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Rapporteur's Report on Innovations, Access to Technology and Competitiveness of Markets

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I

INTRODUCTION

New technologies and inventions are commonly developed in R&D departments (public or private), but they are generally regarded as innovations when they have been applied, commercialised, and introduced in the field/market. One can broadly describe innovation as either technological (product or process) or non-technological (organizational, marketing and policy level). Some innovations can be small incremental refinements of existing products or processes, others can be radical and completely new to the ecosystem (Rosenberg, 1974). Ensuring sustainable food production systems that increase productivity and production, help maintain ecosystem, progressively improve land and soil quality, and simultaneously increases farmers' income, require new technologies and innovations. As the world faces complex challenges of food inflation, climate change, soil degradation, hunger and malnutrition, supply chain disruptions, etc. large set of solutions are expected to come from inventions and innovations in the agricultural and allied sectors.

The fulfilment of several of the Sustainable Development Goals (SDGs) is anchored on the performance of this sector. Harnessing the power of technology and transforming agriculture both in scale and efficiency are the need of the country and not a choice to ensure the food and nutritional security for the ever growing population. Innovation is already triggering a much-needed shift away from foodgrains to value-added crops, livestock sectors, poultry, and fisheries. Quality of seed, planting materials, irrigation system, plant nutrients, feed, etc. have vastly improved in recent years, which collectively improve the input use efficiency, and build sustainability and resilience across crop cultivation and animal husbandry (Goedde *et al.*, 2020). The advances in machinery have expanded the scale, speed, and productivity in the sector. With several agritech firms emerging in the space, advanced technologies in input as well as output sides, can well be integrated with the traditional farming ecosystem to resolve the existing problems efficiently. Digital technologies in agriculture like artificial intelligence, machine learning, big data analytics and utilisation of drones used for crop monitoring, livestock monitoring, equipment management, efficient supply chain management, etc. are helping the farmers in realising better gains. Innovations in service sector like credit and

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insurance facilities, logistics services, access to information, and market connectivity have come a long way. These modern technological innovations are helping in improving agricultural productivity, reducing the transaction costs and making the agricultural/food commodities more competitive in the domestic as well as world market. Several studies find a negative relationship between farmers' age and innovation absorption, as the incentives to adopt new technologies and to innovate may decrease as the farmers approach retirement age (Perales *et al*., 2020). It may also be related to the lower level of formal education among them. This point to a significant role of younger farmers in innovation creation.

With the above background, papers were invited on the following dimensions:

- Innovations in agriculture, horticulture, livestock, or aquatic sector helping in resource use efficiency, profitability, productivity, and/or quality improvement.
- Technology adoption in the area of precision agriculture, and its effect on soil health, groundwater use, GHG emissions, traceability and quality control system, etc., apart from yield and profitability
- Innovations-led transformation influencing competitiveness in input/output markets and relationship with external trade
- Role of Geographical Indications (GIs) in agricultural value chain and farmers' incentives
- Public policies speeding up the innovation cycle and technological development in agriculture

Under this theme, 24 papers were received, out of which 3 papers were accepted for full length publication while rest 21 as summaries. These papers are categorised under three sub-categories - Marketing and Trade; Technology Adoption and Farm Profitability; and Natural Resources and Energy Use.

II

ADOPTION OF INNOVATIVE TECHNOLOGIES AND SERVICES

Unlike most innovations in manufacturing sector, agricultural technology has a degree of site specificity because of the biological nature of agricultural production, in which appropriate technologies vary with changes in climate, soil types, topography, latitude, altitude, and distance from markets. Food and agriculture value chain begins at pre-production level and are extended up to final consumption by the end-user as well as managing waste and residues. In-between, there are hosts of supporting activities like credit, insurance, information related to weather, market, etc. In every stage and process, there is umpteen opportunities for technological

development and innovations to make agriculture profitable, environmentally sustainable, and globally competitive. Feder *et al.* (1981) asserted that additional reasons for innovation adoption, beyond the profit motive, is that farmers apparently prefer to replace heavy demands of human labour, reduce drudgery and improve working conditions. With innovations in services, the constraints of lumpiness in heavy farm machineries and other large investment is also being solved through custom hiring services.

Under this sub-theme, 8 submitted papers have been considered. The authors of these papers have covered various dimensions of technological innovations in agriculture. Brij Bala and Vishal Rana have analysed the challenges in the adoption of various practices of protected cultivation, particularly polyhouse technology in high value crops in Himachal Pradesh state. Although financial support was provided by the state department, but due to lack of training of the target farmers before setting up the infrastructure resulted poor adoption of management practices. Majority of the sample farmers came under low to medium technical efficiency category. High variability in yield and profitability has demotivated the farmers towards polyhouse cultivation. In the paper by G. Karthiga Devi *et al*., the adoption of System of Rice Intensification (SRI) method in paddy in Pudukkottai district of Tamil Nadu state was examined. Although SRI is in practice since long time, but its acceptability among farmers remained patchy. The study shows that the SRI method helped in saving about 46 per cent of irrigation water, increased crop productivity by about 51 per cent, and an additional profit of ₹17,639/acre over non-SRI methods. However, the study didn't probe much into the reasons of poor adoption of SRI despite of such exceptional gains to the adopter farmers.

Adoption of new crop varieties is considered as important innovation in agriculture. In their study, P. Prakash *et al.* examined the factors influencing the adoption of Chinese potato variety 'Sree Dhara', a well-established variety released in 1993 for Tamil Nadu state. They found that potato yield was higher among adopters by 24.52 per cent (15.49 t/ha) and net income by 87.29 per cent (₹2,03,647/ha) over that of non-adopters. However, only 38 per cent of potato area is under Sree Dhara variety among surveyed farmers, while rest 62 per cent area is under local variety. Anjugam and Bharathi observed that by tagging of Kodaikanal hill garlic with geographical indication (GI) market price has increased between Rs. 300 to Rs. 480 per kg, without bringing any change in cultivation and marketing practices.

Exploring the possibilities of value chain upgradation of green pea in Punjab state, Simranpreet Kaur *et al*. studied traditional and modern value chain for green pea in the state. Every value chain has its own characteristics and accordingly producers' share in consumers' price may vary. They observed that majority of the farmers had apprehension of expecting lower price of the produce by the processing units. They are also afraid of delayed payment as one of the major deterrent in adopting upgraded value chain. Similarly, in another paper, small tea growers of

Assam were observed getting benefitted by shifting to organic tea production due to better price realisation. The tea growers have also diversified their farming towards agarwood plantation, the economics of which needs to be studied. Shwetha Kumari and M. Vineeth examined the factors determining adoption of different agricultural technologies offered by agritech startups in Karnataka state. It was concluded that farmer's age, educational level, economic status and farmer category played an important role in the adoption of AgriTech. Babita Kathayat *et al.* estimated the total factor productivity (TFP) in the livestock sector and estimated the economic gains from public investment to the tune of 40.9 per cent as marginal internal rate of return in the sector.

III

INNOVATIONS IN MARKETING AND TRADE

Innovations in marketing- inputs as well as outputs are important factor for creating values in agriculture, particularly for smallholder farmers. Traditionally, large farmers well-endowed with land and capital resources have better access to the modern inputs, farm mechanisation as well as output market (Biswanger et al., 1995; Shenoy, 2017; Fernando *et al*., 2022). Without innovative marketing structure and systems, smallholders' participation remains shallow. In such cases, increasing investment in inputs and technological development may not increase the farmers' income. This suggests that innovation-led interventions in markets such as contracts, effective custom hiring services, facilitation in storage and warehousing, market linkages through digital marketplace, etc. would improve the farm productivity as well as farm profitability and also lead to better competitive advantage in domestic and/or international trade.

Under this sub-theme, 8 research articles are considered for deliberations. Anju Choudhary *et al.* have examined the digital innovation in marketing in Meghalaya where smallholder farmers were connected with a digital platform viz. iTEAMS to transact their horticultural produce and capturing the market information on real time basis. Integrated Technology Enabled Agri Management System (iTEAMS) is designed to connect the farmers to the Agri Response Centre (ARC) through a toll-free number, viz., 1917 for services related to agro-advisory services, market intelligence and transporting of agricultural produce by Agri Response Vehicles. Thus, iTEAMs is connecting all the stakeholders in the value chain seamlessly. There are 15,218 farmers registered with iTEAMs. For the hilly states like Meghalya, the innovation is helping in solving major problems of the farmers which are transportation and market linkage. It has helped the farmers in reducing the marketing cost and better market access.

The export and import trend of major spices in India were analysed in the paper by Manish Sharma and Ram Singh. India contributes almost 48 per cent of global export of spices. The Nominal Protection Coefficient (NPC) revealed that traditional spices are weak in terms of trade competitiveness, while turmeric, ginger, coriander, cardamom, etc. are having comparative advantage in terms of international

prices. Similarly, A. Suresh *et al.* identified structural breaks in production of fish and its relationship with the export trend. The Revealed Comparative Advantage (RCA) analysis exhibited revealed advantages of marine products; however, it is tapering over the years. They also highlighted that scientific composite carp culture technology introduced in 1970s has helped significantly in shrimp production, which was aptly supported by Marine Products Export Development Authority (MPEDA) and ecosystem development. Sonali Katoch and Rakesh Singh studied the extent of integration of five tomato markets (Nashik, Chittoor, Solan, Delhi, and Kolkata) and export trend of tomato. Chittoor market turned out to be the price leader, and it influences the price in Nashik and Kolkata markets. Abhijit Das *et al.* examined the trade distorting domestic support (TDDS) to agricultural commodities by developed and developing countries. The current global TDDS in 2018 was estimated to be 19.7 per cent in China, 17.3 per cent in European Union, and 11.8 per cent in India. Going forward, TDDS entitlement of different developing countries would decrease significantly by 2030. Although the proposed proportionate reduction in TDDS appears skewed in favour of the many developing countries.

Farmers Producers Organizations (FPOs) are playing an important role in increasing maize production and increasing farm profitability for the maize growers in Karnataka. As reported by S. Likhitha *et al.*, though currently small number of farmers are trading maize through the FPOs, but they are getting maximum profit through this channel. L.D. Hatai *et al*. observed that cost of production of Arunachal orange is the lowest among large farmers, while small farmers have higher cost. Recurrent price fluctuation, high marketing and transportation cost, non-availability of adequate storage facilities, and post-harvest losses are major constraints in the state. There is a need for promoting producer's cooperative and providing adequate short term credit facilities particularly in the rural areas. Rahul Kumar Singh argued that wheat farmers in Rajasthan are able to minimize the risk by trading the commodity in future market. The price risk can be reduced by 46 per cent if they sell to future contracts. However, for this, more delivery centres need to be set up in the state.

IV

MANAGEMENT OF NATURAL RESOURCES AND ENERGY USE

The increased agricultural intensification to produce more food from the existing crop area has put the environmental sustainability at stake due to loss of biodiversity, soil health due to increased use of chemical fertilisers and pesticides, nutrients mining, and groundwater overexploitation. In addition, the social capital plays a significant role in the use of recommended practices for managing soil fertility in crop production. According to Farooq *et al.* (2022), the sustainable intensification (SI) approach is also complementary to climate smart agriculture (CSA) as SI requires better and improved agriculture technology, and inputs (crop management practices, improved seed, and fertiliser), natural resource management

(soil fertility, erosion control, increased biodiversity, etc.) and institutional reform and innovation (policy, social infrastructure, easy access to finance, inputs, market, and services).

Under this sub-theme, 8 papers have been considered for the deliberation. Soil amelioration using industrial waste has been one of the major innovations in recent years. The study by Vishwa Ballabh and Aman Dubey examined the market potential and effect of slag-based gypsum (SBG) developed by Tata Steel in agriculture. SBG being rich in several macro- and micro-nutrients, its application alongwith the recommended dose of fertilizers has increased the yield of rice and maize crop in different types of soil. It led to incremental net return to the extent of ₹31,095/ ha in maize and ₹16,282/ha in case of rice. The authors estimated minimum market size of 11-18 million tonnes (mt) for the SBG which may go up to 145 mt. Similarly, adoption of organic soil fertility measures (OSFM) adopted by the farmers in Telangana increased net revenue, as reported by Peddi et al. Using the field survey data, inverse probability weighted regression analysis (IPWRA) was used to analyze the impact of the adoption of OSFM on millet farms.

In the paper by Prabhat Kishore *et al*., estimates on availability and use of irrigation water across different agro-climatic regions of Uttar Pradesh state has been presented. It was found that there is slight surplus water (1.96 per cent) at the state level, however at district and taluka level, there are huge diversity. Bundelkhand zone has the highest water deficit condition (-59 per cent) followed by western plains (34.39 per cent), while north eastern plains zone is the highest water surplus zone (88.55 per cent). The study advocates for rational crop selection as per the water availability in the region. Sangeet Ranguwal *et al*. estimated the energy use (direct and indirect) in and greenhouse gas (GHG) emission from agriculture in Punjab for the year 2018-19. The study found that sugarcane and paddy rank top in terms of input-output energy consumption. Paddy cultivation emitted the highest CO_2 equivalent emission (6691 kg/ha). Around 60 per cent of this emission is contributed by methane only due to submerged paddy cultivation. The results invite attention of different stakeholders towards crop diversification as well as changing the farming practices in the state.

T. Kingsly Immanuelraj and Sant Kumar observed that despite of several benefits of using drip irrigation in sugarcane cultivation, the adoption of drip irrigation is less than 10 per cent in Maharashtra state. High cost of installation of drip was termed as the major reasons for poor adoption. For long run sustainable sugarcane production, sugar mills may be included in the discussion for expansion of drip irrigation. Similarly, farm mechanisation in Bihar was reported low in the paper by Tulika Kumari *et al.* Though there has been significant increase (13 per cent) in farm power availability in agriculture, which has positively influenced the foodgrain productivity (12 per cent) during 2016-17 over 2013-14 in the state. Sourashree Mukharjee and Gaurav Saraswat analysed the factors determining the adoption of technology in West Bengal using household level data of Situation Assessment

Survey for Agricultural Households. Assuming expenditure on a bundle of technologies (irrigation, machinery, chemical fertilisers, and plant protection) as proxy for modern farming, it was concluded that he adoption of modern farming practices are influenced by variety of socio-economic variables. In the paper by Dibakar Sahoo, the factors determining adoption of climate smart agriculture (CSA) strategies in Ganjam district of Odisha state was studied. The increase in maximum and minimum temperature in the district has negatively affected the crop yield. The extreme weather events like cyclones damaged the crops completely. Factors such as perception of climatic risks, educational level, gender, access to irrigation infrastructure, and access to extension services and training all had a significant impact on the adoption of the majority of CSA strategies (different seed varieties, early maturing varieties, changing planting dates, improved irrigation facilities, etc.).

V

ISSUES FOR FURTHER DISCUSSION

To sum up, the theme received a good number of research papers for consideration. These papers covered variety of issues related to innovations in pre-production, production, and post-production stages of agricultural value chains. Adoption of new varieties, technologies, products and services, marketing models, etc. has helped the farmers in improving the input use efficiency, crop yield and farm profitability, and changing the competitive scenario. Some of the papers have analysed the present trend in marketing, trade as well as use of energy and water resources. These papers could have brought into discussion one or other type of innovations in the related field to make it more relevant to the theme. Because of lack of appropriate data, innovation studies on agriculture mostly focus on the adoption of single technologies as a proxy for agricultural innovation (Alston & Pardey, 2020). Furthermore, innovation in agriculture is mostly studied from the input side and, to a lower extent from the output side. Keeping in view all the research papers accepted under the theme, the discussion in this session may address the following key questions:

1. It is assumed that the small firms are often more flexible and leverage the advantages of their "smallness" through innovation. Is it true for the smallholder farmers in India as well? What kind of disparity in innovations exist across different farm category in any region and why?
2. What kind of innovations were able to create impact on crop yield, change in crop choices, marketing behaviour of the farmers, production environment, or trade of agricultural commodities?
3. There are several studies on market integration of agricultural commodities, but mostly remain limited to examine the market integration of price variability across different markets. Even if markets are well integrated across space, local farmers would not benefit, if villages are not well

integrated with the markets. Therefore, the use cases of better village-market integration need to be studied to make such innovations widespread.

4. Improved information technology and/or use of mobile and internet by the farmers is expected to reduce price volatility, transportation costs, marketing costs, post-harvest losses, information asymmetry, and improve access to information, technology, and market access. However, it is not well understood so far, how much subsistence smallholders benefit from these innovations.

5. What kind of innovations- technology, products, services, policies, or institutions- have helped the farmers in mitigating the challenges emerging from climate change, and how to scale up and scale out such innovations?

6. How should public institutions respond to bring more relevant innovations in agriculture and allied sectors? What are the roles of geographical proximity to R&D institutions in innovation performance in agriculture sector?

7. Whether the peculiarities of agricultural knowledge and innovation systems are due to rurality or due to sector-specific issues, such as differences in firm size, human capital, collaboration strategies, capital flow, or weak integration in international markets?

8. In recent years, the government has been proactive in supporting the agri-startups. How far these agri-startups and the policy changes have been successful in bringing the desire outcome?

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