How Much Protected is Protected Cultivation in India

Suresh K. Malhotra
Vice Chancellor, Maharana Pratap Horticultural University, Karnal
Former Agriculture and Horticulture Commissioner
Ministry of Agriculture & Farmers Welfare

Protected cultivation is one of the key technological solutions for sustainable agriculture production under the current scenario of climate change, resource scarcity, and increasing demand for high-quality produce. It enables the regulation of environmental parameters such as temperature, humidity, and light, and facilitating year-round and off-season production of high value crops with superior yield and quality compared to open-field systems. The scope of protected cultivation is expanding rapidly due to its ability to enhance productivity per unit area, improve resource-use efficiency, and reduce climatic risks, which aligns with FAO's emphasis on climate-resilient agricultural systems. Because of the necessity to produce crops in a regulated environment as a result of changing climatic patterns, the idea of protected farming is becoming more and more popular. The growing horticulture trade exacerbates this trend. By employing artificial techniques to get around climate obstacles, protected farming enables the production of crops outside of their typical growing seasons. The growth of this practice has been fueled by the steady demand for several commodities throughout the year. Also, protected cultivation offers immense potential for addressing food security and livelihood improvement for small and marginal farmers through higher returns from limited land. Major crops include vegetables such as tomato, capsicum, cucumber, leafy greens, broccoli, and exotic vegetables, fruits such as strawberry, melon, and blueberry; and floriculture crops including rose, gerbera, carnation, and lilium.

WORLD SCENARIO

The 19th century saw the introduction of greenhouse horticulture to both Europe and the United States. China and Japan currently lead the world in protected farming, however other important nations including the Netherlands, Israel, Egypt, Spain, and Canada also heavily engage in protected agriculture. Usually constructed of glass or plastic, a greenhouse is a framed or inflated structure intended to create a controlled climate for the best possible crop development. Protected

https://doi.org/10.52151/aet2026502.1917

cultivation has expanded rapidly worldwide in recent decades, with the global greenhouse area estimated at approximately 1.3 million hectares, spanning more than 119 countries. Earlier estimates, which include low-technology structures such as plastic tunnels and net houses, suggest that the total protected cultivation area may reach 5–5.6 million hectares globally. The global greenhouse market was valued at approximately USD 33 billion in 2024 and is projected to grow to nearly USD 70 billion by 2033, reflecting the increasing adoption of controlled environment agriculture. These trends clearly indicate that protected cultivation has evolved from a niche practice into a major strategy for agricultural intensification and high-value crop production.

Regionally, Asia dominates the global protected cultivation scenario, with China alone accounting for nearly 60% of the world's greenhouse area, making it the largest contributor globally. Other countries such as Japan and South Korea also play significant roles in the adoption of protected cultivation technologies. Overall, Asia is estimated to hold 70% to 90% of the global protected cultivation infrastructure. In contrast, Europe particularly countries such as the Netherlands, Spain, and Italy is characterized by highly advanced, technology-intensive greenhouse systems with precise climate control, especially in the Mediterranean region where protected cultivation is widely used for high-value vegetable and fruit production. The Americas, led by the United States and Mexico, have developed strong commercial greenhouse industries, particularly for vegetable production, with increasing emphasis on peri-urban agriculture. Meanwhile, Africa and the Middle East are witnessing rapid expansion of protected cultivation, primarily driven by water scarcity and food security concerns. In terms of global food production, protected cultivation plays a disproportionately large role despite its relatively limited land area. Intensive protected systems are estimated to contribute up to 60% of fresh vegetable production in certain regions, particularly under high-input conditions. Protected cultivation is dominated by vegetable crops, followed by ornamentals, fruits, and emerging specialty crops, with increasing adoption driven by the need for higher productivity, improved quality, and climate resilience. The major crops grown under protected cultivation include tomato, cucumber, capsicum, and lettuce, which benefit from controlled environmental conditions, higher productivity, and year-round cultivation.

INDIAN SCENARIO

Protected agriculture is quickly gaining attraction in India thanks to the growing retail sector. High-value, low-volume crops are frequently grown in greenhouses, which have also been shown to work well for a wide range of vegetables, short-duration fruits, and flowers. Ornamental plants including roses, gerberas, chrysanthemums, cacti, anthuriums, and orchids are grown in greenhouses, along with crops like strawberries, capsicum, baby corn, tomatoes, and cucumbers. High-quality yields are encouraged by the regulated environment, which shields the crops from wind and rain. Greenhouses improve quality, increase yield, hasten crop development, and frequently lessen the effects of pests and insects. However, a major obstacle to the broad application of greenhouse technology is still the expensive cost of building. Protected cultivation in India has emerged as a significant technological intervention for enhancing horticultural productivity under changing climatic conditions. The approach should be used more widely because it can boost yields by up to 300%. With an estimated 3 lakh hectares under protected cultivation, India ranks seventh in the world. Of this, 70–80% are under permanent structures (glass houses, greenhouses, polyhouses, shed nets, etc.), and 20–30% are under low tunnels, mulching, flow check, anti-hail nets, and anti-bird nets. Under the Mission for Integrated Development of Horticulture (MIDH), the government encourages protected cultivation; the top four states with the greatest coverage are Tamil Nadu, Gujarat, Karnataka, and Maharashtra. The technology, introduced in the early 1990s, has expanded steadily due to government initiatives such as the National Horticulture Mission, which brought approximately 2.15 lakh hectares under protected cultivation between 2005–06 and 2017–18. Despite this growth, India's share remains relatively small compared to global leaders; estimates indicate that protected cultivation contributes only about 1% of global greenhouse area, highlighting its early-stage adoption. FAO-based global analyses suggest that the worldwide protected cultivation area exceeds 600,000 ha of high-tech horticultural systems, with China alone contributing nearly 45%, whereas India's area remains comparatively limited. Various protected structures such as greenhouse, high-tech polyhouse (fan & pad based systems), naturally ventilated polyhouse, insect proof net-house, shade net-house, walk-in tunnel, poly net-house, low plastic tunnel, hydroponic and aeroponics are prevalent in India. Considering the needs and objectives the different suiting protected structures are used

in different agroclimatic conditions. In terms of cropping pattern, protected cultivation in India is predominantly horticulture-oriented, focusing on high-value crops. Major vegetable crops include tomato, capsicum (bell pepper), cucumber, and cucurbits, while fruit crops such as strawberry and melons are also grown under controlled environments. In addition, floriculture crops like rose, gerbera, carnation, and chrysanthemum constitute an important segment due to export potential. Yield advantages under protected conditions are substantial; mostly significantly higher than open-field cultivation. Regionally, adoption is concentrated in states such as Maharashtra, Karnataka, Gujarat, Andhra Pradesh, and Himachal Pradesh, driven by subsidies, market access, and peri-urban demand. Maharashtra alone accounts for about 7.4% of the national protected cultivation area. Economically, protected cultivation is highly profitable despite high initial investment, with crops like capsicum and rose showing higher net returns compared to open cultivation, which explains increasing farmer interest. However, the Indian scenario is still constrained by several factors, including high initial cost of structures, lack of region-specific designs, inadequate technical knowledge, and weak market linkages, which limit widespread adoption. Nevertheless, recent trends reported that protected cultivation is contributing to increased productivity in the horticulture sector and is expected to expand further with technological and policy support.

ESTABLISHMENT OF INTERNET OF PLANTS (IOP) ON A PILOT SCALE AT MHU, KARNAL

Haryana, a predominantly agrarian state, has long been recognized for its high productivity in wheat and rice, contributing substantially to the central pool of food grains. However, with the country having largely achieved self-sufficiency in staple grain production, the focus has gradually shifted toward nutritional security through agricultural diversification, particularly in horticulture. Recognizing this need and demonstrating forward-looking vision, the Government of Haryana established Maharana Pratap Horticultural University (MHU), Karnal in 2016 as a dedicated institution for advancing horticultural education, research, and extension. The university aims to serve as a centre of excellence in horticulture and allied sectors, contributing to food and ecological security, enhanced farm income, and sustainable livelihoods.

In this context, the concept of Smart Horticulture emerges as a transformative approach that integrates advanced technologies to improve efficiency, precision, and sustainability in horticultural production systems. The proposed establishment of an Internet of Plants (IoP) at a pilot scale at MHU, Karnal, is a strategic initiative to operationalize this concept. The IoP system will act as a centralized Smart Horticulture hub where plant-based data, environmental parameters, and real-time monitoring tools are integrated using sensors, automation, and data analytics. This science-driven approach will enable precise decision-making, optimize resource utilization such as water and nutrients, and enhance crop productivity and quality.

Under the leadership of the author, the pilot establishment of IoP at MHU, Karnal, in collaboration with Kochi University, Japan, will also facilitate international knowledge exchange and technological advancement. This initiative is expected to play a crucial role in the production of high-value vegetable crops, efficient resource management, and overall enhancement of horticultural productivity. Ultimately, the project will strengthen the capacity of farmers and researchers, paving the way for a more sustainable, profitable, and technologically advanced horticulture sector in Haryana.

CONCLUSION

The technology enables precision agriculture practices, including hydroponics, aeroponics, and vertical farming, which can significantly increase productivity while minimizing water and nutrient use. Furthermore, the integration of automation, artificial intelligence, and climate-smart technologies is expected to transform protected cultivation into a highly efficient and knowledge-driven production system in the near future. Economically, protected cultivation is highly promising due to its ability to produce off-season crops that fetch premium market prices, generate employment, and support export-oriented horticulture, particularly in floriculture and exotic vegetables. This system contributes to reduced pesticide use, improved water-use efficiency, and sustainable intensification, making it a cornerstone of future agricultural development.