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The Evolution of Indian Fruit Production: Advancing Sustainability through Precision Horticulture

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In India horticulture industry majorly contributes to the rising economy, making an important input to rural livelihood and agricultural GDP. India is the world's 2nd-largest fruit producer (as 2023), contributing 13% of world's production (FAO, 2021). Mango, banana, citrus, papaya, guava, pomegranate and apple are among the main fruits cultivated in India. The production and productivity of India's fruit crops stays lower than world's standard regardless its notable production, as Indian farmers follows traditional farming systems and improper pre-harvest and post-harvest management systems with scattered land areas etc. India has been moving from traditional horticulture to precision horticulture in order to bypass the limitations in Indian horticulture system , using technologies like GIS, IoT-based sensors, remote sensing and data analytics. Sustainable intensification- means producing more with less resource while maintaining ecosystem integrity. It is now possible because of technology and modernization of farming system. (*Gebbers & Adamchuk*, 2010).

Traditional Horticulture: Fruit was mostly grown for subsistence prior to the Green Revolution, using low-density planting system in orchards and using few outside inputs. Local cultivars and varieties mainly cultivated on natural soil fertility and traditional pest management were used and they were grown under rain-fed circumstances. These leads to lower productivity and market integration, although being environmentally sustainable.

Commercialization and Expansion: With the establishment of the National Horticulture Board (NHB) (1984) and Mission for Integrated Development of Horticulture (MIDH) (2014- 15), the late 20th century was a time of expansion. Yields increased with multiple folds with the introduction of hybrid cultivars, rainfed system exchanged by well-established irrigation system and fertilizer application as an input source. However, excessive input application resulted in decreased biodiversity, insect resistance and nutritional imbalances in the soil (*Chadha*, 2018). At this point, sustainability issues started to show up, particularly in high-value fruit regions like Andhra Pradesh (mango), Himachal Pradesh (apple) and Maharashtra (grapes and pomegranate).

Precision and Sustainable Horticulture: Horticulture entered an age where data is used for everything in the 2000s. Orchard care started to change with the introduction of digital monitoring, climate-smart technologies and precision equipment. Economic benefits for the use of sophisticated technologies were established by programs such as the Mission for Integrated Development of Horticulture (MIDH) (2014) and the National Horticulture Mission (NHM) (2005). Through fertigation, computerized crop mapping and drip-irrigation, these initiatives supported sustainability (Ministry of Agriculture, 2023).

Obstacles in Traditional Fruit Production

Traditional horticulture in India faces a complex web of structural and environmental challenges that prevent it from reaching its full potential. One of the most significant hurdles is the fragmentation of landholdings, where small and marginal farmers operate on tiny, disconnected plots that make it nearly impossible to implement modern machinery or economies of scale. This physical limitation is often compounded by a lack of quality planting material and high-yielding varieties, forcing farmers to rely on aged, less productive orchards. Furthermore, Indian horticulture is heavily dependent on erratic monsoon patterns, and without widespread access to precision irrigation like drip or sprinkler systems, crops remain highly vulnerable to both droughts and unseasonal heavy rains. Beyond the field, the sector struggles with a primitive infrastructure for post-harvest management. The lack of integrated cold chains, specialized refrigerated transport and modern primary processing centers leads to staggering losses—often estimated between 15% to 30% depending on the perishability of the crop. This is exacerbated by a disjointed supply chain dominated by multiple layers of middlemen, which results in a low 'farmer's share' of the consumer's rupee. Additionally, the dearth of technical knowledge regarding modern canopy management, integrated pest management (IPM) and international quality standards limits the ability of traditional farmers to enter lucrative export markets. Without easy access to affordable institutional credit and crop insurance tailored for high-value horticultural crops, many farmers remain trapped in low-input, low-output cycles that hinder the overall growth of the rural economy.

Post-Harvest Loss: lack of efficiency in cold chains transport and handling cause between 25–30% of crops loss (*Singh & Sharma*, 2019).

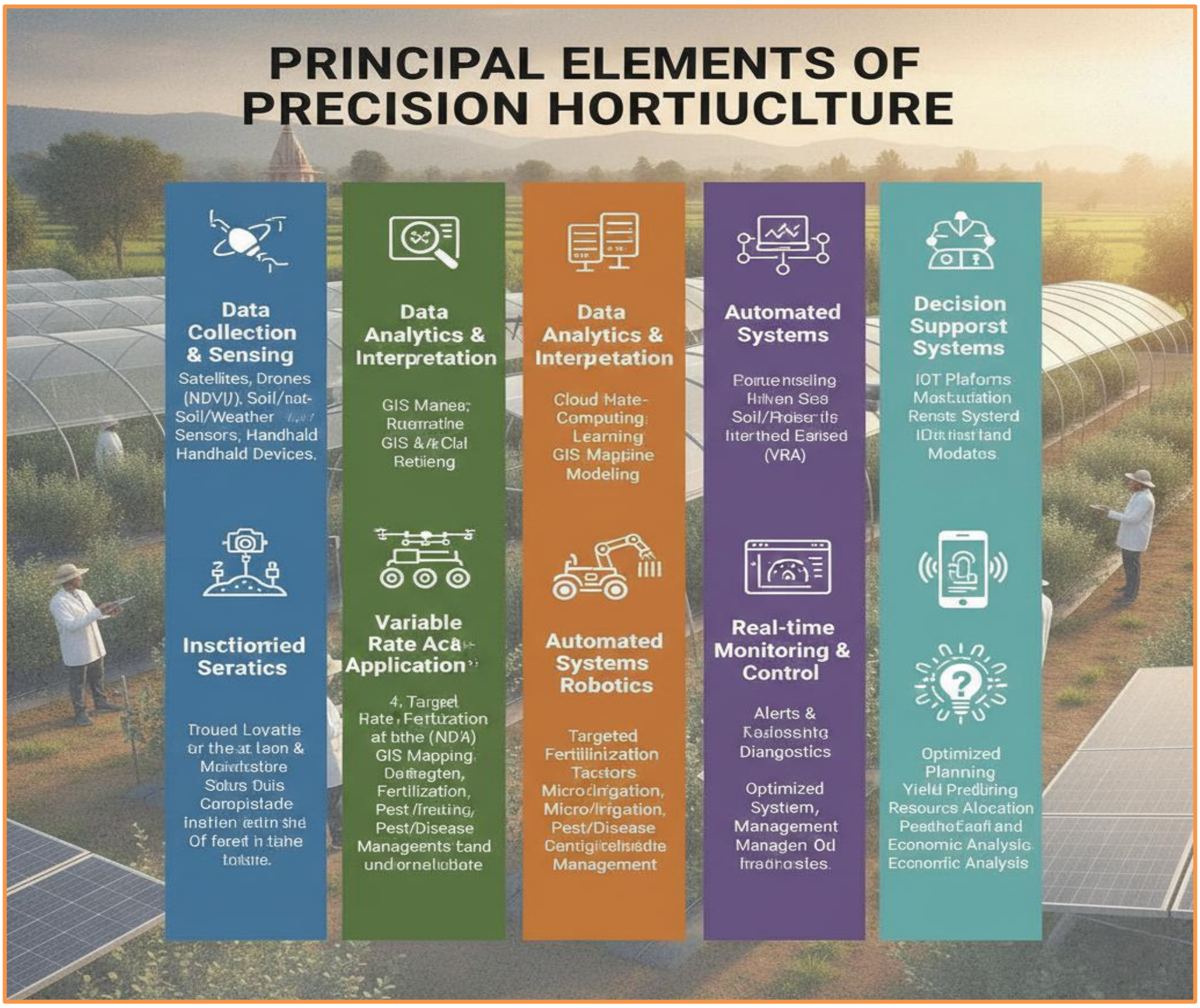
Principal Elements

Drones and remote sensing: obtaining high-resolution images to track disease prevalence, canopy health and irrigation requirements (*Verma & Singh*, 2021)

Global Positioning System (GPS): GPS is a key component of precision farming is the Global Positioning System (GPS), which enables farmers to determine their precise location inside a field. Accurate agricultural mapping is made possible by this satellite-based navigation system, which is essential for organizing field operations like planting, fertilizer and harvesting. Farmers may minimize overlaps and missing regions by utilizing GPS to execute operations with great precision. This increases production and sustainability while also conserving resources like seeds and fertilizer. (D et al.,2025)

Geographic Information System (GIS): GIS is a software tool used to capture, store, analyse and display spatial or geographically referenced data (Neményi et al., 2003). In precision farming, GIS is employed to analyse field variability by collecting information about soil types, terrain, crop yield and other agronomic factors. This data helps farmers make informed decisions about resource allocation. For example, if a particular section of a field has poorer soil quality and GIS can guide site specific interventions to enhance its productivity.

Remote Sensing: Remote sensing is the process of collecting information on crop health, soil conditions and water levels using satellite or airborne photography, including drones. By detecting changes in light reflectance, this technology can identify problems like illness, insect infestations, or nutritional deficits before they are apparent to the unaided eye.
(Brisco et al., 1998).



Variable Rate Technology (VRT): Variable Rate Technology (VRT) leverages GPS data with maps from GIS and sensors to apply inputs like fertilizers, seeds and pesticides at different rates across a field based on the specific needs of different areas. For example, VRT allows a fertilizer spreader to increase or decrease application based on soil nutrient maps, ensuring that each part of the field gets the right amount. This targeted approach improves input efficiency and minimizes environmental impact.

Yield Monitoring and Mapping: During harvesting, crop yield and moisture content are measured using yield monitoring devices, which are usually mounted on combine harvesters. When combined with GPS, this data is used to create yield maps, which display the spatial variation in production throughout a field (Reyns et al., 2002).

Soil Mapping and Sensors: Soil mapping involves analysing soil properties such as texture, pH, organic matter and nutrient content. Proximate sensors, either mounted on equipment or used for manual sampling, provide real time data on these attributes (Adamchuk et al., 2004). This information is crucial for understanding field variability and developing site-specific soil management plans. By applying fertilizers and amendments according to soil needs, farmers can enhance nutrient uptake and reduce waste.

Data Management and Decision Support Systems (DSS): Collecting data alone isn't enough interpreting it effectively is essential. DSS tools help process and analyse large volumes of data from sensors, maps and weather stations. By offering practical suggestions, such as when and where to plant, water, or apply treatments, these systems aid in decision-making. DSS tools are essential for strategic planning and operational efficiency because they convert data into useful insights.

Advantages

- **Enhanced Yield and Quality-** Good quality and quantity fruits that renders high export rates.
- **Resource Efficiency and Cost Reduction-** Fertilizer cost can be cut by reduced by 20–25% using different technology.
- **Environmental Sustainability-** Precision irrigation reduces water loss by 30–40% (*Reddy & Narayanasamy*, 2023).

Decrease of carbon emissions by effective use of chemicals and energy eventually cutting global warming.

Case studies

Mango from Telangana and Andhra Pradesh: To maximise fertigation and irrigation efficiency, farmers in the districts of Chittoor and Warangal employ satellite mapping and soil moisture sensors. This method decreased water use by 30% and increased fruit size uniformity by 25% (*Kumar et al*., 2022). Which shows the need of precision farming in today's world of limited water availability

Apple (Jammu & Kashmir & Himachal Pradesh): Fungal infection losses have been controlled because of high-density plants and drone-based disease diagnosis system. Every year, 15–20% of seasonal production has been saved by the use of early frost detection sensors. (*Verma & Singh*, 2021).

Banana (Maharashtra & Tamil Nadu): In Coimbatore and Jalgaon, sensor-controlled drip irrigation increased bunch weight by 18% while reducing fertilizer waste. Precision fertigation has replaced flood irrigation as a nationwide approach (*Reddy & Narayanasamy*, 2023).

Citrus in Maharashtra and Punjab: Fertilizer recommendations were enhanced using GIS-based nutrient mapping, which resulted in a 22% reduction in input expenditures while preserving fruit sweetness and peel quality (*Singh*, 2020).

Conclusion

By providing a data-driven, effective and sustainable substitute for conventional methods, precision farming brought about a significant change in the agricultural industry. Through the integration of technology such as GPS, GIS, IoT and remote sensing. Farmers are able to optimize inputs and reduce waste while managing field variability with extreme precision. Despite its advantages, there are obstacles to its general implementation, especially in areas with tiny landholdings like India, including expensive costs, technical difficulties and the requirement for farmer education. To overcome these obstacles, government collaborations, public-private partnerships and developments in reasonably priced technology are essential.

Precision farming will play a more crucial role in solving resource shortages, climate change and global food security as it develops. Precision farming can lead the way with focused governmental assistance, infrastructural development and capacity-building initiatives. With targeted policy support, infrastructure development and capacity-building efforts, precision farming can pave the way for a sustainable and productive agricultural future for the world.

References

1. Chadha, K. L. (2018). *Horticulture status in India: An overview*. Indian Journal of Horticulture, 75(3), 1–9.
2. FAO. (2021). *Fruit production and sustainability*. Food and Agriculture Organization of the United Nations.
3. Gebbers, R., & Adamchuk, V. I. (2010). Precision agriculture and food security. *Science*, 327(5967), 828–831.
4. Kumar, R., Singh, P., & Rao, V. (2022). Precision nutrient management in mango orchards of Andhra Pradesh. *Journal of Horticultural Science*, 47(2), 123–130.
5. Verma, A., & Singh, H. (2021). Remote sensing applications in Himachal Pradesh apple orchards. *International Journal of Precision Agriculture*, 9(1), 45–56.
6. Reddy, S., & Narayanasamy, K. (2023). Soil moisture-based irrigation management in Tamil Nadu banana farms. *Indian Journal of Soil Science*, 71(4), 298–307.
7. Singh, G., & Sharma, L. (2019). Status and challenges of fruit production in India. *Horticultural Review*, 27(1), 89–110.
8. Singh, R. (2020). Water management strategies in Indian orchards. *Water Resources Journal*, 52(8), 75–84.
9. DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.051
10. Indian Council of Agricultural Research. (2023). *Precision horticulture research summaries*. ICAR Publication.
11. National Horticulture Mission. (n.d.). *Mission documents*. Ministry of Agriculture, Government of India.
12. Pradhan Mantri Krishi Sinchai Yojana. (n.d.). *Programme overview*. Ministry of Agriculture, Government of India.
13. Agriculture and Farmers Welfare. (2024). *Annual report*. Government of India.
14. World Bank. (2023). *Agricultural technologies for sustainable development*. World Bank Publications.