
Rapporteur's Report on Transforming Horticulture for Sustainable Growth in India

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I

BACKGROUND

With over 30 per cent contribution to gross value added in 2021-22, horticulture is a crucial sector emerging as a significant driver of Indian agriculture. This sector includes various crops such as fruits, vegetables, flowers, medicinal and aromatic plants, spices, coconut, cashew, and mushrooms. Transitioning from a primarily rural focus, India is now the world's second-largest producer of fruits and vegetables and leads globally in producing niche horticultural crops. Further, it ranks second in producing vegetables, including potatoes, onions, cauliflower, and cabbage, accounting for 11 per cent of global vegetable production and 15 per cent of global fruit production (FAOSTAT, 2019). This sector has made a rapid stride by surpassing food grain production with an output of 342 million tonnes (2021-22). Despite a huge surplus of horticultural produce, our country has struggled to leverage its competitive advantages in global markets. Poor development of pre- & post-production logistics resulted in a 25 to 40 per cent loss of produce in the post-harvest phase. Despite advances in research, India lags behind other developed & emerging economies in value addition of horticultural produce.

The horticulture sector is gradually progressing from subsistence cultivation to a commercial business as it attracts a young population due to its economic incentives. The horticulture sector in emerging economies, particularly India, is multifaceted in ensuring food security, diversifying agricultural activities, and driving economic growth. The labour-intensive nature of horticultural crop production has created numerous employment opportunities for women, although comprehensive data on their participation is still limited. As India becomes the third-largest economy globally, there is a shift towards nutritious, easy-to-prepare, and diverse value-added products. This trend is expected to influence the demand for horticultural crops. The country has made significant strides in expanding its crop base through favourable policies and increased R&D support, introducing high-value crops like kiwi, gherkins, kinnow, date palm, oil palm and dragon fruit. The institutional support through various schemes has encouraged the cultivation of high-value crops, including organic produce, exotic fruits, and specialty spices, that enable farmers to achieve premium prices and foster economic welfare. Many horticultural crops, including spices,

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vegetables and MAPs, promote diversification and offer the potential for a second green revolution.

On the policy front, integration of supply chains, managing price volatility, effective market information systems, risk mitigation strategies for farmers, supportive policies and implementing market reforms are crucial. Sustainable practices and innovation in cultivation techniques are also essential for minimizing the impact of external factors contributing to price fluctuations. Innovative institutional arrangements involving public and private sector players such as startups, publicly funded institutions and Farmer Producer Organizations (FPOs) are vital for providing small-scale farmers timely access to resources. Adequate financial support is essential to boost productivity, enhance market competitiveness, and ensure sustainability. The shift to a demand-driven and market-oriented supply chain of horticultural produce presents a multi-faceted challenge for the agrarian economy. These challenges demand the development of robust value chains, the creation of essential infrastructure, effective input delivery, and the assurance of export-quality produce to unlock the sector's full potential.

The horticulture sector in emerging economies, particularly India, is multifaceted in ensuring food security, diversifying agricultural activities, and driving economic growth. Addressing global trade constraints, value chain development, and infrastructure gaps is essential for unlocking the sector's full potential. Additionally, gender disparities must be tackled to achieve sustainable and inclusive growth. Timely and accurate information is critical to improving the socio-economic conditions of Indian farmers, fostering self-reliance, and supporting environmental protection. Furthermore, adding value within the horticulture sector enhances economic returns, creates new market opportunities, and increases profitability. In this backdrop, the Indian Society of Agricultural Economics has chosen Transforming Horticulture for Sustainable Growth in India as one of the themes for discussion at its 84th annual conference to be held at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry.

The theoretical and empirical research contributions encompassing these issues were invited by the Indian Society of Agricultural Economics (ISAE) to address the technological, institutional, infrastructural and policy imperatives for raising productivity and sustainability in the horticultural sector focusing on the following topics: i) spread and relative profitability of introduced crop for horticultural diversification efforts, ii) supply chain and availability of quality inputs at farm level, iii) incorporation of climate-resilient practices to minimize risk, iv) gender disparity in the inclusive growth of horticultural crops, v) integration of technologies and innovations in horticultural sector, vi) contribution of horticultural crops in the achievement of SDGs, vii) innovative value chain strategies, viii) successful case studies of horticultural sub-sectors, ix) fostering self-reliance through the provision of information and improvement of communication networks, x) market reforms affected the competitiveness and market access, xi) cultivation of niche-based horticultural

crops and support to small farmers, xii) mitigate the effects of price volatility on vulnerable farmers, xiii) improvement in global market competitiveness, and xiv) integration of PPP, start-ups, and FPOs into the horticulture ecosystem and how their successful examples can be replicated.

The Society received 79 papers from researchers under this theme, each covering specialized issues and activities relating to the horticultural sector. However, a few aspects have either not been fully covered or partially addressed. For better articulation of ideas, these papers were divided into six categories: (i) Economic viability and resource-use efficiency in horticultural crops, (ii) Growth and demand of horticultural products, (iii) technological intervention in horticulture, (iv) Sustainability issues in horticultural crops, (v) value chain integration and price distortion and (vi) horticulture and climate change. A summary of these papers compiled under the above-mentioned headings is given below.

II

ECONOMIC VIABILITY AND RESOURCE-USE EFFICIENCY

The horticulture sector contributes to the economy, enhances livelihoods, promotes sustainable practices, and ensures food security. The study has empirically ascertained these relationships in Assam (Nidhishree *et al.*). Cultivation of horticultural crops is a highly viable venture at smallholder farms. A higher proportion of the area was seen to be allocated to vegetables. A study of cabbage growers in Tamil Nadu has shown that a majority of vegetable farmers (96.67 per cent) possess holding under 5 acres, and 85 per cent of them allocate up to 1 acre under cabbage cultivation and get better economic returns from its cultivation (Balaji & Selvakumar). Economics of major vegetables in Chhattisgarh indicated that tomato is more profitable, followed by cabbage, cauliflower, brinjal and okra (Gauraha *et al.*). Akhila *et al.* have revealed that institutional intervention in the Vegetable Development Programme has raised the income level of growers in urbanizing rural settlements. Similarly, spice cultivation is a profitable venture. The net return from garlic cultivation ranged from Rs 84642 to Rs. 98978 per hectare, depending on the location, with an average per rupee return of 1.74 (Meena & Sharma). The productivity levels of different vegetables and spices were relatively higher with marginal farmers. They declined as we moved towards large holdings, indicating an essential role in management practices, which may be more scientific at small holdings (Venkatarao, Thasnimol & Pillai). Scholars have advocated the expansion of area under spices, including turmeric, in Kerala and Andhra Pradesh owing to their highly profitable nature. They have also emphasized the rationalization of costs by retaining labourers or encouraging migration in the niche areas. Yet another study by Gokula Kannan and Chatterjee has revealed that coconut plantations were relatively more feasible for all age group plants. However, plants with 41-50 years of age have registered the highest NPV, IRR, and BCR with lower payback periods. The economic viability of raw

cashew nut production in the Kunnur district of Kerala underscores the necessity to enhance domestic production to come up with the massive demand through replanting with high-yielding clones, resorting to high-density plantations and technology-aided production and processing and emphasizing the need for adequate financial support from institutions (Srilakshmi *et al.*). Floriculture, a rapidly expanding sector in developing nations, has seen increased demand for cut flowers like roses, gladiolus, gerbera, orchids, carnations, and lilies. However, two separate studies have noticed that the cultivation of Jasmine and Liliun is highly cost intensive and profitable, which sometimes makes it challenging to manage large areas under these crops (Balamurugan & Senthlinathan; Aishwarya & Devi). This study unlocks the transformative potential of adopting advanced technologies, including protected cultivation technology, for high productivity and superior quality. Supportive policies and financial incentives to the growers as collective groups will further drive the transition towards sustainable horticulture in India. The development of the horticultural sector demands that it contributes towards women's empowerment owing to its strong linkages and predominant role of females in several activities. The organized horticultural sector, like Tea Estates, was observed to maintain parity with common wages for both genders. Still, while laborious jobs are assigned to female labourers, males could find a place at the supervisory or administrative level (Sanjaya & Sridevi). The tea industry's hierarchical structure has high gender disparity, with men occupying decision-making positions.

III

GROWTH AND DEMAND OF HORTICULTURAL PRODUCTS

Historically, fruit consumption was predominantly influenced by local produce and seasonal availability. However, with improved supply chains and processing technologies, there has been a notable shift towards a more diverse and year-round consumption of fruits (Roy, 2007). The household expenditure on horticultural products, including fruits, vegetables, and beverages, has grown robustly. Evidence from South India indicated that the market dynamics for fruits are reflected in broader national trends. Increased urbanization, rising incomes, and growing consumer health consciousness have increased demand for fresh and processed fruits (Sah, Johar, & Karthi, 2022). This shift is further supported by the enhanced marketing and distribution networks that ensure better availability and accessibility of a wide variety of indigenous and exotic fruits (Felix & Ramappa).

During the period from 1992-93 to 2021-22, Indian agriculture has gone through horticulture-led growth, with small farmers allocating more proportion of land towards horticulture compared to large farmers (Shivam, Yadav & Golait). One of the primary studies conducted in the Kashmir valley revealed that farming has been diversifying with more fruit and vegetable crops (Seerat & Hussan Dar). Variables like poor market accessibility and fewer credit advances negatively influence this diversification

process. The estimates of 3SLS revealed that inadequate infrastructure, storage facilities, and limited access to credit hinder the diversification in favour of onion in Maharashtra (Roy & Das). Farmers in midland regions of Kerala have been shifting towards cash crops (rubber, cashew, nutmeg) and crops that generate income (vegetables, banana, tapioca). Scholars emphasize scientific approaches in this diversification process to ensure food security in the region (Aiswarya). Similarly, a study conducted in Punjab and UP observed that in the former state, farmers struggle to find markets for diversified crops, leading them to revert to traditional crops. In another state, despite the potential for profitable crops like Kinnow and Mango, government support remains skewed towards sugarcane due to its assured market. They emphasized comprehensive agricultural governance involving government, private sector, and infrastructure support to facilitate crop diversification and consider environmental health.

A switch over to horticultural crops was reported to increase farm household income by 16 per cent, and the output value of the horticultural sector of the country grew at a CAGR of 4.14 per cent, outpacing cereals, pulses, and oilseeds (Alex, Kumar & Kumar). A study by Vinodhini has shown that Uttar Pradesh and Kerala are gradually switching from food grains to fruits and vegetables and plantation crops owing to their profitable nature.

One of the studies has brought out the emerging demand and rising consumption of fruits in south India considering several factors, including changing economic status, price fluctuations and income levels, which play a crucial role in shaping the demand for fruits. Apple is commercially the most important temperate fruit and is fourth among the most widely produced fruits in the world after banana, orange, and grape. After Jammu and Kashmir, Himachal Pradesh, Uttaranchal, and Arunachal Pradesh, apple is an important fruit next to apricot in Ladakh, accounting for 20.15 per cent of the total fruit production in the country (Hussain *et al.*). Ladakh region has the potential to become an excellent location for producing top-notch organic apples, though apple growth has slackened in recent years. The productivity level of this fruit in Ladakh has exhibited a negative trend, which needs to be reversed through canopy management and scientific management of orchards. Chopra *et al.* studied how Punjab is witnessing a significant shift towards cultivating Kinnow as a viable alternative crop. Researchers have projected that the area under kinnow in Punjab would increase to 60 thousand hectares by 2023-31, and the productivity levels are forecasted to reach 339.98 quintals per hectare and could be an important driver of Punjab's agricultural economy. The cultivation of sunflower, an oil seed crop grown over 226 thousand hectares during 2020-21, has been confined to Karnataka, Maharashtra, Odisha and Andhra Pradesh (Kumari & Malik). The sunflower production has shown about four times increase since 1970-71, and the yield levels have almost doubled during this period.

IV

TECHNOLOGICAL INTERVENTION IN HORTICULTURE

Future horticultural development will increasingly be technology-led, wherein automation and digital provisions must be invoked to harness the potential of existing resources. India's agri-tech sector saw a significant rise in venture capital funding. Despite the downturn, funding for Indian agri-tech startups grew significantly from \$84 million in FY18 to \$1.279 billion in FY23, with increasing deals and varying average deal sizes. The government has prioritized technological integration to boost productivity and enhance farm income. The increasing use of digital technologies such as precision farming, blockchain, IoT, and AI is transforming Indian agriculture, improving productivity, sustainability, and supply chain management (NITI Aayog, 2023). Contributions under this sub-theme highlighted that the economic and productivity advantages of Agritech methods in onion and tomato farming in Coimbatore District have improved profitability and efficiency and enhanced supply chain performance (Sarvesh *et al.*).

Field-level technologies, including Protected Cultivation & Precision Farming techniques in horticultural crops in Chhattisgarh, were observed to have offered significant benefits in terms of productivity gains, cost-effectiveness and economic returns compared to open cultivation (Choudhary, Verma & Verma). Despite higher initial fixed costs, this hi-tech farming resulted in lower operational expenses, primarily due to efficient irrigation and lower plant protection costs. Similarly, a study of five crops (brinjal, tomato, banana, watermelon and mango) in Tamil Nadu revealed that cultivation of horticultural crops under the drip method of irrigation helps save 39 per cent to 55 per cent of water in different crops over the conventional flood method of irrigation and the productivity of selected crops have increased in the range from 33 per cent to 41 per cent compared to farming with flood irrigation (Narayanamoorthy *et al.*). Employing a stochastic production function to estimate the resource use efficiency in bottle guard cultivation in Rajasthan has found that low tunnel technology was more efficient, with a mean technical efficiency of 99 per cent compared to 84 per cent for open fields (Yadav, Yogi & Jakhar). Economic efficiency was also higher for low tunnel systems, with scores of 0.50 compared to 0.29 for open fields. Efficient resource allocation could increase returns by 50 per cent in low-tunnel systems and 35 per cent in open-field systems. Public support for R&D has a pivotal role in making technology development a regular phenomenon. Investment has a long lead time to remain productive, and research investment was seen to have a strong relationship with sustainable growth of crops like cashew, and the marginal returns to investment in cashew research are significant (Kshirsagar *et al.*).

V

SUSTAINABILITY ISSUES IN HORTICULTURAL CROPS

Given the environmental concerns, organic agriculture has garnered the interest of governments and farmers across the globe, who are promoting organic agriculture for its role in safeguarding consumer health and ecosystem integrity. (Yazdanpanah *et al.*, 2022). Grounded in principles of sustainable development, organic agriculture has the potential to supply sufficient nutritious food for the global population, thus rapidly emerging as a burgeoning economic sector. Using binary logistic regression, the study conducted in Himachal Pradesh identifies education level, livestock count, and family size as pivotal factors that significantly impact the uptake of organic farming practices. There are wide variations across regions in the sustainability of Organic Farming in the North Eastern Hill Region of India (Bey *et al.*). On the other hand, Natural Farming (NF) has emerged as a sustainable alternative that emphasizes the usage of minimal external inputs and enhances ecological balance (Sharma & Mandyal; Vashishat *et al.*; Palekar, 2016). An analysis by Ashish Kumar *et al.* in Himachal Pradesh over multiple stages of apple growth reveal that natural farming systems, particularly crop combination 4 (Apple + Pulses + Vegetables), offer superior economic performance.

VI

HORTICULTURE AND CLIMATE CHANGE

The challenges posed by climate change to horticulture in different agricultural ecologies are multifaceted, and these unpredictable weather patterns, the proliferation of pests and diseases, water scarcity, and the potential loss of biodiversity are key concerns. Encouraging diversification can also mitigate the risks associated with climate variability. Developing early warning systems for weather events and improved water management practices, including rainwater harvesting and water-saving irrigation technologies, are critical in ensuring a reliable water supply for crops. Research and development for climate-resilient crop varieties, pest management, and sustainable farming practices are essential for adapting to the changing climate. Strengthening infrastructure and policy support, including financial incentives for climate-smart practices and access to crop insurance, is crucial. By adopting an integrated approach, the horticulture sector in the country can develop resilience, protect farmer livelihoods, and ensure the long-term sustainability of this vital economic activity in the face of climate change.

With the discernible changes in weather patterns leading to consequential climate variations within the current generation, the agricultural sector in India emerges as particularly susceptible to facing adverse ramifications in the coming decades. It is found that crops like coconut, cashew nut, ginger, turmeric, cardamom, and tapioca underperform in production due to higher temperatures. In contrast, lower

temperatures help increase the production of turmeric, cardamom and tapioca (Bhaswanth & Balamurugan). Rainfall patterns seem to have a very minimal positive impact on a whole, while areca nut, banana, pepper, cardamom and tapioca show a negative effect. A perusal of the data from the 77th round of the National Sample Survey Office (NSSO) a study in Maharashtra, infers that farm households exhibited higher exposure to drought risk (41.64 per cent), followed by insect-pest damage (10.64 per cent), other causes of loss (3.13 per cent), and floods (1.74 per cent). However, the vulnerability analysis showed that floods caused a relatively higher per-hectare loss (₹39,793), followed by drought (₹14,142) and insect-pest damage (₹9,356), though there were considerable differences in different regional and in different crop (Athare *et al.*). One of the studies based on the auto-regressive distributed lag model estimates showed that short-term and long-term rainfall improves production. In contrast, carbon dioxide emissions have a detrimental long-term impact on horticultural produce (Vattekkad, Krishnan & Kunchu). In the short run, area, temperature, and fertilizer negatively affect horticultural crops.

VII

VALUE CHAIN INTEGRATION AND PRICE DISTORTION

Contrary to better performance in production, the country's horticultural sector is characterized by the missing links in the existing supply chain. Poor value chain logistics, including inadequate transportation at harvest, infrastructure for the secondary sector, and the absence of cold chain facilities, exacerbate the marketing problems that are prominently reflected in price distortions and losses. Small surpluses available from captive smallholders left them with the option to follow traditional routes and effect distress sales. The absence of organized collectives in the sale of produce either restricts their entry into the markets or allows them to accept any value offered to their produce. Unscientific and poor post-harvest management made farmers sell without differentiating between high and low-quality produce. The financial exclusion of some crucial activities along the supply chain results in sub-optimal returns from the produce. The absence of robust policies and their uniform delivery in practice aimed at integrating the supply chain continues to hinder the sector's growth. The superior quality of many horticultural products indigenous to India provides it with a strong competitive edge in international markets. Globalization of the agricultural markets has brought structural changes in the volume and pattern of agricultural exports. As yet, India has not been able to integrate the global value chain to fully capitalize upon available opportunities in horticulture. India appears to be one of the world's top ten exporters of pineapple, and its northeastern region has experienced positive and significant growth (Singh, Tyngkan & Diengdoh). The overall Revealed Symmetric Comparative Advantage (RSCA) of black pepper and cardamom exports for the period 2008-2022 shows Malaysia, Germany, Brazil, Vietnam, and India are in comparative advantage, while Indonesia, Netherlands, Peru, China, and the UAE are in comparative disadvantage stage (Yazhini & Malaisamy).

India's pepper export faces a comparative disadvantage against Vietnam, with an RSCA of -0.16. Shiv Kumar *et al.* conducted an ex-ante analysis of India's horticultural trade with the EU and compared trade with base year, 2019 with its counterfactual where tariffs are eliminated to check its effect on various trade parameters using World Bank's Software for Market Access and Market Trade (SMART) model. If India agrees, the SMART model estimates the change in total trade in agriculture (238 per cent), Tea, Coffee and spices (357 per cent), vegetables, fruits and nuts (33 per cent) and Cocoa (9 per cent). Ralte & Priscilla, in their study, observed that India's major markets for fresh fruit and vegetables are UAE, Netherlands, and Bangladesh. Another study indicated that the export of highly perishable products from India was mainly confined to the Asian region, while processed products have a more global reach (Bhoi *et al.*). Results indicate that trade creation is higher than trade diversion for horticultural commodities, and hence, this trade agreement benefits Indian horticulture stakeholders. This sector needs to leverage the existing supportive framework to create a conducive ecosystem for territorial market expansion beyond borders. As many as 26 contributors discussed the various aspects of existing marketing arrangements, post-harvest management and export of horticultural produce.

Although significant structural changes have occurred in the marketing of agricultural produce, several studies have shown concern about the predominance of intermediaries. Besides farm size, distance from the market and access to market information were observed to significantly impact the participation of small vegetable growers in Chhattisgarh. There is a long chain of functionaries in effective marketing channels of pea in Himachal Pradesh that deprive growers of actual values. Alternatively, processing peas into frozen products provides extended shelf life and significant returns, though the findings recommend cooperative farming and vertical integration to improve farmer livelihood (Divyanshu *et al.*). Similarly, marketing routes that ensure the flow of form utility at different levels were seen to enhance returns from 32 to 49 per cent in the value chain facilitated by diverse market actors and enablers and otherwise, about 79 per cent of Litchi growers were compelled to opt sale through pre-harvest contractors (Saini *et al.*).

Based upon the application of a multinomial logit model (MNL) on a big data set obtained from the NSSO report on the Situation Assessment Survey Report (77th round), Sendhil, Kanwal, and Soni have attempted to examine the key factors that guide the choice of marketing channel of vegetable and how different channels affect producer welfare and how the socio-economic variables contribute to the observed effects. Apple from Himachal Pradesh has taken several routes to reach the final consumer, and there has been a substantial post-harvest loss of the produce in transit, especially at the wholesale stage (Kumar *et al.*). However, in Rajasthan, the losses of Ber fruit were higher at the pre-processing stage before the movement of the produce in the market. The magnitude of loss was significant at the retail level, emphasizing

the creation of necessary infrastructure (Vikash). Kaur & Goyal observed that the lessons from COVID-19 in Punjab have highlighted a pressing need for the government to facilitate the development of more cold storage facilities at various stages and offer them at viable rates to ensure sustainability across all levels of the supply chain. Singh *et al.* have advocated a system based on 'kilo-curcumin' where the price is based on the availability of curcumin percentage in the produce.

The persistence of asymmetric prices in agricultural markets remains a significant cause of concern for small producers and policymakers in India. This problem is further aggravated by the perishable nature of horticultural crops, which necessitates examining the market performance of the spatially separated agricultural markets for apple, which are widely grown in the Himalayan regions of India. Therefore, the ability to accurately forecast the price behaviour of agricultural commodities over time is an important concern among policymakers and farming communities (Ahmed, Singla, & Bhagat). FIGARCH Model demonstrated the existence of long memory in Kolkata's volatility of onion prices (Mazumder *et al.*). Selected apple markets in India exhibit co-integration and have long-run equal relationships with bi-directional causality in some regional markets. Uttar Pradesh is one of the most influential markets of black gram, followed by Tamil Nadu, as the Uttar Pradesh market caused bidirectional price transmission with the Andhra Pradesh, Madhya Pradesh, Rajasthan, and Tamil Nadu markets, and unidirectional transmission with Maharashtra. Moreover, there is integration among the markets for tomato in the long run, but there is no significant relationship between markets in the short run (Shubham *et al.*). According to the impulse response function, the prices initially fluctuated when a one-degree unit shock was given to markets. Still, after five months, prices started stabilizing in all the markets. Similarly, selected apple markets in India exhibit co-integration and have long-run equal relationships with bi-directional causality with some regional markets. Studies suggested that uniformity and transparency in market regulations can rapidly adjust prices in India's spatially separated markets.

Verma *et al.* observed huge intra-year variations in retail prices of tomato, onion and potato in India; the price rise was the highest in Tomato, but Potato exhibited the highest instability, followed by Onion and Tomato. Price shocks in green pea occurring in the Delhi market were observed to impact the other markets, and the variance in prediction error in the Delhi market is explained by the market itself, both in the short and long term (Divyanshu *et al.*). Pineapple prices in Kerala are inherently volatile due to many factors, such as seasonal variations, weather conditions, and market demand (Arshad *et al.*). Significant inter-district and seasonal variations were seen in the prices of tomato in Telangana, and the variation was influenced by factors like human labour, land lease charges, transport, and marketing costs (Reddy & Mishra). Perishability of the crop and seasonality in production, along with volatility in the prices of pineapple, often cause distress to farmers. Findings revealed that RNNs consistently outperform other techniques regarding prediction accuracy and capturing intricate patterns and

nonlinear relationships in the data (Arshida *et al.*). There is a diverse relationship pattern between different pea markets regarding price formation in Punjab. Scholars highlighted the significance of market integration and strengthened market intelligence to enhance the efficiency of vegetable marketing.

ISSUES TO BE DISCUSSED

- It is crucial and imperative to use sustainable measures in crop revitalization. It should involve conducting comprehensive crop suitability assessments, promoting region-specific crops, and implementing integrated cropping systems.
- Assessment of resource use and economic efficiency in cultivating horticultural crops under different agro-climatic settings is essential; these evidences are expected to align efforts towards better efficiency and productivity.
- There is a need to make a short-term and long-term assessment of domestic demand and export potential of different horticultural crops and their products in consideration of the changing consumption pattern, acceptability of various formats of produce, market experiences and other factors.
- The possibilities of territorial expansion of markets for horticultural crops must be explored. After identifying crops and their products for trade based on comparative advantages, the government should provide policy support, incentivize corporate houses for export promotion and create business and export ecosystems around production centres across India.
- Value addition has been the most important secondary activity in achieving various forms of utilities. Still, at the same time, it is one of the least addressed components of Indian horticulture. The untapped potential in the processing sector has to be tapped to improve farm income, especially for small and marginal farmers
- The mandates of the horticultural sector have to be comprehensive, and environmental and human health concerns must be considered. There is an increasing willingness to pay premium prices for safe food, making expanding capacities for organic and natural farming imperative. The demand for such novel food needs to be assessed and synergized with the productive activities in the field.
- Efforts are required to integrate various actors and activities in the value chain to ensure market integration and smooth penetration of price signals for stable price discovery. These possibilities would accrue better absolute returns to primary stakeholders in the chain.
- Toward demand and data-driven innovations and technological breakthroughs in horticultural investigation, it is required to arrive at viable options for how farmers and innovative youth can be included in the research & development initiatives and priority setting.
- Effective price discovery has been a challenge in the agricultural sector for

years. A comprehensive investigation is required to create a real-time support system for price discovery, price stability and supply of produce for demand.

- Encouraging a network of institutions to transmit messages of agricultural research is urgently needed. Expanding technology exchange services for location-specific agricultural research and its efficient dissemination must be identified as a priority area. This would convince the farmers that the communicated information is valuable for income generation and improving living standards.
- At present, research investment is thinly spread on need-based priority areas. The studies on the economic feasibility of research investment and its priority setting will provide feedback to the research community to justify future funding. This would also provide a framework for short-term and long-term investment strategies for research systems and draw the attention of policymakers.
- Systematic research is needed to quantify the impact on social welfare and conservation of natural resources at each ecological location. It was realized that an appropriate policy environment, infrastructure, and institutions are the preconditions for a greater impact of agricultural research.

KEY MESSAGE FROM PAPER REVIEW

- The yield potential of different horticultural crops can be enhanced by exploiting biotechnological provisions. Technologies and cultural practices need to be integrated to achieve the desired goals of efficiency, equity and sustainability in the agricultural production system. Pluralism of extension providers through coordinated partnerships with experts and communities would prove crucial in improving yield in consideration of ecological issues.
- Further research and policy measures may be necessary to address the challenges of price volatility and market integration in the tomato sector. There is a need to conduct context-based and problem-focused research from a systems perspective to improve efficiency and efficacy. Research may also be directed toward the development of climate-resilient varieties.
- There is an urgent need to enhance investment in the agricultural sector uniformly across the regions of the country, and the allocation of resources under different heads should be based on their marginal impact on growth indicators. An effective public-private alliance in this regard would help to harness long-term gains from capital investments.
- Evaluating the existing policy environment to explore the possibility of reforms in rural institutions and overall planning mechanisms could prove instrumental in pursuing food security and the sustainable livelihood of farming communities.
- A multi-pronged approach, focusing on infrastructure improvement and support for specific farmer demographics, is essential for enhancing market

participation (Jaiswal and Choudhary). A robust market information dissemination system must be established to provide real-time price data to farmers and traders and implement regulatory measures to ensure fair pricing and prevent market manipulation. Developing better price risk management strategies to make markets more stable is equally important.

- There is a need to integrate the global value chain of horticultural produce. Efforts must be made to create demand and encourage collectivization, horti-preneruship, brand development, and communication to expand the market beyond borders.
- The need for climate-adopted horticultural intervention is emphasized to integrate intensive and location-specific expertise to improve productivity. Legislative assistance in market links, financial facilities, and subsidies will encourage farmers to embrace contemporary methods and promote the sustainable expansion of the horticulture industry.

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