



Livestock Innovation System: Reinventing public research and extension system in India

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ABSTRACT

Innovations in livestock sector are needed as in any other sector, thus, continuously generated globally to increase livestock productivity and improve food security. Most of the research results, research and development outcomes and recommended innovations concerning livestock sector, however, remained confined to the laboratories and libraries in many countries including India. Hence, for effective generation and transfer of innovations, there is a need to gear-up the linkages between technology generation (research), technology dissemination (extension), technology users (farmers') and support mechanisms (inputs supply, market credit etc) and form a networking system among all the stakeholders leading to innovation system, which is dynamic in nature. To this end, the authors have focused on the concept of Livestock Innovation System (LIS) on the lines of Agricultural Innovation System (AIS), emphasizing on the idea that innovations come from multi-stakeholders like researchers, practitioners, innovative farmers etc. Among various multi-stakeholders, public research and extension system is a major policy instrument for promoting generation and transfer of innovations in majority of the countries in the world including India. This paper has reviewed public research and extension system in India in an effort to make a case for LIS with lessons drawn from select developed countries. It highlights the existing livestock research and extension system, challenges faced and future strategies for improving livestock productivity in India.

Key words: Agricultural extension, India, Livestock extension, Livestock innovation system, Public extension system, Public research system

Poor productivity and quality of production and products remains a cause of concern in Indian livestock sector (Chander *et al.* 2010). In an attempt to increase livestock productivity and improve food security at both national and household level, efforts are underway to generate and disseminate improved livestock technologies among smallholder farmers. Although various innovations are generated with heavy investments from public and private sources (Beintema and Stads 2008, Dev 2012, Moreddu 2013), most of the research results and recommended innovations concerning livestock sector have not found way to farmers' field. The factors like attributes of technology, socio-psychological and personal factors of farmers', support mechanism like communication networks and inputs play a major role in adoption and diffusion of innovations. Very lately, it has been realized that there is also a lack of awareness on the part of the researchers and extension agencies regarding the farmers' priorities and the

technologies are perceived to be unsuitable or irrelevant to the farm families (Rao *et al.* 1995, Chambers and Ghildyal 1985).

The existing situation in many developing countries, calls for effective linkages between technology generation (research), technology dissemination (extension), technology users (farmers) and support mechanisms (inputs supply, market credit etc) (Chander *et al.* 2010) and form a networking system involving all the stakeholders leading to a dynamic "Innovation System".

Livestock innovation system

On the lines of "Agricultural Innovation System (AIS)", the present study emphasizes on the concept of "Livestock Innovation System (LIS)". AIS is a complex of all the fields like agriculture, veterinary and animal science, fisheries, horticulture, home science etc. but LIS is expected to address only livestock sector issues. Based on the AIS definition of Spielman (2005), LIS can be defined as the set of interrelated agents, their interactions, and the institutions that condition their behaviour with respect to the common objective of generating, diffusing, and utilizing knowledge and/or technology of livestock. The LIS emphasis is given to the idea that innovations come from multiple sources. Not only do innovations come from those

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who have been designated the role of researchers, but also come from practitioners in numerous settings throughout research, extension and production systems. This may include research-minded farmers, researchers, administrators, non-governmental organizations (NGOs), private corporations, and so on (Anandajayasekeram 2011). Another key feature of this model is the recognition that research and technology dissemination systems contain a multitude of actors and organizations with highly diverse objectives.

Components of LIS

On the lines of AIS (Anandajayasekeram 2011), LIS could be a collaborative arrangement bringing together several organizations or multi-stakeholders working towards technological, managerial, organizational and institutional change in livestock sector. Such a system may include the traditional sources of innovations (indigenous technical knowledge); the modern actors (national agricultural research System and international agricultural research institutes); private sector (including local, national, and multinationals), agro-industrial firms and entrepreneurs; civil society organizations (NGOs, farmers and dairy cooperatives, livestock interest groups, consumer organizations and pressure groups); and the institutions that affect the process (laws, regulations, beliefs, customs, and norms) by which livestock innovations are developed and delivered (Fig. 1). Pant and Hambly (2009) have indicated that innovation systems framework has been developed through decades of intellectual debates, and featured recently with in agricultural sciences and rural development studies.

Need and importance of LIS

A growing impetus that technologies in developing countries are not reaching farmers needs to develop a new way of making these technologies acceptable to farmers so

as to increase farmers' perception and invariably their adoption levels (Oladele and Fawole 2007). The metaphor that farmers are mere recipients of technology does not hold good for long, depicting that farmers are not passive consumers but active problem solvers who in fact, develop for themselves (Oladele and Fawole 2007). Hence, there is now a growing concern among the researchers, extension staff and policy makers to better understand the farmers' perceptions with reference to technology generation and adoption. Only a shared vision among the researchers, extension personnel, farmers and the policy makers can help to evolve suitable strategies for increased production and prosperity (Rao *et al.* 1995). In this context, LIS perspective is a popular approach to the study of how different actors of society generates, disseminates, and utilizes knowledge, and how such systems can be strengthened for greater social benefits (Spielman 2005).

The innovation systems framework in the livestock sector as a method to understand generation and transfer of livestock innovations in India towards developing an effective LIS, has not yet been studied. This would further create an effective linkage among various stakeholders in generation and transfer of need based innovations including the realization of the functions to be performed by each stakeholder. Thus, the research and extension system issue in innovation system has also been considered worthwhile including drawing lessons from few developed countries for improving the public research and extension system in India.

Existing public research system in India and world

The public research and extension system referred as National Agricultural Research System (NARS) is one of the major policy instruments for promoting technological innovations and human resource development in India (Pal *et al.* 2008, Dev 2012, Pal *et al.* 2012, Moreddu 2013). India has the largest agricultural research and development

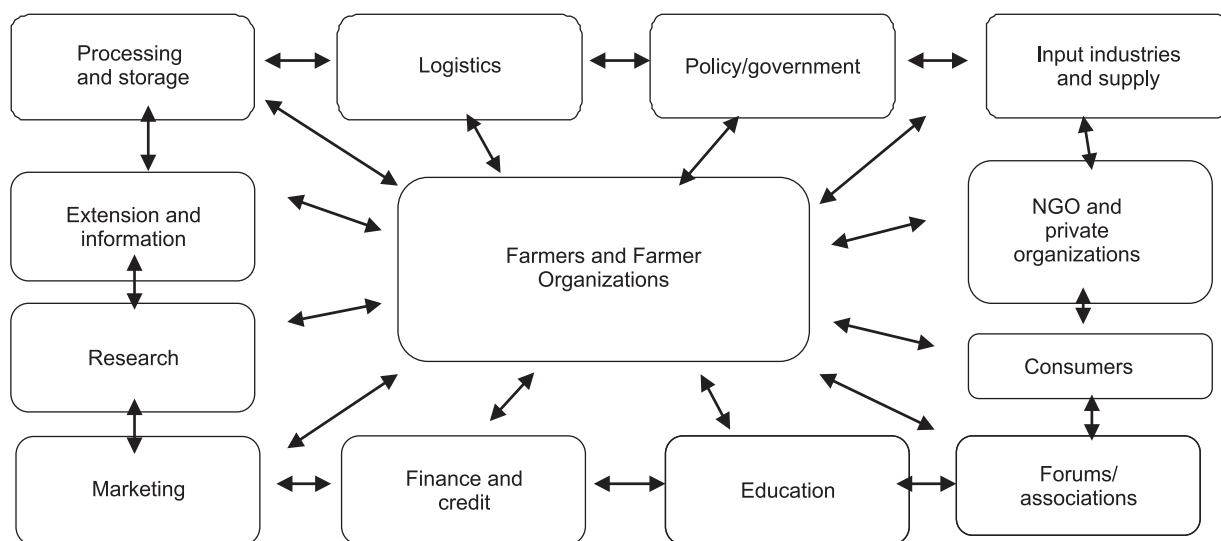


Fig. 1. Livestock Innovations System* (Modified by authors from Arumapperuma 2006).

(R&D) system with Indian Council of Agricultural Research (ICAR) which directly oversees 97 agencies, including 4 deemed universities, 45 research institutes, 17 national research centers, 6 national bureaus, and 25 project directorates. India has more university-based researchers with Ph. D qualification (Stads and Rahija 2012) engaged in research and education relating to agriculture and allied areas but compares less favourably with many developed nations in the world (Balaguru 2013). Although NARS has been responding to the challenges faced by Indian agriculture, it is often criticized for not attending to the demands for improved technologies and also for the poor linkages between research and extension systems (Desai *et al.* 2011).

State agricultural and veterinary/animal science universities have greatly expanded in number with funding support from state governments but their research capacity has weakened (Pal *et al.* 2012) leading to poor interface of research, extension and education. There has been no parallel increase in the number of scientists implying lower research staff at the universities and increased overhead costs due to the proportionally larger administrative burden of more institutes. However, the agricultural R&D financial spending by ICAR institutes have major share (53.7%) followed by state universities (34.2%). About 34.0% of staff is attached to ICAR institutes while state universities have 54.9% of staffing level (Pal *et al.* 2012). Further, the investments for commodity-wise public R&D indicated that crop sciences got highest focus followed by animal sciences and fisheries in India. The Planning Commission, Government of India has approved to set an agricultural R&D intensity target of 2% of AgGDP during 12th Five-Year Plan (Stads and Rahija 2012).

An indicator often used to compare agricultural R&D spending across countries is the research intensity ratio, that is, total spending on agricultural R&D as a percentage of agricultural output (AgGDP). In 1996, for every \$100 of agricultural output, India invested \$0.25 in agricultural R&D which increased to \$0.40 by 2009 (Pal *et al.* 2012). This is less than the comparative figure for China, which invested \$0.50 for every \$100 of AgGDP in 2008, Brazil (\$1.80) and Japan (\$4.75). Research intensities were higher (Fig. 2) in high-income countries and increased from \$0.56

of agricultural R&D for every \$100 of agricultural output in 1960 to \$3.59 in 2009 (Pardey and Beddow 2013), while India has a very poor spending for agricultural R&D. Comparison of agricultural research expenditures to the size of a country's agricultural economy revealed that "research intensities" increased in United States and high-income countries from \$0.56 of agricultural R&D for every \$100 of agricultural output in 1960 to \$3.59 in 2009 (Pardey and Beddow 2013). Besides agricultural R&D, policy and institutional reforms have included improved incentives for farmers, macro-economic stability, relatively strong extension and rural education systems, and improved rural infrastructure and market access (Chen *et al.* 2012, GHI 2011) in Brazil and China.

The public researchers to million farmers' ratio in few Asia Pacific counties revealed that Malaysia (922) and Sri Lanka (164) had very good status while India has the poorest rate of 43 researchers to million farmers (Flaherty *et al.* 2013). Further, among the South Asian and Asia Pacific countries, the major focus of commodity research was crop sciences followed by livestock, natural resources, fishery-related issues, and forestry related issues (Stads and Rahija 2012, Flaherty *et al.* 2013). Studies in developed and developing countries (Thirtle *et al.* 2003, Alston *et al.* 2010, Alston *et al.* 2011) depicted a higher benefit cost ratio from investing in public agricultural research and extension which must be realized by developing countries also for profitable returns and effective innovation systems. Hence, to improve the relevance, effectiveness, and efficiency of research outputs, stronger linkages are also needed between the performers of agricultural research and its end users (Flaherty *et al.* 2013).

Public extension and information system in India and world

The livestock extension services are provided by multifarious agencies (GOI 2007), viz. public, private, non-governmental organizations etc. As a whole, developing country extension models are usually top-down structures, often located within the ministry of agriculture, not usually formally associated with universities (Boone 1989) and therefore have poor linkages with research and extension. In this context, Rivera and Sulaiman (2009) have indicated that public-sector extension agencies and extension workers are finding it difficult to translate their roles from the classical model of agricultural extension to the innovation system perspective.

In developed countries like United States and Canada, extension has always been viewed more in terms of non-formal education for farmers, farm women and rural young people rather than being solely devoted to the transfer of technology (Qamar 2005, Swanson 2008). However, organizing rural youth groups is an effective, long-term strategy of building human and social capital within rural communities and continues to receive top priority in public extension system of United States (Swanson 2008). The United States system is structured as a 'cooperative' system in terms of funding and control between federal, state and

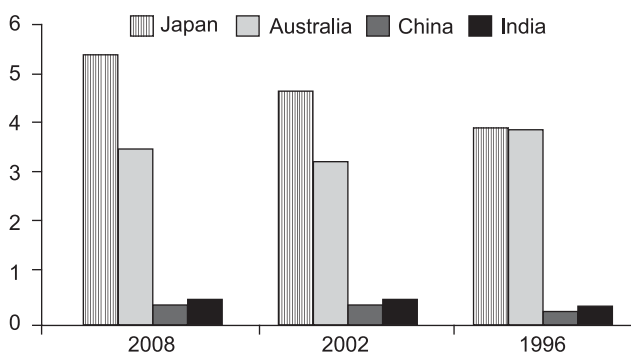


Fig. 2. Public agricultural R&D spending as a share of AgGDP during 1996–2008 (Flaherty *et al.* 2013)

county. It is also known as 'transfer of technology' model since technology is developed on research stations and universities and then transferred through extension agents to farmers' (Anandajayasekeram *et al.* 2008).

The developed countries like United States of America, Canada, Australia and Denmark, having very advanced agriculture, have always enjoyed strong extension services, first public, and recently the private sector has become increasingly involved (Tollefson *et al.* 2002). Their extension services may look very different from those of developing countries, but so are their farms (mostly commercial), farming operations (mostly mechanized) and the number of farmers (mostly a low percentage of country's population). None of these very developed countries has ever considered the discipline of extension as inferior to other disciplines at the time of resource allocation (Qamar 2005). Agricultural and allied extension services have been fully privatized in several European and Latin American countries (Qamar 2005). Another model, developed by British and other colonial powers is commodity based extension services which use vertical linkages for effective management. The developmental and informational paradigms of previous extension education programmes are no longer sufficient to serve farmers' facing changes that lie beyond their individual control (Bahn and McAleer 2007). In this context, public extension systems in many states of US, New Zealand, and Australia have reinvented themselves as successful interfaces between academia and the community (Milburn *et al.* 2010).

Constraints/challenges of existing public research and extension system in India

Weak research-extension linkages: Research-extension linkages are very important in transferring developed technologies from researchers to the end users. Very often, the livestock related technologies developed or modified in the research institutes do not reach the end-users for want of efficient and effective extension mechanisms and procedures (GOI 2013) since public research and extension system is plagued by various challenges and constraints for effective functioning, which will be discussed in this section. The research-extension link has been criticized for not absorbing or using feedback from farmers and extension staff due to passive nature and limited exposure of scientists to field realities (Reddy *et al.* 2006). Further, Sulaiman and Holt (2002) have reported that feedback from extension to research is limited due to which research agenda are not influenced by extension experience. The public system also heavily suffers from failures of various issues like infrastructure, weak linkages and market structure failures (Klerkx and Leeuwis 2009). Further, lack of involvement of all relevant stakeholders in agricultural research, technology development and learning frameworks and actions (GCARD 2010) is also a major challenge for India.

Information delivery and administrative constraints: Owing to static and inflexible nature of the organizations, where a top-down hierarchical approach continues (Raabe

2008), farmers' see the quality of the information provided by the public extension staff as a major shortcoming (GOI 2005) and information flow is considered to be supply-driven and not need-based or area-specific (Raabe 2008). In this context, Babu *et al.* (2012) has indicated that quality and reliability of public extension system is still a constraint. Further, Swanson and Mathur (2003) have also depicted narrow focus of extension, lack of farmers involvement in extension programme planning, supply rather than market driven extension, lack of transparency and accountability, inadequate technical capacity, lack of local capacity to validate and refine technologies, inadequate communication capacity and inadequate operating resources and financial sustainability as other major challenges for Indian extension system.

Financial constraints: A plethora of studies (Sulaiman *et al.* 2005, Swanson 2006, Chander *et al.* 2010, Chander and Rathod 2013) indicated insufficient/poor funds for operational costs and various extension activities like training, demonstration, capacity development etc. leading to limitations in the activities and continual development of the extension staff and the farmers. Only SDAH, Meghalaya had allocated over 10% of the departmental budget for extension activities (Fig. 3), which is considered as optimum percentage of budget allocation in a developing country context. Also, poor human resource development and lack of extension officers has led to low level of outreach by public extension services in India (Chander and Rathod 2013).

Weak linkages and duplication of activities: At the state level, various line departments are criticized for working in isolation, with weak linkages and rare partnerships (Sulaiman *et al.* 2005, Meena *et al.* 2013), which limits information flow. Further, state failures in agricultural and allied extension occur because of problems related to information, incentives, capacity, political interests, and bureaucratic procedures and attitudes (Birner and Anderson 2007). Moreover, public services that are both transaction intensive and discretionary are particularly difficult to provide (Pritchett and Woolcock 2004). In the absence of a market mechanism, public system has trouble in determining the types of knowledge and advice farmers actually need, determining of which is at the heart of making

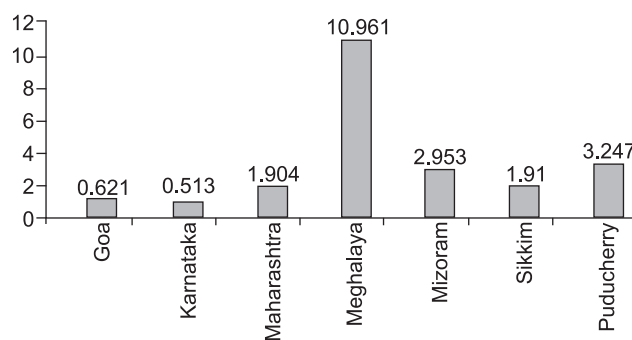


Fig. 3. Budget allocation for livestock extension activities (in %) (2004-05 to 2008-09) (Chander and Rathod 2013).

public sector extension demand-driven (Birner and Anderson 2007). India has a pluralistic extension system, with the public, private and other agencies playing certain roles indicating that the sectors tend to work in isolation from each other (Glendenning *et al.* 2010) and hence, suffer from duplication of programmes, without convergence. Interestingly, after the completion of projects or programmes, extension and research agencies are often left with an increased number of agents or staff members which is difficult to reduce in public sector agencies (Birner and Anderson 2007).

Administrative and institutional constraints: Decentralization is truly a double-edged sword, and if not handled properly, could cause more harm than good unless there is preparation for critical administrative, technical and physical transition (Qamar 2005). According to World Bank (2004, 2005) initiatives like ATMA's were considered very effective instruments for promoting participatory planning and implementation. Although ATMA's improved farm income by strengthening the linkages between research, extension, farming, and markets (Raabe 2008), still tighter linkage can be framed by overcoming shortcomings like limited staff, rigid organization, poor capacity, a top-down linear culture, weak links to the research system and limited reach to farmers. ATMA is pushed as the platform through which the multiple agencies can converge; it suffers from shortages of both personnel and funds (GOI 2007) and capacity and institutional constraints (Babu *et al.* 2013). Another initiative, Krishi Vigyan Kendra (KVK) also known as "Farm Science Centre" clearly revealed a crop bias, with very little contribution towards livestock extension (Chander *et al.* 2010). These institutes also face challenges in terms of staff, partnership etc. which would facilitate the joint offering of demonstrations of recent technologies (Glendenning *et al.* 2010).

Information and communication technologies (ICTs): Information and communication technologies (ICTs) could be useful tool to promote effective innovation system which is considered very poor in hastening knowledge access due to failure from the government or from the farmers' itself. Musa (2011) has classified the challenges for disseminating information through ICT's into socio-economic challenges, cultural challenges, technical constraints and constraint of the method itself. However, Glendenning *et al.* (2010) has indicated that inadequate capacity development, infrastructure challenges, and lack of sustainability of these projects are also major hindrances.

Professional issues: Extension agents often are considered to have a lower social status than many other public sector employees and a lower rank in the civil service system, which affect their morale. Another factor affecting agents' morale is that they do not have the operational funds they need to get to the field and work effectively (Birner and Anderson 2007). Further, Rathore *et al.* (2008) indicated that very often specialists working in research institutions are considered to have higher status than that of the extension scientist inspite of the same level of educational

qualifications. Further, the same study has depicted that professional competency of an agricultural scientist is governed by the number of research publications he has produced than the technologies he has transferred effectively (Rathore *et al.* 2008, Mengistu 2010).

Lack of demarcated activities: Public sector extension agents are often burdened with other activities that are outside the mandate of extension (Anderson and Feder 2004). Another failure inherent in public sector extension is political interest capture which may be due to large scale farmers who often have more political influence than smallholders and weak political commitments of the leaders (Ravikumar and Chander 2006, Feder *et al.* 2010). Further, bureaucratic culture and procedures is a typical obstacle to the reform of public sector agencies often discouraging the coordination of extension with other departments and also weakening the links to agricultural research system inspite of their obvious importance (Birner and Anderson 2007).

Strategies for reinventing public research and extension system for effective LIS

Hall (2006) stated that there are no well recognized innovation system "approach" and blueprints, best practices as toolkits to the emerging perspectives but only the concepts and principles can be operationalized in research and implementation. It should be recognized that public systems in developing countries will change slowly and by themselves, be unable to achieve a well functioning innovation system that meets diverse stakeholders' needs (Chowdhury *et al.* 2013).

Administrative and institutional: The most important of all, government has to develop a strategic vision of how the innovation system should develop, and in what way will it support the development of a country? Within the paradigm of innovation systems, extension agencies can act as innovation intermediaries or innovation brokers, working with many partners to strengthen linkages and provide support for innovations (Singh *et al.* 2013). There must be innovations in extension delivery that embrace different methods and offer flexible adaptations to cater to the needs of users across states, regions, and communities (Glendenning *et al.* 2010). The challenge is to change the organizational culture to incorporate innovation as a core value and to institutionalize the emerging paradigms into research for development processes. However, the issues of training trainers, developing location-specific training materials, and coordinating and financing training at national and regional levels, as well as aspects of on-the-job training, coaching and mentoring, require further attention (Anandajayasekaram 2011).

Public private partnership: A greater understanding of public-private partnerships is also needed, including what works and why, and what mechanisms help encourage partnerships. Hence, public-private partnership which is not existing effectively (Singh *et al.* 2013) can be one of the best modes of strengthening linkages among various stakeholders for effective research and extension activities.

The exchange of knowledge among innovating agents through mechanisms such as development platforms, meetings and seminars and financing of collaboration can be promoted. In this context, there is a need for a thorough evaluation of research and extension approaches to identify best practices and understand their impact on farming communities, and to recognize how research and extension can be strengthened, particularly to reach smallholder and marginal farmers. The ICAR draft policy of November 2012 recommends evolving appropriate models of public private partnership (ICAR 2012).

Innovative approaches: A challenge for innovative approaches in extension is to identify systems that use the potential of the state, the market, and communities to create checks and balances to overcome the failures inherent in all of them (Feder *et al.* 2010). The government can intervene and provide the goods and services efficiently and equitably. As Swanson (2009) has pointed out that market-oriented extension is relevant in economies that are experiencing growth and changes in consumer preferences that create markets for high-value products, India can be effective in making some of their extension market-driven. The extension systems must promote innovative farmers to play local “farmer professor” roles to scale up the enterprises among different groups of farmers which can lead to effective market-driven extension system (Davis *et al.* 2010). There is a need for a thorough evaluation of extension approaches in order to identify best practices and understand their impact on farming communities, and to recognize how extension can be strengthened, particularly to reach smallholder and marginal farmers (Glendenning *et al.* 2010). Although, empirically studies on investment in agricultural research and extension for improved total-factor productivity and rates of return are considered impressive (Gill 1989, Kumar and Rosegrant 1994), livestock research and extension needs critical empirical findings. The extension agent has to be an expert to identify local problems and offer technical solutions for the clients. Based on the conditions, support services for different stakeholders to invest in different entrepreneurial activities in rural and urban areas with research organizations can be looked after. Further, a mechanism to reduce risks to new entrepreneurial activity, such as tax incentives, grants, etc. may be taken-up.

Information and communication technologies (ICTs): ICTs have created positive impact on income growth in developing and developed countries (Waverman *et al.* 2005). In rural areas, ICTs can raise incomes by increasing agricultural productivity (Lio and Liu 2006) and introducing income channels other than traditional farm jobs. Studies depicted that ICTs can improve incomes and quality of life among the rural poor (Goyal 2010, Jensen 2007). In this context, an effort to deliver information to rural masses through ICT, free or at nominal cost, can increase the timely and transparent flow of information to build or strengthen the innovation networks among different stakeholders.

Strengthening linkages and associations: An interaction

between different multi-stakeholders should be organised at the grassroot levels to establish policy dialogues and programme plans for the future (Rathore *et al.* 2008). Further, creation or strengthening of intermediary organizations that can broker and facilitate linkages between poor producers, enterprises and research organizations must be promoted. The farmers associations like livestock interest groups, self-help groups, dairy cooperatives etc. can become more effective business partners and acquire knowledge and technology. In this context, Roling (1986) refers that extension is a weak instrument when it stands alone, but that it becomes powerful when combined with price incentives, input supply, credit, seed multiplication, and so forth. In addition, he pointed out that giving subsidies to farmers may be more beneficial to politicians in helping them to be re-elected.

As in many developing countries, creating and fostering effective linkages amongst heterogeneous sets of actors is often hindered by different technological, social, economic and cultural divides (Pant and Hambly 2009, Oreszczyn *et al.* 2010). Hence, there is a need for creating successful partnerships, networks, and innovation assessment systems and promote the culture of innovation development. The government has to respond to various failures of the system and delegate responsibilities to local governments and other associated semi-public and private organizations to handle the situations. In this context, a consortia-based research funding to encourage public-private sector interaction on emerging novel priority themes can be taken-up to avoid duplication of research and extension activities for topics where interaction between different agencies and research organizations is important.

Role of universities and institutions: Since the extension efforts by ICAR institutes have very limited reach (Chander *et al.* 2010), efforts for effective university curricula involving farmers, private sector and other organizations can be planned. Establishing internship and exchange programmes for under-graduate and post graduate students between different organizations can depict realities of various organizations. As per Government of India (2013) reports, human resource development would be given a high priority in livestock development to meet the qualitative and quantitative shortage of manpower and steps would be taken to encourage establishment of veterinary colleges in private sector complying the prescribed standards of veterinary education. Support to research systems must focus more on developing the interface with rest of the agricultural sector (World Bank, 2006, Rajalahti *et al.* 2008). For extension, the investments should create the capacity to identify new, promising alternatives at the farm level and ensure that they are supported in the right way (Zulu 2011). In this context, varied business models based on small-scale producer networks can be framed. Quality assurance should be of utmost importance in farmers’ trainings, demonstrations and supply of mini-kits along with quantity. Another way of connecting farmers with the scientists thus leading to need based researches is

Participatory Technology Development (Rathore *et al.* 2008). Different extension activities like livestock shows, fairs and exhibitions must be conducted regularly to bring different stakeholders on a single platform and deliver reliable and timely information.

Technological issues: The technologies can more swiftly disseminate to farmers by emergence of stronger research–extension–farmer linkages. The high quality of research activities can be conducted by the process of participatory planning and review that involves farmers, subject matter specialists, and other interdisciplinary experts. As majority of Indian farmers are small and marginal, such farmers would require different content, approach and delivery mechanisms, as they have different information needs and rely mostly on interpersonal sources (Babu *et al.* 2013).

Issues for research and policy implications

Research activities in the areas of AIS have been a well established phenomenon in India and abroad, but research relating to LIS is yet to make a beginning in India. This paper attempts to initiate dialogue towards LIS development for Indian livestock sector by focussing on select few areas.

The Government of India has proposed Science, Technology and Innovation policy (GOI, 2013a) very recently. However, a National Agricultural Innovation Policy or Livestock Innovation Policy can emphasize on agricultural research and development (R&D) by providing a framework for wider perspectives. The innovation system can focus on the analysis of different forms of cooperation among multifarious stakeholders (Fig 1) in various sectoral, spatial, and temporal contexts using different tools like game theory models and social network analysis. Further, the roles and responsibilities of different stakeholders including R&D institutes and organizations at each stage can enhance the effectiveness of the system. A priority within LIS must focus on generating and adapting need based innovations and practices which integrates pro-poor and pro-market agendas and further, must also seriously decide the future of incompatible technologies which are not sustainable. The emerging issues within LIS are the assessment of cost-benefit analysis or total factor productivity of livestock innovations and technologies along with the role of different R and D institutions (Institutional Analysis) in a particular scenario. LIS research can reflect the understanding of innovation with gender perspective and highlight the role of women and youth in this system. Various other issues like role of ICT as enabler of effective LIS, and reorientation of LIS in the changing climate scenario can also be other areas of research priorities. The strengths and weaknesses of the livestock innovation systems framework can be analyzed and strategies for effective LIS can be recommended accordingly.

The authors have highlighted the existing situation and challenges of public research and extension system in LIS, while proposing certain strategies for effective functioning of LIS in India and other developing countries with similar socio-economic and agricultural situations. There is a need

to reorient the research and extension system to produce need based technologies leading to effective adoption and diffusion in the field conditions. Further, empirical efforts are needed towards the development of LIS policy suggesting a way forward in the area of livestock innovations and technology transfer system. Although only few reliable models can be considered from other countries, there is a need to develop original, location-specific, participatory, gender-sensitive and inexpensive extension methodologies and materials instead of applying those methodologies which are promoted as universally suitable. Developing countries and India in particular, have to invest in terms of various resources like financial, human resource etc. for livestock research and extension for promoting effective LIS for higher livestock productivity and sustainability.

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