

National Sectoral Paper

Plantation and Horticulture

Farm Sector Development Department
National Bank for Agriculture and Rural Development
Mumbai





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Development Bank of the
Nation for fostering rural
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NABARD's Mission

Promote sustainable and equitable
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institutional development for
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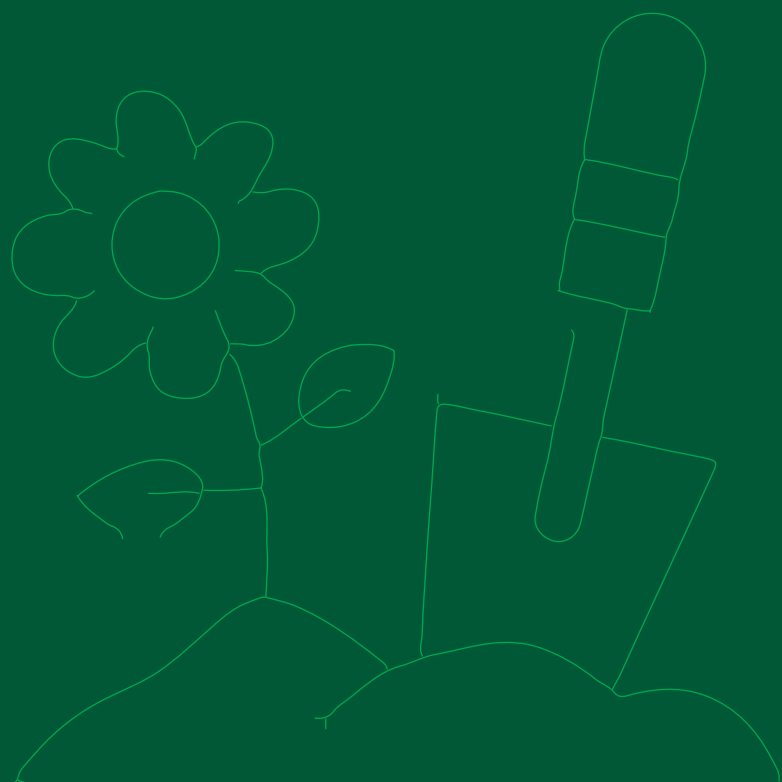


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Foreword

The Plantation and Horticulture sector continues to be a key pillar of India's agricultural economy, offering immense potential for income diversification, employment generation, and nutritional security. With its contribution exceeding 33% of the agricultural Gross Value Added (GVA) while utilizing only about 13% of the gross cropped area, the sector demonstrates high productivity and value generation.

The sector has witnessed rapid transformation through the adoption of modern technologies such as hybrid seeds, micro-irrigation, protected cultivation, hydroponics, and climate-smart practices. These innovations have significantly enhanced productivity and income per unit area, making horticulture a viable and attractive option for small and marginal farmers across diverse agro-climatic zones.

In the budget for the year 2025-26, Government of India has announced that a comprehensive programme for the promotion of production, efficient supply, processing, and remunerative prices for fruits and vegetables will be launched. The programme has been allocated Rs 500 crore for 2025-26. It will target formation and participation of Farmer Producer Organisations and Cooperatives across states. In line with the priorities set forth by Government NABARD has been promoting Farmer Producers Organisations involved in end to end production and supply of fruits and vegetables.

The Government of India's Cluster Development Programme and promotion of Fruit and Vegetable Producer Organizations (FPOs/VPOs) are enabling aggregation, value addition, and direct market linkages. These initiatives are helping farmers realize better price realization, reduce post-harvest losses, and access new markets.

NABARD recognizes the strategic importance of this sector and continues to support its development through, Refinance and credit support for horticulture-based activities, Infrastructure development under the Rural Infrastructure Development Fund (RIDF), in addition to Promotion of FPOs and capacity building for smallholder farmers.

This Sectoral Paper on Plantation and Horticulture provides a comprehensive overview of the sector's current status, emerging opportunities, and key challenges. It also addresses the implications of climate change and outlines strategies for adaptation and mitigation, drawing on insights from leading research and policy institutions.

Shaji K V

Chairman

National bank for Agriculture and Rural Development

Mumbai

August 2025



Message

The Plantation and Horticulture sector encompasses a vibrant spectrum of crops including fruits, vegetables, spices, flowers, medicinal and aromatic plants, mushrooms and plantation crops such as tea, coffee, rubber, coconut, and oil palm. This sector is gaining increasing importance in the rural economy due to its diversity, higher productivity, export potential, and its ability to support intensive production systems, even among small and fragmented landholders.

In totality, horticulture crops production is expected at around 362.09 million tonnes in 2024-25 as per the first advance estimates. The sector contributes over 33% to the agricultural Gross Value Added (GVA), despite occupying a relatively smaller share of cultivated land. India ranks second globally in the production of fruits and vegetables, and leads in the production of bananas, mangoes, papayas, onions, ginger, and okra.

The Government of India has prioritized this sector through several key initiatives: viz. the Mission for Integrated Development of Horticulture (MIDH) continues to support holistic growth and the Clean Plant Programme (CPP), which aims to boost domestic production of high-quality planting material and reduce import dependence. Despite these advancements, the sector faces several critical challenges like High post-harvest losses (5–15% for fruits and vegetables), limited availability of quality planting material, inadequate market access for smallholder farmers, and insufficient cold chain and processing infrastructure.

Horticultural produce is highly amenable to value addition—through grading, storage, packaging, and processing. Vegetables and fruits are poised to be key drivers of agricultural growth. Their development requires targeted investments in harvesting technologies, low-cost storage, processing units, and market infrastructure.

NABARD supports the transformation in Plantation and Horticulture sector by providing production and investment credit through refinance to banks and supporting value chain-based credit planning and Farmer Produce Organization (FPO) development.

An integrated approach that addresses the entire value chain—from production to market—is essential to sustain the momentum of the Golden Revolution. This will not only enhance rural incomes but also address broader goals of employment generation, nutritional security, environmental sustainability, and poverty alleviation.

I commend the C-TAG Team of the Plantation and Horticulture Discipline for preparing this well-documented Sectoral Paper, which provides a detailed sub-sectoral analysis of the potential, challenges, and strategic directions for the Plantation and Horticulture sector in India.

Dr A K Sood

Deputy Managing Director

National bank for Agriculture and Rural Development

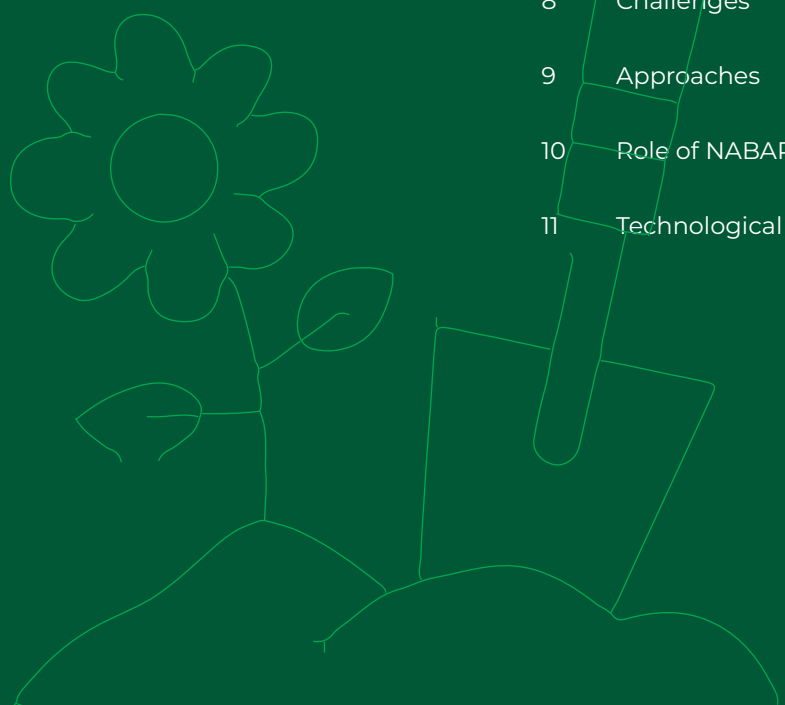
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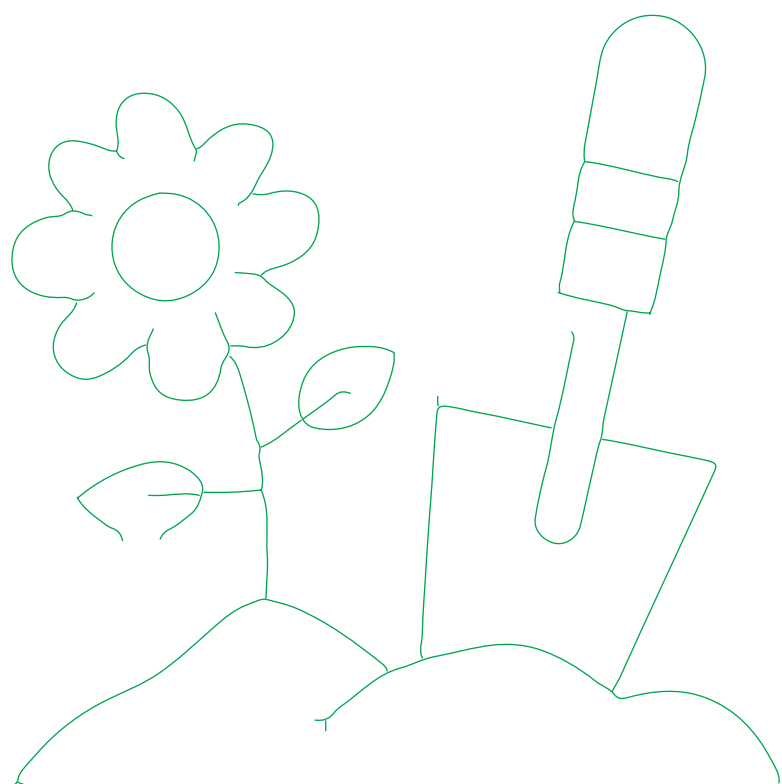
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01

Introduction



India's horticulture sector is a vital pillar of her agricultural economy, contributing significantly to food security, income generation, and rural employment. Over the past few decades, the sector has transitioned from traditional subsistence farming to a vibrant commercially driven industry. With its diverse range of crops, including fruits, vegetables, flowers, spices, medicinal plants, and plantation crops, horticulture plays a crucial role in augmenting agricultural productivity, ensuring nutritional security, and enhancing farmers' incomes.

As the world's second-largest producer of fruits and vegetables, India has become a global leader in horticulture. The country ranks first in the production of bananas, mangoes, papayas, and peas, while also emerging as a key player in floriculture and spice exports. The sector has outpaced food grain production since 2012-13, with horticulture output reaching 352.23 million tonnes (second Advance Estimates for 2023-24) grown across 28.63 million hectares. Vegetables account for the largest share of this production, followed by fruits and plantation crops. Horticulture's share in total agricultural output has risen steadily, now contributing more than 33% to the overall agricultural Gross Value Added (GVA)

Recent Developments and Government Initiatives

The Government of India has been instrumental in driving the growth of the horticulture sector through a series of targeted initiatives aimed at improving productivity, expanding area under cultivation, and developing infrastructure for post-harvest management. Key programs include:

Mission for Integrated Development of Horticulture (MIDH): Launched with the objective of promoting holistic growth in the horticulture sector, MIDH focuses on increasing productivity, strengthening post-harvest infrastructure, and enhancing market linkages for farmers. This mission has significantly contributed to the development of key horticultural crops across India.

National Horticulture Mission (NHM): NHM has facilitated the expansion of horticultural areas, provided subsidies for improved planting material, and supported farmers in adopting new technologies for enhanced crop yields. Special attention has been given to the Northeast and Himalayan regions under this initiative.

CHAMAN (Coordinated Programme on Horticulture Assessment and Management using Geo-informatics): CHAMAN leverages satellite imagery and geo-spatial technology to map horticultural crops, assess crop health, and monitor production trends. This initiative has revolutionized planning and resource management in the sector.

National Bamboo Mission (NBM) and National Medicinal Plants Board (NMPB): These initiatives have focused on promoting sustainable cultivation of bamboo and medicinal plants, enhancing their commercial value, and supporting biodiversity conservation.

Cold Chain and Post-Harvest Management: Recognizing the perishable nature of horticultural produce, the government has invested in expanding cold storage facilities and

integrated cold chains to reduce post-harvest losses. The construction of pack houses, ripening chambers, and cold storages across states has been supported under various schemes like NHM and MIDH [13] [source].

Subsidy and Credit Support Programs: The government offers financial incentives and interest subvention on loans to encourage investments in horticulture. Under the Kisan Credit Card (KCC) scheme, farmers engaged in horticulture are eligible for easy access to credit to procure inputs like seeds, fertilizers, and machinery.

Strategic Importance of the Horticulture Sector

Horticulture plays a pivotal role in addressing key national priorities such as:

- **Income Generation and Employment:** Horticulture offers a higher return per unit of land compared to other crops, making it an important source of livelihood for small and marginal farmers. The sector is labor-intensive, providing employment to millions, particularly women, in planting, harvesting, processing, and marketing activities.
- **Nutritional Security:** Fruits, vegetables, and spices are rich sources of essential vitamins, minerals, and antioxidants, making horticulture critical to enhancing dietary diversity and tackling malnutrition across the country.
- **Export Potential:** India is a major exporter of horticultural products such as mangoes, bananas, grapes, spices, and flowers. The sector has immense potential for boosting exports, with rising global demand

for organic and exotic produce. Enhanced value chain integration, adoption of international standards, and better market access will drive India's horticultural exports to new heights.

Future Prospects and Opportunities

The future of India's horticulture sector is poised for rapid growth, driven by rising consumer demand for high-quality, organic, and nutrient-rich foods, both domestically and globally. Emerging trends and opportunities include:

1. **Protected Cultivation and Precision Farming:** Technologies such as polyhouses, drip irrigation, and precision farming techniques are transforming horticulture by improving water-use efficiency, reducing input costs, and increasing crop yields. These innovations will be key in addressing climate variability and ensuring year-round production.
2. **Organic Farming:** Growing consumer awareness of health and environmental sustainability is fueling demand for organic produce. The government's push towards promoting organic farming in select horticultural crops, supported by dedicated schemes and certifications, presents a significant opportunity for farmers to tap into premium markets.
3. **Value Addition and Agro-Processing:** The development of horticulture-based industries, such as food processing, essential oils, and herbal products, offers immense scope for value addition. Investments in processing infrastructure, coupled



with policy support for startups and micro-enterprises in the agri-processing sector, will further strengthen the horticulture value chain.

4. **Climate Resilience:** With climate change impacting agricultural productivity, the horticulture sector is well-positioned to adopt climate-resilient practices. Developing heat-tolerant and drought-resistant crop varieties, alongside integrating crop diversification, will mitigate risks associated with climatic uncertainties.
5. **Sustainable Practices and Export Growth:** There is increasing emphasis on sustainable cultivation practices, including integrated pest management (IPM), water-efficient technologies, and zero-budget natural farming (ZBNF).

With strategic investments in branding, certification, and export infrastructure, India can capture a larger share of the global market for horticulture products.

Conclusion

In conclusion, India's horticulture sector holds immense potential for transforming the agricultural landscape and driving inclusive economic growth. Through continued government support, technological advancements, and market expansion, the sector is set to play a critical role in achieving national objectives of improving farmers' incomes, enhancing food security, and ensuring sustainable agricultural practices. The future of Indian horticulture is bright, with ample opportunities for innovation, investment, and global leadership.



02

**Growth in Area and
Production**



2.1 Horticulture Crops

The horticulture sector has become a driving force in Indian agriculture, contributing significantly to the overall growth in both productivity and diversification. Over the years, this sector has outpaced traditional crop production, supported by targeted government initiatives and increasing consumer demand for fruits, vegetables, and other horticultural products. According to the Third Advance Estimates of 2023-24 released by the Department of Agriculture and Farmers' Welfare, India's horticultural production is estimated to be about 353.19 million tonnes in 2023-24, cultivated over an area of 28.98 million hectares. This marks a substantial increase in both area and production, underscoring the sector's growing importance in India's agricultural landscape.

Key horticultural crops include fruits, vegetables, spices, flowers, aromatic plants, and plantation crops. Fruits and vegetables account for the largest share of the horticultural output, with vegetables making up approximately 58% and fruits contributing 32%. Notable fruit crops include mangoes, bananas, citrus fruits, and apples, while vegetables such as onions, potatoes, tomatoes, and brinjals dominate the vegetable segment. The sector also encompasses the cultivation of high-value crops like flowers, medicinal plants, and spices, with significant contributions from regions across India.

Horticultural crops offer multiple advantages over traditional field crops. They not only yield higher returns per unit of land but also provide essential vitamins and nutrients, contributing to

national nutritional security. Additionally, these crops are labor-intensive, thus generating significant employment opportunities, especially in rural areas. Horticulture's export potential further enhances its value, with India emerging as a key exporter of products like mangoes, grapes, and flowers.

Recent Performance and Growth

In terms of growth, the area under horticulture crops has been expanding steadily, growing by 2.1% annually, while production has seen an even higher annual growth rate of 3.9% over the past decade. This positive trend is a result of both government interventions and the sector's inherent profitability. Government schemes such as the Mission for Integrated Development of Horticulture (MIDH) have been pivotal in encouraging area expansion, improving productivity, and ensuring the development of post-harvest infrastructure.

Specific segments within horticulture have exhibited robust growth, such as floriculture, which has emerged as a high-growth industry, contributing to both domestic markets and export. Similarly, the cultivation of spices and medicinal plants has expanded, catering to both the domestic industry and international demand.

Looking forward, the future of horticulture in India is promising. The sector is poised to benefit from the increasing domestic and global demand for high-value, organic, and nutritionally rich products. With continued government support and the adoption of advanced technologies like protected cultivation and precision farming, the horticulture sector is set to play a pivotal role in

achieving the national goal of doubling farmers' incomes.

2.2 Fruit crops

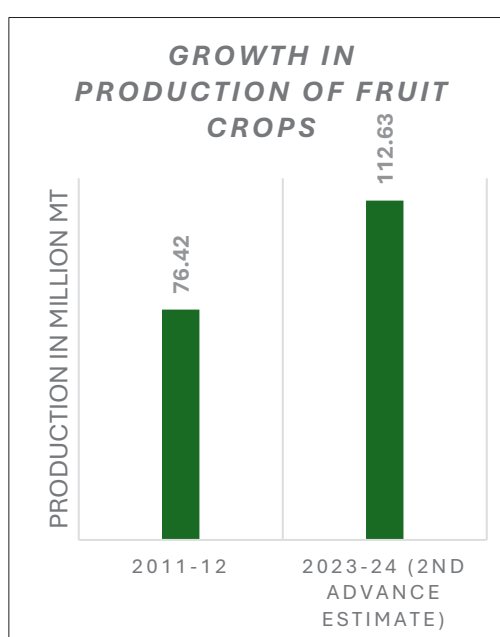
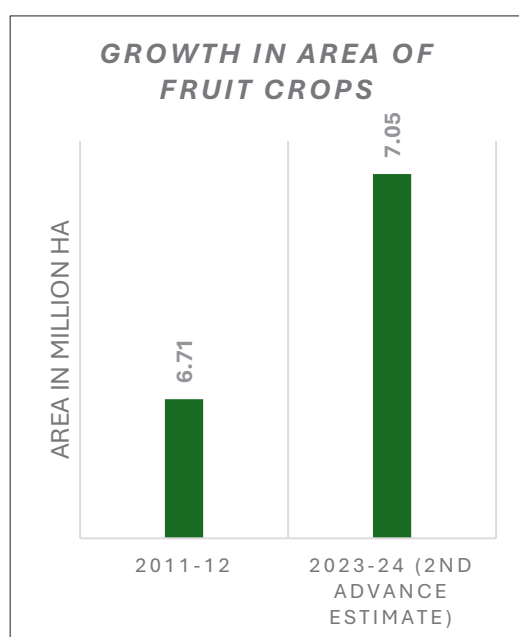
India is blessed with a diverse range of climatic and soil conditions that allow her to grow various kinds of fruits from tropical, subtropical, and temperate zones. Fruits occupy an area of 7.05 million ha as per 2023-24 (2nd Advance estimate, Deptt. of Agriculture and F&W)) with a total production of 112.63 million Tonne and with average productivity of 15.98 Tonnes/ha.

According to 2023-24 (2nd Advance estimate) data from the Ministry of Agriculture and Farmers Welfare, banana contributes the largest to the fruit production in India, with a total production of 37.47 million metric tons. It is followed by mango, which has a production of 22.55 million metric tons, and citrus fruits, which have a production

of 14.74 million metric tons. These three account for more than 65% of the total fruit production in India.

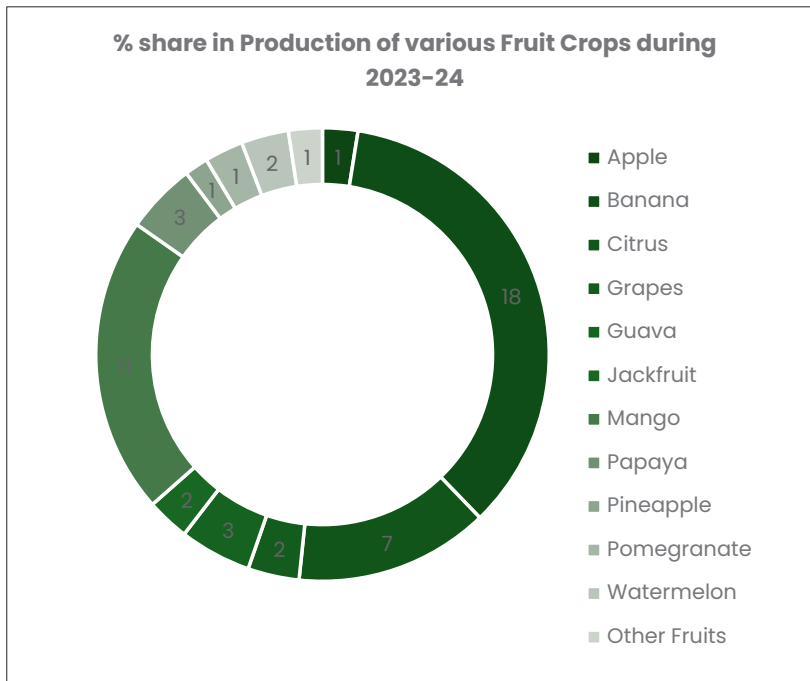
The fruit production in India is dominated by seven states as per 2023-24 (2nd Advance estimate) data. These are Andhra Pradesh (17.79 m MT), Maharashtra (15.17 m MT), Uttar Pradesh (13.17 m MT), Madhya Pradesh (9.61 m MT), Gujarat (8.23 m MT), Tamil Nadu (7.53 m MT), and Karnataka (7.48 m MT). Andhra Pradesh was the top fruit producer in the country in 2022 followed by Maharashtra. India was a leading producer of fresh fruits with a production share of 11.73% globally.

Fruit crops constitute about 32.00% of horticulture production. During the period 2011-12 to 2023-24 (2nd advance estimate), area and production of fruits increased by 5.07% and 47.38%, respectively.





The production share of major fruit crops during 2023-24 (2nd advance estimate) is depicted in the picture below. (Can we have just four or five categoris?)



Between 2011-12 and 2023-24, production of fruits increased by about 47.00% while the area increased by about 5.00%, indicating that the increased production of various fruits in the country is largely due to increased productivity. In fact, the productivity of fruit crops registered a growth of 40%, from 11.39 MT/ha to 15.98 MT/ha during this period. Though Maharashtra holds the largest area under fruit crops (0.86 million ha) followed by Andhra Pradesh (0.79 million ha), the latter accounts for the largest production (17.79 m MT) in the country followed by Maharashtra (15.17 m MT), due to higher crop productivity (22.52 MT/ha in AP vis-à-vis 17.64 MT/ha in Maharashtra).

Major impediments in the growth of fruit crops are:

- High initial capital investment
- Predominance of old and senile orchards
- Poor quality planting materials
- Inadequate post-harvest management practices.
- Less efficient marketing systems coupled with seasonality and perishability.
- Lack of adequate premium for high quality produce.
- Poor access to markets, extension services and credit.
- Poor linkages and integration between various players in the supply chain, such as from farm gate to marketplace, from farmer to processing unit, etc.

Pathways to address challenges.

- Diversification of fruit crops and products is a key strategy to enhance resilience, profitability, and market access. By cultivating a variety of fruits that have different harvesting seasons, nutritional and medicinal benefits, and value addition potential, horticulture farmers can reduce their exposure to climatic and market shocks, increase their income sources, and cater to the needs of diverse consumers.
- Drip irrigation system is highly efficient irrigation method well suited to many horticultural crops.
- Protected cultivation- With controlled environment, farming is being done under the covers with the precise environment the crop needs to flourish. Controlled environment agriculture yields more dependable crops since they are not subject to temperature and precipitation extremes.
- Integrated Nutrient Management (INM)- Adopting the practice of combining organic matter and bio-fertilizers with inorganic fertilizers to deal with the challenges of high cost and low supply of fertilizers, and to enhance the quality and fertility of the soil.
- Adopt strategies such as direct marketing to consumers or using online platforms to reduce intermediaries and increase profit margins.

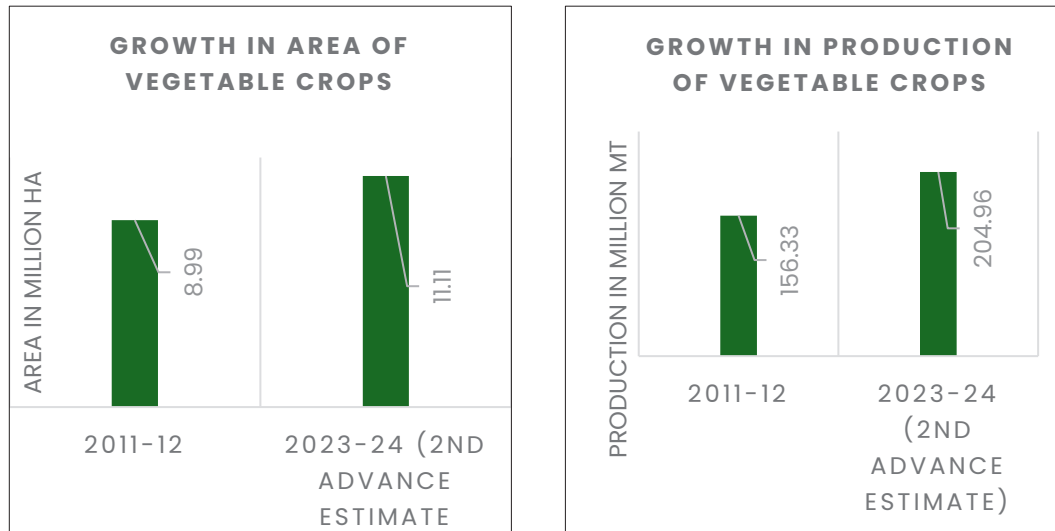
- Need for innovative credit products and motivating bankers to extend term loan for horticultural crops.
- Addressing gaps in infrastructure and post-harvest management.
- Avail benefits from different policies and schemes of the government such as MIDH, National Food Security Mission, PM-KISAN, etc., that can provide them with various forms of financial and technical support such as subsidies, grants, loans, insurance, etc.

2.3 Vegetables

Vegetables are an important crop in the horticulture sector, occupying an area of 11.11 million ha as per 2023-24 (2nd Advance estimate, Dept of Agriculture and F&W)) with a total production of 204.96 million tonne with average productivity of 18.45 Tonnes/ha. India's diverse climate is conducive to the production of a large number of fresh vegetable crops. According to FAO (2021), India is the largest producer of ginger and okra among vegetables and ranks second in the production of Potato, Onion, Cauliflower, Brinjal, Cabbage, etc. India is 2nd largest producer of vegetables in the world after China and accounts for 15% of the world production but average productivity of 17 mt/ha is low in comparison to many other vegetable producing countries.



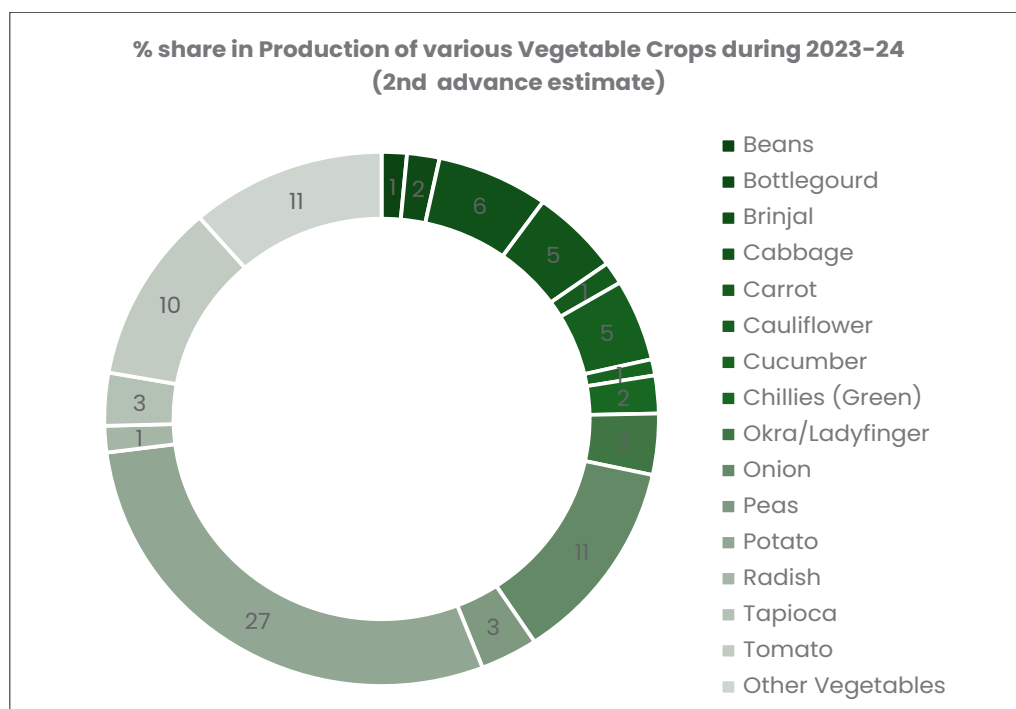
Vegetables constitutes about 58.00% of horticulture production. During the period 2011-12 to 2023-24 (2nd Advance Estimate), area and production of vegetables increased by 23.58% and 31.11%, respectively.



Top three leading crops as per 2023-24 (2nd advance estimate), are Potato (56.76 m MT), Onion (24.21 m MT) and Tomato (21.24 m MT). With a production of 34.19 m MT, Uttar Pradesh leads the country in

vegetable production, followed by West Bengal (29.22 m MT), Madhya Pradesh (23.67 m MT), Bihar (17.09 m MT) and Gujarat (14.30 m MT).

The production share of major vegetables during 2023-24 (2nd advance estimate) is given in the picture below. (Can we reduce it to five or six crops?)



Major impediments for growth of vegetable production in the country are:

- Inadequate supply of quality seeds and high cost of hybrid seeds.
- Less availability of varieties suitable specifically for processing needs
- Small and marginal farmers may have access to suitable technologies.
- High post-harvest crop losses and poor post-harvest management and less diversification of markets.
- Volatile prices of vegetables throughout the year.
- Poor access to markets, extension services and credit.

Pathways to address challenges.

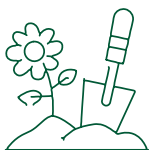
- Financial support for the development of technologies suitable for small and marginal farmers.
- Development of efficient region-specific varieties and hybrids with higher yield potential and resistance to biotic/abiotic stresses are need of the hour.
- Production technologies for water and nutrient management.
- Package of practices for off-season vegetable production.
- Optimization of fertigation schedules for major vegetable crops
- developing disease and pest management practices by including label claim pesticides and fungicides,
- developing crop-wise integrated pest management modules comprising bio-intensive components,
- quality seed production technologies,

- post-harvest management and value-addition.

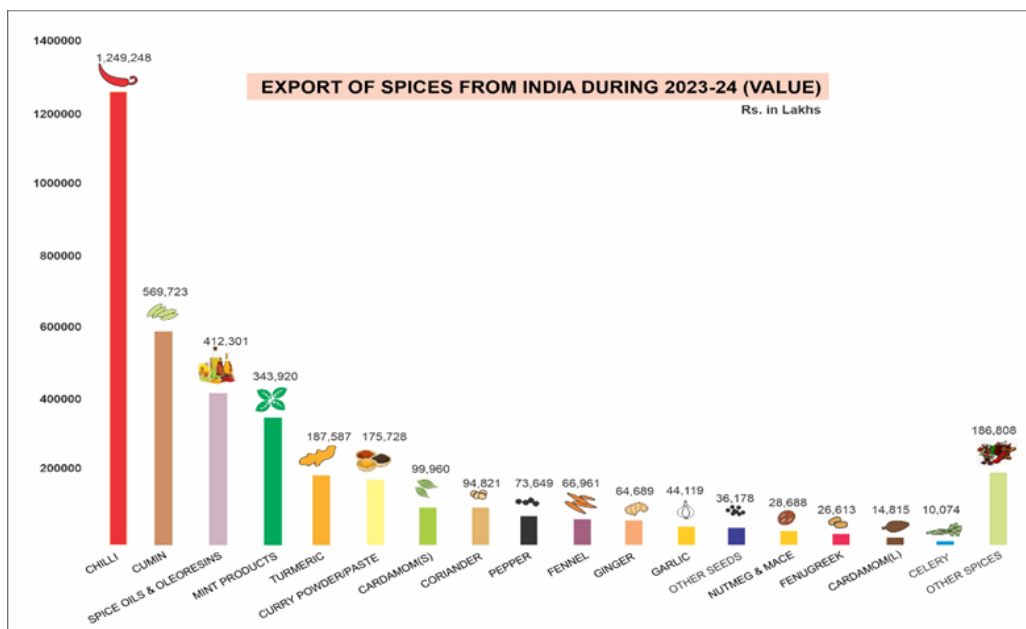
2.4 Spices

India is traditionally known as the spice bowl of the world. The Western Ghats region is believed to be the centre of origin of many spices, particularly black pepper, cardamom and other Zingiberaceous spices. India has been a traditional producer, consumer and exporter of spices. There are about 109 spices listed by International Organization for Standardization, and India grows about 60 of these spices. Almost all the States in the country produce one spice crop or the other.

During the year 2022-23, spices were grown in an area of 4.54 m ha with an estimated production of 11.82 m tons. Indian spices flavour foods in over 130 countries. The USA, Canada, Germany, Japan, Saudi Arabia, Kuwait, Bahrain and Israel are the main markets for Indian spices. During 2022-23, Indian spices exports have been able to continue its increasing trend both in volume and value. India exported 14,04,357 MT of spices and spice products valued at ₹31,761.38 crore (US\$3,952.60 million). India's export of spices increased from 8,17,250 MT valued at ₹13,73,5.39 crore (US\$2,268 million) in 2013-14 to 14,04,357 MT valued at ₹31,761.38 crore (US\$3,952.60 million) in 2022-23 registering an increase of 82 per cent in volume, 131 per cent in value (INR) and 84 per cent in value (US\$). Top three leading spice crops are Garlic (3.23 m MT), chillies (2.78 m MT) and Turmeric (1.16 m MT). The leading states in production of spices are Rajasthan, Andhra Pradesh, Madhya Pradesh, Gujarat and Telangana.



The export of major spice crop (2023-24) is given in the picture below:



The major impediments for growth of spices crops are:

- Shortage of quality planting and seed materials.
- Lack of awareness regarding crop-wise country/region-specific quality standards, including the acceptable levels of pesticide residues, in respect of exportable products.
- Lack of awareness on quality standards.
- Poor access to markets, extension services and credit.

2.5 Flowers

The floriculture industry in India is characterized by growing traditional flowers (loose flowers) and cut flowers under open field conditions and protected environment conditions, respectively. India also has a strong dry flower industry, which contributes to the overall trade. Other segments like

fillers, potted plants, landscape plants, trees, palms, topiary plants, seeds and planting material, turf grass industry, and value-added products also contribute a share in the overall growth of floriculture sector. The traditional flower cultivation, comprising of growing loose flowers mostly for worship, garland making and decorations, forms the backbone of floriculture in India, which is mostly in the hands of small and marginal farmers. Globalization of Indian economy and subsequent liberalization of Seed Act paved the way for the advent of protected cultivation in India during early 1990s. The Government of India has identified floriculture as a sunrise industry and accorded 100% export-oriented status. India's floriculture sector has pivoted towards export-oriented cut flowers, driven by a liberalized economy that encourages entrepreneurial growth.

Due to the favourable atmosphere produced by several reforms in the economics and seed sector, the Indian

floriculture sector, which remained a domestic agricultural practice until the late 1980s, achieved commercial relevance throughout the 1990s. This move has created opportunities for importing novel plant materials and implementing advanced cultivation technologies, further enriching the agricultural practices in the country. Total area under flower crops in India in 2021-22 is 283.27'000 ha, with largest area of flower crops in Karnataka with an area of 44.83'000 ha followed by Tamil Nadu with 42.93'000 ha and Madhya Pradesh with 38.69'000 ha. Other states that produce flowers include West Bengal, Mizoram, Gujarat, Orissa, Jharkhand, Haryana, Assam, and Chhattisgarh. Total loose flower production in India is 2295.07'000 MT in 2021-22 and the leading producer of the loose flower is Andhra Pradesh having 515.71'000 MT production and West Bengal is the leading producer of cut flowers having 218.71'000 MT production. Additionally, India has a robust dry flower market that contributes significantly (more than 70%) to exports of floriculture. India is the world's top exporter and producer of dry flowers, with revenues of Rs.322 crores.

In 2022-23, India exported floriculture commodities exceeding Rs. 707.81 Crores/ US\$ 88.38 Million. The major importing countries were the USA, the Netherlands, UAE, UK and Germany. Karnataka, Andhra Pradesh, and Tamil Nadu each have more than 50% of the floriculture units.

The major impediments for growth of floriculture are:

- Shortage of quality plating and seed materials and high cost of planting material.
- Lack of awareness on quality standards.
- Perishability and lack of adequate post-harvest infrastructure.
- Poor access to markets, extension services and credit.

2.6 Plantation Crops

Plantation crops are an essential part of our agricultural economy and a major factor in the expansion and advancement of the rural economies in many Indian states. Rubber, tea, coffee, oil palm, cashew, coconut, and areca nut are among the main plantation crops grown in the nation. Cocoa and spice crops are also regarded as plantation crops. The plantation crop industry significantly influences the foreign exchange and size of the dividend.

Most of the plantation crops in India are cultivated by smallholder producers. For example, 93% of the total rubber production in the country is done by nearly 1.3 million small farm holdings with an average holding size of 0.54 ha. Holdings of less than two hectares constitute 81% of the total number of holdings in coffee (Coffee Board, 2018). In the case of rubber plantations, the average daily employment increased from 0.16 million in 1976 to 0.46 million in 2012-13.



Area and Production of Plantation crops in India (NHB,2018 as available)

Plantation Crop	2017-18		2018-19		2019-20	
	Area (000 Ha)	Production (000MT)	Area (000 Ha)	Production (000MT)	Area (000 Ha)	Production (000MT)
Arecanut	497	833	518	852	518	853
Cashewnut	1062	817	1101	852	1089	743
Cocoa	89	20	93	743	94	24
Coconut	2097	16413	2215	18	2179	14748
Total Plantations	3755	18082	3927	16046	3880	16368

Major plantation crops producing states

Sr. No.	Crop	States
1	Coconut	Kerala, Karnataka, Tamil Nādu
2	Coffee	Karnataka, Kerala
3	Rubber	Kerala, Karnataka
4	Tea	Assam and Kerala
5	Cashew	Kerala, Tamil Nadu, Maharashtra, Andra Pradesh
6	Cocoa	Kerala, Karnataka

2.6.1 Coffee

India became the world's eighth-largest coffee grower during 2022-2023. Indian coffee is one of the best coffees in the world owing to its high quality and pertains to be premium in the international markets. India produces two types of coffee: Arabica and Robusta. Arabica has a higher market value than Robusta coffee due to its mild aromatic flavour. Robusta coffee is used in making various blends due to its strong flavour. Robusta is a majorly manufactured coffee with a share of 72% of the total production of Indian coffee. India is considered the fifth largest producer of Robusta coffee globally. The industry provides direct employment to more than 2 million people in India. Since coffee is an export commodity for India,

domestic demand and consumption do not drastically impact the prices of coffee.

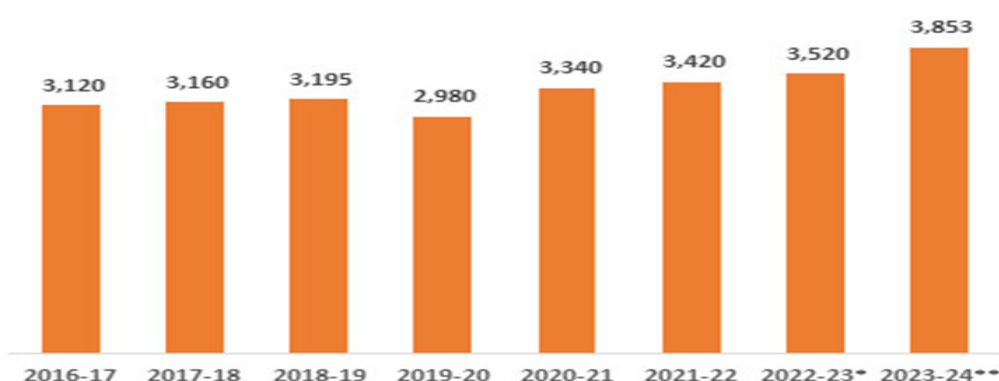
India's combined Arabica and Robusta harvest is forecast to increase for the 2023-24 crop year, beginning in October, according to early estimates from the Coffee Board. The projected total crop is expected to reach 3.74 lakh tonnes, marking a 6.25% rise from the final estimate of 3.52 lakh tonnes for the 2022-23 season. The Board predicts a higher output of Arabica at 1.13 lakh tonnes, up from 1 lakh tonnes in the current season, while robusta production is anticipated to rise to 2.61 lakh tonnes from 2.52 lakh tonnes.

Coffee is produced in the southern part of India. Karnataka is the largest producer accounting for about 71% of the total coffee production in India. Kerala

is the second-largest producer of coffee but accounts only for about 20% of the total production. Tamil Nadu is the third-largest producer with 5% of India's total coffee production. Half of Tamil Nadu's

coffee is made in the Nilgiri district, a major Arabica growing region. Orissa and the north-eastern areas have a smaller proportion of production.

India's coffee production trend (lakh tonnes)



Source: Coffee Board of India

Note: *Final Estimate, ** Post Blossom Estimate (Till 27th March)

2.6.2 Coconut

India is the largest coconut-producing country in the world and accounted for about 31.45% of the world's total production during 2021-22, with a production of 19,247 million nuts. The crop contributes around Rs.307,498 million (US\$ 3.88 billion) to the country's gross domestic product (GDP). The coconut palm provides food security and livelihood opportunities to more than 12 million people in India. It is also a fibre-yielding crop for more than 15,000 coir-based industries, providing employment to nearly 6 lakh people. The productivity of coconut at a national level for 2021-22 was at 9,123 nuts per hectare which is one of the highest in the world. Copra processing, coconut oil extraction and coir manufacturing are the traditional coconut-based activities in the country. India's coconut production is majorly

situated in Kerala, Karnataka, Tamil Nadu and Andhra Pradesh, accounting for 89.13% of the coconut area and 90.04% of the coconut production in the country. Other coconut-producing states in the country are West Bengal, Orissa and Gujarat.

During the year 2021-22, the Government of India has provided financial assistance to the tune of Rs.801 million (US\$10 million, released as of 31st Dec 2021) for covering a fresh area of 4,078 hectares under the expansion of area under coconut initiative and 91-hectare demonstration plots for productivity improvement. This includes establishing six new coconut nurseries and a coconut nucleus seed garden and six new coconut processing units for value-added products like virgin coconut oil (VCO), activated carbon and ball copra, spray dried coconut milk powder.

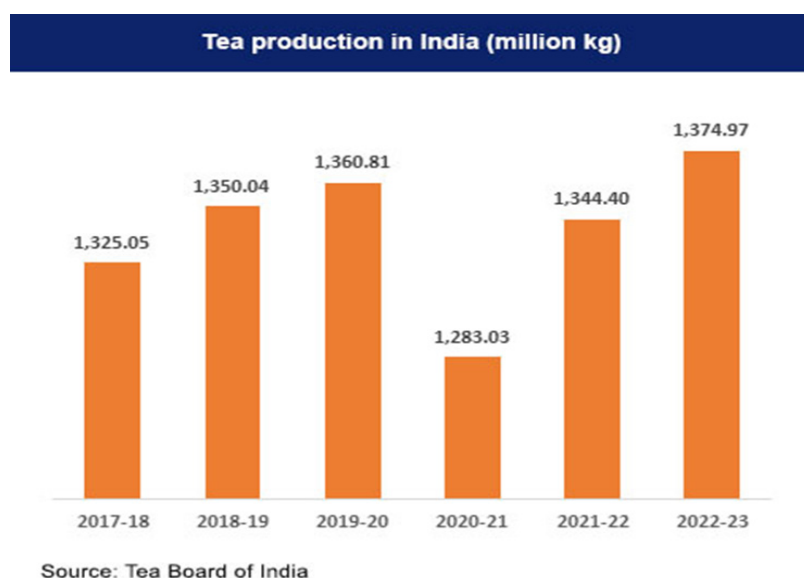


2.6.3 Tea

India is the second-largest producer of tea globally. Indian tea is one of the finest in the world owing to strong geographical indications, heavy investment in tea processing units, continuous innovation, augmented product mix, and strategic market expansion. As of 2022, a total of 6.19 lakh hectares of area was cultivated in India for tea production. India is also among the world's top tea-consuming countries, with 80% of the tea produced in the country consumed by the

domestic population. In 2022-23, India's tea production stood at 1,374.97 million kgs, compared to 1,344.40 million kg in 2021-22.

The Assam Valley and Cachar are the two tea-producing regions in Assam. In West Bengal, Dooars, Terai and Darjeeling are the three major tea producer regions. The southern part of India produces about 17% of the country's total production with the major producing states being Tamil Nadu, Kerala, and Karnataka.



2.6.4 Rubber

India is the third largest producer, the fourth largest consumer of natural rubber and the fifth largest consumer of natural rubber and synthetic rubber together in the world. With around 6000 units comprising 30 large scale, 300 medium scale and around 5600 SSI/tiny sector units, manufacturing 35000 rubber products, employing 400 hundred thousand people, including around

22000 technically qualified support personnel, with a turnover of Rs.200 billion and contributing Rs.40 billion to the National Exchequer through taxes, duties and other levies, the Indian Rubber Industry plays a core sector role in the Indian national economy.

The wide range of rubber products manufactured by the Indian rubber industry comprises all types of heavy-duty earth-moving tyres. Auto tyres,

tubes, automobile parts, footwear, belting, hoses, cycle tyres and tubes, cables and wires, camelback, battery boxes, latex products, pharmaceutical goods, and moulded and extruded goods for mass consumption. The products manufactured also cover hi-tech industrial items. The important areas which the industry caters to include all three wings of defence, civil, aviation, aeronautics, railways, agriculture, and transport as also textile engineering industries, pharmaceuticals, mines, steel plants, ports, family planning programmes, hospitals, sports, practically to every conceivable field.

The rubber industry in India is divided into two sectors – the tyre and non-tyre sector produces all types of auto tyres, conventional as well as radial tyres and exports to advanced countries like the USA.

The non-tyre sector comprises the medium-scale, small scale and tiny units. It produces high-technology and sophisticated industrial products. The small-scale sector accounts for over 50% of the production of rubber goods in the non-tyre category. Going by share of rubber consumption, the automotive tyre sector is the single largest sector accounting for about 50% of consumption of all kinds of rubbers, followed by bicycle tyres and tubes 15% footwear 12%, belts and hoses 6%, camelback and latex products 7%. All other remaining rubber products put together account for 10%.

2.6.5 Cashew

India is among the largest cashew-producing countries in the world. The cashew industry has large economic significance as it employs more than 10 lakh people on farms and factories in rural

areas. The cultivation of cashews in India covers a total of 0.7 million hectares of land, and the country produces over 0.8 million tonnes (MT) annually. Between 2019-20 and 2021-22, India's cashew nut production grew from 0.70 million tonnes (MT) to 0.77 million tonnes (MT). In India, cashew cultivation spread along the coastal regions of the peninsula. Cashew is mainly grown in states like Maharashtra, Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, Odessa, West Bengal, and some parts of the North-eastern region. According to data published by the National Horticulture Board (AHB), Maharashtra stands first in annual cashew nut production during 2021-22 at 0.20 million tonnes (MT), growing from 0.19 million tonnes of cashew nut produced in 2020-21.

Besides the vast scale of cashew production, India is also known for pioneering cashew processing and exporting cashew kernels across the globe. The cashew processing industry was earlier concentrated in Kollam (Kerala), Mangalore (Karnataka), Goa, and Vettapalam (Andhra Pradesh), but now it is spread across many states of India. Over the years, India has emerged as the global processing hub for the cashew industry.

Conclusion

One of the main factors influencing the country's agricultural sector's growth is the plantation crop industry. The difficulties this industry faces are many, but they are not insurmountable. A thriving plantation crop sector in the nation can be ensured by the well-reasoned and cogent application of cutting-edge research, institutional support for development, and innovative policy initiatives.



2.7 Aromatic Crops

Aromatic crops belong to a large group of economically important species. Over the past few decades, there has been a significant increase in demand for essential oils, aroma chemicals, pharmaceuticals, and other aromatic products in the global market. Aromatic compounds are found in various parts of plants such as roots, bark, wood, foliage, flowers, fruits, and seeds.

Important aromatic plants grown in India include Citronella grass, Palmarosa, Vetiver, Sweet Flag (*Acorus calamus*), Lavender, Geranium, Patchouli, Bursera, Mentha (Mint), Musk Mallow (*Abelmoschus moschatus*), Dawana, and Ocimum (Holy Basil). These plants have seen considerable demand both domestically and internationally.

As of 2023, India produced approximately 10 lakh metric tonnes of aromatic crops from 6.8 lakh hectares. Rajasthan, Uttar Pradesh, and Madhya Pradesh are the leading states in aromatic crop production. The government has also introduced several initiatives to encourage aromatic crop cultivation, including improved market access and quality standards awareness for farmers.

Key challenges in the aromatic crop sector include:

- **Shortage of Quality Planting Material:** Farmers face difficulties in accessing certified seeds and saplings.
- **Weak Producer-Industry Linkages:** There is a lack of organized channels to connect producers with industries that use aromatic crops.
- **Limited Knowledge of Quality Standards:** Farmers have limited

awareness of international quality benchmarks.

- **Poor Access to Credit and Market Services:** Financial support and reliable market access remain significant barriers to scaling up aromatic crop cultivation.

2.8 Medicinal Plants

Medicinal plants have long been an integral part of India's traditional medicine systems, including Ayurveda, Unani, Siddha, and Homoeopathy. There are approximately 6,000 to 7,000 species with known medicinal properties, with about 960 species actively traded. Of these, 178 species have annual consumption levels exceeding 100 metric tonnes. Medicinal plants play a critical role in the traditional medicine and herbal industry, contributing to livelihood and health security for many Indian communities.

In 2023, the domestic trade of medicinal plants in the AYUSH industry was valued at ₹100 billion. Export figures for medicinal plant products were estimated at ₹12 billion. With the global resurgence in alternative and traditional healthcare systems, the world herbal market is projected to grow to US\$7 trillion by 2050. However, India's current share in the global herbal trade remains low, signaling the need for further development.

Significant medicinal plants grown in India include Long Pepper, Periwinkle, Rauvolfia, Isabgol, Ammi majus, Belladonna, Cinchona, and Pyrethrum. Due to the declining availability of wild medicinal plants, commercial cultivation is gaining importance. The National

Medicinal Plants Board (NMPB) continues to promote conservation and sustainable cultivation through its various programs.

Key challenges in the medicinal plants sector include:

- **Quality Planting Material:** As with aromatic crops, there is a shortage of certified and high-quality planting material for medicinal crops.
- **Weak Producer-Industry Connections:** There is an urgent need to strengthen links between producers and industries involved in herbal medicine.
- **Awareness of Quality Standards:** Farmers and producers often lack awareness of quality standards required for international trade.
- **Limited Access to Markets and Credit:** The inability to access credit and secure markets restricts the growth potential of the sector.

Through government support, including the Conservation, Development, and Sustainable Management of Medicinal Plants scheme, efforts are being made to increase the cultivation and trade of medicinal plants in India.

2.9 Precision farming

By 2050, India's agri-food production will face a formidable task of feeding close to 1.7 billion people using limited cultivable land, water and energy resources. Our current approach of input application is based on common recommendations of a composite sample or visual symptoms of crops, and it does not account for intra-field variability. It reduces efficiency of input-use and results in environmental

degradation. Thus, intensification of agriculture using modern tools/techniques is essential.

Precision farming is one of the solutions for sustainable development of agriculture, which advocates applying right inputs in right amounts at right time and at right place using the right technologies or techniques.

a) Definition of Precision farming:

Precision farming is defined as information and technology-based farm management system to identify, analyse and manage spatial and temporal variability within fields for optimum productivity and profitability, sustainability and protection of the land resources by minimizing the production costs.

In simple words it can be defined as utilization of inputs with respect to the crop, soil, and weather conditions to achieve effective and optimum utilization of resources without wastage.

b) Insights of Precision Farming:

Precision Farming is a combination of different technologies rather than a one-off approach and allows for site specific management (SSM) to efficiently utilize their resources and get economic gains. Understanding and gaining more knowledge of the natural variability within a farm is one of Precision Farming's vital aspects.

Application of Precision Farming technologies is presently at the nascent stage in India. Some discrete initiatives have been started towards the application of this technology.

Need for precision farming:

- Decline in the total productivity



- Diminishing and degrading natural resources
- Stagnating farm incomes
- Lack of eco-regional approach
- Declining and fragmented land holdings
- Global climatic variation

The intent of precision farming is to match agricultural inputs and practices as per crop and agro-climatic conditions to improve the accuracy of their applications.

Contrary to agriculturally advanced countries where precision farming is practiced in large farms, in Indian context the technology can be adopted even on small holdings by adopting compact area approach involving a group of farmers focusing on high value crops.

Prospects of precision farming in Indian agriculture situation:

- **Agronomic perspective:** Adjustment of cultural practices to consider the real need of the crop rather. e.g., Data acquisition & analysis, decision support system, increased attention to management etc.
- **Technical perspective:** Better time management at the farm level. e.g., GPS System, VRT, SSM Service, Financing etc.
- **Environmental perspective:** Reduction of agriculture impacts.eg Reduce Input Losses, Increase Water and Nutrient Use Efficiency etc.
- **Economical perspective:** Increase of the output and/or reduction of the input and increase efficiency.eg Change in Cost, Change in Revenue, Cash Flow Risk etc.

Basic components/tools of precision farming:

1. Remote Sensing (RS)
2. Geographic Information System (GIS)
3. Global Positioning System (GPS)
4. Yield Monitoring (YM)
5. Variable Rate Technology (VRT)

Components of Precision Farming under Indian Condition

- Good quality seed or planting material
- Precise land preparation
- Timely sowing/planting
- Application of organics (FYM/ Bio compost/cake/green manuring/crop residue)
- Drip/ sprinkler method of irrigation
- Fertigation
- Herbigation
- Mulching
- Plant protection measures

c) Government initiatives:

- The Centre has set up 22 Precision Farming Development Centres (PFDCs) across the country to test new technologies and modify them according to local needs. According to the Ministry, these 22 PFDCs are located across State/Central Agricultural Universities, ICAR Institutes and IITs in TN, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Haryana, Telangana, West Bengal, Ladakh, UP, Punjab, Gujarat, Uttarakhand, Maharashtra, Chhattisgarh, Jharkhand, Bihar, Himachal Pradesh, Kerala, Manipur and Assam.
- **The Agriculture Infrastructure**

Fund (AIF) has provisions for financing infrastructure projects for smart and precision agriculture. Under AIF, individual farmers as well as farmers' communities such as Farmer Producer Organization, Primary Agricultural Credit Societies and SHGs are eligible for loans with interest subvention of 3% for using technological solutions in farm practices. These practices include farm/ harvest automation; purchase of drones, putting up specialized sensors on field; use of blockchain and AI in agriculture; remote sensing and Internet of Things (IoT).

- The Centre is planning to earmark Rs.6,000 crore to promote precision farming, a modern approach that uses smart technology such as the Internet of Things, Artificial Intelligence, drones and data analytics to boost production through maximal use of resources while minimising environmental impact.
- The Union Ministry of Agriculture is planning a Smart Precision Horticulture Programme under the existing **Mission for Integrated Development of Horticulture (MIDH) scheme**. It will cover 15,000 acres of land in five years from 2024-25 to 2028-29 and is expected to benefit about 60,000 farmers.
- The Government of India has launched **the Namo Drone Didi Scheme** with an aim to empower the women Self Help Groups (SHGs) and to provide access to modern agricultural technology. Fertilizers Marketing Companies are involved in creating marketing plan for Drone Didis. During the Viksit Bharat

Sankalp Yatra (VBSY), launched on November 15, 2023, 1.79 lakh demonstration of drone applications were done for spraying nano and water-soluble fertilizers across various crops.

d) Challenges in adopting precision farming in India:

- **High up-front acquisition costs:** Acquisition costs for the latest technologies can be prohibitive for farmers with limited resources or access to capital.
- **Farm data sharing and ownership issues:** Concerns regarding farm data sharing and ownership can pose obstacles to the widespread use of AI in agriculture.
- **Lack of standards:** An absence of uniform standards can hamper inter-operability between different precision agriculture technologies.
- **Lack of technical know-how:** Farmers generally are not trained to use precision tools, interpret data, and implement the findings in their agricultural practices.

Way Forward

- Low-cost sensors are required to monitor soil nutrients, soil moisture, pests and diseases. Wireless sensors will hold the key to precise nutrient and water applications. Indigenous manufacturing of such sensors needs to be promoted.
- Precision Agriculture Service Providers or Start Ups will be required in huge numbers for popularizing and scaling up Precision Farming. As Precision Farming utilizes new technologies, skill development



must be a vital component, in addition to training (pilot license) on the operation of drones. Capacity building for collection of data be included in operationalizing Decision Support Systems.

- Skilled human resource is required for implementing precision agricultural practices. The agricultural universities must initiate HRD through specially designed training modules and course curricula for different levels of activities including teaching, training, and research. This essentially requires exposure and training of faculty in advanced centres of excellence.
- A Network Project on precision agriculture has been recently initiated by ICAR. This needs further strengthening with additional activities covering more institutions, and crops/animals namely pig, poultry, goats and aquaculture. In a few years of its operation, the network can be considered upgradation to an All-India Coordinated Research Project so that Precision Agriculture Research is institutionalized to deliver innovative technologies and methods.

2.10 Organic Farming

Organic farming system is a method of farming system, which primarily aims at sustainable agricultural production in an eco-friendly pollution free environment and being followed from ancient time in India. Organic Production system, keep the environment and ecology alive and in good health by use of natural resources to harness desired agricultural production for human consumption. In Organic production, environment focus

is on using naturally available resources as inputs, such as organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers/ bio control agents) to release nutrients to crops and protect them from insect pest and diseases for increased agricultural production.

Covid-19 pandemic has changed the perception of organic food, with spotlight now on safety and healthy food that is nutritious to build a strong immune system. It is time to talk about nutritional security not of food security only. Among the host of healthy food options available, organic food is perceived as the preferred choice. Therefore, organic food witnessed an uptake since the onset of pandemic. Organically grown foods generally contain higher levels of antioxidants, certain micronutrients, no harmful chemicals, pesticides and fertilizers, better taste and most important thing is organically grown produce aids in the sustainability of the planet and in maintaining ecological balance.

Definition as per FAO: Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs.

Present Scenario of Organic Farming in India:

According to the 2022 survey conducted in 187 countries practicing organic agriculture by the international resource data from the Research Institute

of Organic Agriculture (FiBL) and International Federation of Organic Agriculture Movements (IFOAM), organic food in India is cultivated in 2.6 Mn hectares, fifth largest in the world. The report further revealed that the share of land used for organic farming in total agriculture land is 1.5%, and in the last ten years, India increased its organic agriculture land under cultivation by 145.1%.

The Economic Survey 2022-2023 mentions that India has 4.43 Mn organic farmers, the highest in the world.

As per the Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce & Industries, Government of India:

Area:

As on 31st March 2024 total area under organic certification process (registered under National Programme for Organic Production) is 7.3 mha (2023-24). This includes 44,75,836.91 ha cultivable area and another 28, 50,156.48 ha for wild harvest collection.

Among all the states, Madhya Pradesh has covered largest area under organic certification followed by, Maharashtra, Rajasthan, Gujarat, Odisha, Sikkim, Uttar Pradesh, Uttarakhand, Kerala, Karnataka and Andhra Pradesh.

Production:

India produced around 3.6 million MT (2023-24) of certified organic products which includes all varieties of food products namely Oil Seeds, fibre, Sugar cane, Cereals & Millets, Cotton, Pulses, Aromatic & Medicinal Plants, Tea, Coffee, Fruits, Spices, Dry Fruits, Vegetables, Processed foods etc.

Among different states Maharashtra is

the largest producer followed by Madhya Pradesh, Rajasthan, Karnataka, and Gujarat. In terms of commodities, Fiber crops are the single largest category followed by Oil Seeds, Sugar crops, Cereals and Millets, Medicinal/ Herbal and Aromatic plants, Spices & Condiments, Fresh Fruit Vegetable, Pulses, Tea & Coffee.

Export:

The total volume of export during 2023-24 was 2,61,029 MT. The organic food export realization was around INR 4007.91 Crore (494.80 million USD). Organic products are exported to USA, European Union, Canada, Great Britain, Sri Lanka, Switzerland, Vietnam, Australia, Thailand, New Zealand, Japan, Korea Republic etc.

Need for Organic Farming in India

The Green Revolution in the year 1960 changed the whole scenario in the field of agriculture where the farmers were introduced to high yielding seeds and fertilizers to maintain food security. Increasing productivity ensured profit but ultimately the land was turning barren due to the excessive usage of fertilizers making the soil infertile and pesticides turning the product dangerous to consume.

There are reasons for the need of the Organic Farming in India -

- The organic food industry is rising and is growing very fast, ensuring high profitability.
- Food security needs to be addressed with the growing population and decreasing supply of resources which is why there is a need to increase the production but in a feasible and sustainable manner.



- Maintaining a clean and green environment is equally important, thus environmental sustainability needs to be maintained which can be achieved through organic farming.
- There needs to be an improvement in the health as the consumption can lead to many diseases such as cancer, infertility which happens when the toxic residue remains in the body, thus the safety of humans and animals are of utmost priority.
- The strike of balance between the environment and the livelihood becomes immensely important due to the risks caused by conventional agriculture practices.

Principles of organic farming:

- Principle of health: Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.
- Principle of ecology: Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.
- Principle of fairness: Organic Agriculture should build on relationships that ensure fairness about the common environment and life opportunities. Fairness requires systems of production,

distribution and trade that are open and equitable and account for real environmental and social costs.

- Principle of care: Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

Organic certification

At present in India the growing demand for organic produce is gradually increasing and consumers are looking for the certified products for trusting quality of organic produce. At present in India two types of certification system exists namely

1. Third Party certification (NPOP) system which is governed by APEDA, Ministry of Commerce which is mainly focused for export purpose.
2. PGS-INDIA certification system. PGS-India is governed by Ministry of Agriculture and Farmers Welfare mainly focused for local / domestic market purpose.

The third-party certification bears high fees and more documentation as a result small and marginal farmers are not able to offer for certification. To make it more easy, affordable and simplest system of certification which can be accessible by a greater number of small and marginal farmers to adopt certification and further sale in domestic market, Participatory Guarantee System (PGS)-INDIA organic certification system was launched in

2011 by Department of Agriculture and Cooperation & Farmers Welfare, Government of India.

It is an alternative to Third party (NPOP) certification system. The programme is implemented mainly through National Centre of Organic Farming (NCOF), Ghaziabad and its five Regional Centres (Ghaziabad (HQ), Bangalore, Nagpur, Bhubaneswar, Imphal, as Zonal Councils. NCOF is a PGS-INDIA Secretariat of the PGS-INDIA System, and Director, NCOF as the Executive Secretary and has to play an important role in implementation of all activities of PGS- INDIA programme as per the PGS guidelines.

GOI Initiatives:

the Government of India has taken several initiatives. Some of the prominent steps are mentioned below:

1. **Paramparagat Krishi Vikas Yojana (PKVY)**, launched in 2015, is an extended component of Soil Health Management (SHM) under the Centrally Sponsored Scheme (CSS) National Mission on Sustainable Agriculture (NMSA). PKVY aims at supporting and promoting organic farming, in turn resulting in the improvement of soil health.
2. **Mission Organic Value Chain Development for North east Region (MOVCDNER)**, which became operational in 2015-16 as a sub-mission under the National Mission on Sustainable Agriculture (NMSA), aims to develop crop commodity-specific organic value chain and address gaps in organic crop production, wild crop harvesting, organic livestock management and processing, etc. Under MOVCDNER, financial assistance of INR 10000/

Ha for three years is provided for training, handholding and ICS documentation, and farmers are provided assistance of INR 32500/ Ha for 3 years for off-farm/on-farm organic inputs. Under the scheme, need-based assistance is also provided for various components.

3. **Jaivik Kheti organic e-commerce portal** of the Ministry of Agriculture and Farmers Welfare, along with MSTC, directly links farmers with retail as well as bulk buyers.
4. **The National Programme for Organic Production (NPOP)**, implemented by APEDA, is involved in the accreditation of Certification Bodies, fixing standards for organic production and packaging, promotion of organic farming and marketing etc. With recognition from the accredited certification bodies of India, Indian organic products are accepted by the importing countries.
5. **Production Linked Incentive Scheme for Food Processing Industry (PLISFPI)** was approved by the Union Cabinet on March 31, 2021, with a budget of INR 10,900 Cr for implementation from 2021-22 to 2026-27. The Scheme was launched to support the creation of global food manufacturing champions. The second component of the scheme stipulates that Innovative/ Organic product of SMEs, including Free Range - Eggs, Poultry Meat, and Egg Products in these segments, are also covered.
6. **Support to organic and bio-inputs in the country** through schemes like Bhartiya Prakritik Kheti Bio-Input Resource Centres,



PM Programme for Restoration, Awareness, Nourishment and Amelioration of Mother Earth (PM-PRANAAM), Galvanizing Organic Bio-Agro Resources Dhan (GOBARDhan) scheme, etc are encouraging farmers to use organic fertilizers.

2.11 Protected Cultivation

Protected cultivation involves growing crops in controlled environmental conditions, ensuring protection from adverse weather and pests, and optimizing input use to increase yields. It has become an important method for enhancing productivity, quality, and sustainability, especially in high-value crops like vegetables and flowers.

2.11.1 Current Status of Protected Cultivation

As of 2023, the area under protected cultivation in India has expanded to about 45,000 hectares, almost double the area reported five years ago. This growth has been driven by increased demand for off-season and high-quality produce, as well as the push for climate-smart agriculture. Government schemes such as the Mission for Integrated Development of Horticulture (MIDH) have provided significant support in terms of financial assistance, helping farmers adopt this technology.

2.11.2 Key Developments and Advantages

Recent developments in protected cultivation include:

- **Climate Control Technology:** Low-cost climate control structures like naturally ventilated polyhouses and walk-in tunnels have made the technology more accessible to small and marginal farmers.

- **Yield Increases:** Protected cultivation can increase yields by 5 to 10 times compared to traditional open-field cultivation.
- **Water and Input Efficiency:** Water usage can be reduced by up to 50%, and the use of fertilizers and pesticides can be cut by 25-30%, contributing to sustainability.
- **Quality and Price Premium:** Produce from protected cultivation commands higher prices in the market due to better quality, uniformity, and off-season availability.

2.11.3 Potential and Expansion

The areas with the greatest potential for protected cultivation include:

- **Urban and Peri-Urban Areas:** To meet the year-round demand for fresh vegetables, fruits, and flowers.
- **Water-Scarce Regions:** Areas facing water shortages or irregular rainfall, where protected cultivation offers a high-efficiency solution.
- **Hilly and Challenging Terrains:** Regions like the North-Eastern states, where traditional cultivation faces limitations due to the terrain and climate.

2.11.4 Challenges and Solutions

Despite its benefits, the widespread adoption of protected cultivation is hampered by several challenges:

- **High Initial Costs:** The setup cost for protected structures, even with government subsidies, remains a barrier for small and marginal farmers.
- **Lack of Technical Knowledge:** Farmers often require extensive training to properly manage the

controlled environments needed for optimal production.

- **Limited Access to Markets:** The supply chain infrastructure for selling high-value crops needs to be strengthened, especially for rural farmers.

To address these challenges, the government has introduced credit-linked subsidies, training programs, and partnerships with private players to improve access to technology and markets. Additionally, protected cultivation clusters are being promoted to facilitate group-based cultivation and shared infrastructure.

2.12 Value Chain Financing - Integrated Value Chain Approach

Value chain financing has emerged as an essential component of enhancing productivity, profitability, and sustainability in the horticulture and plantation sectors. It focuses on integrating various stages of production, processing, and marketing through organized channels that offer financing support at each step. In India, traditional supply chains have often led to inefficiencies due to fragmentation, but the shift towards an integrated value chain is addressing these gaps by offering seamless coordination between producers, processors, and markets.

2.12.1 Recent Developments and Opportunities

Since 2020, there has been a growing emphasis on developing producer organizations (FPOs) and encouraging agribusiness ventures that can help smallholder farmers participate in value chains. This initiative is complemented

by digital tools like e-NAM (National Agriculture Market), which helps farmers directly connect with buyers, thus minimizing intermediaries. The expansion of micro-financing options tailored to different stages of the value chain has also provided a pathway for greater financial inclusion.

In 2023, about 150 FPOs have been established under government-sponsored schemes with a focus on value addition in horticultural crops. These FPOs have become a critical part of the Mission for Integrated Development of Horticulture (MIDH), which focuses on improving both forward and backward linkages.

2.12.2 Key Benefits of Value Chain Integration

- **Better Market Access:** By aligning production with market demand, farmers have access to more reliable and profitable market outlets.
- **Increased Productivity:** The integration of financing, technology, and extension services along the value chain has led to an increase in productivity for high-value crops.
- **Improved Profit Margins:** Value chain financing helps reduce post-harvest losses and enables better price realization, boosting the net income for farmers.

2.12.3 Challenges and Solutions

- **Fragmentation of Small Farms:** To address the issue of fragmented landholdings, solutions like contract farming and farmer-producer organizations are being promoted to achieve economies of scale.



- **Access to Finance:** The lack of formal credit continues to be a challenge. Recent developments in fintech and partnerships between banks and agri-tech companies are bridging this gap.

2.13 Integrated Cold Chain Infrastructure for Perishables

2.13.1 Importance of Cold Chain Infrastructure

Cold chain infrastructure plays a critical role in reducing post-harvest losses and ensuring the quality of perishable produce. India remains one of the largest producers of fruits and vegetables, but nearly 30-40% of the total production is wasted annually due to inadequate storage and transportation facilities. This waste results in significant financial losses, especially for smallholder farmers.

2.13.2 Recent Advances in Cold Chain Infrastructure

As of 2023, significant investments have been made in developing an integrated cold chain ecosystem in India. Government schemes like the Pradhan Mantri Kisan Sampada Yojana (PMKSY) and support from the Ministry of Food Processing Industries (MOFPI) have led to the establishment of 250+ new cold storage facilities across states. In addition, India's cold chain sector is expected to grow at an annual rate of 15-20%, driven by the expansion of the food retail and export markets.

2.13.3 Key Components of Integrated Cold Chain

- **Cold Storage Facilities:** New technologies like controlled

atmosphere storage and multi-product cold chambers are becoming more widely adopted, reducing the loss of perishables such as fruits, vegetables, and dairy.

- **Reefer Transport:** Reefer vehicles, equipped for temperature-sensitive transportation, have grown to a fleet of 35,000 as of 2023, addressing a key gap in inter-city transportation of perishables.
- **Packhouses and Processing Units:** Recent government initiatives have focused on setting up packhouses near production centers to facilitate efficient grading, packaging, and linking to cold storage networks.

2.13.4 Challenges and Recommendations

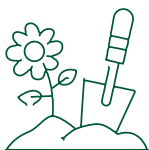
- **Energy Dependency:** Cold storage facilities are energy-intensive, which increases operational costs. Solar-powered cold storage solutions are being promoted to tackle this challenge.
- **Skewed Distribution:** Nearly 60% of India's cold storage capacity is concentrated in just two states, Uttar Pradesh and West Bengal. Expanding cold chain infrastructure to under-served regions remains a priority.

The National Centre for Cold-chain Development (NCCD) continues to play a vital role in creating frameworks for public-private partnerships and ensuring sustainable growth in cold chain infrastructure.



03

**Export Prospects for
Plantation & horticulture
produce**



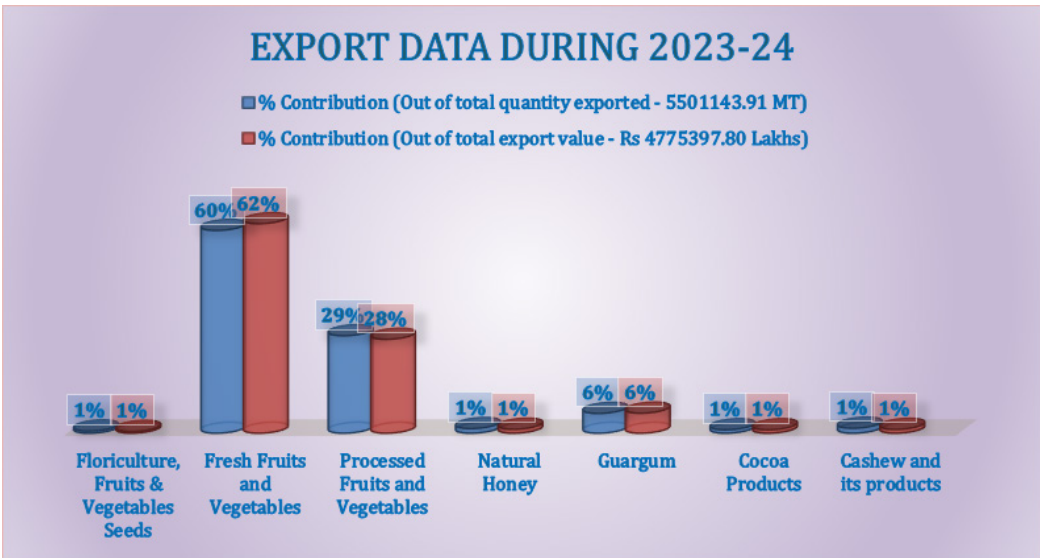
India ranks second in fruits and vegetable production in the world, after China. As per National Horticulture Database (2nd Advance Estimates) published by National Horticulture Board, during 2023-24, India produced 112.62 million metric tonnes of fruits and 204.96 million metric tonnes of vegetables. The area under cultivation of fruits and vegetables stood at 7.04 million ha and 11.11 million ha, respectively.

According to FAO (2022), India is the largest producer of onions, ginger and okra among vegetables and ranks second in the production of potatoes, cauliflowers, brinjal, cabbages, etc. Amongst fruits, the country ranks first in the production of banana (25.56%), mango (44.46%) and papaya (38.64%).

During 2023-24, India exported fresh fruits and vegetables worth Rs. 15039.28 crores which comprised Fresh Fruits worth Rs. 8178.22 crores and vegetables worth Rs. 6,861.05 crores. Further, the processed fruits and vegetables including pulses exported worth Rs. 20,623.71 crore which comprised of processed vegetables including pulses worth Rs. 14,339.94 crore and processed fruits & juices amounting to Rs. 6,283.76 crores in 2023-24.

Grapes, pomegranates, mangoes, bananas, and oranges account for the larger portion of fruits exported from the country while onions, mixed vegetables, potatoes, tomatoes, and green chilly contribute largely to the vegetable export basket. Major destinations for the Indian Fresh Fruits and Vegetables are Bangladesh, UAE, Netherland, Nepal, Malaysia, Iraq, U.K, Sri Lanka, Iran, Oman and Saudi Arabia. Major destinations for the Indian Processed Fruits and Vegetables are U.S.A, UAE, Bangladesh, U.K, Saudi Arab, China and Netherland.

Though India's share in the global market is nearly 1% only, the acceptance of horticulture produce across the country is increasing. There are concurrent developments in the areas i.e. state-of-the-art cold chain infrastructure and quality assurance measures. Initiatives by APEDA for setting up several Centers for Perishable Cargo and integrated post-harvest handling facilities in the country attracted investments from both private and public investments. Capacity-building initiatives at the farmers, processors and exporters levels have also contributed towards enhanced export levels.





04

Key Growth Sectors under Plantation & Horticulture



4.1 Opportunities for Growth of Horticulture Sector

The importance of horticulture sector in improving farmer's income, as a stable livelihood option and earn foreign exchange through exports is well acknowledged. India's diverse agroclimatic conditions, extensive crop variety and rich genetic resources enable production of a broad range of horticultural crops throughout the year. With its vast potential and growing consumer demand, the sector offers numerous opportunities for expansion and innovation.

The major opportunities for growth in India's horticulture sector are as under:

4.1.1 Expansion of Area under Cultivation:

- Utilization of underutilized and marginal lands for horticultural purposes, particularly in arid and semi-arid regions.
- Adoption of vertical farming techniques to maximize space, especially in urban areas with limited land availability.
- Maximising intercropping of fruits, vegetables, medicinal and aromatic plants and commercial cut flowers and foliage, in existing and new plantations based on availability of adequate conditions for intercropping.

4.1.2 Export Potential:

- Horticultural crops have good export potential. Exploring and expanding into international markets by meeting global quality standards and certifications.
- Conflicts between countries resulted in disturbed supply chain worldwide.

Need for exploring new markets especially for food items, including horticulture products. Leveraging trade agreements to access new markets and increase export opportunities will enable India to be 'the key player' in horticulture export.

4.1.3 Advanced Technology:

- Modern technologies such as precision farming with tools like GPS and IoT sensors can aid in optimizing irrigation, fertilization, soil health management and pest management. It is gaining momentum, especially in high tech horticulture farms and need to be introduced to small and marginal farmers also.
- Increased usage of mechanisation and automated systems will enhance efficiency and reduce labour costs. Drone technology is being increasingly used to reduce time and labour in farm operations.

4.1.4 Improved Varieties:

- Developing and promoting high-yield, disease-resistant, and climate-resilient crop varieties through research and development can result in remarkable increase in quantity and quality of produce.
- Development of off-season varieties will ensure that farmers receive better price as also ensure year-round availability to consumers.
- Access to quality seeds timely and in adequate quantity.

4.1.5 Post-Harvest Management:

- Investments in cold storage infrastructure to significantly reduce post-harvest losses and extend the

shelf life of perishable produce. Better storage infrastructure can also prevent distress sale.

- Development of processing units for value addition, such as juices, jams, and dehydrated products. These can open new revenue streams for farmers and create jobs in rural areas.
- The list of eligible activities under Agriculture Infrastructure Fund (AIF) of Govt. of India now includes integrated primary and secondary processing projects.

4.1.6 Market Access and Infrastructure Development:

- Strengthening the supply chain by improving transportation and logistics networks to reduce the time from farm to market and to fork.
- Development of digital platforms and local markets to connect farmers directly with consumers and retailers, thereby ensuring better price realization.
- Leverage the AIF Scheme of GoI to strengthen agricultural infrastructure nationwide.

4.1.7 Sustainable Practices and Consumer Trends and Preferences:

- Promotion of organic farming techniques to meet the growing consumer demand and reduce harmful environmental impact of chemicals.
- Implementing integrated pest management practices to minimize the use of chemical pesticides and maintain ecological balance.
- Tap into the growing consumer interest in health and wellness by promoting the nutritional benefits of horticultural produce.

- Develop and market premium products such as exotic fruits and high-quality vegetables to cater to niche markets.

4.1.8 Research & Development and Skilling:

- Establish innovation centers focused on horticultural research
- Foster collaborations between government, research institutions, and private enterprises to accelerate R&D efforts.
- Provide training programs to farmers on modern horticultural practices
- Enhance agricultural extension services to offer technical support and advice on best practices.

4.1.9 Government Support and Policies:

- Mission for Integrated Development of Horticulture (MIDH) covers different sub schemes implemented by National Horticulture Board (NHB), state governments and other agencies. Utilizing different government schemes and subsidies for infrastructure development, technology adoption, and marketing support in horticulture provides immense opportunity for growth of the sector.
- Advocate for a supportive regulatory framework that simplifies procedures and reduces barriers for horticultural enterprises.
- GoI propose to extend AIF credit guarantee coverage of FPOs through the NABSanrakshan, a subsidiary of NABARD. This will help FPOs in horticulture sector to undertake up more capital-intensive operations.

The horticulture sector in India is set



for significant growth with numerous opportunities for the takers. By leveraging these opportunities and addressing challenges effectively, the sector can contribute substantially to the nation's economy and food security.

4.2 Region Specific Growth Centres/Activities

4.2.1 Southern Region:

Andhra Pradesh:

Major Produce: Andhra Pradesh ranks first in the production of chillies, cocoa, lime, oil palm, papaya, and tomato, and second in cashew, mango, and sweet orange.

Major activities: Protected cultivation practices like greenhouse and polyhouse farming, Micro-irrigation development, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce & Organic farming of major horticulture crops and integrated farming models.

Telangana:

Major Produce: Major producer of Turmeric, chillies, mango and vegetables.

Major activities: Protected cultivation practices like greenhouse and polyhouse farming, Micro-irrigation development, pandal cultivation for gourds, , spice parks, Horticulture nurseries, oil palm, promotion of agro-forestry through introduction of sandalwood, bamboo etc.

Tamil Nadu:

Major Produce: Major producer of banana, mango, flowers, plantation crops and vegetables.

Major activities: Micro-irrigation

development, Terrace gardening, vertical gardening, hydroponics, mushroom, rainfed horticulture, nurseries, palmyrah, chilli cluster development, rejuvenation and replanting in old orchards.

Karnataka:

Major Produce: Major producer of banana, mango, flowers, grapes, pomegranate, pepper, cardamom, turmeric and vegetables.

Major activities: Protected cultivation, micro-irrigation , apiculture, replacement of tobacco with horticulture crops, nurseries, oil palm .

Kerala:

Major Produce: plantation crops such as tea, coffee, rubber, cardamom and other crops such as coconut, pepper, ginger, banana, cocoa, cashew and arecanut.

Major activities: Hi-tech horticulture with focus on export, post-harvest management & Organic farming of major horticulture crops and integrated farming models, rejuvenation of old plantations.

4.2.2 Eastern Region:

West Bengal:

Major Produce: mango, pineapples, litchi, roses, gerberas, orchids, vegetables and tea.

Major activities: Protected cultivation practices, micro-irrigation , post-harvest management, micro-propagated planting materials, commercial and hybrid seed production, creation of model nurseries for quality planting materials, adoption of organic horticulture, cool chain infrastructure development, creation of water harvesting technologies in dry land areas.

Bihar:

Major Produce: mango, pineapple, litchi, guava, banana, cauliflower, cabbage, rose, jasmine and marigold.

Major activities: Protected cultivation, micro-irrigation, post-harvest management, makhana and tea.

Jharkhand:

Major Produce: mango, banana, tomatoe, brinjal and turmeric.

Major activities: Protected cultivation, micro-irrigation, post-harvest management, mushroom cultivation and apiculture.

4.2.3 Northeastern region:

Major Produce: turmeric, ginger, garlic, orchids, citrus fruits, bananas, pineapples and vegetables.

Major activities: Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, mushroom cultivation, organic cultivation of horticulture crops.

4.2.4 Northern region:

Punjab:

Major Produce: kinnow, guava, pear, potato, onion (?) and tomato

Major activities: Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation of horticulture crops

Haryana:

Major Produce: kinnow, guava, mango, potato, onion (?) and tomato

Major activities: Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation of horticulture crops, micro-irrigation, production of micro tubers in potato and introduction of new varieties and mass multiplication through tissue culture techniques.

Himachal Pradesh:

Major Produce: apple, pear, plums, cherries and vegetables.

Major activities: Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation, export-oriented floriculture units, nutrition gardens.

Uttarakhand:

Major Produce: apple, pear, plums, apricots and walnuts.

Major activities: Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation of horticulture crops, pulping units for fruits, wineries, Bee-keeping and cultivation of medicinal and aromatic crops.

Jammu & Kashmir:

Major Produce: apples, walnuts, cherries, almonds, pears, and apricots in temperate area

Major activities: High density production of apples, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce,



rejuvenation of old orchards.

Central Zone:

Uttar Pradesh:

Major Produce: banana, guava, mango, citrus, potato, onion and tomato

Major activities: Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation, micro-irrigation, medicinal and aromatic plants, bee-keeping, mushroom production, food processing and cultivation of betel-vine.

Madhya Pradesh:

Major Produce: oranges, guava, banana, potato, onion and tomato

Major activities: rainfed horticulture, protected cultivation practices, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation of horticulture crops, micro-irrigation.

Chhattisgarh:

Major Produce: mango, guava, lemon, litchi, cashew, walnut, leafy greens and chiku

Major activities: Commercial floriculture, Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, cultivation of medicinal and aromatic crops, sericulture.

4.2.5 Western Zone:

Maharashtra:

Major Produce: seedless grapes, pomegranates, onions, rose, tuberose,

chrysanthemum, gladiolus, zinnias, asters and lillia.

Major activities: High-tech horticulture like high density planting of fruits, dryland horticulture, protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation of horticulture crops, micro-irrigation, medicinal and aromatic plants, mushroom production and food processing.

Gujarat:

Major Produce: bananas, mangoes, citrus fruits, papayas, pomegranates, guavas, brinjal, okra, onions and tomatoes.

Major activities: High-tech horticulture like high density planting of fruits, dryland horticulture, Protected cultivation, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation, micro-irrigation, medicinal and aromatic plants, mushroom production, spices seed production, bee-keeping, oil palm production, coconut cultivation and establishment of kitchen garden.

Rajasthan:

Major Produce: kinnow, oranges, pomegranates, guavas, dates, spices and medicinal plants.

Major activities: Dryland horticulture, Post-Harvest Management - improving post-harvest infrastructure and practices to reduce wastage and improve the shelf life of produce, organic cultivation, micro-irrigation, medicinal and aromatic plants, seed spices – ajwain, fenugreek, fennel, edicinal crops – henna, senna seeds, nigella seeds & psyllium husk.



05

Climate Change & Horticulture



Climate Change commonly refers to influences on climate resulting from human practices. Climate change is mainly on account of increase in the concentration of greenhouse gases in the atmosphere like carbon dioxide, nitrous oxide, ozone and methane. It has direct impact on agriculture and horticulture production. Intercultural operation in agriculture, especially fossil fuel driven farm mechanisation, chemical inputs in the form of fertilizers and pesticide, etc also contributes towards emission. Among agriculture and allied activities, horticulture sector is climate friendly.

The Fourth Intergovernmental Panel on Climate Change (IPCC) report predicted that abiotic stressors like drought, hailstorms, heavy rain, floods, frost, cyclones, and other natural disasters may occur frequently with high intensity to affect farming activities. To improve production in these challenging environments, climate smart horticulture interventions are required, which require a high degree of location specificity and knowledge.

5.1.1 Impact of Climate change on Horticulture

Climate change significantly impacts horticulture, affecting both the productivity and quality of crops. Here are some key points:

5.1.2 Temperature Changes

Increased Temperatures: Higher temperatures can accelerate plant growth but may also lead to heat stress, affecting flowering and fruit setting processes. For instance, crops like tomatoes and peppers may experience flower drop and reduced fruit set due to

early temperature rises.

5.1.3 Altered Growing Seasons:

Warmer temperatures can shift growing seasons, leading to earlier planting and harvesting. This can disrupt traditional farming schedules and affect crop yields.

5.1.4 Water Availability

Higher temperatures increase evapotranspiration rates, leading to greater water demand for crops. This can strain water resources, especially in regions already facing water scarcity.

5.1.5 Changes in Precipitation Patterns:

Altered rainfall patterns can result in droughts or excessive rainfall, both of which can harm horticultural crops. Drought conditions can reduce soil moisture, while excessive rainfall can lead to waterlogging and root diseases.

5.1.6 Pests and Diseases

Warmer temperatures can expand the range and activity periods of pests, leading to increased infestations. Crops like citrus and bananas are particularly vulnerable to pest outbreaks under changing climatic conditions.

5.1.7 Disease Incidence

Climate change can also influence the prevalence of plant diseases. For example, higher humidity and temperatures can promote fungal growth, affecting crops like strawberries and lettuce.

5.1.8 Quality and Nutritional Value

Elevated CO₂ levels and temperatures can affect the quality of horticultural produce. For instance, higher ozone levels can cause leaf chlorosis and necrosis, reducing the aesthetic and nutritional

value of crops.

5.1.9 Nutritional Changes

Climate change can alter the nutrient composition of fruits and vegetables, potentially reducing their health benefits.

5.1.10 Effect on Fruit Crops

The impact of climate change on fruit crops is documented and visible in a number of ways. The impact on fruit crops ranges from altered flowering pattern, flowering time, floral numbers, fruit set, fruit retention and quality. Flowering and fruit set are also affected by reducing the numbers and activity of the pollinators which is one major threat not only to fruit production but the entire ecosystem involving the pollinators.

Mangos have a vegetative bias that affects the phenology of flowering and gets greater with temperature. Higher temperatures were correlated with a higher percentage of hermaphrodite flowers in late emerging panicles. Peak bloom period temperatures of 35°C combined with long sunny hours, low relative humidity of 49%, and heavy transpiration caused panicles to get dehydrated and suffer damage.

According to recent studies, orchards in the Shimla area, which is at a somewhat higher altitude, have switched from high-chilling apple varieties like Royal Delicious to low-chilling cultivars and other fruit crops like kiwi, pear, peach, and plum as well as vegetables. The midhills of the Shimla district are seeing a complete change away from the cultivation of potatoes and apples. It is supported by the downward trend in Himachal Pradesh's apple productivity

and snowfall.

5.1.11 Effect on Vegetable crops

Due to their succulent nature, vegetables are typically sensitive to variations in temperature and moisture content. As a result, low yields are often caused by these factors. Early in the establishment of onion crops, soil water stress resulted in a 26% production reduction. According to IPCC water stress and temperatures above 28°C caused a 30-45% bloom decrease in various tomato varieties. Drought stress affects chillies as well, resulting in a 50-60% reduction in production.

Raising the temperature of onions beyond 40°C decreased their bulb size and raising the temperature above 38°C decreased their yield. High temperatures have been shown to diminish potato marketable grade tuber yield by 10-20%, and frost damage has been shown to reduce tuber output by 10-50%, depending on the severity and timing of the damage.

5.1.12 Effect on Spices and Plantation crops

For abundant flowering, cashew needs a reasonably dry and warm winter (15-20°C minimum temperature) with moderate nighttime dew. The afternoon's high temperature (>34.4°C) and low relative humidity (<20%), which dry out the blossoms, reduce yield. Insufficient and uneven rainfall, elevated temperatures, and strong winds can cause cashew trees to produce fewer fruits, fallen leaves, and dried out flowers. In extreme cases, these factors can even cause the trees to become unproductive.

Unseasonal rains during the apple-ripening stage cause the cashew apples



on trees to rot and the nuts to become black. From January to May, cashew is severely stressed by moisture, which has a negative impact on flowering and fruit set.

At several phases of the plant's life cycle, climate fluctuations have a significant impact on oil palm production. For example, if evapotranspiration is decreased, leaf opening is delayed, and sexual differentiation is impacted. In the first and subsequent harvests, the final production will be lowered if any of these conditions are not satisfied.

5.1.13 Effects on flower crops

Melting of ice cap in the Himalayan regions will reduce the chilling requirement for the flowering of many of the ornamental plants like rhododendron, orchids, tulips, alstromeria, magnolia, saussurea, impatiens, narcissus, etc. Some of them will fail to bloom or flower with less abundance. Flowers do not open fully in tropical orchids wherever temperatures fall below 15°C. High temperature leads to flower bud drop and unmarketable spikes in tropical orchids when temperature remains > 35°C.

Commercial production of flowers, particularly grown under open field conditions, will be severely affected leading to poor flowering, improper floral development and colour. In chrysanthemum, which is a short-day plant, flowering round the year in open field condition is not possible. Low temperatures below 19°C shut down flowering in jasmine and lead to reduction in flower size.

5.1.14 Adaptation and Mitigation Strategies for Climate Resilience

Reducing soil temperature and moisture,

reserving excess agriculture land and restoring soil carbon on the areas with reduced soil quality are ways to increase soil sequestration and reduce greenhouse gas emissions from agriculture. Soil management techniques include minimized tillage, application of manure, incorporation of residues, improvement of soil biodiversity, micro-aggregation and mulching that can be highly effective in storing carbon in the soil. While certain technologies, like site-specific nitrogen management and intermittent drying, can be easily adopted by farmers without additional funding, others necessitate financial incentives and legislative support. The major strategies could be -

- Implementing new farm practices and resource-saving technologies (e.g., fruit bagging, fertigation, mulching, etc.) can be beneficial. Mango fruits bagged at the marble stage with brown paper and a scurting bag had the highest fruit retention (%), while mango fruits bagged with a newspaper bag had the highest fruit weight and were free of spongy tissue.⁷² Pomegranate fruit bagging with prgmen bags reduced fruit cracking and sunburn physiological disorders.
- Increase in Efficiency of Inputs - Developing location-specific models and protocols for soil and water conservation is imperative for the production of organic horticulture crops. Bio-mulches for moisture conservation are another option in stress situations. By improving N usage efficiency, N₂O emissions can be decreased. Water-conserving and efficient measures need to be adopted.
- Use of anti-transpirants such as

chitosane, kaolin, and others to reflect solar radiation from plant parts, thereby reducing water losses through transpiration and lowering the temperature of fruit and leaf surfaces. When compared to the other treatments, the use of 2% anti-transpirant chitosane resulted in substantially higher average finger weight, average hand weight, and bunch weight in banana.⁷⁴ Premium quality pomegranate fruits found in the terra alba (pulverised gypsum) treatment because it lowers the average fruit and leaf temperature relative to the control,⁷⁵ and kaolin treatment significantly reduce sunburn in pomegranate fruit.

- **Developing Suitable Crop Varieties** - The primary objective in maintaining yield stability should be the development of newer crop varieties with enhanced production potential and resistance to various stresses such as drought, flood and salinity (Reddy, 2015). Germplasm improvement of fundamental priority crops for heat-stress tolerance through the breeding programme should be taken up. It is imperative to supply cultivars with a diverse genetic foundation to farmers. The availability of novel kinds that are resistant to heat, salinity and drought, that could aid in their adaptation process and reduce the likelihood of climatic anomalies.
- **Use of Stress-Tolerant Rootstocks** - Plants require rootstocks in order to mediate a variety of adaptive responses that enable them to respond to abiotic challenges (Mitra and Irenaeus, 2014). Rootstock directly affect the plants' ability to

overcome various abiotic stresses in fruits

- **Adoption of Suitable Horti-based Land Use and Farming Systems** - Horti-Silvi-Pastoral System and Multi-Tier Horticultural System holds significant promises to offer a sustainable land use model. This system aims to preserve crucial resources, particularly soil, while simultaneously ensuring a satisfactory level of production for fruits, vegetables, fuel wood, lumber, fodder and other essential items.
- **Location-specific climate smart horticulture** - Climate smart horticulture is not a single specific agricultural technology or practice that can be universally applied. It is an approach that requires site-specific assessments to identify suitable production technologies and practices to address multiple challenges faced by agriculture and food systems simultaneously and holistically.
- **Increase carbon sink** - Tropical fruit trees are considered being more resistant to climate change owing to their perennial character. Annual crops can sequester between 0 and 450 kg of soil carbon per/ha, while perennial crops can sequester between 320 and 1,100 kg of soil carbon/ha and they are more likely to achieve higher yields at higher temperatures. Raising carbon sequestration in soil via soil moisture and temperature manipulation, restoring soil carbon on depleted lands and reserving excess agricultural land can all help to reduce CO₂ emissions from agriculture. Manuring, minimum tillage, residue



incorporation, mulching, micro aggregation and improving soil biodiversity can all help to sequester carbon in soil. Farmers can easily implement certain strategies, like intermittent drying and site-specific nitrogen management, with little additional investment, while others require financial inducements and policy support.

- Adoption, Analysing the Science and Fine Tuning of Indigenous technical knowledge (ITKs) - Studies in anthropology and sociology have emphasized the value of social learning and community-based resource management in enhancing people's ability to adapt to the potential impacts of future climate change. Potential indigenous methods for managing nutrients and weeds, producing crops, protecting plants and absorbing and preserving rainwater are abundant in tribal and hill knowledge systems. Utilizing this information and improving it to meet contemporary demands is imperative. People's long-standing, traditional ecological knowledge may offer opportunities for adaptation as well as useful insights.

5.1.15 Conclusion

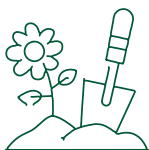
Climate change is likely to put pressure on horticultural production, limiting

the ability to procure future production targets. Changing climatic parameters have influenced growth and development, changed flowering behaviour, influenced fruit quality, and caused shifts in pest and disease incidence. Recent climate change appears to have influenced geographic distribution, local population of plants and pollinators and phenology. The key strategies for addressing this challenge will be the development of new horticultural crop varieties that are resistant to high temperatures, resistant to pests and diseases, and produce high yields under stress conditions, as well as the use of high-tech horticulture and prudent natural resource management. There is a scarcity of data on the practical effects of pests and diseases in a changing climate, which could influence future food availability by reducing productivity and quality. Plant diversity loss and area suitability issues would lead to more problems. In the face of such challenges to country's horticulture production, a plan-based strategic scientific evaluation of such impacts, as well as adaptation and mitigation strategies, should be quantified.



06

Government Programmes and interventions for Horticulture Development



6.1 Government Programmes

Several development programmes are under implementation which aims at integrated development of horticulture crops. These include:

- Mission for Integrated Development of Horticulture (MIDH)
- National Horticulture Board (NHB) programmes focusing on hi-tech horticulture and post-harvest management infrastructure, including cold storages and reefer vans. Majority of the schemes of NHB are credit-linked.
- National Medicinal Plants Board (NMPB) which coordinates with all matters relating to medicinal plants and support policies and programs for growth of trade, export, conservation and cultivation. The Board works under the Ministry of Ayurveda, Yoga & Naturopathy, Unani, Siddha & Homeopathy (AYUSH).
- National Mission on Oilseeds and Oil Palm, which includes promotion of oil palm cultivation in select areas.
- National Bee Board (NBB) for promoting bee keeping as a means to improve crop productivity.
- Setting up of dedicated “Centres of Excellence” for identified crops across different regions to promote hi-tech horticulture enterprises through demonstration, training & capacity building, technology transfer and handholding support. These CoEs also serve as source of planting material for fruits and vegetable seedlings for protected cultivation and used for transfer of technology and knowhow in diverse areas, viz., Post-Harvest management, Irrigation and Fertigation, Plant protection, Introduction of New Varieties, Pollination etc. Under the scheme, 49 CoE have been approved so far.
- Programmes / promotional schemes of commodity boards like Tea Board, Coffee Board, Rubber Board, Spices Board, for the respective crops
- MIDH - Cluster Development Programme: The Cluster Development Programme (CDP) is designed to leverage geographical specialisation of horticulture clusters and promote integrated and market-led development of pre-production, production, post-harvest, logistics, branding, and marketing activities. DA&FW has identified 55 horticulture clusters, of which 12 have been selected for the pilot phase of the CDP.
- Improvement in farm produce logistics, Introduction of Kisan Rail: Kisan Rail has been launched by Ministry of Railways to exclusively cater to movement of perishable agrihorti commodities. First Kisan Rail was started in July 2020. Under the scheme, presently, 45% subsidy is given in freight transport charges.
- Agri Infrastructure Fund (AIF): Since inception of AIF in the year 2020, an amount of Rs.32472 crore has been sanctioned for 43318 projects, out of which Rs.20102 crore has been disbursed mobilising an investment of Rs. 55248 crore in Agriculture sector. Agriculture Infrastructure Fund is a medium - long term debt financing facility scheme. Under the Scheme, an amount of Rs. One lakh crore is to be provided to the eligible

borrowers by banks and financial institutions with Interest Subvention @ 3% and Credit Guarantee facility. These infrastructures include warehouses, primary processing units, custom hiring centres, sorting & grading units, cold store projects, assaying units and other kinds of post-harvest management projects and community farming assets aimed at creating worldclass farm gate infrastructure in the country thereby ensuring minimal post-harvest losses and globally competitive quality produce.

- Clean Plant Programme (CPP) by MoA&FW, GoI, having an outlay of Rs. 1766 crore is a recent initiative to address critical issues in horticulture by providing access to high-quality, virus-free planting material. The programme is poised to deliver numerous benefits across various stakeholders, from farmers to consumers, and bolster India's position in the global fruit market. Key components of the programme are establishment of nine world-class Clean Plant Centres (CPCs) equipped with advanced diagnostic therapeutics and tissue culture labs; and implementation of a robust certification system under the Seeds Act 1966.

6.2 Mission for Integrated Development of Horticulture

With the objective to channelise renewed efforts for horticultural development in the country, Government of India launched Mission for Integrated Development of Horticulture (MIDH) in 2014. MIDH is a Centrally Sponsored Scheme for the holistic growth of the horticulture

sector covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic crops, coconut, cashew, cocoa and bamboo. While Government of India (GOI) contributes 85% of total outlay for developmental programmes in all the states except the states in North-East and Himalayas, 15% share is contributed by State Governments. In the case of North-Eastern States and Himalayan States, GOI contribution is 100%. Similarly, for development of bamboo and programmes of National Horticulture Board (NHB), Coconut Development Board (CDB), Central Institute for Horticulture (CIH), Nagaland and the National Level Agencies (NLA), GOI contribution shall be 100%.

MIDH is an umbrella scheme anchoring the following sub-schemes:

1. NHM – National Horticulture Mission
2. HMNEH – Horticulture Mission for Northeast and Himalayan Regions
3. NBM – National Bamboo Mission
4. NHB – National Horticulture Board
5. CDB – Coconut Development Board
6. CIH – Central Institute of Horticulture

MIDH is often praised to be the major developmental and promotional intervention aimed at holistic development of horticulture sector in the country. Apart from the above, MIDH works closely with National Mission on Sustainable Agriculture (NMSA) towards development of Micro-Irrigation for all horticulture crops and protected cultivation on farmers' field. It also provides technical advice and administrative support to State



Governments/ State Horticulture Missions (SHMs) for the Saffron Mission and other horticulture related activities like Vegetable Initiative for Urban Clusters (VIUC), funded by Rashtriya Krishi Vikas Yojana (RKVY)/NMSA.

6.3 National Horticulture Board (NHB)

The main objectives of the NHB are to improve integrated development of horticulture industry and to help in coordinating, sustaining the production and processing of fruits and vegetables.

Detailed objectives of the Board are as under:-

- i. Development of hi-tech commercial horticulture in identified belts and make such areas vibrant with horticultural activity, which in turn will act as hubs for development of horticulture.
- ii. Development of modern post-harvest management infrastructure as an integral part of area expansion projects or as common facility for cluster of projects.
- iii. Development of integrated, energy efficient cold chain infrastructure for fresh horticultural produce.
- iv. Popularization of identified new technologies/tool/techniques for commercialization / adoption, after carrying out technology and need assessment.
- v. Assistance in securing availability of quality planting material by promoting setting up of scion and root stock banks / mother plant nurseries and carrying out accreditation / rating of horticulture nurseries and need based imports of

planting material.

- vi. Promotion of Farm Mechanization in Horticulture through demonstration and its uses at farmers field level to reduce labour cost and increase the productivity of Horticulture crops.
- vii. Promotion of applied R & D for standardizing post-harvest management protocols, prescribing critical storage conditions for fresh horticulture produce, bench marking of technical standards for cold chain infrastructure etc.
- viii. Transfer of technology to producers/ farmers and service providers such as gardeners, nurserymen, farm level skilled workers, operators in cold storages, work force carrying out post-harvest management, including processing of fresh horticulture produce and to the master trainers.

6.3.1 National Horticulture Board (NHB) Schemes:

National Horticulture Board implements programmes as sub-scheme of Mission for Integrated Development of Horticulture (MIDH). NHB also houses the national level TSG under MIDH including NHM and NBM and extend administrative, logistical and personnel support towards their implementation. The schemes being implemented by NHB are given as under:-

I. Development of Commercial Horticulture through Production and Post-Harvest Management of Horticulture Crops

- a. Commercial Horticulture Development in open field conditions on project mode
 - i. Activity (ies) allowed and Area norms: Integrated commercial horticulture development projects in open

field conditions on project mode, including components viz planting material, plantation, irrigation, fertigation, mechanization, precision farming, GAP etc. for projects covering area over 2.00 ha. (5 Acres). In case of NE Region, projects having area over 1 ha (2.5 acres) are eligible.

- ii. Crops eligible: Can be seen from cost norms of Open field cultivation under NHB scheme.

b. Commercial Horticulture Development in protected cover on project mode

- i. Activity (ies) allowed and Area norms: Commercial horticulture development projects under protected cover on project mode including components viz planting material, plantation, irrigation, fertigation, mechanization, etc for projects having area over, 2500 sq meter. In case of NE Region, projects having area over 1000 sq meter are eligible. Activities like construction of green houses, shade net house, plastic, mulching, and plastic tunnel, anti bird /hail nets etc are promoted. Provision has been made for selecting a variety of construction material for green houses and shade nets houses. Preference to using locally available material to minimize cost of construction of such structures

- ii. Crops eligible: Flowers: Anthurium, Orchids, Rose, Lilium, Chrysanthemum, Carnation and Gerbera.; Vegetables: High value vegetables: Capsicum, Cucumber, Tomato

Pattern of assistance: In both a and b schemes mentioned above the Pattern of assistance is Credit linked back-ended subsidy @ 40% of the total project cost

limited to Rs 30.00 lakh per project in general areas and @ 50% of project cost limited to Rs. 37.50 lakh in NE Region, Hilly States and scheduled areas.

c. Integrated Post Harvest Management projects

- i. Activity (ies) allowed: Integrated Post Harvest Management projects relating to Pack House, Ripening Chamber, Refer Van, Retail Outlets, Pre- cooling unit, Primary processing etc. NHB also takes up projects in component mode and for standalone projects of PHM components.
- ii. Crops eligible: In case of primary processing, projects related to Fruits, Vegetables, Flowers, Aromatic plants and Cashew are only eligible for subsidy.
- iii. Pattern of assistance: Credit linked back-ended subsidy @ 35% of the total project cost limited to Rs 50.75 lakh per project in general area and @ 50 % of project cost limited to Rs. 72.50 lakh per project in NE Region, Hilly States and Scheduled areas.

II. Capital Investment Subsidy Scheme for construction/ expansion/ modernization of Cold Storages/ Storages of Horticulture Products

- a. Components Credit linked projects relating to Cold Storages including Controlled Atmosphere (CA) and their modernization are eligible for assistance under this component.

- b. Infrastructure/Activity and Crops eligible: Assistance for setting up of new Cold Storage infrastructure will be available only to multi-chamber cold Storage units with technologies which are energy efficient with provision of thermal insulation, humidity controlled,



advance cooling systems, automation, etc, having specification and standards approved by the Ministry. To ensure, compliance of notified standards, all projects will be subjected to technical scrutiny by NHB empaneled Technical appraisal agency. ; In case of CA Stores, projects of temperate fruit crops located in production areas for which to NHB protocols are available, are only allowed.

c) Capacity and Pattern of Assistance: - The assistance will be given as subsidy @ 35% of the capital cost of project in general areas and 50% in case of NE, Hilly States & Scheduled Areas for a storage capacity above 5000 MT up to 10000 MT. In case of North-East states, projects with a capacity of 1000 MT or above are also eligible for application and consideration.

III. Technology Development and Transfer for promotion of Horticulture

Projects for popularization of identified new technologies/tools/techniques for commercialization/ adoption shall be undertaken through following sub-components of the scheme:-

Components:

- i. Setting up of block/mother plant and root stock nursery (Area above 4 ha)
- ii. Acquisition of technologies including import of planting material from other countries for evaluation and mass multiplication in order to increase production & productivity of horticulture crops
- iii. Import/procurement of machines and Tools for horticulture for demonstration purpose
- iv. Development & Transfer of Technology
- v. Long Distance Transport Solution

- vi. Product Promotion and Market Development Services- Horti-fairs
- vii. Exposure visits of farmers (Outside State)
- viii. Visit Abroad for Government Officers
- ix. Organization/Participation in Seminar/symposia/workshop for development of horticulture
- x. Accreditation and Rating of Fruit Plant Nurseries

Note: Description on each component, pattern of assistance and other scheme/component details can be accessed at https://www.nhb.gov.in/tech_div_transfer_scheme_guideline.aspx?enc=3ZOO8K5CzcdC/Yq6HcdlxErQ5utN8LLGWEtR9yfNUQg=

IV. Market Information Scheme for horticulture Crops: The scheme is being implemented with following objectives.

- i. To generate information on wholesale prices, arrivals and trends in various markets of the country for important fruits, vegetables & flowers etc and also on retail prices for increased number of selected markets
- ii. To analyze the trends of arrivals, prices and other related factors of the selected fruit and vegetables such as stock in storage, crop stand etc and generate Market Intelligence Reports
- iii. To establish a nation-wide communication network for speedy collection and dissemination of market information data for its efficient and timely utilization.
- iv. To prepare farmers' advisory and issue the same for the benefit of producer farmers especially by making use of statistics so generated

and collected for optimizing returns to the producers

- v. To collect and compile horticulture database and strengthen existing system of 'Crop Estimation Survey- Fruits & Vegetables' (CES-F&V) as far as possible
- vi. Information dissemination through publicity, advertisements, films, printed literature etc.
- vii. Development of technology packages in electronic form to be shared through IT

More Details of the scheme can be accessed at https://www.nhb.gov.in/market_Info_Service.aspx?enc=3ZOO8K5CzcdC/Yq6HcdIxlvCz3h4o20BpGYoMJgsxhU=

V. Horticulture Promotion Services / Expert Services:

Under this component, specialized studies and surveys shall be carried, and study / survey reports shall be brought out for use by targeted beneficiaries. In addition, technical laboratories shall be set up or cause to be set up and also provide technical services including advisory and consultancy services. This shall be done by NHB.

More Details of the scheme can be accessed at https://www.nhb.gov.in/horticulture_promotion_service.aspx?enc=3ZOO8K5CzcdC/Yq6HcdIxLxpICcF7pFyMdtTpWI8ME4=

6.4 National Medicinal Plants Board (NMPB)

NMPB is implementing a Central Sector Scheme for Conservation, Development and Sustainable Management of Medicinal Plants. The main objectives of the scheme are as follows:

- i. Promote in-situ conservation of medicinal plants which are important to the AYUSH and Folk systems of medicine.
- ii. Promote ex-situ conservation by supporting such programs in rural/ degraded forest/ public/non-public/ institutional lands/ urban & peri-urban lands and waste lands.
- iii. Promote R&D in all aspects of medicinal plants, development of agro-techniques, post-harvest management, storage and processing, developing molecular characterization tools etc. and promotion of IT.
- iv. Mapping, upgrading, modernizing of medicinal plants supply chain and creating/ optimizing market linkages and value addition.
- v. Quality standardization, Good Collection Practices (GCPs) and Good Agricultural Practices (GAPs) for medicinal plants.
- vi. Promote mainstreaming of medicinal plants in climate change mitigation strategies & promote regeneration/ afforestation of medicinal plant tree species towards carbon sequestration.

The component-wise details of the schemes being implemented by NMPB are as under:-

- i. Conservation: Under this component support for In-Situ Conservation, Ex-Situ Conservation and Support to JFMC's / BMCs / Van Panchayats are provided to eligible entities.
- ii. Research and Development: NMPB supports Research & Development activity on various aspects of medicinal plants. Project based



financial assistance is provided to various research organization/institutions for Research & Development on medicinal plants.

- iii. Herbal Gardens: Herbal Gardens are promoted under the NMPB scheme to create awareness about traditional usage of medicinal plants. Herbal Garden like Home Herbal Gardens, School Herbal Gardens, Institutional/ Public Herbal Gardens, Herbal Gardens of State and National Importance are promoted under this component.
- iv. Information, Education and Communication (IEC): NMPB involve in IEC activities for disseminating the traditional knowledge among the masses with the objective of spreading awareness about Medicinal Plants. NMPB provides the financial assistance to IEC activities as per operational guidelines mentioned in Central Sector Scheme of NMPB.
- v. Marketing and Trade: Proposals from reputed agencies having experience in in the field on medicinal plants considered in project mode for commissioning studies relevant for the sector promotion.

International Cooperation Support to various activities for international cooperation

The details on the scheme can be accessed at Scheme Components | National Medicinal Plants Board|Government of India (nmpb.nic.in)

Voluntary Certification Scheme for Medicinal Plant Produce (VCSMPP): In order to encourage Good Agricultural

Practices (GAP) and Good Field Collection Practices (GFCP) in medicinal plants and enhance quality and safety of these plants, the NMPB, in collaboration with the Quality Council of India (QCI), has launched a Voluntary Certification Scheme for Medicinal Plant Produce (VCSMPP). The details on the same can be accessed at Voluntary Certification Scheme for Medicinal Plant Produce (VCSMPP) | National Medicinal Plants Board|Government of India (nmpb.nic.in)

6.5 National Mission on Oilseeds and Oil Palm (NMOOP)

The National Mission on Oilseeds and Oil Palm (NMOOP) was launched by the Government of India to boost the production of oilseeds and palm oil, reduce the country's dependence on imports, and ensure self-sufficiency in edible oils. It is now part of the National Mission on Edible Oils - Oil Palm (NMEOP), which has a broader focus on palm oil production, particularly in India's North-Eastern states and the Andaman and Nicobar Islands, where climatic conditions are ideal for palm cultivation.

India's vegetable oil consumption is expected to reach approximately 26 to 27 million tonnes by 2025-26. In the 2022-23 period, consumption was around 22.85 million tonnes, reflecting a slight increase compared to the previous year. India is one of the largest importers of vegetable oil, primarily palm oil, with imports of around 14 million tonnes during the 2022-23 season. Palm oil dominates the market, accounting for about 33% of the total edible oil consumption, followed by soybean, rapeseed, and sunflower oils.

Looking ahead, India's domestic

vegetable oil production is projected to grow, although the country will continue to rely heavily on imports to bridge the gap between domestic demand and supply. Palm oil remains the leading imported vegetable oil, followed by soybean and sunflower oils. The increasing demand is driven by a growing population and a shift towards healthier oils.

Considering the growing domestic demand for edible oils, the staggering deficiency and the cost to the exchequer on account of imports, National Mission on Edible Oils - Oil Palm (NMEO-OP) was approved with the aim to enhance the edible oilseeds production and oils availability in the country by harnessing Oil Palm area expansion, increasing Crude Palm Oil (CPO) production and to reduce import burden on edible oils. At present against a total potential area of around 28 lakh hectares, only 3.70 lakh hectares is under oil palm cultivation.

The target fixed for Oil palm area expansion by 2025-26 under NMEO-Oil palm is given below:

1. To increase area of oil palm to 10 lakh hectares from 3.5 lakh ha during 2019-20 by 2025-26 (additional 6.50 lakh ha) of which it is targeted 3.22 lakh hectares for general state and 3.28 lakh ha in North-Eastern states with targeted FFBs production of 66.00 lakh tonnes.
2. To increase in CPO production from 0.27 lakh tonnes during 2019-20 to 11.20 lakh tonnes by 2025-26.
3. Increase consumer awareness to maintain consumption level of 19.00 kg/person/annum till 2025-26.

Strategy

The strategy to implement the proposed NMEO-OP will include increasing production of seedlings by establishment of seed garden, nurseries of oil palm to assure domestic availability of seedlings as per target fixed under NMEO-OP. Improving productivity of FFBs, increasing drip irrigation coverage under oil palm, diversification of area from low yielding cereals crops to oil palm, inter-cropping during gestation period of 4 years, would provide economic return to the farmers when there is no production. The scheme would be implemented in a mission mode through active involvement of all the stakeholders.

6.6 Centres of Excellence

Considering the need to promote horticulture, Centres of Excellence (CoEs) have been identified for various horticultural crops which can be of demonstrative effect for promoting horticulture. Under the Mission for Integrated Development of Horticulture (MIDH), the Government of India has approved 49 Centers of Excellence (CoEs) across various states. These CoEs serve as hubs for the demonstration and dissemination of advanced technologies in horticulture, focusing on areas such as post-harvest management, irrigation, fertigation, plant protection, and new crop varieties. They also provide training and quality planting material to farmers. Maximum eligible cost for setting up of CoE is Rs.1,000.00 lakh per centre with 100% assistance to be established only in public sector. The CoE can be established through bilateral cooperation also.

Recent additions include:



1. CoE for Kamlam (Dragon Fruit) in Bengaluru, Karnataka, focusing on high-yield production and self-sustaining Kamlam fruit cultivation.
2. CoE for Mango and Vegetables in Jajpur, Odisha, which integrates Israeli technology for nursery management and precision agriculture.
3. CoE for Vegetables and Flowers in Goa, which emphasizes hi-tech nursery management and post-harvest quality production.

These centers aim to boost productivity, improve quality, and train farmers on the latest horticultural practices.

A photograph of a man standing in a field of young palm trees. The man is wearing a light blue t-shirt and dark blue jeans. He is standing in the center of the frame, with several palm trees around him. The ground is covered with green grass and some dry leaves. The background shows more palm trees and a clear sky.

07

**Thrust areas / Hi-tech
horticulture enterprises for
development with credit**



Considering the emerging opportunities, growth potential due to widening market opportunities and relatively higher profitability, the following activities are considered as the thrust areas for promotion with institutional credit support.

1. Protected cultivation
2. Organic farming
3. Precision farming
4. Integrated Value chain financing
5. Integrated Cold chain infrastructure for perishables
6. Fruit & Vegetable processing

7.1 Credit Linkages

Since investments in these thrust areas are highly capital-intensive, with long gestation periods, facilitating institutional credit assumes significance. Several of the interventions and incentives under government programs facilitate an enabling environment for investments in critical infrastructure and offer scope for convergence with credit plans of financial institutions.

7.2 Approach for Augmenting Credit Flow for P&H Sector

- Innovative Credit Products: To cater to diverse credit needs of plantation and horticulture sector activities.
- Crop/Activity Specific Banking Plans: Area Development Plans dovetailed with government-sponsored programs like MIDH (Mission for Integrated Development of Horticulture) and NMOOP (National Mission on Oilseeds and Oil Palm).

- Incentives for Smallholders: Bringing smallholders into high-value horticulture production through incentives and group/cluster approaches.
- Extension and Capacity Building: Investments in extension services, capacity building, and hand-holding support to enhance productivity.
- Investment in Post-Harvest Infrastructure: Addressing gaps in post-harvest management through investments by the private sector or in PPP (public-private partnership) mode.
- Risk Mitigation: Focus on integrated farming models, crop-specific insurance products, and mandatory insurance coverage to mitigate risks.
- Promotion of Dry Land Horticulture: Through micro-irrigation systems like drip irrigation.



08

Challenges



India's population is projected to reach 2 billion (source please) by 2050, which will significantly increase the pressure on the horticulture sector to meet the rising demand for fruits and vegetables. This demand is expected to rise to 450 million ton, up from the current production level. Additionally, the growing demand for processed products, where a 1% increase in processing equates to an extra 2.5 to 3 million ton of fruits and vegetables, combined with expanding export needs, could push total demand to around 540 million ton by 2050. Consequently, the challenge over the next three decades is to nearly double the production of fruits and vegetables from the current level. However, several challenges accompany this growing demand, as highlighted below:

(A) Inadequate Extension Work: The future of horticulture will be knowledge and information intensive, leading to an exponential growth in farmers' demand for information on seeds, fertilizers, agronomic practices, weather forecasts, markets, prices, trade, etc. However, currently, the outreach of the formal extension system (including government extension systems, research institutes, agricultural universities, mass media and ICTs) is limited. Public extension services have been unable to meet the needs of the diverse and smallholder-dominated Indian agricultural sector. Increased private sector participation is crucial for last mile reach of latest technology & innovation. Restructuring extension services is essential for developing the sector into a major source of growth in the Indian economy. There is a lack of adequate understanding and coordination between different organizations involved in allied activities.

The absence of effective extension services means that farmers are less likely to adopt modern technologies and innovations that could enhance yields and improve quality, leading to stagnation in horticultural production.

(B) Low Productivity: A notable concern in Indian horticulture is the sub-optimal productivity of fruits, vegetables, flowers, and medicinal crops. For instance, the average productivity of fruit crops is 14 MT/ha in India compared to many leading fruit producing countries [Indonesia (25.4 MT/ha), U.S.A (22.4 MT/ha), Brazil (16.1 MT/ha), Italy (15.6 MT/ha)]. In case of vegetables, the productivity in India is around 18.46 MT/ha for the past several years which is much below the productivity of several leading vegetable producing countries [Spain (38.9 MT/ha) U.S.A (39.02 MT/ha), Egypt (24.66 MT/ha), Russia (22.16 MT/ha)], (As per Horticulture at Glance 2021). The primary factors contributing to this low productivity include the lack of use/availability quality planting material, depleting natural resources, resource-limited farmers, and insufficient adoption of modern technologies. Addressing this issue requires a strategic approach to enhance productivity by improving factor productivity across all horticultural production inputs while ensuring sustainability through the implementation of good agricultural practices and precision farming principles.

- i. Indian agriculture is predominantly characterized by smallholder farming, with over 82% of agricultural holdings classified as small and marginal. The average size of landholdings has steadily decreased over time, from 2.28 hectares in 1970-

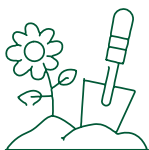
71, to 1.55 hectares in 1990-91, 1.23 hectares in 2005-06, and currently stands at 1.08 hectares in 2015-16 (Number of Operational holdings as per Agriculture Census 2015-16). If this trend continues, the average size of a landholding in India could reduce to a mere 0.3 hectares by 2050. This reduction in farm size will create more pressure on land use, especially for growing fruits and vegetables, making it harder to meet the expected production needs. On top of that, managing the natural environment is becoming more challenging, with soils losing nutrients and organic matter, irregular rainfall, dropping groundwater levels, and worsening water quality. Even in areas with good arable land, the problems of land and water degradation remain daunting

challenges to maintaining long-term productivity.

- ii. **Inadequate Access to Irrigation Water and Poor Soil Management Practices:** Insufficient access to water for irrigation, combined with poor soil management practices such as over-tilling, excessive fertilization, and mono cropping, can significantly reduce soil fertility, resulting in lower yields and diminished quality of produce. The lack of proper irrigation, particularly during dry spells or drought conditions, can be detrimental, as crops may wither and die due to inadequate water supply. Conversely, the overuse of water can also have adverse effects, leading to waterlogging, root damage, and a subsequent reduction in crop yields.

(C). Major Crop Specific Problems:

Crop	Problems
Fruit crops	- Long gestation period - Predominance of senile orchards (e.g. apple, mango) - Lack of technology to manage issues like spongy tissue, alternate bearing, and malformation in mango, wilt in guava, decline in citrus, bacterial blight in pomegranate and powdery & downy mildew in grapes. - Unavailability of location-specific technologies.
Vegetable crops	- High cost of production due to labor-intensive methods - High hybrid seed costs - Risk-intensive production system - Lack of low-cost greenhouses for quality production - Supply and demand profile fluctuates with season, year, and vegetable type
Potato	- Lack of varieties for diverse processing problems - Low seed multiplication rate - Rapid variety deterioration due to viral complexes - Lack of cold storage space and low-cost short-term storage - Late blight in potato



Mushroom	- Cost-ineffective technology - Lack of low-cost mushroom house designs - Inadequate availability of quality spawns - Huge untapped potential in which mushroom like Lion's mane, Shitake, Ganoderma, Cordyceps etc. Local demand is mostly being met through inputs.
Tuber crops	- Slow multiplication rate - Poor pest and disease management, e.g., sweet potato weevil and cassava mosaic
Floriculture	- Lack of indigenous production techniques - Hybrids being underutilized - Narrow product range - High tariffs by importing countries
Medicinal & Aromatic plants	- Secretive trade due to lack of regulatory mechanisms - Few plants under cultivation
Spices	- Lack of host resistance variability for biotic and abiotic stresses - Severe crop losses due to diseases and pests - Monsoon vagaries affect crop growth, productivity, and sustainability
Coconut	- Large area of old and senile plantations - Rain-fed cropping - Prevalence of pests and diseases like root-wilt, ganoderma wilt, red palm weevil
Arecanut	- Disease incidence like yellow leaf disease - Lack of irrigation facilities
Oil palm	- Poor water management in palm orchards
Cocoa	- Large areas of old and senile plantations - Lack of high-yielding clones - Black pod rot persists as a problem - Farm-level processing is inadequate
Cashew	- Increasing senility of plantations - Poor pest management, e.g., tea mosquito bug and stem borer - Inadequate farm-level processing
Tea	- Old age of tea bushes - Slow replanting pace - Poor drainage and irrigation facilities - Stagnant productivity and high land-labor ratio
Coffee	- Large number of tiny growers with small holdings - Old, moribund plant material resistant to replanting with new varieties

(D) Post-Harvest Losses

Horticulture production has reached around 334.60 million ton in W2020-21. Despite abundant production, an estimated 10-40% of fruits and vegetables are lost between harvest and consumption due to several factors including perishability of the crop, inadequate infrastructure, sub-par transportation, and limited knowledge of post-harvest handling, market inefficiencies, and technological gaps. These losses have profound consequences, spanning economic setbacks for farmers, compromised food security, environmental degradation, and market.

(E) Value Addition

Horticultural crops are ideal for value addition because they are more profitable, have a high degree of process ability, are rich in health-promoting compounds, and have a higher potential for export. India, as the second-largest producer of fruits and vegetables, processes only 10 percent of its horticultural produce. However, in other developed and developing countries, 40-80 percent of the produce is value-added. This gap is generally caused by factors such as quality downgrading due to handling, physiological spoilage (rooting and sprouting), pathological spoilage from pests and diseases, and market oversupply.

(F) Changing Focus on Quality and Global Competition

Horticultural crops are rich in essential nutrients and minerals that are important for health and nutrition. As the purchasing power of the Indian population increases and consumers become more focused on health and

quality, it is crucial to ensure that horticultural produce is safe and of high quality. Additionally, there is a growing demand for high-quality processed products. With changes in global trade, India must also produce horticultural crops that meet international standards. One of the key challenges is the lack of proper quality monitoring systems for the domestic market, which needs to be addressed.

(G) Climate change

In the light of a changing climate and a growing population, ensuring food security is a topic of global discussion. The global population is projected to reach nine billion by the end of 2050, and therefore increasing agricultural productivity is the need of the hour. In the face of more pressing environmental issues, the need to address climate change has sparked a search for novel ways to mitigate its consequences. Climate change is a major environmental concern with profound implications for the horticulture sector. Rising global temperatures, driven by greenhouse gas emissions, could lead to challenges such as heat stress during key growth phases, excessive moisture from extreme rainfall, and increased outbreaks of pests and diseases, including the emergence of new ones. Higher temperatures may also exacerbate water stress by increasing evapotranspiration rates. Shifts in seasonal temperatures could alter agro-ecological zones, creating new regions suitable for horticulture. As a result, climate change will have a substantial impact on the productivity, yield, and quality of horticultural crops.

Some of the effects of climate change noticed in India in major horticulture crops are given as under:



- Early or delayed flowering, multiple reproductive flushes, variations in fruit maturity, abnormal fruit set and transformation of reproductive buds into vegetative ones, leaf scorching and twig dying in Mango.
- Fruit fly in guava is becoming alarming due to hot and humid conditions.
- The crop like apple, peach, plum, apricot which requires low chilling temperature also showing sign of decline in productivity in their natural growing areas due to increase in temperature during critical growth period.
- Under vegetables, recent impact of climate change includes advancement of appearance of aphids by 2 weeks in crops like potato due to increase in temperature. Onion crop farmers in Maharashtra are also facing reduction in bulb size due to temperature variation.

(H) Carbon Sequestration

Globally, approximately 120 giga-tons (Gt) of carbon are sequestered annually through plant photosynthesis, with horticultural crops playing a significant role. Perennial fruit trees, gardens, and similar plant systems can store 25–100 times more carbon in their biomass compared to traditional agricultural fields. However, there are several opportunities to use the carbon stock and sequestration capacity in the soil of different ecosystems, but there are a number of obstacles. The sequestration potential of different horticulture crops varies in accordance with their biomass, though measuring carbon is not much easier due to the involvement of complex variables (composition may vary due to soil

type, microclimate, etc.) This assessment requires the complete harvesting of trees and the measurement of different parts. Additionally, measuring the biomass below the ground is laborious, time-consuming, resource-intensive, and expensive due to the presence of deep root systems.

(I) Market Linkage and Price Fluctuations:

The horticulture marketing chain faces its own set of challenges due to the perishable nature of fruits and vegetables, which makes it difficult to store and transport them efficiently. Poor logistics and lack of equitable cold storage and warehousing facilities contribute to delays and wastages. As per the study conducted by NABARD Consultancy Services (NABCONS) in 2015 on “All India Cold-chain Infrastructure Capacity (AICIC-2015)”, required capacity of cold storages at that time was 351.00 lakh MT against the existing capacity of 318.2 lakh MT in 2014. As per available information, currently there are 8653 cold stores in country with capacity of 394.17 lakh MT. However, Cold storage units are concentrated in states like Uttar Pradesh, West Bengal, Punjab, and Gujarat, whereas regions with high horticulture production, like the North-East and Southern states, face a shortage of such facilities. TOP crops (Tomato, Onion & Potato) have a short shelf life because of the absence of storage and warehousing facilities, which causes price fluctuation every year. Also, there is an urgent need to establish multipurpose cold storages across India as about 75 percent of the current capacity is suitable only for potato storage. Although it requires heavy initial investments but the long-term returns can be rewarding.

Inadequate post-harvest support in the form of warehouses (cold or controlled atmospheric) near the farm is one of the key ailments of the sector. Private investment in value chains can address some of the infrastructural bottlenecks. There is also a lack of guidance for farmers on which crops to plant, resulting in overproduction of certain commodities and shortages of others. Establishing appropriate supply chain mechanism and upgradation of market infrastructure facilities for obtaining information on fluctuating prices poses a major threat for horticultural producers in realizing higher returns.

The horticulture sector also suffers because of weak Farmer Producer Organisations (FPOs), which typically play a vital role in the development of the horticulture sector by providing farmers with access to markets, financing, and technical assistance. Lacking in linkage with marketing platforms (i.e. NCDEX, e-NAM). The weakness of these organisations contributes to the sector's challenges, limiting farmers' ability to benefit fully from the opportunities available.

(J) Challenges in Horticulture Exports Sector

(i) Backward Integration

- i. The backward integration in India especially for perishables is inefficient and unorganized, resulting in quality and longevity issues.
- ii. From the export perspective, the importing nations are becoming more and more stringent with respect to the production norms/traceability at the farm level.

(ii) Training & Skill development at

farm level

- a. Unregulated input (chemicals) usage at the farm level.
- b. Inadequate harvest and post-harvest management affects quality and shelf life of the produce
- c. Infrastructure and Logistics
- d. The connectivity of the land locked production areas to the ports or terminals is a stiff challenge. Eg. Bihar, Jharkhand, NE states and hilly regions like Himachal Pradesh, Uttarakhand and J&K.
- e. The link roads from farms to the main road is underdeveloped in most of the states. Congestion at the ports due to high waiting periods of the shipment.
- f. Since, the commodities are perishable in nature, availability of containers at the optimum time at the ports is critical.
- g. Volatile freight rates in the peak season.

(K) Phytosanitary Challenges

The Indian horticulture industry faces several significant phytosanitary challenges that affect the export of fruits and vegetables to international markets. These challenges revolve around meeting the strict plant health and safety standards required by importing countries. Key phytosanitary challenges include:

- **Pest and Disease Management:** India's diverse climate and agricultural practices make it susceptible to various pests and diseases. Exporting countries have strict regulations to prevent the introduction of pests, such as fruit



flies, fungi, and nematodes. India's challenge lies in ensuring that its fruits and vegetables are pest-free and meet international quarantine requirements.

- **Pesticide Residue Levels:** Many countries impose strict Maximum Residue Limits (MRLs) for pesticides in imported horticultural produce. Inconsistent use of pesticides and inadequate adherence to recommended guidelines in India often result in produce exceeding these limits. This can lead to rejected shipments, market bans, or the imposition of stricter controls on Indian exports.
- **Lack of Infrastructure for Post-Harvest Treatment:** International markets often require specific post-harvest treatments, such as fumigation, heat treatment, or irradiation, to eliminate any pests or diseases in the produce. In India, the availability of advanced infrastructure and facilities for such treatments is limited, especially for small and medium-scale farmers, making it difficult to meet the phytosanitary requirements of importing countries.
- **Poor Quality Control and Traceability:** Indian horticultural exports face challenges in maintaining consistent quality control and traceability. Many international markets require detailed records of the production process, including the use of pesticides, fertilizers, and post-harvest handling. The absence

of a robust traceability system increases the risk of non-compliance with global standards.

- **Lack of Phytosanitary Certification Awareness:** Smallholder farmers, who constitute a large part of Indian agriculture, often lack awareness of international phytosanitary requirements. This results in improper documentation and the inability to meet the certification requirements for export. Additionally, there is limited access to trained professionals who can inspect and certify produce for phytosanitary compliance.
- **Varying Standards of Importing Countries:** Different countries have different phytosanitary standards, making it challenging for Indian exporters to comply with a broad range of regulations. The cost and effort required to meet varying international standards, such as the European Union's stringent rules or the United States' Food Safety Modernization Act (FSMA), present hurdles for many exporters.
- **Erratic Enforcement of Domestic Phytosanitary Regulations:** While India has phytosanitary laws in place, their enforcement is sometimes inconsistent, particularly at the farm level. This leads to gaps in compliance with international standards, ultimately affecting the competitiveness of Indian horticultural exports in the global market.



09

Approaches



To address the challenges in Indian horticulture, the following approaches may be adopted

Enhancing Crop Productivity

- a. Consolidation and Management of Horticultural Genetic Resources: Efficiently catalogue and manage genetic resources using AI and ML.
- b. Development of Improved Varieties/ Hybrids: Use conventional breeding and advanced techniques like marker-assisted breeding, in vitro methods, transgenic technology, and CRISPR for stress resistance.
- c. Application of Space Technology: Utilize satellite imagery and remote sensing to improve yield potential and productivity.
- d. Agro-techniques for Improved Productivity: Implement methods for better canopy architecture and high-density planting to optimize light interception and photosynthesis.
- e. Efficient Techniques for Quality Seed/Planting Material Production: Develop methods for producing high-quality seeds and planting materials.
- f. Maintenance Breeding and Supply: Ensure the supply of adequate quantities of breeder seed and mother plant material.
- g. Multiplication and Distribution of Quality Seed and Planting Material: Ensure traceability and quality assurance in the distribution process using blockchain technology.

Enhancing Crop Productivity through Efficient Resource Management

- a. Protected Cultivation and Vertical

Farming: Optimize resource use in protected cultivation and vertical farming using IoT for climate control.

- b. Breeding for Protected Cultivation and Mechanized Farming: Develop varieties suitable for these conditions.
- c. Technologies for Aeroponics, Hydroponics, and Soilless Culture: Implement real-time monitoring and management of these systems using IoT.
- d. Efficient Water and Nutrient Management Systems: Develop automated micro-irrigation and fertigation systems.
- e. Precision Farming Techniques: Implement crop-specific nutrient management, farm mechanization, and energy management using precision farming tools.
- f. Application of GIS/Remote Sensing: Use GIS and remote sensing for diagnosing nutrient deficiencies and optimizing resource use.

Enhancing the Quality of Horticultural Produce

- a. Breeding for High Nutritive, Aesthetic & Medicinal Value: Develop varieties with high nutritive, aesthetic, and medicinal value.
- b. Breeding for Improved Shelf-life: Develop varieties with extended shelf-life.
- c. Technologies for Organic Production: Implement methods for monitoring and managing organic fruit and vegetable production.
- d. Crop Production Management: Use analytics to enhance the quality of horticultural produce.

Evolving Sustainable and Climate-Resilient Technologies

- a. Integrated Horticulture-Crop Based Farming Systems: Adapt climate-resilient technologies for farming systems.
- b. Phenotyping Germplasm for Stress Tolerance: Develop stress-tolerant genotypes and rootstocks using AI and ML.
- c. Genomic Studies: Understand genetic variation in stress tolerance traits using genomic tools.

Minimizing Post-Harvest Losses

- a. Integrating Pre- and Post-Harvest Protocols: Implement real-time monitoring and management to minimize post-harvest losses using IoT.

- b. Value-Addition and Product Diversification: Identify opportunities for value addition and product diversification.
- c. Utilization of By-products and Waste: Optimize the use of by-products, residues, and horticultural waste for value-added products.

Marketing

- Efficient Linkages and Strategies: Develop alternate marketing arrangements, market intelligence, and price forecasting using AI and ML.
- Returns on Investment and Total Factor-Productivity Studies: Conduct comprehensive studies on returns on investment and total factor productivity.



10

**Role of NABARD in
development of P&H Sector**

NABARD as an apex development bank is playing prominent role in development of horticulture sector through credit. The strategic action plan for enhanced role of NABARD in development of Horticulture sector is given below:

- a. Mapping potential and credit planning
- b. Enhancing the credit delivery and linkage of financial assistance schemes of GOI
- c. Facilitating credit absorption at ground level- Area Development Projects/banking plans, etc.
- d. Capacity building of banks/ credit institutions
- e. Capacity building and promoting producers' organization/collectives
- f. Piloting innovations through technology transfer
- g. Promoting dry land horticulture through watershed approach
- h. Climate resilient Horticulture and climate change adaptation
- i. Marketing-building brands, industry linkages etc.
- j. Promoting food processing at all levels (primary, secondary or tertiary)
- k. R&D support for applied research and field demonstration of adoptable technologies



11

Technological Innovation in Horticulture Sector

1. Protected Cultivation Technologies

1.1 Protected Cultivation of Vegetable Crops for Sustainable Food Production

With the increasing population, urbanization, and industrialization, feeding millions in India is becoming a challenge. Protected cultivation of vegetables, using structures like greenhouses, offers a promising solution. This method can significantly boost productivity and cropping intensity, producing three to ten times higher yields compared to open cultivation. The advantages are

- **Year-Round Production:** Enables continuous cultivation, overcoming adverse climatic conditions.
- **High-Quality Produce:** Produces clean, healthy, and high-quality vegetables.
- **Water Efficiency:** Saves water and is environmentally friendly.
- **Employment Opportunities:** Provides jobs, especially in peri-urban areas.

Suitable Crops:

High-value crops like tomato, cherry tomato, capsicum, and parthenocarpic cucumber thrive under protected cultivation. Varieties developed by public sector research organizations have shown promise.

Challenges:

- **Design and Fabrication:** Need for region-specific greenhouse designs.
- **Breeding Programs:** Development of suitable varieties for greenhouse cultivation is limited.

- **Pest Management:** Threats from soil-borne pathogens and pests.
- **Marketing:** Lack of proper marketing strategies hampers timely disposal of produce.

Economic Feasibility:

Initial investment is high, but subsidies and financial support from the government make it viable. Hydroponic cultivation, though in its infancy in India, shows potential for growth.

Protected cultivation, with proper planning and support, can play a crucial role in sustainable food production and improving the socio-economic status of farmers

1.2 Hi-Tech Cultivation of Capsicum

Capsicum, also known as bell pepper, is a high-value greenhouse crop. Advanced cultivation techniques include protected structures like polyhouses and net houses, which provide controlled environments to optimize growth. Soilless systems such as hydroponics use nutrient-rich solutions, enhancing plant health and yield. Climate control is crucial, with optimal temperatures between 18-30°C for flowering and fruit setting. Pruning and training methods improve air circulation and light penetration, boosting productivity. These technologies ensure higher quality produce, efficient water and fertilizer use, and better pest and disease management, making capsicum cultivation more profitable and sustainable.

Advantages of cultivating capsicum under polyhouse conditions:

- **Higher Productivity and Profitability:** Polyhouse cultivation can significantly increase the yield and



quality of capsicum, leading to better market prices.

- **Efficient Use of Resources:** Water and fertilizers are used more efficiently, reducing waste and costs.
- **Pest and Disease Management:** The controlled environment helps in better management of pests and diseases, ensuring healthier plants.
- **Off-Season Production:** Capsicum can be grown throughout the year, allowing farmers to meet market demand even during off-seasons

1.3 Recent novel interventions for Hi-tech potato seed production under net house in north-western plains of India

Hi-tech Potato Seed Production:

Utilizes net houses and tissue culture techniques to produce high-quality, virus-free potato seeds. This method has higher multiplication rates and shorter field exposure compared to conventional methods. This method uses net houses to create an insect-free environment for cultivating healthy potato seeds. It involves micropropagation using tissue culture techniques, followed by transplanting under net houses or aeroponics. This approach ensures high-quality, virus-free seed production with higher multiplication rates and reduced field exposure. High-density planting and successive cropping under net houses enhance productivity. Additionally, soilless methods like using cocopeat help in producing disease-free minitubers, making it a viable option for areas with soil-borne diseases. Proper management and government subsidies can make this technology accessible to farmers.

Successive Cropping:

Allows for two potato crops within a single season under net houses, doubling productivity and increasing net returns.

Canopy Management:

Using nylon nets to manage plant canopy improves light penetration, air circulation, and overall tuber productivity, reducing the number of undersized tubers.

1.4 Low-cost plastic rain-shelter and poly-tunnel for protected vegetable cultivation in high rainfall

- Low-cost plastic rain-shelters and poly-tunnels are used to grow high-value crops like tomatoes and king chillies in high rainfall areas of Arunachal Pradesh, improving yields and income. The low-cost rain-shelter and poly-tunnel structures are made from locally available bamboo and UV-stabilized polythene. These structures help protect crops from excessive rainfall and create a conducive micro-climate for growing high-value vegetables like tomatoes and king chillies.
- The rain-shelter also incorporates a rainwater harvesting system, capable of collecting up to 2.8 lakh liters of water annually, which is used for irrigation. This method allows for off-season cultivation, leading to better yields and higher income for farmers. The cost-benefit ratio for the rain-shelter is 1.81, making it economically viable.
- Similarly, the poly-tunnel is used for raising vegetable nurseries, ensuring disease-free seedlings and higher germination rates. The cost-benefit ratio for the poly-tunnel is an impressive 26.18, highlighting

its profitability. These technologies provide a sustainable solution for smallholder farmers, enabling them to improve their livelihoods through enhanced productivity and income.

- **Economic Viability:** The cost-benefit ratio for rain-shelters is 1.81, and for poly-tunnels, it is 26.18, making them economically viable options for farmers.
- **Income Generation:** Farmers can generate significant income from these structures, with potential earnings of ₹141,312 from rain-shelters and ₹101,830 from poly-tunnels in the first year.
- **Advantages:** These structures provide better micro-climatic conditions, allow off-season cultivation, and protect crops from biotic and abiotic stresses, leading to higher productivity and quality.

1.5 Protected Cultivation Technology of Lilium

Floriculture is emerging as a profitable alternative to traditional field crops, with lilies ranking among the world's top ten flowers due to their striking colors, admirable vase-life, and invigorating fragrance. The genus *Lilium*, a member of the Liliaceae family, is extensively used in the floral industry both as cut flowers and potted plants. *Lilium* species are categorized into three principal groups crucial for commercial cut-flower cultivation: Asiatic hybrids, LA hybrids, and Oriental hybrids.

Cultivation in Shade-Net Houses:

Lilium thrives well in partial shade and can be cultivated under protected environments like shade-net houses. Optimal growth requires a light intensity of 2000–3000-foot candles and

temperatures between 8-20°C. Sandy loam soil with good drainage is ideal for cultivation.

Soil Preparation and Planting:

Soil sterilization using formaldehyde and proper soil preparation are essential. Bulbs should be planted at a depth of 4-12 cm, depending on their size and soil type. Larger bulbs result in taller and more robust plants with consistent flowering.

Nutritional Requirements and

Irrigation: *Lilium* requires minimal fertilization due to its salt sensitivity. Adequate soil moisture before planting is crucial for swift rooting.

Harvesting and Storage:

Flower spikes are harvested when they begin to show colour. Proper storage at 2-3°C with 70% relative humidity is essential for preserving bulb quality.

Economic Potential: *Lilium* cultivation under protected conditions can yield significant profits, making it a lucrative venture for farmers.

2. Innovative Storage and Post-Harvest Technologies

2.1 Low-cost storage structure for perishable horticultural produce – Pressing priority for small and marginal farmers

Post-Harvest Losses: Approximately 30-35% of fruits and vegetables are lost during various stages from harvest to distribution, severely impacting small and marginal farmers.

Low-Cost Storage Solutions: Various low-cost storage structures like the Zeer pot, Zero Energy Cool Chamber (ZECC), and Pusa-Farm Sun Fridge are highlighted as effective methods to



reduce post-harvest losses.

Technological Innovations:

- **Zeer Pot:** An evaporative cooler using nested pots and wet sand to extend the shelf life of fruits and vegetables.
- **Zero Energy Cool Chamber (ZECC):** A low-cost, evaporative cooling structure made from bricks and sand, ideal for small farmers.
- **Pusa-Farm Sun Fridge:** A solar-powered cold storage system that maintains low temperatures using solar panels and thermal storage.
- **Cool-Bot:** A device that converts a standard air conditioner into a produce cooler, making cold storage affordable for smallholder farmers.

The technological innovations not only improve the efficiency and sustainability of horticultural practices but also significantly enhance the livelihoods of small and marginal farmers.

2.1 An innovative onion storage structure: low-cost onion storage structures

Innovative onion storage structure designed to address the challenges faced by Indian farmers, particularly in Maharashtra, during the summer season. This structure is a single span hut shape with dimensions of 60 feet in length, 5 feet in width, and 7 feet in height, oriented east-west to optimize ventilation and minimize the impact of monsoon rains. Constructed using MS pipes, metal wire mesh, tarpaulin, and shade net, the structure is both affordable and durable, costing approximately ₹50,000.

The design ensures a better micro-climate for onion storage, maintaining

cool, dry, and well-ventilated conditions, which are crucial for extending the shelf life of onions and minimizing storage losses to around 8-10%. The structure can store up to 30 tonnes of onions for six months, helping farmers avoid distress sales during market gluts and ensuring better prices during lean periods.

The erection process is straightforward, taking about five hours, and involves assembling 12-unit frames with nuts and bolts, followed by the installation of metal wire mesh and shade net. This innovative storage solution not only reduces the dependency on traditional wooden structures, which are prone to termite attacks and high maintenance costs, but also offers portability and ease of installation.

Overall, this technology provides a cost-effective and efficient solution for onion storage, enhancing the economic stability of farmers by allowing them to store their produce and sell it at more favourable market conditions.

- **Design:** Single span hut shape with east-west orientation, made from MS pipes, metal wire mesh, and tarpaulin/shade net.
- **Capacity:** Can store up to 30 tonnes of onions for six months, maintaining a better micro-climate to enhance shelf-life and minimize storage losses.
- **Cost:** Approximately ₹50,000, with storage costs around ₹167 per quintal of onions.
- **Advantages:** Easy to install, durable, portable, and maintains market stability by reducing distress sales during the summer glut.

2.2 Advances in processing and post-harvest management of indigenous vegetables

Dehydration and Drying Technologies:

Advanced dehydration technologies for vegetables focus on preserving nutritional value and sensory qualities while extending shelf life. Methods like freeze-drying, vacuum drying, and microwave-assisted drying offer superior quality retention compared to traditional air drying. These techniques minimize thermal damage, maintain colour and flavor, and result in products that rehydrate well. Energy efficiency and reduced processing times are key advantages of these modern approaches. The choice of drying method depends on factors like product type, dryer availability, cost, and final product quality. Osmo air-drying is particularly recommended as a simple technology for small entrepreneurs and home-scale industry.

Edible Coatings: Edible coatings are innovative, environmentally friendly solutions for extending the shelf life of fresh vegetables. These thin, edible layers are applied directly to vegetable surfaces, creating a semi-permeable barrier that controls moisture loss and gas exchange. Made from natural materials like proteins, lipids, or polysaccharides, these coatings can significantly reduce respiration and transpiration rates. Common examples include carnauba wax and shellac-based coatings, which provide a glossy finish and enhance visual appeal. Beyond preservation, edible coatings can serve as carriers for functional ingredients such as antioxidants, antimicrobials, or flavors. This technology not only prolongs freshness but also maintains nutritional

quality and can improve food safety, making it a valuable tool in reducing post-harvest losses and enhancing vegetable marketability.

Steeping preservation: A non-thermal technology designed to extend the shelf life of vegetables, particularly during peak harvest seasons. This method involves immersing vegetables in a solution containing permissible chemical preservatives and food additives. The process aims to maintain the sensory and nutritional properties of the vegetables while inhibiting microbial growth and enzymatic reactions. Key advantages of steeping preservation include its simplicity, cost-effectiveness, and suitability for rural adoption, especially by women entrepreneurs. The technology allows for the handling of large quantities of surplus vegetables, reducing post-harvest losses. By using low levels of permitted additives, it strikes a balance between food safety regulations and consumer demand for minimally processed products. This preservation method can help stabilize vegetable prices and improve farmers' incomes by allowing for longer storage and off-season availability.

Potential vegetable processing technologies (Dehydration, Steeping preservation, Ready-to-eat convenience vegetables, Easy-to-cook leafy vegetables and Bio-preservation of vegetables aim to improve the efficiency and effectiveness of vegetable processing, reduce post-harvest losses, and increase the value addition in the vegetable sector.



3. Hydroponics and Vertical Farming

3.1 Hydroponic vegetables: A sustainable food production system and profitable venture under climate change

Hydroponics is a soil-less cultivation method that uses nutrient-rich water solutions to grow plants. This technology is particularly beneficial in areas with limited arable land and water resources. A sustainable and efficient method of food production, offering numerous advantages over traditional farming, especially in the face of climate change and urbanization. A brief overview of the technology used in hydroponics:

- **Growing Media:** Instead of soil, hydroponics uses inert growing media like gravel, vermiculite, rockwool, peat moss, sawdust, coir dust, and coconut fiber. These media provide mechanical support and retain moisture and nutrients for the plants.
- **Nutrient Solutions:** Plants are supplied with nutrient-rich solutions that contain essential minerals dissolved in water. These solutions can be delivered to the plant roots through various methods such as flooding, misting, or immersion.
- **Oxygenation:** To prevent root drowning and ensure healthy plant growth, hydroponic systems often use air stones and air pumps. Air stones disperse tiny bubbles of dissolved oxygen throughout the nutrient solution, which helps distribute nutrients evenly and keeps the roots oxygenated.
- **Types of Systems:** There are several types of hydroponic systems,

including Wick System, Water Culture, Ebb and Flow, Drip System, Nutrient Film Technique (NFT), and Aeroponic System. Each system has its unique way of delivering water, nutrients, and oxygen to the plant roots.

- **Environmental Control:** Hydroponic systems are often set up in controlled environments like greenhouses or indoor farms. This allows for precise control over temperature, humidity, light, and other factors, leading to faster growth rates and higher yields.
- **Profitability:** Hydroponic farming can be highly profitable, with significant returns on investment, especially for crops like lettuce. It is gaining popularity in India due to its efficiency and productivity.

3.2 Vertical farming for higher profit and family nutrition

Vertical Farming Overview: Vertical farming involves growing crops in vertically stacked layers, often integrated into urban structures like skyscrapers or repurposed warehouses. This method aims to produce more food per square meter and meet urban food demands.

Advantages: Vertical farming increases crop yield with less land, conserves local flora and fauna, allows year-round crop growth, and uses significantly less water. It also supports organic production with minimal chemical exposure.

Current Status in India: Limited to high-value crops, vertical farming is expanding with technical and financial support. It is seen as a solution to urban food security and resource pressure.

Case Study: An experimental vertical farming project at the College of Agriculture, Kyrdemkulai, demonstrated successful cultivation of various vegetables, yielding significant income and meeting family nutritional needs. The crops, including capsicum, tomato, chilli, brinjal, cabbage, and broccoli, performed very well under vertical farming, yielding a total of 185 kg of vegetables from a small area of 38.4 m². The gross income generated from the vertical farming system was , Rs 13,587, with king chilli being particularly profitable at , Rs 200/kg. The vertical farming system met the daily vegetable requirements of the farm family, contributing to their nutrition and reducing their expenditure on vegetables. The system utilized limited space efficiently, demonstrating the potential for high yield and income from small areas.

4. Water Management and Tissue Culture Innovations

4.1 Regulated deficit irrigation (RDI) in fruit crops – Grow quality fruit with minimum water

Regulated Deficit Irrigation (RDI):

RDI is an irrigation practice that provides less water than the full requirement for optimal plant growth, aiming to improve water-use efficiency and control plant growth.

Principles and Benefits: RDI uses water deficit-induced root signals to manage plant responses, improving water productivity and harvest quality while reducing excessive vegetative growth.

Implementation: Successful RDI requires identifying water stress-sensitive stages, understanding plant responses,

and using efficient irrigation systems like drip irrigation.

Promotion in India: The Indian government supports RDI through subsidies and precision agriculture initiatives, making it a viable option for water-deficient regions.

4.2 A novel and cost-effective hardening technology for tissue-cultured banana

In-vitro Propagation: This method produces a large number of banana plantlets quickly, offering advantages like high multiplication rate, uniformity, and disease-free material.

Hardening Technology: A novel, cost-effective method using polypropylene (PP) bags for hardening tissue-cultured banana plants improves survival rates and reduces transportation costs compared to traditional pro-trays. This method significantly reduces mortality rates (2-3%) compared to traditional pro-trays (5-8%). PP bags are lightweight, flexible, and can be reused multiple times, making them ideal for long-distance transport. The process involves transferring plantlets to PP bags filled with autoclaved cocopeat, maintaining them under controlled conditions for 30 days, and then acclimatizing them in a shade net house. This approach enhances plant survival and reduces transportation costs.

Commercial Adoption: Tissue culture technology is widely adopted by commercial firms due to rising demand for healthy, disease-free plantlets.



5. Horticulture Development under Technology Mission in Northeastern States

Northeastern States: The region's diverse agro-climatic conditions support a wide variety of horticultural crops. The Horticulture Mission for North East and Himalayan States (HMNEH) has led to significant improvements in production and infrastructure. The Technology Mission for Integrated Development of Horticulture in North Eastern States (TMNE) was launched to harness the region's potential, focusing on research, production, post-harvest management, and processing. Various technologies implemented under the Technology Mission for Integrated Development of Horticulture in Northeastern States (TMNE). Here are the key technologies:

- **Quality Seed and Planting Material:** Emphasis on providing high-quality seeds and planting materials to improve crop yield and quality.
- **Post-Harvest Management:** Development of on-farm handling units, cold storage facilities, and efficient transport systems to reduce post-harvest losses and improve market linkages.
- **Protected Cultivation:** Use of greenhouses and other protected cultivation methods to mitigate the impact of harsh weather conditions and extend growing seasons.
- **Irrigation Improvements:** Introduction of drip and sprinkler irrigation systems to enhance water use efficiency and ensure consistent crop growth.

- **Organic Farming:** Promotion of organic farming practices to maintain soil fertility and produce high-quality, chemical-free crops.

These technologies aim to increase production, improve quality, and ensure sustainable horticulture practices in the Northeastern states of India.

6. Entrepreneurship through Khejri Technology

- **Khejri Tree:** Khejri (*Prosopis cineraria*) is a vital tree in the Thar Desert, providing food, fodder, and environmental benefits. Its immature pods (sangri) are highly nutritious and valuable.
- **Technological Advancements:** ICAR-CIAH, Bikaner has developed techniques for vegetative propagation, orchard establishment, and value addition of khejri. This includes bud-grafting, crop regulation, and low-cost drying methods.
- **Commercial Potential:** Farmers are increasingly interested in commercial orcharding of khejri due to its high yield, ease of management, and economic benefits. Standardized packaging and marketing protocols have been developed to maximize profits.
- **Sustainable Income:** Cultivating khejri can provide sustainable income through high-value dried sangri and nutrient-rich fodder, supporting rural entrepreneurship and improving livelihoods in arid regions.

7. Use of Drones in Precision Horticulture:

The advent of precision agriculture has revolutionized the way we approach farming and crop management. Among the myriad of technological advancements, drones, also known as unmanned aerial vehicles (UAVs), have emerged as a pivotal tool in the realm of precision horticulture. Their ability to monitor, analyze, and respond to crop health and environmental conditions has opened up new horizons for efficient and sustainable farming practices.

Applications of Drones in Precision Horticulture

Drones in precision horticulture are employed for a variety of purposes, each contributing to more informed decision-making and improved crop management. The primary applications include:

- 1. Mapping and Surveying:** Drones equipped with high-resolution cameras and sensors can quickly map vast agricultural lands, providing detailed topographical and vegetative information. This data is crucial for planning crop layouts, irrigation systems, and understanding soil variations across the field.
- 2. Crop Monitoring and Health Assessment:** Through the use of multispectral imaging, drones can assess plant health by capturing data beyond the visible spectrum. This allows for the early detection of diseases, nutrient deficiencies, and water stress, enabling timely interventions to mitigate crop damage.

- 3. Precision Irrigation:** By identifying areas of the field that are either too dry or adequately moist, drones can help optimize irrigation schedules and water usage. This not only conserves water resources but also ensures that crops receive the right amount of water at the right time.
- 4. Pest and Weed Control:** Drones can spot treat areas infested with pests or weeds, reducing the need for blanket applications of pesticides and herbicides. This targeted approach minimizes chemical usage, protecting the environment and reducing costs.
- 5. Data Collection and Analysis:** The continuous collection of data over time allows for the analysis of crop growth patterns, yield predictions, and the effectiveness of different farming practices. This wealth of information supports data-driven decision-making, enhancing the overall productivity and sustainability of horticultural operations.

The integration of drones into horticultural practices not only streamlines operations but also elevates the precision with which these tasks are performed, leading to healthier crops and higher yields. The deployment of drones in precision horticulture offers numerous benefits, including **Increased Efficiency, Reduced Costs, Enhanced Crop Health and Yields, Environmental Sustainability, Scalability**

Despite these advantages, the adoption of drone technology in precision horticulture is not without challenges. Regulatory hurdles, high initial investment costs, and the need for technical expertise can be significant



barriers for some farmers. However, as technology advances and becomes more affordable, and as support structures for drone usage in agriculture strengthen, these challenges are gradually being overcome. While drones hold great promise for transforming horticultural practices, several challenges need to be addressed to fully realize their potential are **Regulatory Compliance, Technical Training, Cost and Accessibility.**

In conclusion, drones represent a transformative tool in the field of precision horticulture, offering innovative solutions for crop management and environmental sustainability. By embracing these technologies, the agricultural sector can navigate towards a future of increased productivity and resilience in the face of changing global conditions.



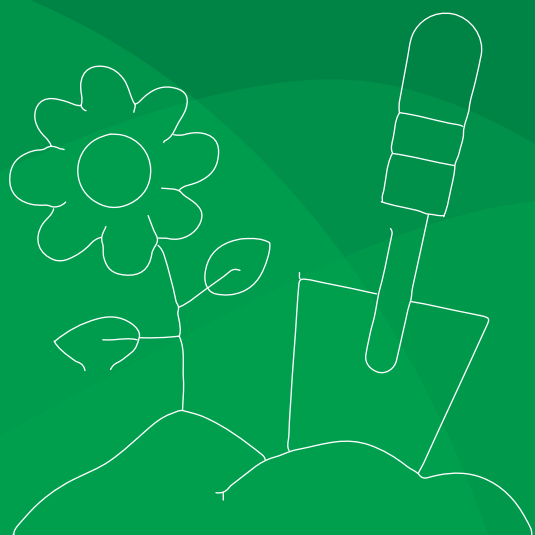
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National Sectoral Paper **Plantation and Horticulture**



Farm Sector Development Department
National Bank for Agriculture and Rural Development
Mumbai