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# Innovation and Sustainability Dynamics in the Horticultural Sector
# Dinámicas de innovación y sustentabilidad en el sector hortícola

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ABSTRACT

The paper focuses on the horticulture sector of India's Kashmir valley, analyzing its sustainable potential within the framework of the agricultural innovation system. The horticulture sector has been very productive in the Kashmir valley by providing economic pathways to most populations, either directly or indirectly. Engaging the science, technology and innovation application in the sector are believed to increase the growth based on production and productivity. However, such applications without limited measure may act detrimental to the environment on economic accounts' interests. Such applications must be productive, economically viable, and environmentally sound; they must conserve natural resources, make optional use of on-farm resources, and enhance the quality of life for farmers, members of rural communities, and society. All such components remark the concept of sustainable development accounting all the three major factors like social, economic and environmental interrelations. In this study, applying the agricultural innovation system framework will help understand the positive and negative aspects of horticulture within sustainable development. This paper argues that the three domains of sustainable development (i.e., social, economic and environmental) in horticulture will not steady parallel until innovations implemented are projected in an appropriate mechanism.

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

RESUMEN

El presente artículo se centra en el sector hortícola del valle de Cachemira de la India y analiza su potencial sustentable dentro de un marco de trabajo del sistema de innovación agrícola. El sector hortícola ha sido muy productivo en el valle de Cachemira por facilitar vías económicas a la mayor parte de la población, ya sea de manera directa o indirecta. Se cree que al vincular la ciencia, la tecnología y la aplicación de innovación en el sector, aumenta el crecimiento en función de la producción y la productividad. Sin embargo, aquellas aplicaciones que no tienen una medida limitada pueden desempeñar una situación perjudicial para el medio ambiente sobre los intereses de las cuentas económicas. Tales aplicaciones deben ser productivas, viables económicamente y racionales ambientalmente; deben conservar los recursos naturales, hacer uso opcional de los recursos en la explotación y mejorar la calidad de vida de los agricultores, los miembros de comunidades rurales y la sociedad. Todos estos componentes señalan el concepto de desarrollo sustentable y consideran tres factores principales, como las relaciones sociales, económicas y ambientales. En este estudio, la aplicación del marco de trabajo sobre el sistema de innovación agrícola ayudará a entender tanto los aspectos positivos como negativos de la horticultura en el desarrollo sustentable. Este artículo sostiene que los tres ámbitos (social, económico y ambiental) del desarrollo sustentable en la horticultura no se mantendrán paralelos hasta que las innovaciones implementadas se presenten en un mecanismo adecuado.

Palabras clave: sistema de innovación agrícola, desarrollo sustentable, la India, innovación, sistema de innovación, horticultura.

## INTRODUCTION

Sustainable development strategies within the social, economic and environmental perspective present new challenges for agriculture, especially in developing countries. The highly productive industrial agricultural has simultaneous environment and social impacts (Kremen and Miles, 2012). Agricultural activities impacts everything from greenhouse gas emissions to the bio-diversity, livelihoods, water quality, soil erosion, soil quality, pollination services, huma health, carbon sequestration, food security, food chain and livelihoods (Zhang *et al*., 2007, Hayes *et al*., 2011, Tscharntke *et al*., 2012). Taking the case of India, which has experienced high agrarian crisis need to find the sustainable ways to promote agriculture. To eradicate poverty, generate livelihoods and employment, and provide food security to the whole nation, agriculture was focused immensely since after independence, as most of the population relies on it for basic survival needs. This has huge pressure on this sector intended to focus on sustainable agriculture. Environmental quality, natural resource conservation, profitability, preservation of farming communities, productivity, and human health are all interrelated aspects of sustainable agriculture (Sitarz, 1998). Within various agricultural sub-sectors, horticulture is considered as a major high profit and value sector focusing more on commercial crops, resulting in livelihood generation and improving farmers' income. On the other hand, the intensive rely of horticulture on science and technology tackles the challenges of sustainable development, which the agriculture innovation system framework may approach. Reinert (1996) even suggests that one can find explicit connections between a discussion about development centered on the role of technology and innovation in a systemic way. This motivates to take horticulture sector into consideration, and Kashmir valley being more dominated in this sector develops the interest to analyze it within the agricultural innovation system framework. AIS analysis helps to understand the horticulture sector of Kashmir valley, thereby determining sustainable development's potential and status within the sector. Huge population inputs high pressure via agriculture on resources to meet people's needs, especially for food and livelihoods. The increase in production and productivity always led by science, technology and innovations marked the importance of agricultural innovation systems. However, the negative impact of the sector on the environment caused due to the use of innovation and technology in the form of fertilizers, pesticides, and other chemicals bring in to address sustainable development.

### Literature review

Innovation and technology are considered as a potential factor for agricultural growth and development, thereby suppressing and overcoming the challenges. Continuing focus on household food and nutrition security, decelerating growth in total and partial factor productivity, unsustainable land and water use practices, and economic and ecologically access to food, especially for the poor, are agricultural development challenges. These, coupled with the need for promoting the competitiveness of Indian agriculture and gearing agricultural systems, including technology systems, to the pressures of international agreements affecting access and application of technologies, make the task ahead more challenging (Pal *et al.*, 2008). Enhanced productivity, profitability, and competitiveness surface as the main sources of agricultural growth for the future, triggered by innovations and science and technology applications in agriculture. A paradigm shift in research strategies on agriculture from research mediated commercial crops used as industrial raw material towards food crops to cater to the national policy goal of achieving food security. In the study, two main frameworks used are sustainable development and agricultural innovation system. The paper tries to link the two concepts to understand the impact of the horticulture sector on sustainability within the dimensions on environmental grounds. Hence the literature review within the agricultural innovation system and sustainable development helps carry out this research study. Agricultural innovation systems (AIS) thinking has become an increasingly applied framework to analyze the technological, economic and institutional change in agriculture (e.g., Hall *et al.,* 2003; Morriss *et al*., 2006; Spielman *et al*., 2008). In the AIS approach, innovation is considered the result of a process of networking and interactive learning among

a heterogeneous set of actors, such as farmers, input industries, processors, traders, researchers, extensionists, government official, and civil society organizations (Leeuwis, 2004; Hall *et al*., 2006; Roling, 2009). The AIS approach emphasizes that agricultural innovation is not just about new technologies but also about institutional change; it requires alternative ways of organizing, for example, markets, labor, land tenure and distribution of benefits (Leeuwis, 2004; Spielman *et al.,* 2009). Given the interaction between heterogeneous actors, related to the several dimensions of agricultural innovations (e.g., technology development, institutional change, supply chain reorganization, market development, creating societal acceptance), it has been noted that AIS can be regarded as Complex Adaptive Systems (CAS) (Ekboir, 2003; Hall and Clark, 2009; Spielman *et al*., 2009). The complexity within the context of technology dissemination and agriculture usage needs to be accompanied by sustainable characteristics. In the 1990 farm bill, Congress defined sustainable agriculture as "an integrated system of plant and animal production practices having a site-specific application that will, over the long-term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agriculture economy depends; make the most efficient use of non-renewable resources and integrate where appropriate, natural biological cycles and control; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole (Food, Agriculture, Conservation, and Trade Act of 1990)." According to the World Bank (2006), AIS is a collaborative arrangement bringing together several organizations working toward technological, managerial, organizational, and institutional change in agriculture. Such a system may include the traditional sources of innovations (indigenous technical knowledge); the modern actors (NARIs, international agricultural research institutes, and advanced research institutes); private sectors, including (local, national, and multinationals) agro-industrial firms and entrepreneurs; civil society organizations (NGOs, farmers and consumer organizations, and pressure groups); and those institutions (laws, regulations, beliefs, customs, and norms) that affect the process by which innovations are developed and delivered. The AIS concept focuses on the totality of actors needed to stimulate innovation and growth and emphasizes knowledge generation and adoption outcomes. The framework captures the influence of market forces and the impacts of organizational learning and behavioral change, nonmarket institutions, and public policy processes (World Bank 2006). It highlights the importance of framework conditions and linkages to other sectors and the broader S&T community both within and outside the country. The overall complexity of the actors and networks engaged in the agriculture sector by implementing the innovation and technology had led to the agriculture revolution by growth in production and productivity. But, in the current period, the agricultural revolution face environmental constraints that were not considered during the early Green Revolution. The sustainability of agricultural systems is high on the agenda and the preservation of ecosystems and biodiversity will be important for the potential of agriculture in the future. All such environment-related issues call for the approach of sustainable development within the agriculture sector. The origin of sustainable development can be traced back to 1987 in the World Commission on Environment and Development or “Brundtland Commission.” The term SD was coined and defined as the “development that meets the needs of the present without compromising future generations' ability to meet their own needs” (Le Blanc, D. *et al*. 2012:1). One of the defining moments for SD was the UNCED, known as the “Earth Summit”, held in Rio de Janeiro in 1992 with the agreement by member States to launch a process to develop a set of sustainable development goals (SDGs) that could be a useful tool for pursuing focused and coherent action on sustainable development (United Nations 2012:15; Le Blanc, D*., et al*. 2012:17). The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. The recent 17 Millennium Development Goals build on various nations' consensus while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace, and justice, among other priorities. The goals are interconnected, often the key to success on one will involve tackling issues more commonly associated with another. The SDGs work in the spirit of partnership and pragmatism; often the right choices now to improve life in a sustainable way for future generations. They provide clear guidelines and targets

for all countries to adopt in accordance with their own priorities and the environmental challenges of the world at large. The SDGs are an inclusive agenda. They tackle the root causes of poverty and unite us to make a positive change for both people and the planet. “Poverty eradication is at the heart of the 2030 Agenda, and so is the commitment to leave no-one behind,” To foster sustainable development has become imperative in current times. A vision to promote this laid out in the new sustainable development agenda aiming to end poverty, promote prosperity and people’s well-being while protecting the environment by 2030. It is reported that most of the rural population of the world, especially from the developing nations are facing poverty as compared to the urban populations. In such rural areas, most of the promising sectors to alleviate poverty and provide food is the agriculture sector. The growth in both production and productivity values of the sector has a positive sign of the economy's growth. The technology-based revolution in the sector in the form of innovations acts as an important factor in boosting growth. The innovations in the sector in the form of knowledge, technology, and tools are represented by the innovation act system approach. However, technologies and innovations to perform in the sustainable perspectives are centers of focus. With lower productivity in agriculture, wages will be higher in the modern sector, which induces labor to move from agriculture to the modern sector, which generates economic growth. Other precursors, such as Schultz (1964), also point out the importance of the agricultural sector's food supply. In Schultz’s view, agriculture is important for economic growth because it guarantees subsistence for society, without which growth is not possible. This view on the role of agriculture in economics matched Kuznets’ (1966) empirical observation that the agricultural sector's importance declines with economic development. In this view, the role of agriculture in economic development is to supply cheap food and low-wage labor to the modern sector. Johnston and Mellor (1961) account explicitly for agriculture as an active sector in the economy. In addition to providing labor and food supply, agriculture plays an active role in economic growth through production and consumption linkages. For instance, agriculture can provide raw materials for non-agricultural production or demand inputs from the modern sector. On the consumption side, higher productivity in agriculture can increase the rural population's income, thereby creating demand for domestically produced industrial output. In the early 1990s, the focus was near term technologies and enhanced productivity. However, unsustainable cultural practices, expansion of agricultural activities to marginal and hazard-prone agro-ecological zones, and concerns that agricultural practices do not adequately address the environmental externalities accompanying technological changes led to the incorporation of environmental and ecological considerations. Currently, research is expected to contribute to broader developmental goals, such as poverty alleviation, food and nutritional security, environmental sustainability, and other Millennium Development Goals. This links research directly to the development and cannot be achieved by developing technologies or knowledge alone. Innovation is crucial to the realization of development impacts.

## METHODOLOGY

The research study is qualitative and exploratory based on both the primary and secondary data regarding the horticulture sector of Kashmir valley. As the research is related to the horticulture sector of Kashmir valley, primary data collected from the farmers and the higher authorities engaged within the sector. For secondary data, websites and reports of various actors and stakeholders engaged in the Kashmir horticultural sector like Directorate of Horticulture Kashmir, Horticultural Produce Marketing & Processing Corporation Ltd., Sher-e-Kashmir University of Agricultural Sciences and Technology Srinagar, and financial bodies, are analyzed to bring forth the framework of the horticultural innovation system. Assessing the impact of horticulture on social, economy, and environment is a two-phased study conducted by reviewing relevant reports of the horticulture sector of Kashmir valley and taking into account the information and data from the farmers and the higher authorities concerned with the sector. Horticultural policies, the laws related to the environment, and on-farm site visits to collect relevant data and visual observations regarding the impact on the biophysical and socio-economic conditions of surrounding spaces were also engaged. To collect such information and data from the farmers, focus group discussion were conducted in

which five groups of ten farmers from five different villages of district Shopian were taken into consideration. Shopian district is considered for the research study, because it is the famous district of J&K for apple production both in production and quality perspectives. Horticulture is a diverse crop sector comprising of the production of various commodities like fruits, vegetables, etc. Among which the fruits are considered as more valuable and most profitable crops as compared to other agricultural products. The state of J&K is famous for horticulture as it acts as the backbone of the economy, with apple production as the most dominating and profitable crop. Figure 1 shows the area and production of the horticulture sector of the state.

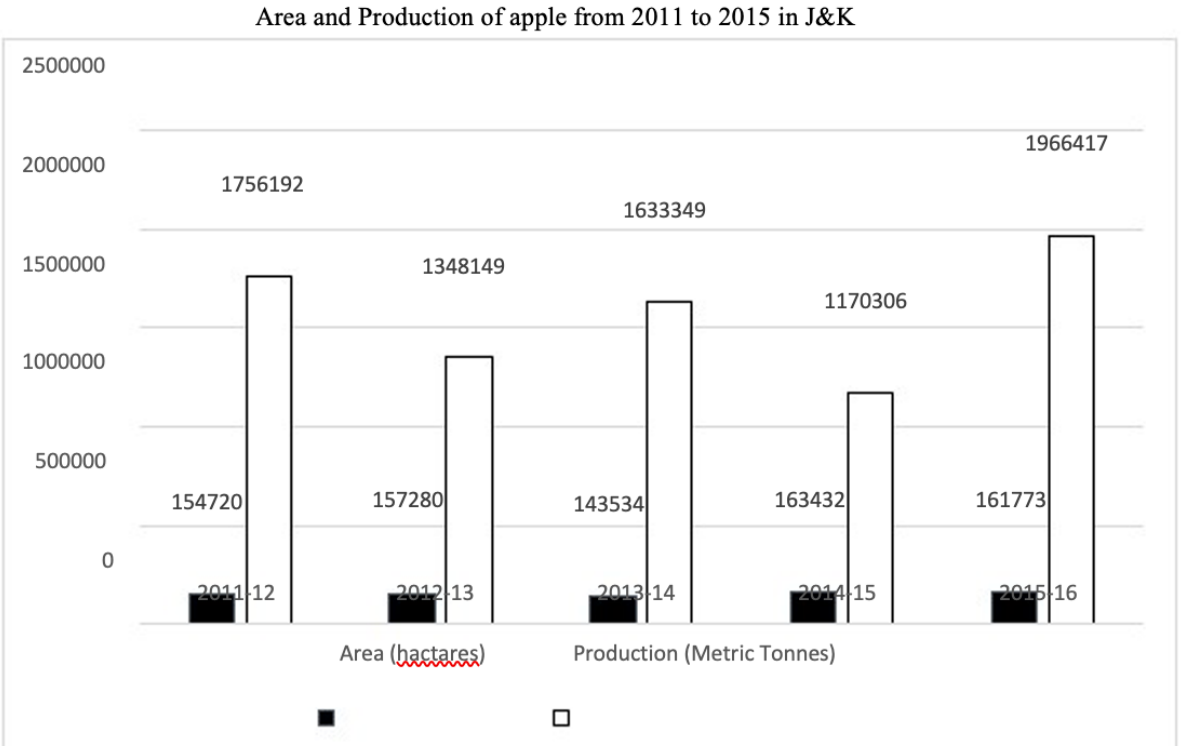


Figure 1 Increase in area and production of apple in J&K (2011-2015).
Source: Directorate of Horticulture (P&M), J&K (2018).

Innovation system and sustainable development: Agricultural perspective

In various countries, including India, a considerable 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 their interactions in promoting technical or technological development in the sector. The technical development of agriculture is based on four pillars: 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 sustainability. Technological innovation has a potentially vital 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 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 a radical change in the structure 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 needs primary concern to produce technology/innovations and formulate innovation policies within the notion of sustainability at the 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 critically affect 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 the most encompassing technological innovation level, called the level of transition, is 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 optimized systems that have far advanced at the learning curve, i.e., are optimized 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 in socio-economic development and the environmental dimension to be taken into consideration (Bleischwitz *et al*., 2009). When it comes to agriculture, the environment and natural resources are essential components other than the anthropogenic entities, emphasizing sustainable development concepts. Innovation and sustainable development are horizontal policy areas that need to be interfaced with the agricultural systems, and AIS can posit such possibility. Increasing economic competition implements huge pressure on natural resources through science, technology, and innovation strategies within the agricultural communities, imping 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, farmworkers, 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 innovation, science and technology and sustainable development. Ehrlich and Holdren (1972) formulated an equation addressing the impact of technology and other factors on the environment given as:

$$I=P\times A\times T$$

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 a technology-intensive sector, a growing population with higher affluence values may impact nature and natural resources vary drastically, which needs to be addressed. Hence, the notion of sustainability within the innovation policy and systems is crucial in the horticulture sector. It isn't easy to integrate the innovation and sustainability concept (Hines and Martin, 2004), requiring that the innovation be economically and environmentally sustainable, optimizing all of these developments. It requires transition and transformational policy strategies, looking at modified roles of different stakeholders, and reinventing societies' institutional set-up. Maximizing and harnessing the potential of technology and innovation within the limits of sustainability at the later stages is enormously challenging to policy formulating authorities and concerned societies. However, integrating sustainability concerns into innovation and technology within a 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 emphasises the explicit interest of the normative direction of development, taking into consideration the balanced three-pillar ap oach (economic, environmental and social sustainability)'. The challenge for innovation and innovation system does not rest wholly on economic opportunities and benefits and 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 based on 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.

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 the cold arid desert areas of Ladakh, second the temperate Kashmir Valley third the humid subtropical region of Jammu. Each has its specific geo-climatic condition, which determines the cropping pattern and productivity profile. The state is divided into twenty-two districts, ten for the Kashmir region, two for the Ladakh region, and ten for the Jammu region. Figure 2 depicts the map of the state showing districts as below.



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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 horticultural crops, covering various 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. Apart from this, well-known spices like saffron and black Zeera are also cultivated in some state pockets. It is observed that most of the diversification took place towards apple cultivation as the area under such cultivation has prominently increased. Within both entities like area and production, apple is the dominating fruit, as shown in the Table1.

Table-1 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 |



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Source: Directorate of Horticulture J&K (2015)

It has significant contributions in the area as well as production when compared to other horticultural crops.

Environmental sustainability and horticulture sector

Horticulture has the greatest environmental impact on all economic activity types, 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 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 a shortage of arable land, producers have to focus on preserving and enhancing soil productivity. To analyze the horticulture sector's impact on the environment, we focused on the whole annual activities implemented in the sector's production process. The discussions with the farmers and higher authorities reported that this sector utilizes a huge share of pesticides, fertilizers, and other chemicals. It was also reported that more and more harmful chemicals are observed year by year as the plant growth increases. As the area under such production is also at a higher pace also requires more use of the chemicals. All such chemical substances are harmful to nature, especially to water and soil, which inhabits many organisms. A significant reduction of groundwater levels may accompany the other impacts on natural resources like water, soil waterlogging results from mismanagement of water, flooding, channel modification, siltation, excess increment of nutrients in water bodies (eutrophication), pollution for surface and groundwater through waste, organic, toxic chemicals, competition for water resources (Gotvajn *et al*., 2001). Removing trees, shrubs, and grasses during land preparation for orchard activities will break the natural compactness of soils and hold water capacity due to the erratic nature of rainfall, soil erosion, and loss of nutrients may happen. The use of fertilizer, pesticides, and types of machinery may disturb the physical and chemical nature of the soil. Imbalance in biological activities may appear due to soil contamination with toxic chemicals, loss of organic nutrients, salinity, alkalinity, and solidicity (Smith, 2008). Loss of flora and fauna occur when orchards are established at the spot or in the vicinity. Moreover, the introduction of new species or change of cultivation may cause the development of pests, diseases, or weeds. To get proper benefit of horticulture, it is necessary to use biocides to keep away the produce from pests, bacteria, weeds, and diseases. If doses of fertilizers and biocides are not carefully used, directly/indirectly, water will be contaminated or polluted that can be injurious for aquatic and terrestrial animals and nearby communities (MEA, 2005; Plestina and Mercier, 1996). An increase in horticultural production due to an increase in its land area will require more implementation of innovations and technologies in fertilizers and pesticides. Other than the natural disturbance, people engaged with the sector also face various diseases due to continuous exposure to chemical sprays. Taking the example of Kashmir valley, various farmers dealing with pesticide spraying suffer from diseases like dementia. Modern horticultural schemes are labor-intensive, engaging more people in the sector. They may also get health problems due to exposure to the chemicals. Due to content with chemicals and pesticides, skin allergy and irritation, and inhaling polluted air, chemicals and pesticides inside/around outside of the orchard disturb cardiovascular processes. Emission of toxic gases, vapours, dust, emission of toxic liquid, and their cumulative effects can badly affect human health inside and around outside of the project (Pingali and Roger, 2012). There may be death and injuries to human beings due to improper loading-unloading, storing, and disposing of chemicals. 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 reduces the availability of land resources and where the cultivated land area is on the rise due to the reclamation of new land. The variety of organic fertilizers is quite limited.

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. In addition to the controls as implemented by the producers, governments should regulate the public and environmental safety of fertilizers. 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 farmworkers. In the case of the technological inputs used in horticulture, pesticides are the most dangerous agents considered to the environment as compared to fertilizers. In the horticulture sector of Kashmir valley, the consumption of pesticides includes mainly four groups of chemicals like insecticides, fungicides, rodenticides, and herbicides. Table-2 shows the consumption of different groups of pesticides (MTs) used in the agriculture sector of J&K..

Table-2 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).

The table 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.

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 fertilisers creating a hazard to human and nature are given as under:

Water body contamination

Fertilisers and fertilisers contain substances like nitrates, sulphur 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 fertilisers 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 fertilisers. 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 fertilisers 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, sulphur, nitrogen and other chemicals present in the fertilisers 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 fertilisers 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

Fertilisers 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.

## 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, fertilisers 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. Within the horticulture sector of Kashmir valley, it is observed that the production and productivity have tremendously increased by science, technology and innovation applications. The sector has definitely valued the social and economic dimensions of sustainable development by generating more income and livelihood opportunities but not considering environmental dimension into proper concern. The continuous and increasing use of fertilizers, pesticides, insecticides, fungicides and other chemical compounds degrades the ecological values, which marks the need for eco-innovation to be more focused and implied. All the relevant components configuring agriculture sector like, farming communities, financial bodies, research and development actors, policy formulating authorities, marketing platforms, technology providing bodies etc. should initiate on the principles of sustainability. The technologies or innovations to be framed or implemented should be on the basis of sustainable concerns in social, ecological and economic dimensions. Moreover, eco-innovations need to be more promoted to promote the sustainable development, especially in the agricultural sector. Focus on agriculture sector is important in order to meet the first two millennium goals of sustainable development, i.e. eradicating poverty and provide food for all, and the second goal i.e. overcome hunger, achieve food security and improved nutrition and promote sustainable agriculture. These procedures need to be analyzed, whether the Indian agricultural sector parallels such reforms or not. It needs to bring forth the actors who concern with the sustainability projects in the country to meet present and conserve for future within the agriculture sector.

As per the Gliessman's taxonomy of agroecology the horticulture sector of Kashmir is in prerequisite of the improving horticultural system efficiency to reduce the use of hazardous inputs (L1), and substituting proper sustainable inputs and practices into horticultural farming systems (L2). Agroecological farming systems with biologically diversified systems, have been found potentate of meeting global food requirements sustainably and efficiently (Gliessman, 2014). Indeed, agroecological farming systems can produce higher or equivalent yields than conventional farming while enhancing ecosystem services and profitability (Davis *et al*., 2012, Kremen and Miles, 2012, Prieto *et al*., 2015). Thus, farms based on agroecology, have achieved high levels of productivity and environmental performance, even with limited funding, offering an impressive return on investments. Therefore, when integrated with the significant policy and proper organizational support, more agroecological research programs will exit to offer the pragmatic approach for successfully fulfilling the right to food while restoring environmental quality in challenge of global climate change and huge environmental degradation (Dalgaard *et al.*, 2003, De Schutter, 2014; and Bommarco *et al.*, 2013). Taking the hazardous impact of pesticide into concern, it is suggested to apply the concept of agro-ecological farming system in the horticultural sector of Kashmir valley to conserve the nature and natural amenities.

## REFERENCES

Bommarco, R., Kleijn, D., & Potts, S. G. (2013). Ecological intensification: harnessing ecosystem services for food security. *Trends in ecology & evolution*, *28*(4), 230-238.

Coenen, L., & López, F. J. D. (2010). Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. *Journal of cleaner production*, *18*(12), 1149-1160.

Dalgaard, T., Hutchings, N. J., & Porter, J. R. (2003). Agroecology, scaling and interdisciplinarity. *Agriculture, Ecosystems & Environment*, *100*(1), 39-51.

Davis, A. S., Hill, J. D., Chase, C. A., Johanns, A. M., & Liebman, M. (2012). Increasing cropping system diversity balances productivity, profitability and environmental health. *PloS one*, *7*(10), e47149.

De Janvry, A., Murgai, R., & Sadoulet, E. (1998). *Rural development and rural policy* (No. 1557-2016-132972).

De Schutter, O. (2014). The specter of productivism and food democracy. *Wis. L. Rev.*, 199.

Dercon, S. (2009). Rural poverty: Old challenges in new contexts. *The World Bank Research Observer*, *24*(1), 1-28.

Dockes, A., & Talis T, and Bettina, B. (2011) . "WP1: Reflection paper on AKIS." SCAR Collaborative Working Group on AKIS.

Ekboir, J. (2003). Why impact analysis should not be used for research evaluation and what the alternatives are. *Agricultural systems*, *78*(2), 166-184.

Elzen, B., Barbier, M., Cerf, M., & Grin, J. (2012). Stimulating transitions towards sustainable farming systems. In *Farming Systems Research into the 21st century: The new dynamic*(pp. 431-455). Springer, Dordrecht.

Giovannucci, D., Scherr, S., Nierenberg, D., Hebebrand, C., Shapiro, J., Milder, J., & Wheeler, K. (2012). Food and Agriculture: The Future of Sustainability. A Strategic Input to the Sustainable Development in the 21st Century (SD21) Project. United Nations Division for Sustainable Development, New York.

Gliessman, S.R., (2014). Agroecology: The Ecology of Sustainable Food Systems (3rd ed.), CRC/Taylor & Francis Group, Boca Raton, FL.

Hall, A., Janssen, W., Pehu, E., & Rajalahti, R. (2006). Enhancing Agricultural Innovation: How to go beyond the strengthening of research systems. doi: 10.1596.

Hall, A., Sulaiman, V. R., Clark, N., & Yoganand, B. (2003). From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. *Agricultural systems*, *78*(2), 213-241.

Hayes, T. B., Anderson, L. L., Beasley, V. R., De Solla, S. R., Iguchi, T., Ingraham, H., ... & Willingham, E. (2011). Demasculinization and feminization of male gonads by atrazine: consistent effects across vertebrate classes. *The Journal of steroid biochemistry and molecular biology*, *127*(1-2), 64-73.

Hocdé, H., Triomphe, B., Faure, M., & Dulcire, M. (2008). From participation to partnership: a different way for researchers to accompany innovation processes–challenges and difficulties. *Innovation Africa: Enriching Farmers Livelihoods*, 135-152.

Johnston, B. F., & Mellor, J. W. (1961). The role of agriculture in economic development. *The American Economic Review*, *51*(4), 566-593.

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

Kremen, C., & Miles, A. (2012). Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecology and society*, *17*(4).

Kuznets, Simon Smith. Economic growth and structure: selected essays. Heinemann, 1966.

Leeuwis, C. (2004). Communication for Rural innovation: Rethinking Agricultural Extension Blackwell Science Inc.

Lundgren, J. G., & Fausti, S. W. (2015). Trading biodiversity for pest problems. *Science Advances*, *1*(6), e1500558.

Morriss, S., Massey, C., Flett, R., Alpass, F., & Sligo, F. (2006). Mediating technological learning in agricultural innovation systems. *Agricultural systems*, *89*(1), 26-46.

Pal, S., Joshi, P. K., & Saxena, R. (2003). *Institutional change in Indian agriculture* (No. 1139-2016-92498).

Pant, L. P., & Hambly-Odame, H. (2009). Innovations systems in renewable natural resource management and sustainable agriculture: a literature review. *African Journal of Science, Technology, Innovation and Development*, *1*(1), 103-135.

Pingali, P. L., & Roger, P. A. (Eds.). (2012). *Impact of pesticides on farmer health and the rice environment* (Vol. 7). Springer Science & Business Media.

Plestina, R., & Mercier, M. (1996). Human health and environmental hazards arising from the use of chemicals in developing countries. *Science of the total environment*, *188*(1), S135.

Prieto, I., Violle, C., Barre, P., Durand, J. L., Ghesquiere, M., & Litrico, I. (2015). Complementary effects of species and genetic diversity on productivity and stability of sown grasslands. *Nature Plants*, *1*(4), 1-5.

Reinert, E. S., & Genesis, X. I. I. I. (1996). Diminishing Returns and Economic Sustainability; The Dilemma of Resource-based Economies under a Free Trade Regime. *Genesis*, *13*(6), 1-25.

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

Schultz, T. W. (1964). Transforming traditional agriculture. *Transforming traditional agriculture.*

Sitarz, D. (Ed.). (1998). *Sustainable America: America's environment, economy and society in the 21st century*. Nova Publishing Company.

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

Tscharntke, T., Clough, Y., Wanger, T. C., Jackson, L., Motzke, I., Perfecto, I., ... & Whitbread, A. (2012). Global food security, biodiversity conservation and the future of agricultural intensification. *Biological conservation*, *151*(1), 53-59.

Žgajnar Gotvajn, A., Zagorc-Koncan, J., & Tisˇ ler, T. (2001). Estimation of environmental impact of some of the most often occurring pesticides in Slovenian surface and underground water. *Water science and technology*, *44*(7), 87-90.

Zhang, W., Ricketts, T. H., Kremen, C., Carney, K., & Swinton, S. M. (2007). Ecosystem services and dis-services to agriculture. *Ecological economics*, *64*(2), 253-260.

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