this process, she interacts with her cows/goats/pigs, crops, weeds, tools, fertilizer, insecticides, along with neighbors, dealers, transporters, financiers and also with the extension agents. These interactions are her sources of learning as articulated by the NIS perspective, which is multidimensional. These interactive learning along

conduct experiments and observe subtle changes over time. They integrate new technologies from the formal sector into their management practices, blending both traditional and modern knowledge and make decisions based on cultural preferences, local contexts and budget constraints. As Sanginga 2009) argues, small farmers, rather than being blind adopters of the innovation offered from above, develop more appropriate ways of managing resources and overcome local challenges by synthesizing local and scientific knowledge systems and applying them to changing circumstances. Wu and Zhang (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). Though the local specific problems that induce them to innovate may be too insignificant for the national/global players, they are crucial for the food security, employment and environmental sustainability of the small farmers. Women play particularly important roles in on-farm innovation relating to conservation and nutrition (Bragdon 2015)[3]

However there is hardly any systematic research concerning innovation of the 'bottom billion' (Lorentzen 2010). Hence the innovation by small farmers along with their role in influencing the research agenda of the formal sector, are rarely documented in peer-reviewed journals and are thereby difficult to access and remain unnoticed. Most documentation remains in project reports, civil society organizations' websites and less academic-oriented literature such as magazines (Wettasinha et al 2014). Further the AIS perspective, drawing insights from the NIS, has not taken into account the power relations that exist in the agricultural value chain. While the influence of power relations could be limited in more homogenous societies wherein NIS concept emerged, this is bound to have its implications in the context of agricultural sector in developing countries wherein such power relations' does matter.[4]

---

with the inherited knowledge enables farmers to innovate.

[3] Bragdon Susan. H. and Chelsea Smith (2015), *Small-scale farmer innovation,* (Quaker United Nations Office, Geneva).

[4] For a detailed on the Indian context, see Bhaduri (1973).

This fundamental difference is not adequately recognized by the AIS leading to generalized conclusions and untargeted policy prescriptions. Spielman et al (2009) argues that few AIS studies examine distributional and poverty-related effects of innovation and very few are focused on technological or institutional changes that are explicitly pro-poor. Even when farmers are included, heavy emphasis is often on the role of institutions and organizations introducing innovation to farmers and facilitating technology adoption (Kraemer-Mbula and Wamae 2010). Under the AIS convened by the 'formalized' institutions and organizations, knowledge and innovative capacity of resource poor small farmers is undervalued and unequal power dynamics are perpetuated. With declining public sector funding for research and influx of public-private partnerships and 'philanthro-capitalists' there has been a shift in focus away from the public interest and those most in need to market-based solutions for those with the ability to pay (Kraemer-Mbula and Wamae 2010).

The broader perspective of AIS, incorporating all the actors in the agricultural value chain, has the potential risk of overlooking differences in values, interests and communication barriers in knowledge sharing arising *inter alia* out of the unequal power relations (Wu and Zhang 2013). Attempts are being made to articulate SSF innovation systems as a 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 (Sanginga 2009). The basic premise is that the farmers have the capacity to innovate, which emerges mostly as an outcome of experience-based learning leading to DUI mode of innovations along with STI mode of innovation. In a sense, given the unequal power relations in the rural agrarian settings, the SSF innovation system perspective recognizes the ideas and voices operating at the low end of the agricultural value chain and often unheard when amalgamated into the larger whole.

Table 2 presents the distinguishing characteristics of small farmer innovation systems as compared to AIS and the conventional paradigms in agricultural innovation. There is significant difference across these three paradigms with respect to the primary actors in the system, role of formal sector, type of innovation and more importantly the role of farmers therein. While the small farmers innovation systems conceived the role of farmers as key agents that innovate and adapt, the AIS consider them as participants in the innovation process. On the whole, while the conventional paradigms focused on innovation for the farmers, the focus of AIS is in innovation with farmers and that of the small scale farmer innovation system is on innovation by the farmers.

Table 2: Three paradigms in agricultural Innovations

	Conventional agricultural Innovation	Agricultural Innovation systems (AIS)	SSF innovation system
Innovation is a(n)….	Output	Process	Process
Primary sectors	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*

Source: (QUNO 2015)

Considering the significance of small farmer innovations, FAO (2014) rightly calls for recognizing the importance of family farmers, and support them in innovating for achieving sustainable productivity increase. FAO is more categorical and reflective of a proper understanding of reality in developing countries when it highlights two interrelated pathways along which small farmers' productivity may be increased. This include the development and application of new technologies and practices, including farmer-led and formal research in combination with traditional integrated farming systems.

To what extent the institutions governing agricultural innovations have taken cognizance of the small farmer innovations. We shall now explore this issue by taking the case of India and China.

Section 2

Small farmer innovations in India and China

India: a case of benign state neglect?

India is one of the pioneering developing countries to recognize the role scientific research in transforming its traditional agriculture and successfully transformed the colonial research institutions for meeting the country's food security (Raina). Over the years India established one of the largest and institutionally most complex agricultural research systems in the world (Mruthyunjaya and Ranjitha (2002) comprising 4 National Institutes, 45 Central Institutes, 30 National Research Centres, 10 Project Directorates, 4 Bureaux, 80 all-India Co-ordinated Research Projects, 261 Krishi Vigyan Kendras and 29 State Agricultural Universities (ICAR vision 2020) with a view to address the changing needs of the sector from time to time.

Not only that India's agricultural research system has grown over the years, it has also been evolving to catch up with the moving target. The earlier approach - National Agricultural Research System – which resulted in India's green revolution and remarkable increase in the productivity of some of the staple crops focused on enhancing the generation and diffusion of new agricultural technologies to the farm sector. Two notable initiatives with The World Bank assistance were Training and Visit (T&V) system Krishi Vigyan Kendra (KVK), ICAR's leading vehicle for extension introduced in 1974 and later extended to other parts of the country. This was followed by the Agricultural Knowledge and Information System" (AKIS) perspective - more demand driven with its greater emphasis on the links between research, education, extension and the identification of farmers' demand for new technologies. (Rajalahti et al 2005; RAKESH).

Broadly with in the AIS perspective attempts have been made over time to involve other actors especially the private sector and non-governmental organizations/CSOs. This has been accomplished *inter alia* through NATP, Agricultural Technology Management Agency (ATMA), National Agricultural Innovation Project (NAIP) and other Government programmes. NATP, sponsored by the world Bank aimed at more effective involvement of scientific community in addressing the needs of poor farmers within their production systems and enhanced collaboration amongst NARS, public and private institutions, both within and outside India. Within NATP, Agricultural Technology Management Agency (ATMA) was conceived with a view to bring about effective knowledge sharing among various actors. The National Agricultural Innovation Project has been implemented since 2006 with a view to facilitate an accelerated and sustainable transformation of the Indian agriculture from self-sufficiency to market orientation. This envisaged collaborative development and application of agricultural innovations by the public organizations in partnership with private sector, NGOs, farmers' groups, and other stakeholders.

Along with these initiatives, there has been a considerable increase in the role of private sector in R&D and extension. Pray and Nagarajan (2012) observed that private investment in agricultural research, mostly by MNCs increased more than 4.5 times in a short period of four years from 2004-05 (from US$54 million in 1994/95 to US$250 million in 2008/09). Further, growth in private R&D expenditure was particularly rapid in the seed and plant biotechnology industry, which grew by more than 10 times between the mid-1990s and 2009. The increasing role of MNCs is evident from the fact that during 2000-2010 while Indian companies were granted 95 patents for agriculture related inventions in India, those granted to MNCs was more than five times (519).

Considering the immense potential for harnessing ICT for agricultural development in general and extension in particular, there are a number of projects within broad ambit of e-agriculture. Most notable are the mobile applications at the instance of private sector including mobile service providers, private sector and non profit organizations (REFERENCE). The services provided by these actors include but not limited to extension in the narrow sense of advice on farm production, information relating to prices of inputs and farm products, administration of financial and other services, and the collection of data for research at varying terms and conditions.

Notwithstanding these welcome developments, small farmer innovations appear to have not received the attention that they receive in India's AIS as it stands today. Based on a study of ten farmers' innovations/Grass root innovations from Andhra Pradesh NAIP 2014 b) observed that they are often need based and offer solutions to local problems. The major inferences drawn from the study included:

• Lack of formal connectivity between R&D and the grassroots rural innovations systems
• Inadequate up scaling and validation opportunities for GRIs
• Inadequate finance for product development
• Grassroots rural innovations are sustainable in local ecosystem

It has been argued that formalization of such innovations from the informal sector is often complex (NAIP 2014b). The credibility of the conclusions drawn from such a small sample drawn from a vast country like India is under suspect. All the more, while many of the small farmer innovations could have profound implications for addressing issues of productivity enhancement, cost reduction and sustainability, the study appears to dismiss away the farmer innovations as solutions to local problems.

At the same time, a large number of NGOs are working closely with farmers' innovations with varying perspectives (Smith et al 2017). The largest database of such innovations (over 100,000, according to the official website of National Innovation Foundation) has been collected by the volunteers of Honey Bee Network (HBN), the informal association of like-minded people (academics, farmers, scientists, and students) initiated by Professor Gupta (Ustyuzhantseva 2017).). HBN based itself on a philosophy of recognizing and rewarding the knowledge of grassroots people and its dissemination for the benefit of society. The role of the state, as of now, is limited to the meager financial support offered to NIS, which is presently an autonomous body under the Department of Science and Technology. Initial support for the work of the HBN from mainstream policy came when the NIF was established in 2000 to strengthen grassroots technological innovations and outstanding traditional knowledge. In 1999, the Indian Finance Minister had announced the need to set up a Micro Venture Innovation Fund for helping small innovators and traditional knowledge holders, and in October 2003 the fund was established, with a corpus of Rs. 5 crore (approximately US$1.1 million). In February 2007, it was announced that NIF would be given the status of an autonomous institution under the DST, with an annual budget of Rs. 8–10 crore per year (approximately US$1.8–2.2 million). In June 2010, the pattern of funding was changed from the 'corpus fund' to a regular annual budget. NIF was converted to a grant-in-aid institution under the DST, with a total project outlay of approximately US$5.6 million during the Eleventh Five Year Plan (2007–2012) (Fressoli 2014)

So far with the help of NIF 39 patents have been granted to grassroots innovations in India and four in the US. Further, 19 applications were filed under the Protection of Plant Varieties and Farmers' Rights Act, 12 Design Registrations and 15 Trademark applications. NIF has funded 183 projects under MVIF to the extent of Rs. 23 million. (Nature ARTICLE). Even within NIF or NGOs to the best of our knowledge to there are not many programmes for nurturing their innovative capabilities. This indicates the rampant institutional inertia for change both at the national and sub national levels, which stands in the way of fostering interactive learning, innovation and competence building which is at the core of National Innovation System perspective.

Small farmer innovations: Case of cardamom

The issue of our concern is the nature and character of small farmer innovations and their role in the AIS as it exists today. There are numerous evidences to suggest that small farmers have been innovative although there is hardly any systematic data exists. NIF (2013) states that a database of more than 1,74,000 ideas, innovations and traditional knowledge practices (not all unique, not all distinctive) from over 550 districts of the country (out of 707 in 2016) have been generated through the help of Honey bee network. NIF (2013) provides details of 243 award winning innovations (see table 3) dividing tem into the broad categories like those relating to agriculture, energy related, transport, utility and those by the students which are often for crosscutting ones. It is of relevance to note that innovations relating to agriculture that include tools and equipment for agriculture, new plant varieties and agricultural practices together accounted for over 40 per cent of the award winning innovations (Table 3). Most of these innovations located by the Honey bee network are contributed by either small farmers and those engaged in farming related activities.

Table 3: Distribution of Grass root innovations that received national innovation award till 2013

STATES	Agriculture related				Power/ Energy Related	Transport	Utility/others	Innovation by Students	Total
	Tools & Equipment Related	Development Plant Varieties	Agricultural Practices	Total					
Andhra Pradesh	2		2	4			4		8
Arunachal Pradesh									
Assam	1		1	2	3	3	12	1	21
Bihar					1	3	3	2	9
Chattisgarh							1		1
Goa									
Gujarat	11	3		14	2	2	11	2	31
Haryana	3	1	1	5		2	2	1	10
Himachal Pradesh						1			1
Jammu & Kashmir	1			1	1	1	3		6
Jharkhand							1	3	4
Karnataka	4	3	3	10	3		1	2	16
Kerala	9	9	4	22	2	4	4	2	34
Madhya Pradesh	5	1		6		1	2		9
Maharashtra	4	2		6	1	2	4	1	14
Manipur							6		6
Meghalaya					1				1
Mizoram									
Nagaland	1			1					1
Orissa	2		1	3				4	7
Punjab						1	2	2	5
Rajastan	6	3	2	11	1	4	1	2	19
Sikkim									
Tamil Nadu	4	3	2	9	1		6	4	20
Uttarkhand		1		1	1		1		3
Uttar Pradesh	1	2		3	1	1	1	1	7
West Bengal	1			1			3	1	5

Delhi							2	3	5
Total	55	28	16	99	18	25	70	31	243

It is important to note that out of the 28 new plant varieties for which innovation awards were given, five were for developing new cardamom varieties. The finding that those engaged in cardamom and spices in general and those from Kerala in particular were more innovative is an issue that calls for further enquiry. It could be hypothesized that literate farmers, with an organizational network that facilitate interactive learning and the potential for more income, will be more innovative.

Cardamom in India is mainly grown by the small growers in the relatively backward ever green forests of Western Ghat region in the three southern states in India - Kerala, Karnataka and Tamil Nadu. The yield of cardamom during 1980s was around 70-80 kgs per ha. Though there was a growing market from the oil rich Arab countries, it was difficult for the cardamom sector to face the heightened competition from Guatemala with an average productivity of over 300 Kgs. Hence, the dream of cardamom growers was to reach an yield level of 300 kg per ha, comparable to that of Guatemala. The Indian Cardamom Research Institute (ICRI) under the Cardamom Board, Kerala Agricultural University (KAU) Indian Spices Research Institute under the Indian Council for Agricultural Research (ICAR) used to undertake research on cardamom. The organized research, though came up with many new varieties, none of them were proved useful in addressing the issue. But thanks to a variety developed by a small farmer, today there are gardens with productivity more than 600 Kg/ha. This new variety, Njallani gold, named after the small farmer Mr Joseph Njallani, who developed this variety, has diffused widely into the whole cardamom growing areas in Kerala, Karnatka and Tamil Nadu (Joseph and George 2010). Njallani Gold have an yield potential of over 600kgs /ha for which he received National Innovation award from the National Innovation Foundation in the 2001. Following Njallani other small growers developed other varieties with different characteristics (see table 4) of cardamom and received the national innovation awards from NIF. Today, more than 90% cardamom growers in India uses the cultivars evolved by the farmers.

Apart from developing new plant varieties, the small farmers have also developed innovative cultural practices relating to plant propagation[5] and planting[6]. The innovations in plant propagations almost halved the time lag between planting and harvesting and

Table 4: New cardamom varieties developed by small farmers

Variety name	Characteristics
Njallani gold	The pioneering high yielding variety most popular among the cardamom growers
Wonder cardamom	High yielding, adaptable to lower altitudes and low rainfall regions Scope for intercropping in rubber plantation
While flowered cardamom	High yielding suitable for water logged areas, high oil content, high resistance to various biotic and abiotic stress
Panikulangara Green Gold	High yielding and less prone to disease and pest Bold capsules and ripe ones retain green colour even after drying.
PNS Vaigai	High yield and high recovery rate than other varieties

Source: NIF (2013)

Apart from developing new plant varieties, the small farmers have also developed innovative cultural practices relating to plant propagation[7] and planting[8]. The innovations

[5] The scientific method of propagation as per the package of practices often proposed by scientific agencies was through seedling. With this method the plants take nearly 3-4 years for start yielding. The new method proposed by the innovative farmers is by using rhizomes and with this new process the plant starts yielding from one and a half years

[6] As per the package of practice recommended by the scientific agencies, cardamom should be planted in a pit with the size 60*60 cms. The innovative growers recommended a small one spade deep pit for planting and adding more soil as the plant grows. The new practice leads to reduction in the cost of planting and soil erosion in the sloppy terrace.

[7] The scientific method of propagation as per the package of practices often proposed by scientific agencies was through seedling. With this method the plants take nearly 3-4 years for start yielding. The new method proposed by the innovative farmers is by using rhizomes and with this new process the plant starts yielding from one and a half years

[8] As per the package of practice recommended by the scientific agencies, cardamom should be planted in a pit with the size 60*60 cms. The innovative growers recommended a small one spade deep pit for planting and adding more soil as the plant grows. The new practice leads to reduction in the cost of planting and soil erosion in the sloppy terrace.

in plant propagations almost halved the time lag between planting and harvesting and considerably reduced the cost of cultivation. Innovations in planting practices, apart from reduction in cost of production, also led to considerably less tilling leading to reduction in soil erosion from the sloppy terrains where cardamom is cultivated. Thanks to these innovations, area under cardamom and its production increased significantly (data). Cardamom being a shade-loving crop, bringing new area under cultivation necessitates planting trees for providing shade for the crop. Hence, the expansion of the area under cultivation also has contributed to afforestation by farmers contributing towards environmental sustainability. There are also innovations by the small cardamom growers relating to post harvest operations especially in evolving energy efficient curing houses. This in turn led to reduction in the use of firewood and its positive environmental outcomes. Yet another small farmer received national innovation award for developing a cardamom-polishing machine. The case of cardamom, illustrates that the small farmers have the capacity to generate innovations, which could even substitute the organized research. Thus viewed the small farmer innovations in cardamom have been effective in addressing the twin issues of environment and livelihood of cardamom growers. However, even in a state like Kerala, which is known for its decentralized development planning wherein about 35 to 40% of the plan funds is devolved to local governments, there exists hardly any efforts either to promote or harness farmers' innovations.

China: a case of proactive State and innovative small farmer

Since the introduction of reforms in 1978 China recorded a remarkable economic performance with an annual average growth of nearly 10 per cent for 30 years and was able to accomplish all the Millennium Development Goals (MDGs) by 2015 and that had significant effect on the achievement of MDGs at the global level. The number of rural poor declined from 260 million (36 per cent of rural population) in 1978 to 26.9 million (2.8 per cent of rural population) in 2010 (China, National Bureau of Statistics, 2012).[9] In this process about 200 million small farmers in China, with an average holding size of 0.6

[9] In November 2011 with the revision of poverty line from RMB 1,196 to RMB 2,300 (USD $360 at 2010 constant prices or about USD 1 per capita per day) by national government has increased the estimate of rural poor to 128 million[1], about a 100 million more than the earlier estimates and the incidence of rural poverty to 13.4 per cent. Even then, the decline in the incidence of rural poverty is significant

hectares, played a crucial role. Cereal production doubled from 277 MT in 1980 to 557 MT in 2015 on account of the two-fold increase in yield from 2937Kgs to 5886 Kgs (WDR 2016). The volume of fruits and vegetables increased by 8.6 times between 1979 and 2008, that of animal protein (meat products) 5.6 times (Ferroni zhou). By about 2000 per capita grain output reached the developed country levels and many farmers shifted to high value crops (Huang et al, 2002).

The performance China's agricultural sector and the reforms undertaken have attracted considerable attention of scholars (Guisheng at al 2003). One set of studies focused on the returns to public investment in R&D and shown that rates of return to research investment in Chinese agriculture are high, ranging from 36% to 90% in 1997, and the rates are increasing over time (Fan 2000). This may to be compared with an estimated rate of return of only 20 per cent during 1965-92 (Fan and Pardey 1993) Studies have explored the impact of institutional reforms like the introduction of HRS argued that about 50 percent of the recorded output growth of 7.7 percent during 1978-82 could be attributed to total factor productivity on account of decollectivisation (Lin 1992). OECD (2005) observed that HRS boosted production incentives, encouraged farmers to reduce costs, take risks, and enter new lines of production.

Yet another set of studies dealt with trends in research funding along with other institutional interventions in the form of government decisions and laws that led to reform of agricultural research and extension system in the country over time[10]. The inclusive public agricultural extension system extending to all the township established in the 1980s, while made considerable contribution to agricultural production, it became overstaffed over time and turned out to be a financial burden for local governments. To address this issue a series of reforms were introduced since the mid-late 1980s.

With a view to enhance the effectiveness of extension at the village level the recent

---

10 Fan and Pardey, (2002) noted that since mid 1980 there were over 40 government decisions, regulations, and laws that aimed at reform of the science, technology extension system.

reforms focused on increasing the quality of services provided to farmers. To ensure that the agents are more proactive, the reform includes a system of accountability and a monitoring and evaluation component. The evaluation system tracks the percentage of farmers visited in the responsible village, the number and type of services provided, and the responsiveness to emerging issues among other indicators (Hu et al., 2012b). This system has three distinct characteristics: the inclusion of all farmers as target beneficiaries; effective identification of farmers extension service needs; accountability system to provide better extension, and technical advisory services to farmers (Huang and Rozelle, 2014). It was found that the inclusive reform initiative increased the availability and acceptance of public agricultural extension services across the board (Hu et al., 2012a, b)

What is unique about the research and extension system in China is its reach down to the lowest level. National People's Congress (NPC) and its Standing Committee frame legislation in accordance with the Constitution of the PRC. The State Council, which is appointed by the NPC, makes policies and get implemented down through the state organs at the provincial and local government levels. While implementing policies, there is considerable flexibility at the local levels with wide discretionary powers with respect to the implementation of policies. Generally research is coordinated by the Ministry of Science and Technology (MOST) system and the Ministry of Agriculture (MOA) manages the extension. The training and education of farmers – however, involves two institutions: China Association for Science and Technology (CAST) and the Ministry of Agriculture (MOA). Similar to the research system the extension and training system also go down to the lowest level. Studies have observed that limits related to investment deficiency, low-quality and redundant extension team not withstanding, the establishment of the five-level Agricultural Technology Extension organizations established after 1992 is much better in its setting hierarchy, functions and extension efficiency (Gao and Zhang 2008).

Unlike India, China, as of now, doesn't have an explicit institutional architecture (like NIF in India) to locate, disseminate and harness, small farmers' innovations. Yet the research, extension and training system in China, with its much better reach out to the local level appears to promote farmers innovations and its diffusion. A study of nearly 2000 grass root innovations in China shows that there exist a strong interaction between the grassroots innovators and local government, which in in turn acts as a support system generating innovations (Zhang and Mahadevia 2012). Local governments also play a key role in the diffusion of such innovations through farmer associations and cooperatives (Zhang and Liu, 2012). China's commitment to farmer led innovation is further evident from the fact that of all countries, the System of Rice Intensification (SRI), a farmer led innovation from Madagasker, though viewed with indifference or sometimes hostility by the scientific community, China was the first country where the agricultural research establishment quickly showed interest in this innovation (Uphoff 2008)[11]. Further, it was in China that the Honey Bee Network evolved in India, found acceptance first time out side India.

Apart from the above facilitating environment for innovation by the farmers, the flexibility provided to the lower level administrative structures enabled them to support the individual farmers in their innovative efforts. Further, the numerous farmers Associations/ cooperatives established at the instance of the State acted as support structures for the innovation by farmers and its diffusion. Notwithstanding their important role in facilitating farmers' innovations, with the exception of a few (Shen et al 2006;   ) their role in innovation has not been subjected to in-depth inquiry. A more recent development has been the facilitation of the establishment of Farmer led research institutes that act as innovation platforms and innovation intermediaries as articulated by the literature on agricultural innovation system (   ).

Case of Chinese onion

Like the new high yielding variety of cardamom in India developed by a small farmer, a small farmer brought out a new variety of Chinese onion in 1983 along with many

---

[11] In 2002, an international conference to assess SRI was hosted jointly by the China National Hybrid Rice Research and Development Center and China National Rice Research Institute in Hangzhou

innovations associated in its production process[12]. The new Chinese onion variety, named "Wu Yeqi" had an yield of over 3400 kg per Mu (I Mu=0.16 acre) as compared to1500-2000 kg/Mu for the traditional variety. With in a period of 10 years the new variety diffused throughout China. In 1992, there were 2,500 mu of Wu Yeqi seed-production areas nationwide, producing 125,000 kg of seeds. The seeds produced were enough to cultivate 625,000 mu of "Wu Yeqi" (200 gram of seeds per mu). The average increase in production would have been 1300 kg per mu, which brought 162.5 million RMB (0.2 RMB per kg) extra income on account of the need variety developed by the small farmer.

While the development and diffusion of new cardamom variety in India received hardly any institutional support the case of new Chinese onion variety is illustrative of how the institutional architecture in China has been conducive for the learning innovation and competence building of small farmers wherein the state has a key role.

In China, small farmers are increasingly organized into farmer producer organizations, which could be Farmer Producer Associations (FPAs) or farmer cooperatives. The Cooperative Laws allow farmers to organize themselves and to link up with agribusinesses (Ferroni and Zhou 2011). These organizations and cooperatives are engaged in a wide variety of activities addressing specifically the needs of their members. They undertake farmer training, processing and marketing of the produce. By 2005 there were over 150,000 specialized farmers' co-ops in China. What is more the farmers also establish their own research organizations, which are supported by the local governments. Over the years the farmers research associations emerged as new mode of science popularization among farmers. Shen et al (2006) observed that for all types of FPAs, in villages in which the upper level government has taken actions to promote FPAs, associations have emerged more frequently, progressively with more FPA activity. Thus viewed the government clearly has a big influence on the emergence of FPAs—of all types.

The development of the new variety of Chinese onion was at the instance of the

[12] This innovation was brought out at the instance of a small farmer, Mr Chen Guangxing in Baodi County, Tianjin.

Association of Yuanluo Chinese onion and garlic farmers in a context wherein there was hardly any formal research on Chinese onion. The Association was formed in 1983 and registered in 1990, at the instance of a small farmer (Mr Chen) with a view to facilitate the sharing of experience among farmers and facilitate learning. In 2005, Chen and his fellow farmers established the Jinbao Chinese Onion and Garlic Research Institute (hereafter the Institute) to continue their research. The Institute's research team was made up of farmer experts from the association, technicians from the Tianjin Academy of Agricultural Sciences and the teachers of a local agriculture school. Chen and his farmers' research association already had a good research background and Chinese onion and garlic had become important to the local rural economy, therefore, the Institute received several research grants (see table 5). These projects were applied individually or jointly from the

Table 5: Details of research grants received by farmers

<table>
<tr><th colspan="2">Title</th><th>Sponsor</th><th>Undertaking unit</th><th>Support (In RMB '000)</th><th>Project period</th></tr>
<tr><td colspan="2">Breeding and Diffusion of "Wu Yeqi"[20]</td><td>Tianjin S&T Bureau</td><td>Seed Company of Baodi Agricultural Bureau</td><td>100</td><td>1993-1994</td></tr>
<tr><td colspan="2">Technique research and application of chemical weeding in Chinese onion production</td><td rowspan="4">Baodi S&T Committee</td><td rowspan="2">Farmers' Association</td><td>30</td><td>2003</td></tr>
<tr><td colspan="2">Research and application of chemical weeding in garlic production</td><td>Approved but no funds</td><td>2005</td></tr>
<tr><td colspan="2">Ditching tool for Chinese onion planting (cooperating with Baodi Agricultural Machinery Bureau)</td><td rowspan="7">Jinbao Chinese Onion and Garlic Research Institute</td><td>10</td><td>2005</td></tr>
<tr><td colspan="2">Research of high yield planting technique for Chinese Onion, Garlic and Chili</td><td>10</td><td>2006</td></tr>
<tr><td rowspan="3">Sub-project of the Baodi S&T enrich people project</td><td>Experiment of nationwide comparing and selecting high quality Chinese onion seeds[21]</td><td rowspan="3">MOST</td><td>10</td><td>2008-2012</td></tr>
<tr><td>Demonstration and application of planting techniques for "Shuangwei"[22]Chinese onion</td><td>20</td><td>2008-2012</td></tr>
<tr><td>Garlic rejuvenation experiment</td><td>20</td><td>2008-2012</td></tr>
<tr><td colspan="2">New variety breeding and diffusion of "Shuangwei" Chinese onion</td><td>Tianjin S&T Bureau</td><td>200</td><td>2005-2009</td></tr>
<tr><td colspan="2">Introduction of Gansu garlic, comparison experiment with Baodi garlic, demonstration and diffusion</td><td>Baodi S&T Bureau</td><td>25</td><td>2006-2008</td></tr>
</table>

Experiment and demonstration construction of high quality and yield and green production of Baodi Chinese onion		Farmers' Cooperative	10	2008-2009
Experiment and demonstration zone for construction of high quality and yield and green production of Baodi Chinese onion	Tianjin Agricultural Committee		300	2008-2009
Technology integration and demonstration zone construction for green and high yield planting of Baodi garlic	Tianjin S&T Committee	Baodi S&T Committee	200	2011-2013
"Double smell" Chinese onion variety breeding and high-yield planting technique diffusion	Tianjin S&T Committee	Cooperative	200	2010-2012

Source: Zhang and Mahadevia (2011)

local S&T bodies, such as the Tianjin S&T Committee, Baodi S&T Bureau and Agricultural Bureau. Research by the small farmers resulted in a number of innovations towards addressing the issues associated with the production of Chinese onion. This included, but not limited to new methods for increasing the germination rate, protecting the crop from water logging, optimum use of seed and planting distance, developing new plough and others (Zhang and Mahadevia 2014). Many of these innovations also received the Tianjin S&T Progress Awards by the Tianjin Municipal People's Government.

Concluding observations

It is generally held that for many of the developing countries an innovative agricultural sector is at the core of addressing poverty reduction, livelihood security, economic growth and environmental sustainability. It has also been argued that since more than nine out of ten farms in the world are small farms, their innovation capability is crucial for addressing these challenges There has, however, been a paradigm shift in understanding the bearing of agricultural R&D and innovation in facilitating agrarian transformation. The new paradigm, Agricultural Innovation System (AIS), drawing insights from the National System of Innovation (NSI), perceives that in agriculture innovations emerge from interaction and knowledge flows between research and entrepreneurial organizations in the public and private sectors engaged in the agricultural value chain. This is in contrast to the earlier view that research organizations produced new knowledge that the farmers blindly adopted. A newly emerging literature on small-scale farmer (SSF) innovation articulates small farmers as innovators themselves rather than mere implementers of innovations as often viewed. In this context this paper explores how small farmers are integrated within the AIS and how conducive are the institutions for enhancing and harnessing their innovation capabilities for addressing varied issues pertaining to agricultural development. The paper examines this issue by taking case studies from China and India with a view to draw lessons for informed policy making.

The paper argues that the broader approach of AIS to bring together all the stakeholders in the agricultural value chain is a welcome departure. But it fails to acknowledge the multiple spaces of exclusion along with power relations that hamper the interactive learning process in developing countries. Though the State could paly an important in such contexts, while translating NIS into AIS the term ‘national’ disappeared with its serious implications. The approach of AIS to innovate with farmers is a marked improvement over the earlier approaches towards innovating for the farmers. However, AIS appears to consider farmers as a homogenous category and innovation capabilities of the small farmers seems to have not received the attention that it deserves. The two case studies from China and India illustrate the differences in the institutional architecture that exists in these two courtiers for fostering and harnessing small farmer innovations. In India, the elaborate institutional architecture that still adopts top down innovation and diffusion process, considers the small farmer innovations as not having any significant implications. On the other hand, in China small farmers innovation capabilities are promoted through active state support for farmers' research institutes, farmers associations and farmers cooperatives. The study makes the case for promoting and harnessing small farmers' innovation capability to evolve a more inclusive AIS towards addressing the pressing needs of food safely, rural employment, livelihood and environmental sustainability

References:

Anandajayasekeram, P and Gebremedhin, B (2009). Integrating innovation systems perspective and value chain analysis in agricultural researchfor development: Implications and challenges, Working Paper No. 16, //oemmndcbldboiebfnladdacbdfmadadm/https://cgspace.cgiar.org/bitstream/handle/10568/513/IPMS%20Working%20paper%2016.pdf?sequence=1

Bhaduri, A. (1973). A study in agricultural backwardness under semi-feudalism. *The Economic Journal*, *83*(329), 120-137.

Biggs, S. D., & Clay, E. J. (1981). Sources of innovation in agricultural technology. World Development, 9(4), 321-336.

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

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

Byerlee, D., & Alex, G. E. (1998). Strengthening national agricultural research systems: Policy issues and good practice (Vol. 24). World Bank Publications.

Cassiolato, J. . Matos, M. and Lastres, H. (2014) Innovation Systems and Development., in International Development: Ideas, Experience, and Prospects, edited by Currie-Alder, B., R. Kanbur, D.

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

Clark, N. (2002). Innovation systems, institutional change and the new knowledge market: Implications for third world agricultural development. *Economics of Innovation and New Technology*, *11*(4-5), 353-368.

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.

Edquist, C. (1997). Systems of innovation: technologies, institutions, and organizations. Psychology Press.

Ekboir, J., & Parellada, G. (2001). Continuous innovation processes: public–private interactions and technology policy. Agricultural research policy in an era of privatisation: experiences from the developing world (Byerlee D and Echeverría RG, eds.). Wallingford, UK: CAB International, 120-154.

Fagerberg, J., & Sapprasert, K. (2011). National innovation systems: the emergence of a new approach. Science & Public Policy (SPP), 38(9).

Fan S. (2000) Research investment and the economic returns to Chinese agricultural Research, Journal of Productivity Analysis, 14, 163–182

Fan, S., & Pardey, P. G. (1992). Agricultural research in China: Its institutional development and impact. *The Hague: International Service for National Agricultural Research. AGROVOC Descriptors agricultural policies*, 5.

Fan, S., & Pardey, P. G. (1997). Research, productivity, and output growth in Chinese agriculture. *Journal of Development Economics*, *53*(1), 115-137.

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

Ferroni, M. and Zhou, Y. (2012), "Review of agricultural extension in India", in Ferroni, M. (Ed.), Transforming Indian Agriculture: India 2040, Centennial Group International, Washington, DC, pp. 187-237.

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., ... & Balzer, C. (2011). Solutions for a cultivated planet. *Nature*, *478*(7369), 337-342.

Freeman, C. (1987), Technology Policy and Economic Performance, London: Pinter.

Fressoli, M., Arond, E., Abrol, D., Smith, A., Ely, A., & Dias, R. (2014). When grassroots innovation movements encounter mainstream institutions: implications for models of inclusive innovation. *Innovation and Development*, *4*(2), 277-292.

Government of India (2014). Agricultural Census, New Delhi.

Gu, S., & Lundvall, B. Å. (2006). Introduction: China's innovation system and the move towards harmonious growth and endogenous innovation.

Guisheng, W., Jun, T., & Shulin, G. (2003). Innovation system and transformation of the agricultural sector in China, with the case of Shouguang City. In *Globelics conference on Innovation and Development, BNDES, Rio de Janeiro, November* (pp. 3-6).

Gulati. A Fan S. and Dalafi S (2008) The Dragon and the Elephant: Learning from Agricultural and Rural Reforms in China and India, **Economic and political weekly 43(49)**

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

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., & Clark, N. (2001). Why research partnerships really matter: innovation theory, institutional arrangements and implications for developing new technology for the poor. World development, 29(5), 783-797.

Hall, A., Sulaiman, V. R., Clark, N., & 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(2), 213-241.

Hall, A.J. 2002. "Innovation Systems and Capacity Development: Agenda for North-South Research Collaboration?" International Journal of Technology Management and Sustainable Development 1(3): 146-152.

Hall AJ, Yoganand B, Sulaiman RV, Rajeswari Raina S, Shambu Prasad C, Naik Guru C and Clark NG. (eds.). 2004. Innovations in innovation: reflections on partnership, institutions and learning. Patancheru 502 324, Andhra Pradesh, India, and Library Avenue, Pusa, New Delhi 110 012, India: Crop Post-Harvest Programme (CPHP), South Asia, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and National Centre for Agricultural Economics and Policy Research (NCAP). 252 pp. ISBN 92-9066-461-4 Order code: BOE032.

Hall, A.J. 2005. "Capacity Development for Agricultural Biotechnology in Developing Countries: An Innovation Systems View of What It Is and How to Develop It." Journal of International Development 19(5): 611-630.

Hall, A.J. 2006. "Public-Private Sector Partnerships in a System of Agricultural Innovation: Concepts and Challenges." International Journal of Technology Management and Sustainable Development 5(1)

Hall, A.J., L. Mytelka, and B. Oyeyinka. 2004. Innovation Systems: Concepts and Implications for Agricultural Research Policy and Practice . Maastricht: United Nations University.

Hall, A.J., L.K. Mytelka, and B. Oyelaran-Oyeyinka. 2006. "Concepts and Guidelines for Diagnostic Assessments of Agricultural Innovation Capacity." UNU-MERIT working paper series 2006-017. Maastricht: United Nations University–Maastricht Economic and social Research and training centre on Innovation and Technology.

Hu, Z. F., & Khan, M. S. (1997). Why is China growing so fast?. *Staff Papers*, *44*(1), 103-131.

Huang, J. and Rozelle, S. (2014), "Agricultural R&D and extension", in Fan, S., Kanbur, R., Wei, S. and Zhang, X. (Eds), The Oxford Companion to the Economics of China, Oxford University Press, London, pp. 315-319.
Huang, J., Hu, R., Rozelle, S., Qiao, F., & Pray, C. E. (2002). Transgenic varieties and productivity of smallholder cotton farmers in China. *Australian Journal of Agricultural and Resource Economics*, *46*(3), 367-387.
Huang, J., Yang, J., & Rozelle, S. (2014). The Political Economy of Food Price Policy in China. *Food Price Policy in an Era of Market Instability*, 362-383.
Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. Å. (2007). Forms of knowledge and modes of innovation. *Research policy*, *36*(5), 680-693.
Joseph, K. J. (2014). Exploring exclusion in innovation systems: case of plantation agriculture in India. Innovation and Development, 4(1), 73-90.
Juma, C. New Harvest: Agricultural Innovation in Africa; Oxford University Press: New York, NY, USA, 2011.
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. (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., Hall, A. and Leeuwis, C. (2009). Strengthening agricultural innovation capacity: are innovation brokers the answer? *Int. J. Agric. Resour. Gov. Ecol*. 8: 409–438.
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
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
Lin, J. Y. (1992). Rural reforms and agricultural growth in China. *The American economic review*, 34-51.
Lorentzen, J. (2010). Low-income countries and innovation studies: A review of recent literature. *African Journal of Science, Technology, Innovation and Development*, *2*(3), 46-81.
Lundvall, B. Å. (1985). Product innovation and user-producer interaction. Aalborg Universitetsforlag.

Lundvall, B. A. (1992). National innovation system: towards a theory of innovation and interactive learning. *Pinter, London*.
Lundvall, B. Å. (2007). National innovation systems—analytical concept and development tool. *Industry and innovation*, *14*(1), 95-119.
Lundvall, B. Å., Joseph, K. J., Chaminade, C., & Vang, J. (Eds.). (2009). Handbook of innovation systems and developing countries: building domestic capabilities in a global setting. Edward Elgar Publishing.
Malone and R. Medhora, Chapter 33. Oxford: Oxford University Press
Mowery, D. C., & Oxley, J. E. (1995). Inward technology transfer and competitiveness: the role of national innovation systems. *Cambridge journal of economics*, *19*(1), 67-93.
Neef, Andreas, and Dieter Neubert. "Stakeholder participation in agricultural research projects: a conceptual framework for reflection and decision-making." Agriculture and Human Values 28.2 (2011): 179-194.
Nelson, R. R. (Ed.). (1993). National innovation systems: a comparative analysis. Oxford university press.
North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge university press.
Poulton, C., Dorward, A., & Kydd, J. (2010). The future of small farms: New directions for services, institutions, and intermediation. World Development, 38(10), 1413-1428.
Pray CE. 2008. Globalization of private agriculture research and innovation: Opportunities for
Pray, C. E., & Nagarajan, L. (2012). Innovation and research by private agribusiness in India. *International Food Policy Research Institute (IFPRI)*.
QUNO (2015) Small-scale farmer Innovation systems, A review of the Current literature, QUNO office, Geneva.
Raina, Rajeswari (2003). Institutions and Organisations; Enabling reforms in Indian agricultural research and policy, *International Journal of Technology Management and Sustainable Development*, 2 (2), 97-116.
Raina, Rajeswari and Rasheed Sulaiman V. (2007). From Technology Dissemination to Learning Approaches: Institutional Change for Rural Development. In Viswa Ballabh (ed.) *Institutional Alternatives and Governance of Agriculture*, Academic Foundation, New Delhi.
Raina, Rajeswari, Sunita Sangar, Rasheed Sulaiman V. and Andrew J. Hall (2006). The soil sciences in India: Policy lessons for agricultural innovation, *Research Policy*, 35(2006) 691-714.
Rajalahti, R., Janssen, W., & Pehu, E. (2008). Agricultural innovation systems: From diagnostics toward operational practices. Agriculture & Rural Development Department, World Bank.
Rajalahti, R., Woelcke, J., & Pehu, E. (2005). *Developing research systems to support the changing agricultural sector* (Vol. 14). Agriculture & Rural Development Department, World Bank. Washigntion, DC.
Rao Hanumantha C H (1994) Agricultural growth, rural poverty and environmental degradation in India, Oxford University Press, New Delhi
Research Institute for the Semi-Arid Tropics (ICRISAT), and National Centre for

Agricultural
Rogers, E.M. 1962. *Diffusion of innovation*. New York: Free Press
Röling, N. (1990). The agricultural research-technology transfer interface: a knowledge systems perspective. *Making the link: Agricultural research and technology transfer in developing countries*, 1-42.
Sachs, J. D., & Woo, W. T. (2001). Understanding China's economic performance. *The Journal of Policy Reform*, *4*(1), 1-50.
Sanginga, P.C. (Ed.). (2009). Innovation Africa: enriching farmers' livelihoods. Earthscan
Schut, M., L. Klerkx and C. Leeuwis, 2015. *Rapid Appraisal of Agricultural Innovation Systems (RAAIS). A toolkit for integrated analysis of complex agricultural problems and innovation capacity in agrifood systems.* International Institute of Tropical Agriculture (IITA) and Wageningen University.
Sen, A. (2000). Social exclusion: Concept, application, and scrutiny. Social Development Papers No. 1, ADB.
Shen M, Rozelle S, Zhang L, Huang J (2006) Farmer's professional associations in rural China: state dominated or new state–society partnerships? Working paper, Freeman Spogli Institute of International Studies, Stanford University
Smith A., Fressoli, M. Abrol D and Ely A (2017) Grassroots innovation movements, Routledge London
Spielman, D. J., Ekboir, J., & Davis, K. (2009). The art and science of innovation systems inquiry: Applications to Sub-Saharan African agriculture. *Technology in Society*, *31*(4), 399-405.
Sulaiman V.R (2003). Agriculture Extension: Involvement of Private Sector, Occasional Paper, 29, National Bank for Agriculture and Rural Development (NABARD), Mumbai. Sulaiman,V.R. and Hall, A.J. (2004). Towards Extension-Plus: Opportunities and Challenges, Policy Brief 17, National Centre for Agricultural Economics and Policy Research, New Delhi.
Sulaiman, V.R. and Hall, A.J. (2002). Beyond Technology Dissemination: Reinventing agricultural extension, *Outlook on Agriculture*, Vol. 31, No. 4, pp. 225-233. Sulaiman, V.R. and Hall, A.J. (2003). India: The emergence of Extension-Plus: Future for extension beyond technology transfer? In Rivera, W.M. and Gary Alex (eds.) *Extension and Rural Development*., The World Bank, Washington, D.C.
Susan H. Bragdon and Chelsea Smith (2015), *Small-scale farmer innovation,* Quaker United Nations Office, Geneva.
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.
Uphoff, N. (2008). The System of Rice Intensification (SRI) as a system of agricultural innovation. *Jurnal Tanah dan Lingkungan*, *10*(1).
Ustyuzhantseva, O. (2017). Studies of inclusive innovation in sociotechnical systems: case studies in Russia and India. *Innovation and Development*, *7*(1), 83-100.
Wang, X., & Rungsuriyawiboon, S. (2010). Agricultural efficiency, technical change and productivity in China. *Post-Communist Economies*, *22*(2), 207-227.
Wettasinha, C., Waters-Bayer, A., van Veldhuizen, L., Quiroga, G., & 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.

Wortmann, C. S., Christiansen, A. P., Glewen, K. L., Hejny, T. A., Mulliken, J., Peterson, J. M., ... & Zoubek, G. L. (2005). Farmer research: Conventional experiences and guidelines for alternative agriculture and multi-functional agro-ecosystems. *Renewable Agriculture and Food Systems*, *20*(04), 243-251.

World Bank. (2007). *World Development Report 2008: Agriculture for Development*. World Bank, Washington DC

World Bank. (2012). Agricultural Innovation Systems: An Investment Source book, World Bank, Washington DC

Wu, B., & Zhang, L. (2013). Farmer innovation diffusion via network building: a case of winter greenhouse diffusion in China. *Agriculture and human values*, *30*(4), 641-651.

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

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

Zhang, L., & Mahadevia, D. (2012). Institutional architecture for grassroots innovations: a case of Hua County, China. *Innovation and Development*, *2*(1), 175-188.

Zhang L and Mahadevia D (2014) Translating science and technology policies and programs into grassroots innovationsin China: A case study, Journal of Science & Technology Policy Management Vol. 5 No. 1, 2014 pp. 4-23