

RESEARCH ARTICLE

SPATIO-TEMPORAL ANALYSIS OF HORTICULTURAL DEVELOPMENT IN INDIA: TRENDS, REGIONAL DISPARITIES AND POLICY IMPLICATIONS

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ABSTRACT

Horticulture has emerged as one of the most dynamic subsectors of Indian agriculture, reflecting both structural diversification and responses to changing socio-economic and agro-ecological conditions. This study undertakes a spatio-temporal analysis of horticultural development in India, examining long-term growth trends and regional disparities. Using secondary data from the Ministry of Agriculture and Farmers Welfare, the analysis covers the period 1991–92 to 2024–25, with a focus on area, production, and productivity. Temporal findings reveal a significant transformation: the area under horticultural crops expanded from 13 million hectares in 1991–92 to 29.3 million hectares in 2024–25, while production surged nearly fourfold from 97 million tonnes to 368 million tonnes. Productivity doubled over the same period, rising from 8 MT/ha to 12.6 MT/ha, driven by technological interventions, improved irrigation, and adoption of high-yielding varieties. Spatially, the analysis highlights stark regional disparities. In 2004–05, states such as West Bengal, Uttar Pradesh, and Maharashtra dominated production, with Punjab and Uttar Pradesh recording high productivity. By 2024–25, Uttar Pradesh and Madhya Pradesh emerged as horticultural leaders, while several North-Eastern and arid states continued to lag behind. The comparative assessment underscores a dual trajectory—widespread productivity-driven growth alongside persistent spatial imbalances. The findings emphasize that horticulture has become central to India's agricultural transition, contributing to nutritional security, farm income enhancement, and export potential. However, targeted interventions are necessary to address regional disparities and ensure inclusive, sustainable horticultural development.

KEYWORDS

Horticulture, Agricultural diversification, Spatio-temporal analysis, Productivity, Regional disparities,

1. INTRODUCTION

Agriculture has historically been the backbone of India's economy, ensuring food security, employment, and rural livelihoods for a majority of its population (Chand et al., 2011). Traditionally, Indian agriculture has been dominated by cereals, particularly rice and wheat, which occupy the largest share of cultivated land. However, in recent decades, a gradual but profound structural transformation has been underway. Horticulture has emerged as one of the most dynamic and rapidly expanding subsectors of Indian agriculture, representing both an internal diversification and a response to changing socio-economic and agro-ecological conditions (Pingali, 2007; Joshi et al., 2004). Small and marginal farmers, who account for nearly 86% of India's farming community (Government of India, 2019), increasingly perceive horticulture as a viable alternative to traditional cereals. Declining profitability from subsistence farming, stagnating cereal yields, and shrinking farm sizes have collectively driven farmers towards crop diversification into fruits, vegetables, and spices (Birthal et al., 2012). From a temporal perspective, horticulture has gained importance as it ensures higher returns per unit of land, while spatially, states with favorable agro-climatic conditions, better infrastructure, and proximity to urban markets have shown stronger transitions towards high-value horticultural crops (Singh and Kumar, 2015; Reddy et al., 2017). The economic and nutritional significance of horticulture is now well established. Horticultural crops—including fruits, vegetables, spices, flowers, and plantation crops—not only enhance dietary diversity and nutritional security but also contribute to rural employment, women's empowerment, and export earnings (Joshi et al., 2004; Kumar et al., 2019).

India is currently the second-largest producer of horticultural crops globally, contributing nearly 12% of world output (NHB, 2023). The expansion has been remarkable: the area under horticulture increased from 16.5 million hectares in 2001–02 to over 28 million hectares in 2021–22, while production nearly doubled from 145 million tonnes to more than 350 million tonnes during the same period (GoI, 2023). This rapid growth has been facilitated by policy interventions such as, the Mission for Integrated Development of Horticulture (2014), and investments in cold chain and market infrastructure (Chand, 2017; National Horticulture Mission, 2005). Despite these achievements, horticultural development in India displays significant spatial disparities. States such as Andhra Pradesh, Maharashtra, Uttar Pradesh, West Bengal, and Tamil Nadu dominate production, while others lag behind due to agro-climatic constraints, poor infrastructure, and limited market access (Reddy et al., 2017). Moreover, the trajectory of horticultural growth reflects broader societal shifts: urbanization, rising incomes, and changing dietary preferences are increasing demand for nutrient-rich foods, thereby reshaping the structure of Indian agriculture (Pingali, 2007). Several studies have analyzed horticultural growth and diversification in India. The research highlighted its role in income growth and risk reduction, while emphasized regional clustering around favorable conditions (Birthal et al., 2012; Singh and Kumar, 2015). The study documented crop specialization in states like Maharashtra (grapes, pomegranates) and Himachal Pradesh (apples) (Reddy et al., 2017). However, most existing research remains either crop-specific or region-specific. There is still a gap in comprehensive spatio-temporal analysis at the national scale that integrates both area and production trends,

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examines spatial disparities, and connects these with socio-economic drivers and policy frameworks. In this context, the present study undertakes a spatio-temporal analysis of horticultural development in India. Specifically, it examines long-term trends in cropping intensity, the expansion of horticultural area and production, and regional variations across states. By integrating temporal and spatial dimensions, the study provides fresh insights into how horticulture is reshaping the trajectory of Indian agriculture—moving from subsistence to market orientation, from calorie-based security to nutritional security, and from low-value to high-value farming systems.

1.1 Research Objectives

- To analyze the spatio-temporal trends in area and production of horticultural crops in India.
- To examine the spatial disparities and identify the factors driving horticultural development across different regions.
- To assess the implications of these patterns for agricultural diversification.

1.2 Research Questions

- How has horticultural development in India evolved over time in terms of area and production?
- What are the spatial patterns of horticulture across Indian states, and what explains these variations?

2. METHODOLOGY

2.1 Data Sources

The present study is based exclusively on secondary data obtained from published government reports and official statistical handbooks. The principal data sources include:

- Horticultural Statistics at a Glance (Ministry of Agriculture and Farmers Welfare, Government of India) for state-wise area, production, and productivity of horticultural crops.
- Second Advance Estimates of Horticultural Production (2024–25) released by the Ministry of Agriculture and Farmers Welfare.
- Supplementary information was drawn from annual publications of the National Horticulture Board (NHB) and the Directorate of Economics and Statistics, Government of India, for validation and cross-checking.

2.2 Study Period and Scope

The study covers two temporal dimensions:

- Long-term trends (1991–92 to 2024–25) to analyze the national-level growth in area, production, and productivity of horticultural crops.
- Short-term comparative analysis (2004–05 and 2024–25) to assess spatial variations in horticultural development across Indian states and union territories.

This dual scope allows for an integrated assessment of both temporal growth and spatial disparities in horticulture.

2.3 Analytical Framework

Temporal Analysis: Temporal changes in horticultural development were examined by analyzing trends in area, production, and productivity. Growth performance was assessed using descriptive statistics and compound annual growth rates (CAGR).

Productivity was calculated as

$$2.4 \text{ Productivity (MT/ha)} = \frac{\text{Total Production}}{\text{Area under horticultural crops}}$$

Spatial Analysis: Spatial disparities were analyzed using state-wise data for two benchmark years (2004–05 and 2024–25). States and union territories were categorized into high, medium, and low performance groups based on relative shares of area, production, and productivity. To visualize these disparities, GIS-based choropleth maps were prepared, showing the spatial distribution of horticultural development across states. These maps highlight regional clusters of high-performing and lagging states.

2.4.1 Indicators Used

- Area under horticultural crops (lakh ha)
- Production of horticultural crops (MMT)
- Productivity (MT/ha)
- Compound Annual Growth Rate (CAGR) of area, production, and productivity over the study period.

2.4.2 Tools and Techniques

Data compilation and statistical analysis were carried out using MS Excel. For spatial representation, QGIS software was employed to generate state-wise choropleth maps of horticultural area, production, and productivity for 2004–05 and 2024–25.

3. RESULTS

3.1 Temporal Growth of Horticultural Development in India (1991–92 to 2024–25)

The temporal analysis demonstrates a remarkable expansion of horticultural activity in India during the past three decades. As shown in Table 1 and Figure 1 and 2, the total area under horticultural crops increased from 13 million hectares in 1991–92 to an estimated 29.27 million hectares in 2024–25, marking nearly a 2.3-fold growth. More significantly, production rose from 97 million tonnes to 367.7 million tonnes over the same period, reflecting a nearly fourfold increase. Productivity levels improved steadily, rising from 8 MT/ha in 1991–92 to 12.56 MT/ha in 2024–25. This consistent growth highlights the contribution of high-yielding varieties, improved irrigation practices, and technological interventions such as polyhouses and drip irrigation systems. The evidence suggests that productivity gains have been a key driver of output growth, in addition to the moderate expansion of cultivated area.

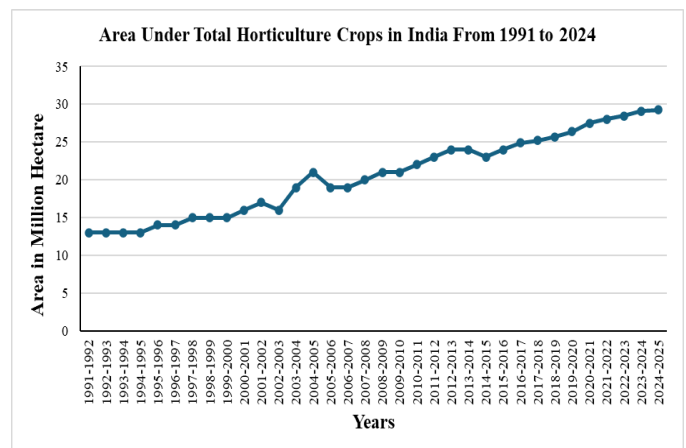


Figure 1: (1991-1992 to 2024-2025 – 2nd Advance Estimates)

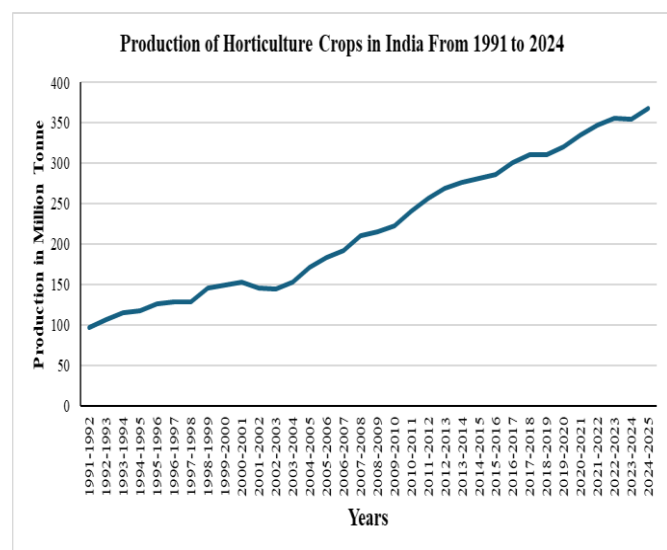
Table 1: Area, Production and Productivity of Total Horticultural Crops in India

Year	Area (In Million Hectare)	Production (In Million Tonne)	Productivity in MT/Hectare)
1991-1992	13.00	97.0	8.0
1992-1993	13.00	107.0	8.0
1993-1994	13.00	115.0	9.0
1994-1995	13.00	118.0	9.0
1995-1996	14.00	126.0	9.0
1996-1997	14.00	129.0	9.0
1997-1998	15.00	129.0	9.0

Table 1: Area, Production and Productivity of Total Horticultural Crops in India

1998-1999	15.00	146.0	10.0
1999-2000	15.00	149.0	10.0
2000-2001	16.00	153.0	10.0
2001-2002	17.00	146.0	9.0
2002-2003	16.00	144.0	9.0
2003-2004	19.00	153.0	8.0
2004-2005	21.00	171.0	8.0
2005-2006	19.00	183.0	10.0
2006-2007	19.00	192.0	10.0
2007-2008	20.00	211.0	11.0
2008-2009	21.00	215.0	10.0
2009-2010	21.00	223.0	11.0
2010-2011	22.00	241.0	11.0
2011-2012	23.00	257.0	11.0
2012-2013	24.00	269.0	11.0
2013-2014	24.00	277.0	12.0
2014-2015	23.00	281.0	12.0
2015-2016	24.00	286.0	12.0
2016-2017	24.90	300.6	12.0
2017-2018	25.20	310.7	12.0
2018-2019	25.70	311.1	12.1
2019-2020	26.40	320.0	12.12
2020-2021	27.48	334.6	12.18
2021-2022	28.04	347.18	12.38
2022-2023	28.44	355.48	12.50
2023-2024	29.09	354.74	12.20
2024-2025	29.27	367.72	12.56

Source: Ministry of Agriculture and Farmers Welfare, Government of India (ON4264) & Past Issues.

**Figure 2:** Spatial Patterns in 2004–05

The spatial distribution of horticulture across Indian states in 2004–05

reveals sharp regional disparities (Table 2, Figure 3 and 4). West Bengal (20.7 MMT), Uttar Pradesh (18.8 MMT), and Maharashtra (15.2 MMT) were among the top producers, together contributing a substantial share of national horticultural output. In terms of productivity, Punjab (15.6 MT/ha), Uttar Pradesh (16.1 MT/ha), and Jharkhand (14.8 MT/ha)

performed significantly better than the national average of 8.4 MT/ha. Conversely, Rajasthan (1.16 MT/ha), Sikkim (2.06 MT/ha), and Mizoram (2.99 MT/ha) recorded extremely low yields. These disparities suggest that while agriculturally progressive states had already embraced modern horticultural practices by 2004–05, several states were still dependent on low-yield traditional systems.

3.2 Spatial Patterns in 2024–25 (2nd Advance Estimates)

By 2024–25, horticultural development had become more widespread, though inter-state disparities persist (Table 3, Figures 5 and 6). Uttar Pradesh emerged as the single largest horticultural producer with 52.8 MMT, followed by Madhya Pradesh (38.7 MMT), West Bengal (35.4 MMT), Maharashtra (33.7 MMT), and Andhra Pradesh (30.6 MMT). Collectively, these five states contributed nearly half of India's total horticultural production. Productivity improvements were also notable. Uttar Pradesh (19.83 MT/ha), Punjab (18.62 MT/ha), Andhra Pradesh (18.35 MT/ha), Bihar (17.47 MT/ha), and West Bengal (16.91 MT/ha) ranked as the highest-performing states. In contrast, states such as Rajasthan (2.81 MT/ha), Sikkim (3.51 MT/ha), and Mizoram (4.29 MT/ha) continued to record poor yields. Outliers such as Daman and Diu (67 MT/ha) and Delhi (15.97 MT/ha) reflect intensive but small-scale production systems with limited contribution to the national total.

Table 2: State-wise Area, Production and Productivity of Total Horticulture Crops in India (2004-2005)			
States/UTs	Area (In `000 Hectare)	Production (In `000 MT)	Productivity (In MT/Hectare)
Andaman and Nicobar Islands	42.4	158.1	3.73
Andhra Pradesh	1506.1	13668.8	9.08
Arunachal Pradesh	80.8	218.8	2.71
Assam	410.1	3189.6	7.78
Bihar	1192.6	16189.0	13.57
Chandigarh	0.2	2.8	14.00
Chhattisgarh	232.2	1636.2	7.05
Dadra and Nagar Haveli	2.2	20.6	9.36
Daman and Diu	0.1	0.2	2.00
Delhi	48.3	652.8	13.52
Goa	99.8	313.2	3.14
Gujarat	1023.3	9402.6	9.19
Haryana	236.6	3268.2	13.81
Himachal Pradesh	277.2	1739.7	6.28
Jammu and Kashmir	308.8	2170.7	7.03
Jharkhand	256.8	3798.3	14.79
Karnataka	1508.1	10569.9	7.01
Kerala	1689.1	9323.3	5.52
Lakshadweep	3.2	54.3	16.97
Madhya Pradesh	737.6	4129.5	5.60
Maharashtra	2010.8	15192.8	7.56
Manipur	79.1	417.0	5.27
Meghalaya	85.2	555.8	6.52
Mizoram	35.8	107.1	2.99
Nagaland	29.8	163.7	5.49
Odisha	1304.9	9997.7	7.66
Puducherry	25.9	140.6	5.43
Punjab	217.3	3390.2	15.60
Rajasthan	2599.2	3019.2	1.16
Sikkim	57.4	118.3	2.06
Tamil Nadu	1061.1	13681.6	12.89
Tripura	76.2	908.3	11.92
Uttar Pradesh	1173.1	18850.6	16.07
Uttarakhand	285.5	1778.5	6.23
West Bengal	1501.9	20725.6	13.80
India (Total)	20198.7	169828.8	8.41

Source: Ministry of Agriculture & Farmers Welfare, Govt. of India.

Table 3: State-wise Area, Production and Productivity of Total Horticulture Crops in India (2024-2025)			
States/UTs	Area (In `000 Hectare)	Production (In `000 MT)	Productivity (In MT/Hectare)
Andaman & Nicobar Islands	31.73	191.52	6.04
Andhra Pradesh	1670.10	30652.22	18.35
Arunachal Pradesh	41.74	161.97	3.88
Assam	663.15	6939.72	10.46
Bihar	1316.16	22987.89	17.47
Chhattisgarh	773.70	9491.47	12.27
Dadra and Nagar Haveli	0.17	2.62	15.14
Daman and Diu	0.03	2.28	67.06
Delhi	23.50	375.25	15.97
Goa	108.39	493.34	4.55
Gujarat	2174.39	27577.47	12.68

Table 3 (cont): State-wise Area, Production and Productivity of Total Horticulture Crops in India (2024-2025)			
Haryana	409.36	6368.07	15.56
Himachal Pradesh	341.80	2575.57	7.54
Jammu & Kashmir	341.44	3770.04	11.04
Jharkhand	450.21	5827.31	12.94
Karnataka	2627.60	17042.48	6.49
Kerala	1476.72	9633.87	6.52
Ladakh	3.70	20.42	5.51
Lakshadweep	3.08	1.43	0.46
Madhya Pradesh	2670.24	38677.41	14.48
Maharashtra	2491.79	33715.22	13.53
Manipur	81.11	813.23	10.03
Meghalaya	156.92	1095.66	6.98
Mizoram	192.44	826.24	4.29
Nagaland	148.28	889.99	6.00
Odisha	1595.85	14514.99	9.10
Puducherry	7.83	16.21	2.07
Punjab	545.14	10152.15	18.62
Rajasthan	1819.87	5107.53	2.81
Sikkim	86.99	305.41	3.51
Tamil Nadu	1600.96	22737.90	14.20
Telangana	344.72	3690.90	10.71
Tripura	136.18	1666.42	12.24
Uttar Pradesh	2663.46	52815.20	19.83
Uttarakhand	172.48	1131.31	6.56
West Bengal	2096.20	35453.02	16.91
India (Total)	29267.43	367723.73	12.56

Source: Ministry of Agriculture and Farmers Welfare, Govt. of India.

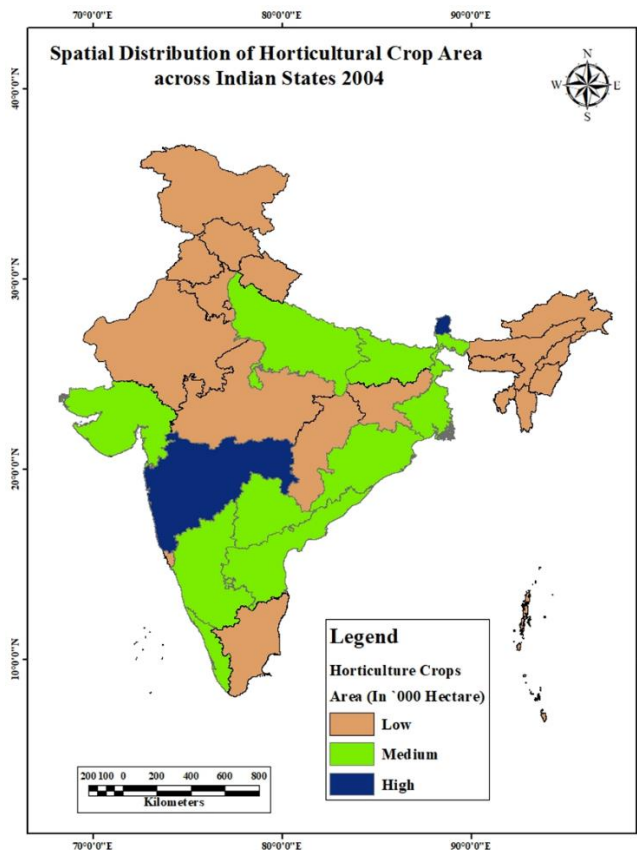


Figure 3

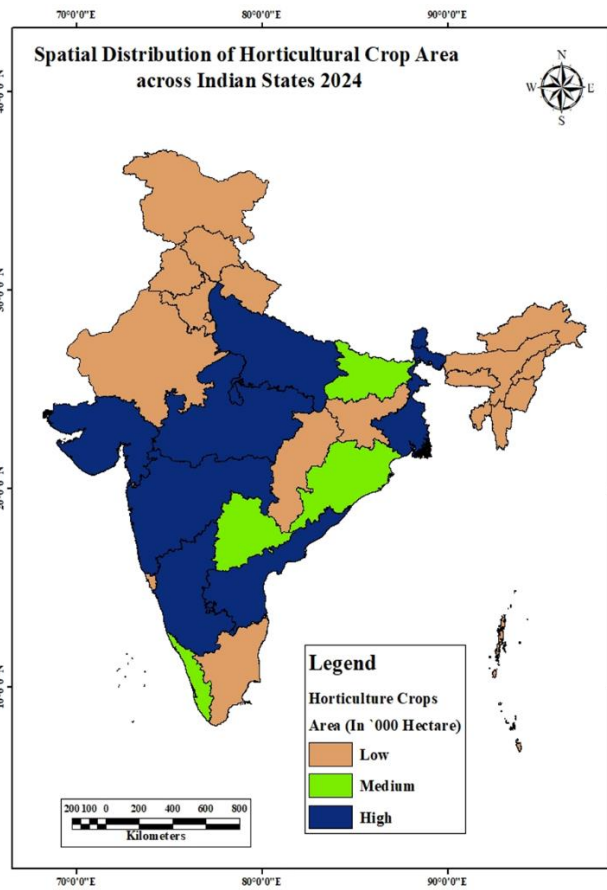


Figure 4

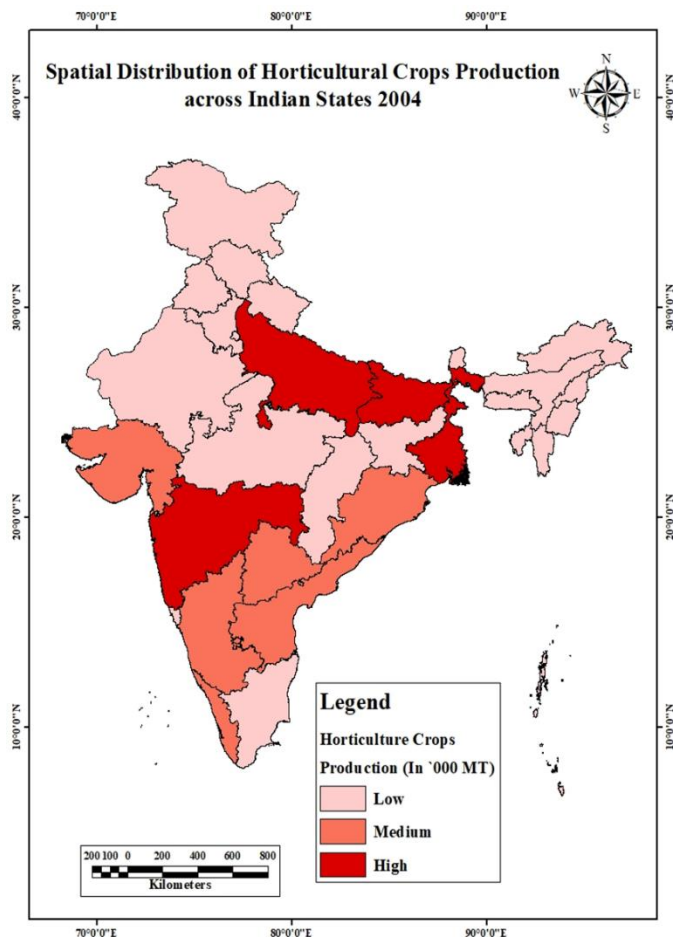


Figure 5

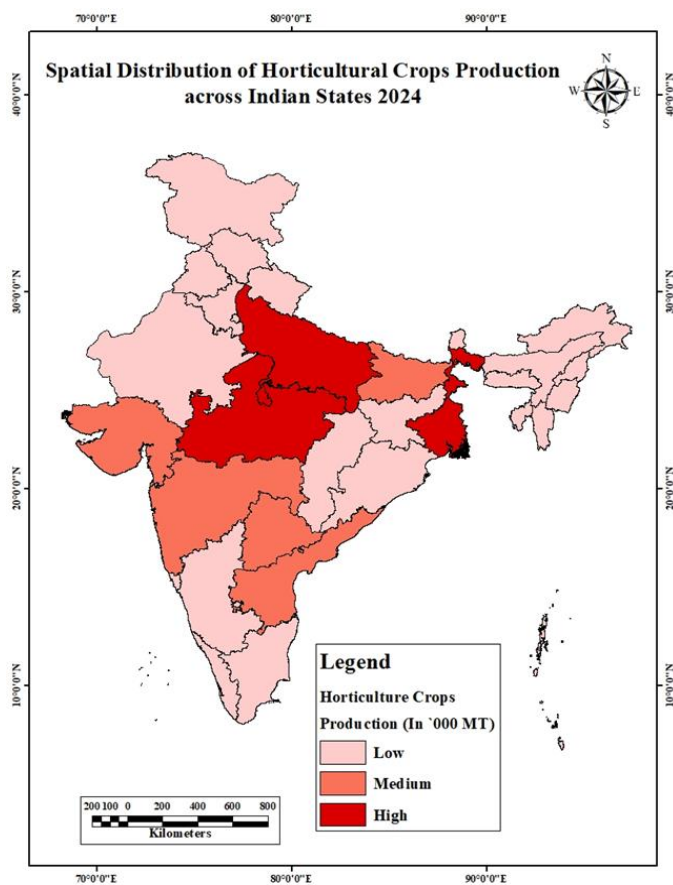


Figure 6

3.3 Comparative Shifts (2004–05 vs. 2024–25)

A comparison between Table 2 (2004–05) and Table 3 (2024–25) reveals

significant transformations in India's horticultural geography. While states such as Andhra Pradesh, West Bengal, and Maharashtra retained their leading positions, Uttar Pradesh and Madhya Pradesh registered the most striking gains in both production and productivity. Productivity levels across most states improved substantially, with Uttar Pradesh and Punjab approaching 20 MT/ha, almost double the national average in 2004–05. However, the persistence of low productivity in parts of the North-East, arid western states, and hilly regions indicates continued regional imbalances.

3.4 Overall Interpretation

The findings underscore that India's horticulture sector has entered a phase of rapid, productivity-driven growth. Expansion in area has been modest, but significant increases in production and yield reflect technological adoption, policy support (e.g., National Horticulture Mission, MIDH), and market integration. Nevertheless, wide spatial disparities remain, suggesting that future strategies must focus on lagging regions through infrastructure development, extension services, and climate-resilient horticultural practices.

3.5 Findings

3.5.1 Temporal Trends in Horticulture (1991–92 to 2024–25)

The analysis reveals a substantial expansion of horticultural activity in India over the past three decades. The total area under horticulture has increased from approximately 16 million hectares in the early 1990s to over 29 million hectares by 2024–25 (2nd Advance Estimates), reflecting nearly a 1.8-fold growth. More strikingly, production has surged from about 97 million metric tonnes (MMT) to over 367 MMT during the same period, representing a nearly fourfold increase. Consequently, productivity has doubled, rising from around 6 MT/ha in the early 1990s to 12.56 MT/ha in 2024–25. This consistent improvement highlights the contribution of technological advancements, improved irrigation facilities, adoption of high-yielding varieties, and better crop management practices in enhancing output efficiency.

3.5.2 State-wise Patterns in 2004–05

In 2004–05, states such as West Bengal, Andhra Pradesh, Maharashtra, and Uttar Pradesh emerged as major contributors to horticultural output, accounting for a significant proportion of national production. States like Punjab, West Bengal, and Uttar Pradesh displayed relatively higher levels of productivity (>15 MT/ha), whereas Rajasthan, Mizoram, and several North-Eastern states recorded low productivity levels (<5 MT/ha). This pattern indicates the early emergence of regional disparities, with agriculturally progressive states maintaining a competitive advantage in terms of both area and yield.

3.5.3 State-wise Patterns in 2024–25 (2nd Advance Estimates)

By 2024–25, Uttar Pradesh has emerged as the leading horticultural state, producing 52.8 MMT, followed by Madhya Pradesh (38.7 MMT), West Bengal (35.4 MMT), Maharashtra (33.7 MMT), and Andhra Pradesh (30.6 MMT). Collectively, these five states account for nearly half of India's horticultural production. In terms of productivity, Uttar Pradesh (19.83 MT/ha), Punjab (18.62 MT/ha), Andhra Pradesh (18.35 MT/ha), Bihar (17.47 MT/ha), and West Bengal (16.91 MT/ha) demonstrate the highest levels of efficiency. Conversely, states such as Rajasthan (2.81 MT/ha), Sikkim (3.51 MT/ha), and Mizoram (4.29 MT/ha) continue to lag behind despite considerable area under cultivation in some cases, reflecting persistent intra-state disparities. Outliers such as Daman and Diu (67 MT/ha) reflect small-scale, high-intensity cultivation systems, but their contribution to the national aggregate remains negligible due to their limited cultivated area.

3.5.4 Comparative Analysis (2004–05 vs. 2024–25)

A comparative assessment demonstrates a notable shift in the geography of horticultural production. While Andhra Pradesh, Maharashtra, and West Bengal retained their prominence, Uttar Pradesh and Madhya Pradesh recorded exceptional gains, positioning themselves as horticultural powerhouses. Productivity has improved across most major states, with some—such as Uttar Pradesh and Punjab—approaching or exceeding 20 MT/ha. However, the persistence of low productivity in several North-Eastern and arid states underscores significant regional disparities and scope for policy interventions.

The evidence suggests that India's horticulture sector has undergone a phase of rapid growth, characterized by modest expansion in area, substantial increases in production, and marked improvements in productivity. The diversification towards high-value horticultural crops has played an instrumental role in enhancing farm incomes, contributing to nutritional security, and reducing the pressure on cereal-based systems.

Nonetheless, the coexistence of high-performing states alongside persistently lagging regions underscores the need for targeted technological, infrastructural, and policy support to ensure balanced regional development in horticulture.

4. DISCUSSION

Horticulture in India has shown a consistent upward trend in both area and production during the past two decades. According to the National Horticulture Board (NHB, 2023), India currently ranks second in the world in fruit and vegetable production, accounting for nearly 12% of global output. Between 2001–02 and 2021–22, the area under horticulture expanded from about 16.5 million ha to over 28 million ha, while production increased from 145 million tonnes to more than 350 million tonnes (GoI, Ministry of Agriculture & Farmers' Welfare, 2023).

4.1 Reasons for Increase

4.1.1 Economic Diversification

Traditional field crops such as cereals provide low returns, especially for small and marginal farmers who constitute more than 86% of India's farming community (Agricultural Census, 2015–16). Horticulture offers higher value per hectare and better market prospects, encouraging farmers to diversify.

4.1.2 Urbanization and Changing Diets

With rapid urbanization, food habits in India are shifting from carbohydrate-heavy cereals towards more nutrient-rich foods, including fruits, vegetables, milk, and meat. Middle-class demand for fresh produce, processed foods, and nutritional diets has fueled horticultural growth (Pingali, 2007; NSSO, 2019).

4.1.3 Government Support

Policy interventions such as the National Horticulture Mission (2005), Rashtriya Krishi Vikas Yojana (RKVY), and infrastructure for cold storage, food processing, and market linkages have played a major role in accelerating horticulture production.

4.1.4 Export Potential

Rising global demand for Indian fruits like mango, banana, and grapes has encouraged commercial cultivation. India exported over *6.7 million tonnes of horticultural products* in 2021–22 (APEDA, 2022).

4.2 Spatial Patterns

The spatial pattern of horticulture development in India is uneven. States like Andhra Pradesh, Maharashtra, Uttar Pradesh, Madhya Pradesh, West Bengal, and Tamil Nadu contribute the majority of production (NHB, 2023). Several factors explain this variation:

Agro-climatic Suitability: Western Maharashtra and Andhra Pradesh have favorable climates for fruits like grapes, mango, and banana, while hill states (Himachal Pradesh, Jammu & Kashmir) specialize in apples and temperate fruits.

Land Pressure and Profitability: In states with smaller average landholdings (e.g., Kerala, West Bengal, Bihar), farmers adopt intensive horticulture to maximize returns from limited land.

Market Access and Infrastructure: Proximity to urban centers (Delhi, Mumbai, Kolkata, Chennai) boosts horticultural adoption due to assured

demand and better connectivity.

Traditional vs. Commercial Orientation: Subsistence farmers in less profitable cereal-based systems are gradually shifting to horticulture, while commercial farmers with access to irrigation and storage facilities expand production for both domestic and export markets.

4.3 Why Spatial Pattern is Changing

Rural–Urban Transformation: With declining dependence on cereals for food security and rising demand for perishable, high-value crops, regions closer to urban markets are diversifying faster.

Policy Push and Schemes: Special Horticulture Zones, subsidies on drip irrigation, and cold-chain development have led to expansion in newer states (e.g., Jharkhand, Chhattisgarh, Northeast).

Climate Change Adaptation: Farmers are moving to crops that are less water-intensive (vegetables, fruits) compared to paddy or sugarcane in water-stressed states like Maharashtra and Karnataka.

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