Linking the agricultural innovation system and sustainability approach within horticulture sector of Kashmir valley

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Abstract

In most of the developing countries including India, the agriculture stays the main economic backbone of the nation and an important source of food, income, and livelihoods for the majority of rural people. Science, technology, and innovation led the green revolution in order to combat the poverty and hunger by improving production and productivity values within the agricultural sector. Innovation systems approach on agricultural research and technological change are fast becoming a popular framework to the study of how society generates, disseminates and utilizes knowledge, science, technology, and innovation. Within the agriculture sector, horticulture considered as one of the most important subsector based on high-profit value outputs relying on intensive technology and labor inputs. This paper attempts to understand the impact of innovation and technology on the sustainability within the horticulture sector of Kashmir valley of India. Three dimensions of sustainability to be analyzed are social, economic and environmental. Agricultural Innovation System approaches used as the analytical framework to trace the actors and networks responsible for innovation and technology generation and dissemination. Farmers from various areas of Kashmir valley of India selected to carry out this research study on the primary data basis helped to understand the technological impact on their behaviour and their concerns with the sustainable development. It is observed that horticulture fulfills the criteria of sustainable development in economic and social dimensions but to environmental dimensions, it lags far away. It needs policy suggestions like empowering the eco-innovations, organic farming, high-density plantation, less use of chemicals but standardized only, strengthening the formal and informal linkages within the sector.

Keywords: innovation, agricultural innovation system, horticulture, sustainable development.

1. Introduction

In most of the developing countries including India and even some developed countries, the agriculture stays the main economic backbone of the nation and an important source of food, income, and livelihoods for the majority of rural people. Science, technology, and innovation led the green revolution in order to combat the poverty and hunger by improving production and productivity values within the agricultural sector. Innovation systems approach on agricultural research and technological change are fast becoming a popular framework to the study of how society generates, disseminates and utilizes knowledge, science, technology, and innovation. This paper attempts to understand the impact of innovation and technology on the sustainability within the horticulture sector of Kashmir valley of India. Three dimensions of sustainability to be analyzed are social, economic and environmental. Agricultural Innovation System approach used as the analytical framework to trace the actors and networks responsible for innovation and technology generation and dissemination. We need to understand and describe the horticultural innovation system of Kashmir valley, which allows mentioning these actors, networks and their interactions involved in the sector interacting horticulture innovation and sustainability linkages. Their intra and inter-linkages within these actors and stakeholders to promote production sector by means of science, technology, and innovations are determined by applying the agricultural innovation system as the analytical framework. It also helps to mention the sustainability dynamics impacted by horticultural production within the social, economic and environmental dimensions. By applying all these concepts of innovation system along with agricultural innovation system will help in developing the theoretical basis of innovation system and sustainable development, which will be the contribution of this study to the existing literature of innovation system and sustainable development. The innovation systems literature represents a significant change from the conventional, linear approach to research and development by providing an analytical framework that explores complex relationships among heterogeneous agents, social and economic institutions, and endogenously determined technological and institutional opportunities. Recent empirical work extends the innovation systems approach from studies of national innovation systems in industrialized-country manufacturing to developing-country agriculture and shifts the emphasis from a unidirectional technology transfer approach to a more complex, process-based systems approach. This shift in perspective is appropriate for the study of developing-country agriculture because it captures the intricate relationships between diverse actors, processes of institutional learning and change, market and nonmarket institutions, public

policy, poverty reduction, and socioeconomic development. The paper is divided into eight main sections. In section first, the introduction of the research work is presented, section second states the main objectives of the research study, and section third discusses the literature review of the study, section four describes the relationship between Innovation system and sustainable development within agricultural perspective. In section five, the geographic and socio-economic profile of the case study area is given, section six presents the methodology of the research work, section seven discusses the result and discussions and finally, section eight provides the concluding remarks.

2. Research objectives: (a) To understand the interactions within sustainability and horticulture sector of Kashmir valley of India. (b) To analyse the actors and networks involved in framing the horticultural innovation system of Kashmir valley.

3. Literature review

It is well described in the research study of Spielman (2005) how innovation and innovation system evolved in the agricultural sector. The author stated that earlier innovation studies trace to Adam Smith (1776) when he first noted the innovation influence, viz, 'new production techniques and new division of labour' on society and output. Later on, Ricardo (1821) provided an important point of discussion on innovation and technological change in agriculture within economic perspectives, analyzing the fundamental challenges in agricultural production like land's diminishing marginal returns and importance of technology in shifting possibilities of agricultural production (Spielman, 2005). Ricardo's analysis also introduced factor bias as a determinant of the technological change on productivity, income, and welfare. Ricardo did this by distinguishing between two types of technology, first, which "increases the productivity powers of the land" or second, which "obtains its produce with less labour". The first technological impact exists in the form of innovation processes, like water management, crop rotation, preserving soil fertility etc. and the other technological impact presents the product innovation like the application of new tools and techniques to reduce the number of labour. Ricardo's analysis gave rise to further interest in the socio-economic effects of technological change by such classical political economists as List (1841) and Marx (1894). In fact, it is List who is credited with the earliest description of a "national system of political economy" a precursor to the innovation system concept, in which production results not only from the activities of the firm but also from those social and economic institutions (e.g., education, infrastructure) that make production possible (Lundvall et al., 2002 & Freeman, 1995).

System approach to agriculture is not new as the systematic applications in such sector began in the mid-20th century. This concept started with farming systems research to account farm level productivity constraints in the 1970s and later on expanded to organizational and institutional analysis applications resulting in AIS concept (Anandajayasekeram, 2011). The prominent importance of agricultural innovation system approach in various studies is not only because it provides a holistic explanation of knowledge and technology production, diffusion and usage but it also emphasizes the actors and processes determining and analyzing the developmental factors of the agricultural sector. Enhanced productivity, profitability and competitiveness surface as the main sources of agricultural growth for the future. This can be triggered by innovations and applications of science and technology in agriculture. It is now understood that supporting innovation goes beyond increasing the supply of new scientific knowledge and technologies. Rather, innovation emerges out of the interplay between scientific, technological, socio-economic, institutional and organizational arrangements (Smits, 2002). Further, innovation stems from collaboration and interactions among a diverse network of actors, forming innovation coalitions (Engel, 1995) or, more recently, public-partnerships (Hall et al., 2001 & Hartwich and Tola, 2007). This understanding has influenced the agricultural innovation systems perspective that has gained currency in understanding agricultural development (Biggs, 1990; Spielman, 2005 & World Bank, 2006).

The Agricultural innovation system approach needs more attention, debate, and discussions, however, it confronts the whole actors and networks, knowledge, innovation and technology within the sustainable development terms in developed and poor agricultural systems. It is proposed that AIS approach came in action after the failure of National agricultural research systems (NARS) and Agricultural knowledge and information system (AKIS), as these two approaches were not capable of determining the heterogeneity of actors, networks, and institution involved in the innovation process of a system, especially in the public-private partnership era (Hall, 2007). NARS perspective mainly pursued a linear approach to agricultural innovation (transfer, adoption, and diffusion of technologies) as well as the AKIS perspective that emerged as a response to the rather limited linear approach NARS. While AKIS is mainly concerned with studying why and how farmers adopt or disregard agricultural innovations and practices in the first place, it tends to produce the little incentive for collaboration between research and education and is focused on research dissemination that sometimes does not correspond to the actual knowledge needs of farmers and food business. The AKIS concept was again criticised for still being focused on the formal

research system as the only supplier of knowledge for agricultural innovation. Table- 1 shows the comparison of the three approaches regarding the agriculture sector, how they were involved in the evolution of AIS.

Table-1 *Comparing the three main approaches within the agriculture sector used to promote knowledge and innovation*

Defining feature	National agricultural research system	Agricultural knowledge and information system	Agricultural innovation system
Actors	Research organisations	Farmer, research, extension, education	Wide spectrum of actors
Core actor	Formal research focused organisations	Research and education organisations	Farmers
Outcome	Technology invention and dissemination	Technology adoption and innovation	Diverse innovations
Organising principle	Science based technologies	Accessing agricultural knowledge	Innovation uses of knowledge for socio-economic change
Innovative mechanism	Technology transfer	Information and knowledge exchange	Interaction and innovation among stakeholders
Role of policy	Resource allocation, priority setting	Linking research, education and extension	Enabling innovation
Nature of capacity	Strengthening infrastructure and human capital	Strengthening linkages between rural actors	Strengthening multi actor interactions, enabling environment
Weakness	innovation and knowledge less focused	More focused on formal knowledge as compared to innovation	Sustainability not considered

Source: Adapted from World Bank (2006)

According to Spielman (2015), the NARS perspective recognizes the public goods nature of agricultural research and the absence of market access or purchasing power among many agrarian agents, and thus places necessary emphasis on the role of the state in fostering technological change. Yet the NARS approach tends toward linearity in so far as the movement of knowledge is described as originating from some known source (the scientific

researcher) and flowing to some end user (the farmer), with the assumption that social and economic institutions in which this process occurs are largely exogenous and unchanging.

The AKIS perspective highlights the linkages between research, education, and extension in generating knowledge and fostering technological change. More importantly, by focusing on the dynamics of dissemination through extension, the approach rectifies some of the conceptual gaps that had impeded analyses of how knowledge moves between knowledge producers and end users. The AKIS perspective, embedded as it is in the study of how knowledge flows between and among agents, is less linear than the NARS approach. The innovation systems approach broadens the NARS and AKIS perspectives by focusing on the processes by which diverse agents engage in generating, disseminating, and utilizing knowledge, the organizational and individual competencies of such agents, the nature and character of their interactions, and the market and nonmarket institutions that affect the innovation process.

AIS thinking emerged parallel to AKIS (Assefa et al., 2009) influenced by ideas on 'national systems of innovation' as developed by Lundvall (1992) and pioneered by Hall and colleagues (e.g. Hall et al., 2001) in the agricultural domain. Hall (2006) defined AIS as, "a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of the organisation into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge". The main principles of the AIS concept as given by Nederlof, Suzanne, Mariana and Femkevan (2011) are given in Table- 2 below.

Table-2 *Principles of Agricultural Innovation System*

Main feature	Specifications	Strength
Focus on innovation rather than production	Innovation considered as application of knowledge to achieve socio-economic outcomes	Knowledge as input to capital formation
Interaction and learning	Innovation as interactive process within various actors	Knowledge acquisition and learning promoting innovative capabilities
Linkages for accessing knowledge and learning	Relationships sustaining acquisition of knowledge and interactive learning are critical	Building partnerships, commercial transactions, networks or platforms

New actors and new roles in innovation process	Broad spectrum of actors with important diverse roles, change in relative importance of actor	Actors play role also outside the government, evolving to new roles
Attitudes, practices and interaction of behavioural pattern	Institutions (rules) regulate the interactions between various actors to innovate	Determine propensity to innovate
Policies are important in innovation	Innovation as a set of outcome of policies	Analyse the effectiveness of policies
Demand side must be included in innovation process	Actors and their behavioural patterns making organisations and policies sensitive to demands	Policy sensitivity to stakeholders agenda or demands
Changing to cope with change	During shock or risk it reconfigure networks and patterns	Sustainability and adaptation values
Building on sticky information	Sticky information when it is locally based or generic	Local, informal or generic knowledge used
Focus on demand domain rather than supply domain	Markets need to be more established and linkages of supply and demand domain strengthened	Production is promoted with more value chains

Source: Adapted from Nederlof, Suzanne, Mariana and Femkevan (2011).

This shortcoming of AKIS was addressed in the conceptualization of the AIS perspective which has been partially derived from innovation systems in the industrialized world, adding value to the conventional, linear perspective on agricultural research and development (R&D), by providing a framework for analysing complex relationships and innovative processes that occur among multiple agents, social and economic institutions, and endogenously determined technological and institutional opportunities. The complex integrative features of science, technology, and innovation in agriculture sector bring forth various actors to act in order to meet the demands of production and productivity on-demand domain (food and economy) but implying more pressure on the resources. Other than the food, agriculture produces livelihoods and other important assets for diverse kind of economic processes utilizing investments and natural resources. Agriculture should be capable of maintaining sustainable concerns both in producing and consuming resources i.e. outputs and inputs, especially that of environment and economy (livelihoods). This shows the multi-functional view of agriculture requiring keen analysis at each subsector level, as

it comprises of various sectors. AIS help in analyzing all these minor to major actors and networks responsible for proper functioning of the system.

Agricultural innovation is the process whereby individuals or organizations bring existing or new products, processes and forms of the organisation into social and economic use to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability, thereby contributing to food and nutritional security, economic development and sustainable natural resource management. Innovation within the agriculture makes the way within a dynamic actor networking – individuals and organizations – fostering learning and interaction through responsiveness and adaptation to emerging opportunities and challenges. An agricultural innovation system holds various actors like farmers and their organizations, policy makers, businesses, marketers, processors, transporters, input suppliers, regulatory agencies, researchers, extension services, service providers, civil societies etc. These are directly or indirectly involved in agricultural production, marketing, processing, distribution, and trade. Innovation defined under such view is thus a complex, interactive, flexible and dynamic process involving experience, learning and the knowledge application among these actors. Simultaneously, agriculture has developed into an international agribusiness sector constituted of highly specialized value chains and production branches (e.g. in horticulture, see Bokelmann, 2009) involving not only a specialized supplier industry with its own R&D activities but also very many SMEs besides large corporations as pesticide suppliers and food trade. Hence, innovation processes cannot be assumed to follow a single and linear (research-based) logic; rather, value chains have to be understood as the action arena where innovations are developed in double feedback looped processes determined by innovation system approach.

The Agricultural Innovation System has been defined as "a network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new form of organisation into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge (World Bank, 2006). The actors or organizations may be formal or informal depending upon their structure and function. In AIS, Informal organizations (for example, innovation networks or value chains) are increasingly recognized as important sources of innovation, because they complement and bond to formal organizations through a dense web of personal relations (Hakansson & Ford, 2002). Figure 1 provides a conceptual framework for Agricultural Innovation System as shown below.

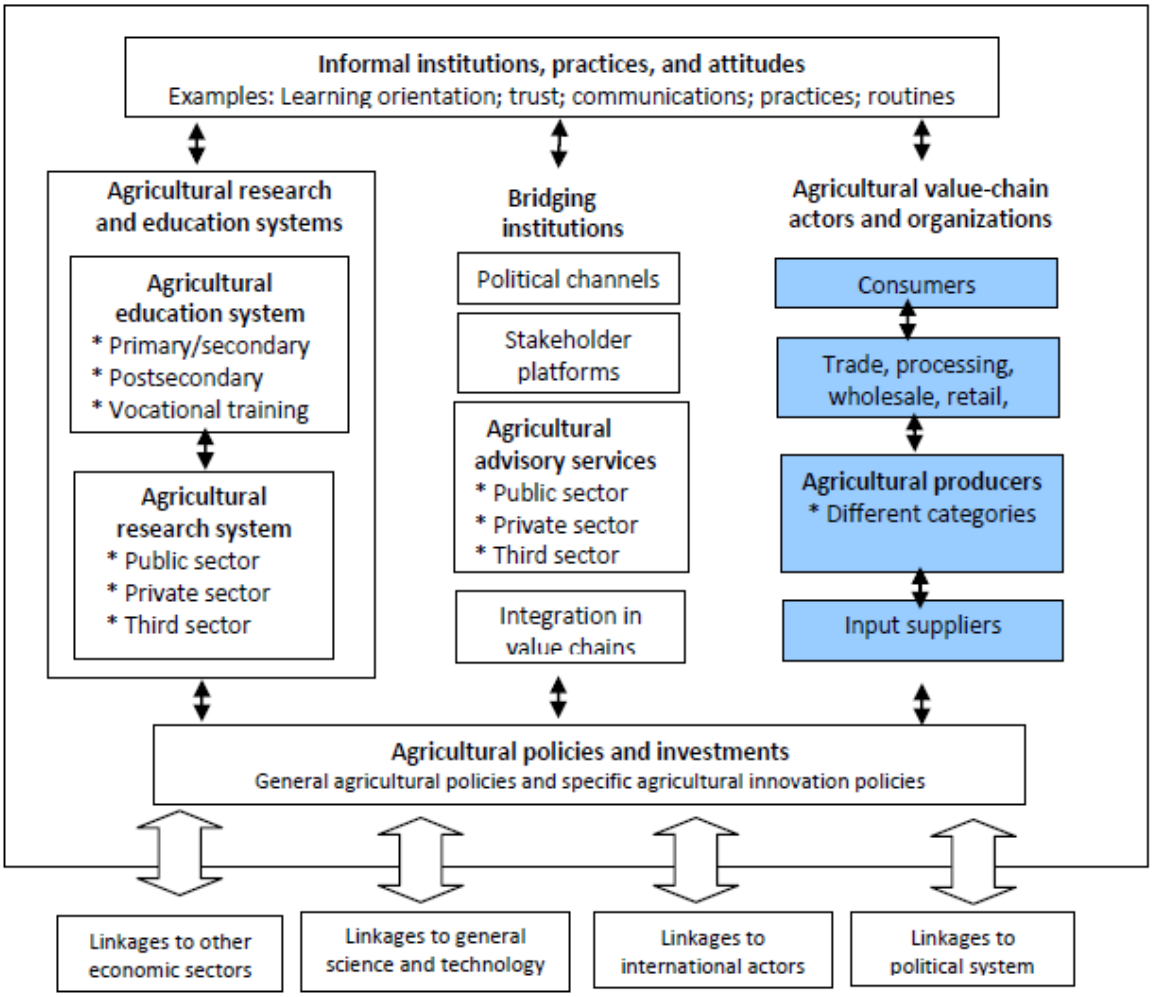

Figure-1 Agricultural innovation system framework

Source: World Bank (2007).

It captures the essential elements of an innovation system, the linkages between its components, and the institutions and policies that constitute the enabling environment for innovation. Within this AIS framework, agricultural producers must be understood as crucial actors in the value chain that are not just assisted by agricultural research and education systems via bridging institutions that build capacities for agricultural innovation, but also by other actors in the value chains such as the input suppliers and seed producers in agribusiness that provide valuable technical assistance, as well as retailers and their demands in order to comply with the standards of good agricultural practices. One of the major attractions of the innovation systems framework has been its explicit recognition that innovation is not a research-driven process simply relying on technology transfer. Instead, it is a process of generating, accessing and putting knowledge into use (Hall et al., 2001, 2003, & World Bank, 2006).

All these components are linked to each other in the direct or indirect way in order to promote and fulfill the demand domain of a sector. Such model has not yet included the concept of sustainability (critical need of the modern world). All such actors are engaged in the promotion of production with reinforcement of science, innovation, knowledge, and technology. It leads to seeking interest in applying the notion of sustainability along with such parameters in the various sectors. In this study, we take horticulture as the matter of concern for such analysis. As this subsector of agriculture has the tremendous increase in area and production, but less paid attention towards the sustainable development. It needs attention to analyze whether such sector is forwarding within the characteristics of sustainable development or not. A generic AIS incorporates a complete system of diverse agents whose interactions are conditioned by formal and informal socioeconomic institutions. The essential elements of an innovation system include (a) a knowledge and education domain, (b) a business and enterprise domain, and (c) bridging institutions that link the two domains. The AIS concept focuses on the totality of actors needed to stimulate innovation and growth and emphasizes the outcomes of knowledge generation and adoption. The framework captures not only the influence of market forces, but also the impacts of organizational learning and behavioral change, nonmarket institutions, and public policy processes (World Bank, 2006). The AIS perspective provides a means of analyzing how knowledge is exchanged and how institutional and technological change occurs in a given society by examining the roles and interactions of diverse agents involved in the research, development, and delivery of innovations that are directly or indirectly relevant to agricultural production and consumption.

The agricultural innovation system is an understanding of how a country's agricultural sector can make better use of new science, technology, innovation, knowledge and design interventions that go beyond research investments. It is a collaborative arrangement bringing together several organizations working towards technological, managerial, organizational and institutional objectives. Empirical studies based on the AIS framework highlight the ways in which heterogeneous actors interact in the generation, exchange, and use of information and knowledge; how individuals and organizations learn and change; and how social and economic institutions condition these interactions and processes. Such studies provide new insights into ways of increasing both the efficiency and effectiveness of innovation processes by identifying and exploiting comparative advantages of different actors and organizations; reducing transaction costs in the exchange of knowledge and technology; and achieving economies of scale and scope, exploiting complementarities, and

realizing synergies in innovation (Davis et al., 2007). The linkages between the agricultural innovation system and other economic sectors are important because other sectors (such as the manufacturing or service sectors) create demand for agricultural products, thus creating incentives for process and product innovation.

Klerkx et al. (2012) stated that 'the agricultural innovation system is an outcome of multiple interactions between various components of farming systems, economic systems, supply chains, policy environments and societal systems'. This framework maintains that improved interaction helps to forge stronger linkages between stakeholders which will result in better information exchange, and more ideas and opportunities. To enhance such interaction amongst different parties, a number of recent initiatives have worked with the concepts (and practice) of innovation platforms (in addition to the cases in this book, see for example Critchley et al., 2006 & Perez et al., 2010). In the context of developing countries, as in other regions, intermediaries facilitate the setting of the innovation agenda: by organising producers and the rural poor; by building coalitions of different stakeholders; by promoting platforms for information and knowledge sharing; by experimenting with and learning from new approaches: and by facilitating organisational and institutional capacity and enhancing business skills (Klerkx et al., 2009).

According to Sharma et al. (2014), the agricultural innovation system approach points a drastic shift from the concept of innovation as linear research and development process leading to economic and technical change, extending beyond the generation of knowledge to encompass factors affecting demand and use of new knowledge in useful and novel ways. He further added that the agricultural innovation system approach provides the center stage to two interlinked dimensions of innovation. First, the interactions within various players in economic systems, their role and the way to facilitate the transmission, adaptation, and implementation of ideas and hence enabling learning and innovation. The second dimension comprises the way locating process and the contexts shaping innovation process, including habits and practices of various actors, historical, political and cultural setting giving shape to innovation. There are various agricultural research studies taking innovation system as the research framework like shrimp cultivation in Bangladesh, medicinal plant cultivation in India, Vanilla plantation in India, pineapple cultivation in Ghana and cassava processing in Ghana, National Agricultural innovations system defined by World Bank (2006) as, "a network of organisations, enterprises, and individuals focused on bringing new products, processes and new form of organisation into economic use, together with the policies and institutions that affect the way different agents interact, share, access, exchange and use

knowledge". It is further assumed regarding the innovation system framework that innovation is not only a research-driven process relying on technology transfer, but it is a phenomenon of generating, accessing and framing knowledge into use (Hall et al., 2001). Other than supporting actors and activities in isolation like research and research organizations or supporting the generation of results and outputs, such as agricultural information and knowledge, emphasis should be laid on supporting outcomes that lead to sustainable development through agricultural innovation systems (Hall, 2002). Innovation capacity is sustainable only when a much wider set of attitudes and practices comes together to create a culture of innovation, including a wide appreciation of the importance of science and technology in competitiveness; business models that embrace social and environmental sustainability; attitudes that embrace a diversity of cultures and knowledge systems and pursue inclusive problem solving and coordination capacity; institutional learning as a common routine; and a forward-looking rather than a reactive perspective. In the medium to long-term, the development of these types of attitudes and practices will be critical to economic performance.

Various factors regulate the innovation process and sustainability dynamics of the sector among which the major ones are: social, economic and political and other factors like access to the facilities and technologies. Various actors and networks within a proper institutional setup which are defined by the innovation system perspective govern all these factors. The importance of the institutional setup, which is assumed to be a fundamental element of a national innovation system, is the especially relevant issue in areas which have largely established the primary institutional elements but are now undergoing the radical institutional transformation as they shift to market-based economic regimes. The agricultural diversification towards horticulture is also a market-based economic regime shift from staple to commercial production. In order to analyze the impacts of horticultural diversification on the livelihood and environmental sustainability, we need to fully analyze the structure of whole horticulture sector of Kashmir valley. Some researchers to analyze the horticulture sector of particular regions have earlier applied an innovation system approach. Taking the example of research work of Menrad and Gabriel in studying the horticulture sector of Germany and Netherlands in 2007, we are also taking innovation system in our research study to analyze the horticulture sector of Kashmir valley. Based on the innovation system conceptual framework, the characteristics of firms and important industries, the role of universities and education institutions as well as penetration of innovations related to horticulture are analyzed for Germany and the Netherlands.

Understanding the agriculture production system as complex social-ecological system drives the research to deal with the long-term effects and environmental externalities. It involves a broad set of stakeholders in such process which may be analyzed by the innovation system perspectives.

Sustainability term used in the CGIAR's mission statement in 1989 to mean "successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources" (TAC/CGIAR, 1989). Innovation implemented should run parallel with the features of sustainability. Some structural conditions as shown in Table- 3 enabling or constraining function of innovation systems within agriculture sector should take into consideration the notion of sustainability.

Table-3 *Structural conditions in innovation system functioning*

Structural conditions for innovation	Description
Infrastructure and assets	Knowledge, research and development infrastructure; physical infrastructure including roads, irrigation schemes and agricultural inputs distribution; communication and financial infrastructure
Institutions	Formal institutions including agricultural policies; laws; regulations; (food) quality standards; agricultural subsidies; monitoring and evaluation (M&E) structures; organisational mandates; market (access) and trade agreements; informal institutions such as socio-cultural norms and values
Interaction and collaboration	Multi-stakeholder interaction for learning and problem solving; development and sharing of knowledge and information; public-private partnerships; networks; representative bodies (e.g. farmers' association); power dynamics
Capabilities and resources	Agricultural entrepreneurship; labour qualifications; human resources (quality and quantity); education and literacy rates; financial resources (e.g. number of extension officers and funds to backstop farmers)

Source: Schut et. al. (2015)

Pretty (2008) assumed that concerns regarding the sustainability focus on the need to develop agricultural practices and technologies that, do not have the harmful impact on the

environment, are effective and accessible to farmers and lead to improvements in productivity and imposing positive effects on the environment. He further added that agricultural sustainability incorporates the concepts of resilience and persistence, and addresses various wider economic, social and environmental outcomes. Resilience meaning the system capacity to buffer stresses and shocks while persistence defines the long run continuity of the system. Horticulture as a subsector of agriculture is the largest livelihood generating activity in Kashmir valley of India, transforming from supply-driven to demand-demand approach. Diversification in the sector convene demand patterns with supply and act as a risk mitigation value for the farmers. The research study concerning the transition, diversification, and sustainability intends to use innovation system perspective as the analytical framework. The impact of transition and horticultural diversification on sustainability focuses on major important value like socio-economic changes (livelihoods) and an environment. Such complexity involves various actors and processes (implementation of innovations and technologies) that can be highlighted by the innovation system approach.

4. Innovation system and sustainable development: agricultural perspective

In various countries including India, huge population pressurizes the agricultural resources to produce more food and income for science, technology and innovation applications affecting the natural resources and environment. At this point, it shows a connection between the innovation systems and sustainable development. AIS addresses the actors, networks and there interactions involved in promoting technical or technological development in the sector. The technical development of agriculture is based on four pillars like the chemical, biological, technical and human factors (Takacs-Gyorgy et al., 2014). The results of agricultural technological development, mechanization, pesticide production, variety breeding, etc. meet the society's claim to reduce pesticide use (both in terms of applied quantity and frequency) to feature the sustainability. Technological innovation has a potentially important role to play in improving the sustainability of agricultural systems through a range of innovations in engineering, information technology, pesticides and biotechnology, reducing the load of known toxins, substituting safer alternatives, protecting ground or surface waters, protecting natural habitats, reducing nutrient loads in soils, reducing gaseous nitrogen loss (Pitkin et al., 1996) or reducing the amount of non-renewable energy used in the cropping cycle. The nature of Innovation or technological process is itself non-linear and uncertain in various natural systems, depending on the multitude of factors like institutions and culture. To link the notion of sustainability within innovations requires

the radical change in the system of governance also. Any attempt to find a way to govern the transition to sustainability cannot avoid a systemic analysis, as the innovation originates from a network of relationships and interactions between various firms, organizations, and institutions (Edquist, 2006). Framing the innovation system within the sustainable development framework, it needs primary concern to produce technology/innovations and formulate innovation policies within the notion of sustainability at their earlier stages of their development and implementation. Hence the sustainable innovation system will produce sustainable technology output, meaning that all the processes, products, organizational ways and institutions do not affect critically the present and the future dynamic equilibrium of nature and its resources. As per Segura-Bonilla (1999), natural and human elements and relations which interact in the production, diffusion, and use of new, and economically useful knowledge constitute a sustainable innovation system. Mulder (2007) argued that most encompassing technological innovation level called as the level of transition are crucial for long-term sustainable development, because of its largest improvement potential. Adding further that the transitions for sustainable development are often impossible, 'as the new systems have to compete with fully developed and optimised systems that have far advanced at the learning curve, i.e., are optimised by various systems and incremental innovations'.

Various studies in policy arenas have shaped innovation directives in economic goals, societal values, and institutional arrangements. It is an emerging challenge to address innovation not only in socio-economic development but also in the environmental dimension to be taken into consideration (Bleischwitz et al., 2009). When it comes to agriculture, environment and natural resources are important basic components other than the anthropogenic entities, emphasizing the sustainable development concepts. Innovation and sustainable development are horizontal policy areas which need to be interfaced with the agricultural systems, and such possibility can be posited by AIS. Increasing economic competition implements huge pressure on natural resources through use of science, technology and innovation strategies within the agricultural communities which directly impinges the environmental degradation. Sustainability in agricultural production systems could be defined as practices, techniques, and approaches that contribute to food security and safety, sustained economic viability, enhanced environmental quality, and higher quality of life for farmers, farm workers, and society as a whole (NRC, 2010).

Environmental quality, natural resource conservation, profitability, preservation of farming communities, productivity, and human health are all interrelated aspects of sustainable

agriculture (Sitarz, 1998). Within the agricultural sector, horticulture is mostly based on high technology applications, which motivates to observe the issues between the innovation, science and technology and sustainable development. Ehrlich and Holdren (1972) formulated an equation addressing the impact of technology and other factors on environment given as:

$$\mathbf{I = P \times A \times T}$$

Where, I = environmental impact, P = population, A = affluence (consumption of services and products per capita) and T technology, (environmental burden per product or service unit).

It is observed from the above equation that environmental impact is directly proportional to population factor, affluence, and technological applications. As stated above horticulture is technology-intensive sector, growing population with higher affluence values may impact the nature and natural resources very drastically which needs to be addressed. Hence the notion of sustainability within the innovation policy and systems is the crucial issue in the horticulture sector.

It is difficult to integrate the innovation and sustainability concept (Hines and Martin, 2004) requiring that the innovation should be economically and environmentally sustainable, optimising all of these developments together. It requires transition and transformational policy strategies, looking at modified roles of different stakeholders and reinventing institutional set-up of societies. Maximising and harnessing the potential of technology and innovation within the limits of sustainability at the later stages is enormously difficult to policy formulating authorities and concerned societies. However, integrating sustainability concerns into innovation and technology within systemic perspective may be highly productive at initial phases of their implementation and development.

Gjoksi (2011) in a research study regarding the 'European Sustainable Development Network' on innovation and sustainability within the policy frameworks assumed that the, 'sustained development emphasizes the explicit interest of the normative direction of development, taking into consideration the balanced three-pillar approach (economic, environmental and social sustainability)'. The challenge for innovation and innovation system does not rest wholly on economic opportunities and benefits, but also in societal changes persuaded by innovative capacity and the consequences on environmental and social sustainability. The author further added that redefining innovations within sustainable development perspective, innovations should meet values like system innovation approach, framing sustainable development innovation policy paradigms on the basis of evolutionary

perspectives rather than neo-classical environmental perspective, radical changes in green innovation and multi-level perspectives in socio-technical transitions. Kemp (1994) stated that neo-classical approaches are insufficient in explaining the determinant affecting the supply side of innovation, as they focus mostly on markets demand-pull control and "right price signal". The evolutionary approaches also include non-market-determinants such as decision-making at the firm level, institutional factors, knowledge capabilities, prevailing technology paradigms and regimes.

Sulaiman (2015) stated that producing and implementing new knowledge is important for all industries, enterprises, including farming, but such knowledge which can enhance competitiveness, productivity and sustainability is not broadly adopted at scale. The lack of innovation in agriculture intended to search new frameworks like innovation systems that attempted in understanding the process of agricultural innovation and enhancing its quality. AIS framework takes into account not only technical innovation but also organizational and institutional innovation. AIS recognizes innovation as an interactive process as the outcome of interactions and learning, interactions within different actors and their ideas, also comprising institutions (meaning rules, laws, attitudes, habits, norms, practices) shaping how organizations and individuals interact and generate knowledge and technology. This shows the inclusion of technical, organizational and institutional innovation involved in the agricultural sector. Technical innovation defines the adoption of new technologies, organizational innovations considers the organizations (e.g. farmers), and institutional innovations consider the laws, rules, (e.g. uncertainties in land leasing via policy changes). All such kind of innovation as a process and product in the agricultural sector are the outcomes of AIS.

5. Geographic and Socio-Economic Profile of J&K

The state of Jammu and Kashmir lies in the north area of the country India. The entire State lies between 32.17" and 36.58" North altitude and East to West, and between 73.26" and 80.30" longitude. The standard time is 5.30 hours ahead of Greenwich Time as in the rest of India and has a difference of half an hour with the local time. The state is mainly divided into three different regions based on various factors like political, climatic, economic assets, resources etc., one is cold arid desert areas of Ladakh, second the temperate Kashmir Valley and third the humid sub-tropical region of Jammu. Each has its own specific geo-climatic condition which determines the cropping pattern and productivity profile. The state is divided into twenty-two districts, ten for Kashmir region, two for Ladakh region and ten for Jammu region. Figure 2 depicts the map of the state showing districts as below.

Figure-2 Showing map of J&K

Source: http://www.mapsofindia.com/maps/jammuandkashmir/

J&K state is well known for its horticultural produce both in India and abroad. The state offers good scope for cultivation of horticultural crops, covering a variety of temperate fruits like apple, pear, almond, peach, cherry, plum, apricot and sub-tropical fruits like mango, guava, citrus litchi, phalsa and Berete. Besides, medicinal and aromatic plants, floriculture, mushroom, plantation crops and vegetables are cultivated in the state. Apart from this, well-known spices like saffron and black Zeera are also cultivated in some pockets of the state. It is observed that the most of the diversification took place towards the apple cultivation as the area under such cultivation has a prominently increased. Comparing the area under apple cultivation within a decade of 2005 to 2015, it was 111881(Ha) in 2005-2006 and 163432(Ha) in 2014-2015 for the whole J&K. Individually for Kashmir valley, the area under such cultivation figures 1444733(Ha) in 2014-2015 showing the dominance of such production.

Table-4 *Area (Ha) and Production (MT) of horticulture (2014-2015)*

	Area (Ha)		Production (MT)	
	Total	**Apple**	**Total**	**Apple**
J&K	359089	163432	1542676	1170306
Kashmir	237598	144733	1355000	1139180
Jammu	121491	18699	187676	31126

Source: Directorate of Horticulture J&K (2015)

From the above Table- 4, it is depicted that the total area of state under horticulture is 359089 Ha, in which Kashmir has double horticultural area as compared to Jammu. In the production process, total is 1542676 (MT) for the whole state, in which Kashmir has major portion. Within the both entities like area and production apple is the dominating fruit. It has major contributions in area as well as production when compared to other horticultural crops. So, in order to get the appropriate data regarding the horticultural diversification, we take Kashmir valley as case study site for research purpose and especially apple industry into consideration. This is because the valley is most dominated in horticulture production as compared to Jammu and Ladakh.

6. Methodology

Kashmir valley comprises of ten districts, but we take only five districts for the research purpose. The five districts considered on the basis of their highest area and production of apple are Baramullah, Shopian, Anantnag, Kupwara and Kulgam as shown in the figure 3 below.

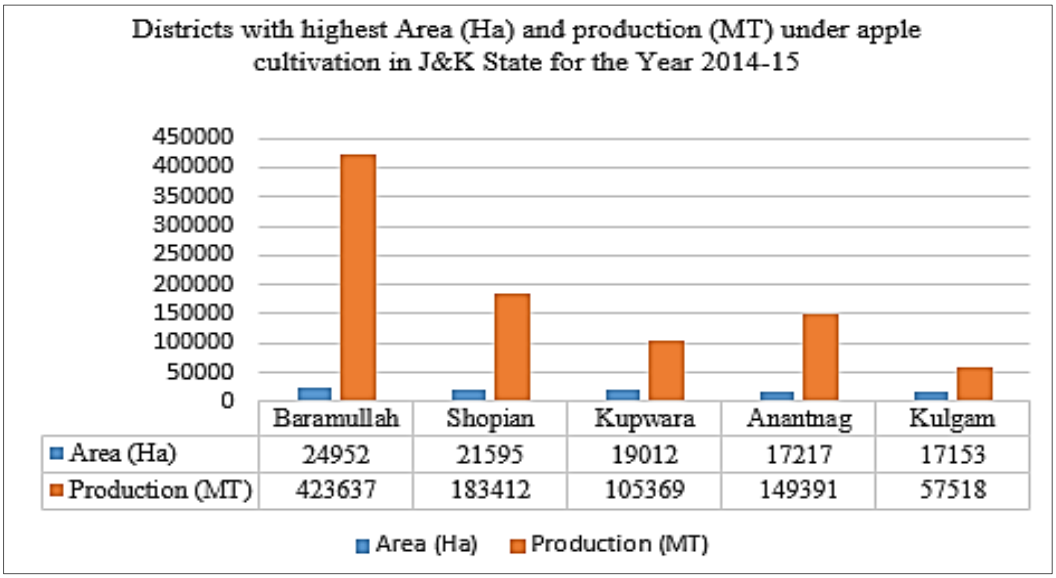

Figure-3 Graph showing area and production of apple cultivation

Source: Own compilation

While observing the diversification figures towards apple cultivation, these five districts show a prominent increase in such area, making them suitable- for the research purpose. For collecting data and information from rural households, we used a deliberate sampling method to select five districts namely Baramullah, Shopian, Anantnag, Kupwara, and Kulgam. The districts selected for the research purpose based on their highest production and area of apple cultivation. After selecting these five districts we conducted a pilot survey to observe the horticulture sector in these districts. It was observed most of the orchards seen comprise of apple trees, which developed much interest to carry out such research study. Then we selected four villages each from a district hence a total of twenty villages were selected. Among those four villages of each district selected, a strategy was followed, two villages near the market and two far from the market. From each village, ten households were selected for research purpose, hence a total of two hundred households were taken into consideration. This selection of villages and households was done randomly, but all of them were rural based on the basis of population factor analyzed from the census 2011 reports and not covered under the municipal corporation of the concerned district. These villages taken into consideration are linked mostly with the agriculture sector for their economic purposes especially horticulture sector. The households taken under consideration from the above districts were provided with the structured questionnaire. To have proper interactions with them, we used their local language and another factor was that most of the farmers were uneducated. Some households fill up the questionnaire on their own but some were not able to do so. They were interviewed and the information provided was noted.

In order to get the information and data from the experts, higher authorities, the scientists dealing with horticulture sector, it required visiting such institutions. First, we visited the Directorate of Horticulture J&K and conducted some unstructured interviews with various officials. They provided worthy information and data useful for our research study. Then we visited Sher e Kashmir University of Agricultural Sciences and Technology, Srinagar (SKUAST). There we also approached various officials and scientists working in the horticulture sector. Interviews conducted and discussions held to gather more information and data purposive for this research study. Other formal institutions dealing with the horticulture sector like Jammu and Kashmir Horticultural Production and Management (JKHPM), Krishi Vigyan Kendras (KVKs), Central Institute of Temperate Horticulture were also visited and same research methods were processed to obtain some information and data regarding the horticulture.

7. Results and discussions

This section divided into two main portions, one discusses about the horticultural innovation system of Kashmir valley and second portion discusses about the sustainability dynamics interrelated with horticulture.

7.1 Horticultural innovation system of Kashmir

The horticultural innovation system on the basic framework of agricultural innovation system will help to analyse the actors and networks as given in the figure 4 below. It comprises of three majors domains like education and research institutes, marketing strategies and the bridging actors involved in various processes. Other domains like the linkages with political system are limited in horticulture to great extent. There occurs a diverse network of formal actors at state or national level engaged in integrating the value chain mechanism of the sector. Various actors presented in the figure are named in abbreviation form whose details are given separately.[1]

[1] APEDA: Agricultural and Processed Food Products Export Development Authority
ATMA: Agricultural Technology Management Agency
CITH: Central Institute of Temperate Horticulture
DMI: Directorate of Marketing & Inspection
HMNEH: Horticulture Mission for North East and Himalayan States
ICAR: Indian Council of Agricultural Research
JKHPMC: Horticulture Produce Marketing and Processing Corporation Ltd
JKSTIC: J&K Science, technology innovation council
KVKs: Krishi Vigyan Kendras
NABARD: National Bank or Agriculture & Rural Development
NAFED: National Agricultural Cooperative Marketing Federation of India Ltd
NCDC: National Cooperative Development Corporation
NHB: National horticultural board
NHM: National Horticultural Mission
RKVY: Rashtriya Krishi Vikas Yojana
SKUAST: Sher-e-Kashmir University of Agricultural Sciences and Technology

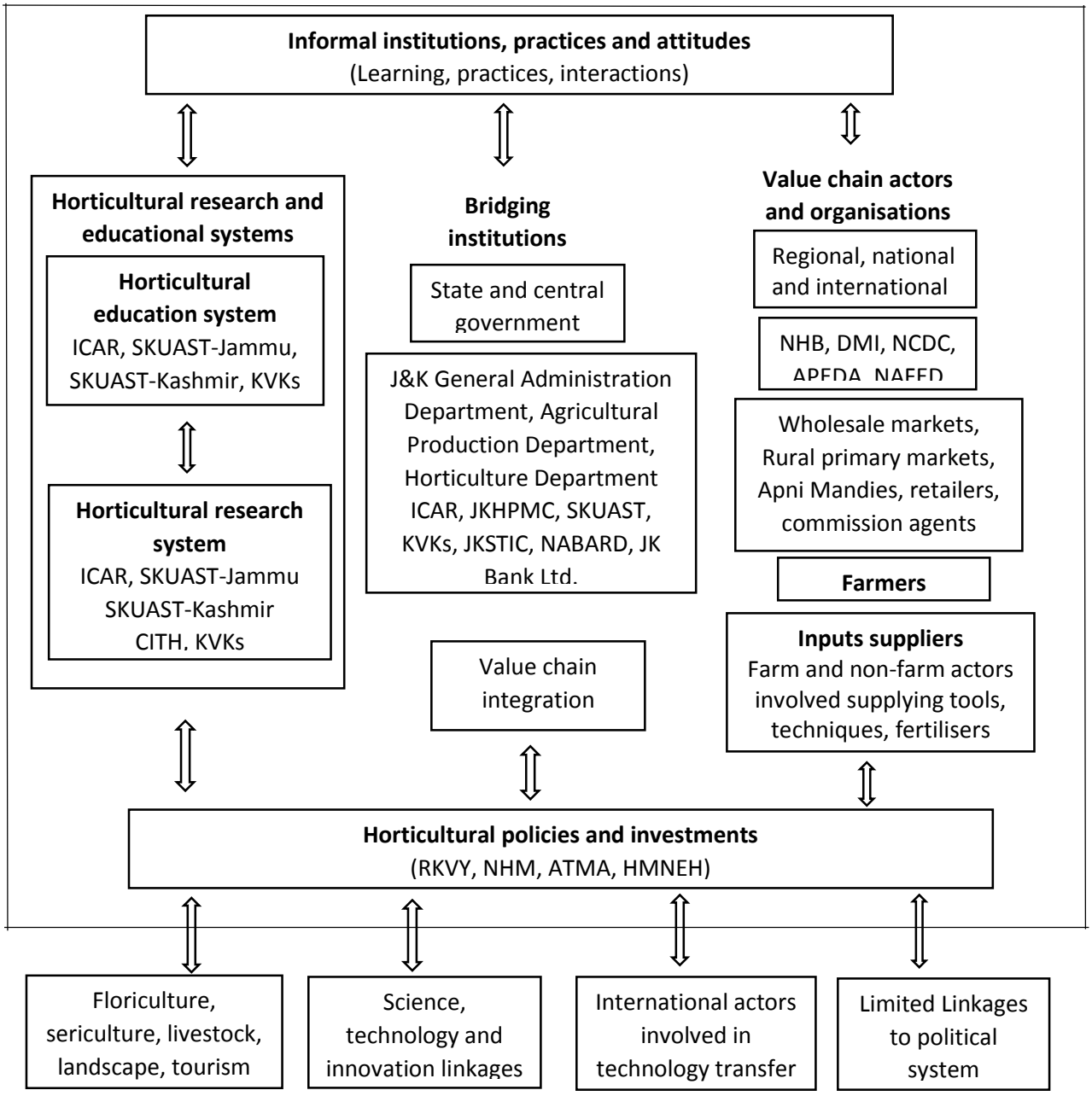

Figure-4 Horticultural innovation system of J&K

Source: Own compilation

For education and research, the main actors involved are SKUAST, CITH, and KVKs at the state level and ICAR at the national level. The technology and knowledge generated are systematically transferred to farmers. In the marketing strategies, various actors at regional, state or national level play important role in maintaining the forward and backward linkages of produce and input. Various policies and schemes funded by state or central government had also been important in the development of the sector.

The management of harvested fruit to avoid its degradation is a great challenge, as this causes a heavy loss to the industry. In case of the postharvest management, most of the actors engaged are formal in nature acting on the national level. The important actors linked are National Horticulture Board (NHB), National Bank for Agriculture and Rural Development (NABARD), Directorate of Marketing & Inspections (DMI), Horticulture Cooperative Development Corporation, Agriculture Produce & Development Authority (APEDA) and National Agricultural Cooperative Marketing Federation (NAFED). All these actors listed above function at the national level as there are others which function in such process at regional level like SKUAST, Directorate of Horticulture and some private cold storage firms.

The National Horticulture Board (NHB) of the Government of India regularly publishes and announces the wholesale price and market arrival figures of apple in different terminal markets for the benefit of the growers. It has set up a market information service for the benefit of growers. The actors viz National Horticulture Board (NHB), Directorate of Marketing & Inspections (DMI), Horticulture Cooperative Development Corporation, Agriculture Produce & Development Authority (APEDA) and National Agricultural Cooperative Marketing Federation (NAFED) secure infrastructural development of apple sector by taking support from Government of India.

The organizations like National Horticultural Board (NHB), National Co-operative Development Corporation (NCDC), Agricultural and Processed Food Products Export Development Authority (APEDA) provide incentives to traders and exporters to improve their infrastructural facilities like grading and packaging centers, refrigerated transport, setting up of pre-cooling, cold storage and auction platforms. The NCDC is undertaking procurement and marketing of apple on a limited scale. NCDC been established to promote and develop integrated cold chain in India for perishable agriculture and horticulture produce including perishable from allied sectors. The main objectives of the center are to recommend standards and protocols for cold chain infrastructure, suggest guidelines for human resource development and to recommend appropriate policy frame-work for development of cold chain.

7.2 Socio-economic sustainability within horticulture sector

It is observed that the horticulture is most profitable sector as compared to the other sectors of agriculture. In various areas of the country, the transition led to horticulture from other crops had increased the income of related people. It is labour and technology intensive sector. Being labour intensive, the Kashmir horticulture sector has attracted a large number

of labour class from the other states of India like Bihar and west Bengal. Hence, the sector not only providing income and economy to the native people but also to the other states also in the form of wages for poor and high profit to the business class within and out of the state. Being highly profitable sector, most farmers are attracted day by day towards the sector in the production of fruits, flowers, and vegetables. In the agricultural sector of Kashmir valley, the transition has been prominent from paddy cultivation to horticultural sector within the diversification perspectives. Such diversification and transition cause change in prices of staple and commercial crops. With falling staple food prices and rising urban incomes, the payoff has shifted to strategies that enhance agricultural diversification and increase the value addition of agricultural production (Barghouti et al., 2004).

However, according to the estimates of the Horticulture department, around 20 lakh people are employed in this sector. In a research study conducted by the 'Giri Institute of Development Studies' Lucknow, it is revealed that the 'farming of apple is providing 77 per cent higher man-days of employment (95 per cent higher in case of paid workers and 71 per cent in case of family workers) as compared to the cultivation of agricultural crops'. The proportion of paid workers in the apple cultivation increases with the increase in the orchard size. So there is a need to allocate substantial resources from rural development to the programs of horticulture so that total area could expand area expansion, as rural development programs are mostly oriented towards creating job opportunities. Horticulture development would prove to be the best investment in this direction as a one-time investment made in plantation programs would continue to provide job opportunities for years to come. From the last few years, the increase in the horticultural production increased with increase in the area in such cultivation. Horticulture diversification generates more income and employment for the rural people. The marginal farmers who had also practiced the horticultural diversification have improved their life status. This is because the horticulture products are most valuable as compared to the paddy cultivation. The farmers who do not meet the livelihoods by practicing paddy have transferred to such sector not only due to income factors but due to also other factors as well. Table- 5 below shows the trend of increase in the area within the horticulture sector from the year 2009 to 2015.

Table-5.*Year wise kind wise area under horticultural commodities*

S.No	Kind of fruit	Year wise Area in Hectares				
	Fresh fruit	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2014-15**
1.	**Apple**	138191	141717	154720	157280	163432
2.	**Pear**	12547	12536	13218	13883	15006
3.	**Apricot**	5248	5856	6051	6287	6458
4.	**Peach**	2364	2425	2510	2772	2619
5.	**Plum**	4085	4335	4341	4628	4870
6.	**Cherry**	3412	3469	3488	3728	3874
7.	**Grapes**	306	310	329	344	431
8.	**Citrus**	12756	13436	13655	13882	14531
9.	**Olive**	430	481	514	533	559
10.	**Mango (G)**	5659	6784	7291	7466	7998
11.	**Mango (D)**	5003	5003	5015	5032	5059
12.	**Ber**	7836	7852	7852	7904	7886
13.	**Anola**	520	1248	1466	1530	1720
14.	**Guava**	2045	2280	2342	2372	2479
15.	**Kiwi**	2	14	45	18	12
16.	**Others**	9376	9311	17348	9121	9136
Total		209780	217057	240185	236780	246071
	Area under dry fruits					
17.	**Walnut**	87280	89788	83613	93641	96397
18.	**Almond**	17540	17654	16418	15932	15776
19.	**Peacan-nut**	461	428	551	619	656
20.	**Others**	144	148	2024	251	188
Total		105425	108018	102606	110443	113017
	Grand total (Ha)	315204	325075	342791	347223	359088

Source: Directorate of Horticulture J&K (2015)

From 2009-2010 to 2014-2015, the area under horticulture has increased from 315204 Ha to 359088 Ha. Presently the process of diversification is also on good pace as most of the farmers are practicing this process. Hence, this shows a positive relation between diversification and inclusive development of the rural poor. The increase in the area means more scope for income and employment of the people. The increase in area is directly

proportional to the production of the crop within the favorable conditions required. Table-6 shows the year-wise horticultural production in the state of J&K. From the year 2009-2010 to 2014-2015, the production has increased continuously except the year 2014-2015 which was affected by the natural hazards like floods, rain, etc. Keeping aside the impact of natural hazards, the production will increase definitely as the area is going on increasing. In order to manage risks and uncertainty in income the diversification towards and within horticulture has proven beneficial.

Table-6 *Year wise horticultural production (MT)*

S.No	Kind of fruit	Year wise production in Metric tons				
	Fresh fruit	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2014-15**
1.	**Apple**	1372973	1852412	1756192	1348149	1170306
2.	**Pear**	47982	52503	47820	54847	59721
3.	**Apricot**	15609	15572	10310	14501	15381
4.	**Peach**	4262	4781	3910	4855	5698
5.	**Plum**	7687	8603	8102	8682	7973
6.	**Cherry**	10910	11445	11467	11122	9530
7.	**Grapes**	543	569	803	746	781
8.	**Citrus**	19067	18988	19734	20814	21792
9.	**Olive**	20	22	77	22	33
10.	**Mango (G)**	3813	11570	8098	8206	7645
11.	**Mango (D)**	8252	29524	14762	14884	10059
12.	**Ber**	15917	12756	13074	13200	13141
13.	**Anola**	512	669	1248	1324	1768
14.	**Guava**	7238	5444	5608	5692	5101
15.	**Kiwi**	1	1	2	1	10
16.	**Others**	19896	20697	47966	17548	15648
Total production		1534682	2045556	1949173	1524593	1344553
Dry fruit						
17.	**Walnut**	165024	163745	208738	209051	181443
18.	**Almond**	12515	12506	3258	8208	16537
19.	**Peacan-nut**	20	15	0	12	13
20.	**Others**	170	170	0	278	130
Total production		177728	176436	211996	217549	198123

Grand total (MT)	1712409	2221992	2161169	1742142	1542676

Source: Directorate of Horticulture J&K (2015)

As per the above data, it indicates a decrease in production besides an enormous increase in the area. The farmers reported that the production depends on various factors like weather, climate, technological inputs etc. However, it does not remain constant in the consecutive years depending on such factors whether favorable or not. But if the production will be low, it will still compensate the livelihood sustainability as compared to the crops like paddy, mustard etc.

According to Bhandari and Chakraborty (2015), economic growth of J&K measured in terms of per capita gross domestic product (GDP) from 2004-05 to 2013-14 was 12 percent per annum, at least 2 percentage points lower than the national average. With this slow growth, the state could do very little to reduce the poverty rate during this period. The per capita income of Jammu & Kashmir at current prices is worked out at Rs. 51493 in 2012-13 as against Rs. 45198 in 2011-12, thereby showing growth of 13.93 percent. As per the Tendulkar Committee's poverty estimates (2011-2012), poverty reduction in J&K in the seven-year period since 2004-05 has been merely three percentage points, from 13 percent in 2004-05 to 10 percent in 2011-12, compared with an average decline of 15 percentage points at the national level. The poverty level is decreased due to the growth of all the three primary, secondary and tertiary sectors, but as inclusive development is taken into consideration then the primary sector is mostly focused.

In discussing with the apple growers of Kashmir from some selected areas it was noted that the transition towards horticulture is at a high pace. They reported that cultivating other crops at large scale other than the apple is not too much beneficial and profitable. However, the diversification towards horticulture and diversification within the horticulture has also a good feature of risk and shock regulation. This shows the concern of sustainability within the social and economic dimensions.

7.3 Environmental sustainability and horticulture sector

Horticulture has the greatest environmental impact of all types of economic activity, mainly because it is so land-intensive. A wide variety of factors hinders the cultivation of new land, including low soil quality, arid climate, lack of infrastructure and environmental restrictions. In the progressive demand for food and income, horticulture has caused significant environmental damage, primarily through fertilizer and pesticide application to a great extent. Despite these concerns, the world's population continues to expand and global

agriculture can barely cope with its key task of providing people with food. The global demand for food increases with every year. In addition to soaring population levels, this growing demand is triggered by improved living standards in emerging countries, especially in China and India. Since the agricultural sector requires increased food output per unit of land in the context of a shortage of arable land, producers have to focus on preservation and enhancement of soil productivity.

In prolonged horticultural use, the soil content of certain macronutrients required for plant nutrition decreases, making mineral fertilizers vital in agriculture. The application of mineral fertilizers is indispensable where urbanization is reducing the availability of land resources, and also where the cultivated land area is on the rise due to the reclamation of new land. The variety of organic fertilizers is quite limited, and as a result of the enrichment of soil fertility chiefly depends on the application of mineral fertilizers produced from nitrogen, phosphates, potash and natural gas. The global agricultural industry uses three types of mineral fertilizers: nitrogen, phosphate and potash fertilizers. They contain only the basic macronutrients necessary for all plants. Industrially manufactured fertilizers provide plants with the required nutrients in a digestible form. The public and environmental safety of fertilizers should be regulated by governments in addition to the controls as implemented by the producers. Increased and frequent use of fertilizers in horticulture has various prominent issues which need to be addressed and lowered.

The second environmental hazardous agents creating injustice to the environment are pesticides. The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. The use of pesticides is directly linked with the agricultural benefits by increasing production, productivity by destroying the harmful agents destroying the crop. The high-risk groups exposed to pesticides include production workers, formulators, sprayers, mixers, loaders and agricultural farm workers

In case of the technological inputs used in the horticulture, pesticides are the most dangerous agents considered to the environment as compared to the fertilizers. In horticulture sector of Kashmir valley, the consumption of pesticides includes mainly four groups of chemicals like insecticides, fungicides, rodenticides, and herbicides. Table-7 shows the consumption of different groups of pesticides (MTs) used in the agriculture sector of J&K.

Table-7 *Consumption of pesticides (MTs) in J&K*

Chemical group	2013-2014	2014-2015	2015-2016
Insecticides	129.386	87.518	79.346
Fungicides	1406.678	1580.904	1902.512
Rodenticides	2.183	2.716	1.808
Herbicides	184.374	249.771	267.666

Source: J&K Envis Centre, Department of Ecology Environment and Remote Sensing, J&K Accesses from: http://jkenvis.nic.in/agriculture_pesticides.html (10/02/2017).

Figure 5 shows the share of various pesticides consumed in agricultural practices in J&K for the year 2015-2016. The figure depicts that the fungicide consumption is too high as compared to other chemical products. The fungicides are more used in horticultural products at regular intervals especially apple trees as compared to other chemical.

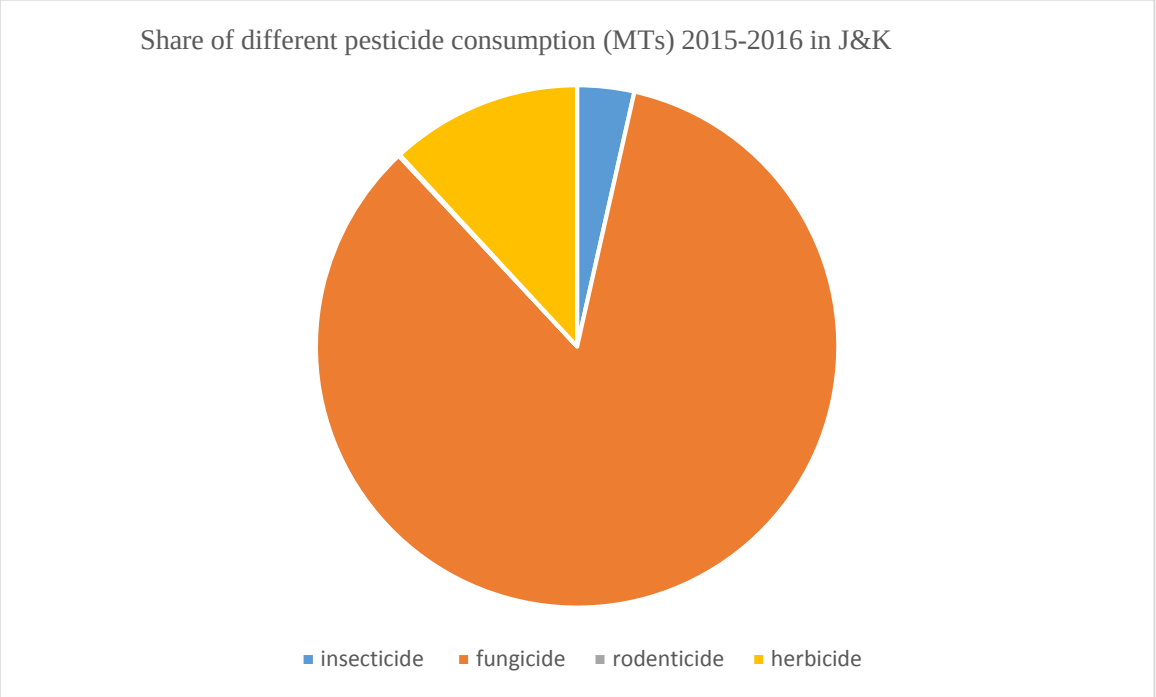

Figure-5: Share of different pesticide consumption (MTs) 2015-2016 in J&K

Source: Adapted from Department of Ecology Environment and Remote Sensing, J&K (2015)

The fungicides as a group of pesticides are also hazardous as compared to other chemical products used as pesticides. The horticulture of Kashmir threatened to the fungal diseases like scab etc. has felt the need of more use of fungicides. The farmers reported that in order to get the superior quality grade one apple, we have to use such chemical substances frequently without keeping in mind the environmental sustainability concern. They cannot compromise with their produce in order to make less use of these hazardous substances.

Some farmers reported that these chemicals sprayed are substandard and spurious resulting in increased use of them as they are not effective. If such tools are proper and effective then use will be less and need not be sprayed frequently thereby producing less impact on the environment. Some of the impacts led by the use of pesticides and inorganic fertilizers creating a hazard to human and nature are given as under:

Water body contamination

Fertilizers and fertilizers contain substances like nitrates, sulfur, and phosphates that are flooded into lakes and oceans through rains and sewage. These substances prove to become toxic for the aquatic life, thereby, increasing the excessive growth of algae in the water bodies and decreasing the levels of oxygen. This leads to a toxic environment and leads to the death of fish and other aquatic fauna and flora. Indirectly, it contributes to an imbalance in the food chain as the different kinds of fishes in the water bodies tend to be the main food source for various birds and animals in the environment.

Degrades soil quality

It is the fact, that using high use of fertilizers and pesticides in the soil can alter the fertility of the soil by increasing the acid levels in the soil. In order to maintain the proper soil profile, it is recommended to get a soil test at least once in every 3 years so that you can keep a track whether or not you are using the right amount of fertilizers. The levels of soil pH vary from 0-14, wherein 0 is considered to be the most acidic and 14 being the most basic. 7 is considered to be alkaline or neutral. The ideal soil pH varies from plant to plant and can be altered by bringing in some changes. The bottom line for using too much of fertilizers in the soil is that, though it may seem to work currently, there are high chances that you may not use it for plant yielding in the long run.

Human Health

The phosphorus, sulfur, nitrogen and other chemicals present in the fertilizers and pesticides also affects the ground waters and waters that are used for the purpose of drinking. It is important to know that the use of lawn fertilizers and pesticides can cause health risks like cancer and chronic diseases in humans, especially in children. Bhat et al. (2010) in a research study analyzed the pesticide relationship with brain cancer in various apple growers of Kashmir valley. They reported that “90.04% (389 out of 432) patients were orchard farm workers, orchard residents and orchard playing children exposed to the high levels of multiple types of neurotoxic and carcinogenic (chlorpyriphos, dimethoate, mancozeb, and captan) chemicals for more than 10 years”. From their study, it is revealed that the human health is profoundly impacted by the pesticide usage in the horticultural sector.

Global climate changes

Fertilizers consist of substances and chemicals like carbon dioxide, methane, ammonia, and nitrogen, the emission of which has contributed to a great extent in the quantity of greenhouse gases present in the environment. This, in turn, is leading to global warming and weather changes. In fact, nitrous oxide, which is a by-product of nitrogen, is the third most significant greenhouse gas, after carbon dioxide and methane. These facts are alarming and a serious step needs to be taken as soon as possible to avoid more severe consequences.

8. Conclusion and suggestions

The agriculture sector comprises of various components dealing with research, education, marketing, value chain integration, civil societies and the core group farmers. Horticulture has same components engaged with different activities a kind of 'division of activities' for its proper and systemic function. The different actors or stakeholders and their interactions are responsible for proper development of the sector in the units of production and productivity. All these actors and their interactions and linkages are analyzed by using agricultural innovation system as the analytical framework. Horticulture sector is the main economic backbone of Kashmir valley of India. The sector is mostly predominated by the apple cultivation as compared to other temperate fruits. This sector among agriculture is more labor and technology intensive sector. It mostly relying on intensive innovations and technology obviously generate more income and economy but at the same time, it hazards the environment. On one hand planting plants and trees are healthy for the environment but the later overuse of insecticides, pesticides, fertilizers and other chemicals prove degrading agents for the environment. All these issues address the notion of sustainability to be concerned within the sector. Analysing the horticulture sector of Kashmir valley within the notion of sustainable development applying innovation system approach observed that horticulture sector is fulfilling the criteria of sustainability with the context of social and economic dimensions only and not the environment domain. The higher authorities, policy makers should take this issue into consideration.

Use of organic manures and biological fertilizers helps in restoring soil health, reducing quantity and cost of chemical fertilizers. Promotion of eco-innovation should be promoted to nurture the environment. Farmers and research and education organization need to strengthen their linkages. Awareness on biological nitrogen fixation, phosphate solubilizers, and mycorrhizal fungi must be created among the farmers.

References

Anandajayasekeram, P. (2011). The Role of Agricultural R&D within the Agricultural Innovation Systems Framework. Report Prepared for the ASTI/IFPRI-FARA Conference, Accra, Ghana.

Assefa, A., Waters-Bayer, A., Fincham, R., & Mudahara, M. (2009). Comparison of frameworks for studying grassroots innovation: Agricultural Innovation Systems (AIS) and Agricultural Knowledge and Information Systems (AKIS). In P. Sanginga, A. Waters-Bayer, S. Kaaria, J. Njuki, & C. Wettasinha (Eds.), *Innovation Africa: Enriching farmers livelihoods* (pp. 35–56). London: Earthscan.

Barghouti, S., et al. (2004). Agricultural Diversification for the Poor: Guidelines for Practitioners. Agriculture and Rural Development Discussion Paper 1. World Bank, Washington, DC.

Bhat, A. R., Wani, M. A., & Kirmani, A. R. (2010). Brain cancer and pesticide relationship in orchard farmers of Kashmir. *Indian Journal of Occupational and Environmental Medicine 14*(3), 78–86.

Biggs, S. D. (1990). A multiple source of innovation model of agricultural research and technology promotion. *World Development* (18), 1481-1499.

Bleischwitz, R., et al. (2009). Eco-innovation: putting the EU on the path to a resource and energy efficient economy. *Wuppertal Spezial* (38). Wuppertal: Wuppertal Institute.

Bokelmann, W. (2009). Wertschöpfungsketten im Gartenbau. In: Dirksmeyer, W. (Hrsg.): TI Landbauforschung. Sonderheft (330), 115–129.

Critchley, W., Verburg. M., & Veldhuizen. L., (2006). Facilitating Multi-stakeholder Partnerships: Lessons from Prolinnova. A publication in the series on Promoting Local Innovation. IIRR, Silang, Cavite, Philippines and ETC, Leusden, The Netherlands.

Davis, K., (2007). IFPRI Discussion Paper 00736, Strengthening Agricultural Education and Training in Sub-Saharan Africa from an Innovation Systems Perspective Case Studies of Ethiopia and Mozambique.

Edquist, C. (2006). *Institutions and Organizations in Systems of innovation*. In C. Edquist (Ed.), System of innovation. Pinter.

Ehrlich, P. R., & Holdren J. P. (1972). Impact of Population Growth. *Resources and the Environment*. Washington, D.C.: US. Government Printing Office. Pp. 365-77

Engel, P. G. H. (1995). Facilitating innovation: An action-oriented approach and participatory methodology to improve innovative social practice in agriculture. Wageningen University, Wageningen, The Netherlands.

Freeman, C. (1995). The National Innovation Systems in historical perspective, *Cambridge Journal of Economics* 19(1).

Gjoksi, N. (2011). Innovation and sustainable development: Linkages and perspectives for policies in Europe. *European Sustainable development Network Quarterly Report*.

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– 52.

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), 783-797.

Hartwich, F., Tola, J. (2007). Public-private partnerships for agricultural innovation: concepts and experiences from 124 cases in Latin America. *Int. J. Agricultural Resources, Governance and Ecology* (6), 240-255.

Hines, F. & Marin, O. (2004). Editorial building innovations for sustainability: 11th international conference of the greening of industry network, Business Strategy and Development (13), 201-208.

Kanssona, H., & Ford, D. (2002). How should companies interact in business networks? *Journal of Business Research* (55), 133 – 139.

Katalin, T. et al., (2014). Sustainable New Agricultural Technology – Economic Aspects of Precision Crop Protection. *Procedia Economics and Finance* (8), 729-736.

Kemp, R. (1994). Technology and the transition to environmental sustainability: The problem of technological regime shifts, Futures (26) 1023-1046.

Klerkx, et al., (2012). Advances in knowledge brokering in the agricultural sector: Towards innovation system facilitation, *IDS Bull* (43), 53–60.

Klerkx, L., Hall, A., & Leeuwis, C. (2009). Strengthening agricultural innovation capacity: Are innovation brokers the answer? *International Journal of Agricultural Resources, Governance and Ecology* 8(5/6), 409-438.

List, F. (1841). *The National System of Political Economy*. London: Longmans, Green and Co.

Lundvall, B. A. (1992). National Innovation Systems: Towards a Theory of Innovation and Interactive Learning, London, Pinter Publishers.

Lundvall, B., Johnson, B., Anderson, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research Policy* (31), 213–231.

Marx, K. (1894). *Capital*, vol. 1. Reprint, London: Penguin Classics.

Menrad, K. & Gabriel, A. (2007). National Innovation Systems in Horticulture in Germany and the Netherlands, Fifth International Symposium on Management of Technology (ISMOT'07) Hangzhou (China), ZheJiang University, 1st to 3rd June 2007

Mulder, K.F. (2007). Innovation for sustainable development: from environmental design to transition management. *Sustainability Science* 2(2), 253.

Pérez, S. A., Klerkx, L., & Leeuwis, C. (2010). Innovation brokers and their roles in Value Chain-Network Innovation: Preliminary Findings and a research agenda. Proceedings of the International and Sustainable Development in Agriculture and Food. ISDA, Montpellier, France.

Pitkin, P. H., et al. (1996). Targeted Inputs for a Better Rural Environment: Farmers' Views of New Technology" in Proceedings Crop Protection in Northern Britain.

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Philosophical Transactions of the Royal Society* B(363), 447–465.

Raina, S. R. (2009). Innovation for Development: Policy Trajectories and Reform for Rural India, Working Paper SIID- 17.

Ricardo, D. (1821). *Principles of Political Economy and Taxation* (3rd ed.). Amherst, NY: Prometheus Books.

Schut, M., Klerkx, L., & Leeuwis, C. (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, November 2015, pp.140.

Segura-Bonilla, O. (1999). Sustainable systems of innovation: The forest Sector in Central America. SUDESCA Research Paper No. 24. Dep. Business Studies. Aalborg University, Denmark, Aalborg.

Sharma, R. (2014). Agriculture Innovation System Approach for Sustainable Agriculture Development: A Review. *International Journal of Agro Economist* 1(1), 1-7.

Smits, R. (2002). Innovation studies in the 21st century: Question from a user's perspective. *Technological Forecasting and Social Change* (69), 861-883.

Spielman, D. J. (2005). Innovation systems perspectives on developing-country agriculture: A critical review. ISNAR Discussion Paper 2. Washington DC: IFPRI.

Sulaiman, R.V. (2015). Agricultural Innovation Systems. Note 13. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.

World Bank. (2006). Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems. Washington DC, pp. 135.