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AUGMENTING FARMERS' INCOME THROUGH PROTECTED CULTIVATION

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EXECUTIVE SUMMARY

India's agriculture is experiencing a gradual structural transformation, with a growing contribution of non-cereal sectors to the Gross Value of Agricultural Output (GVOA), even though cereals still dominate the cropping pattern. Cereal crops constituting around 62 percent of the gross cropped area (GCA), while horticulture crops account for a much smaller share of 11 percent of GCA. However, the share of cereals in total GVOA has reduced from 17.5 percent in triennium ending (TE) 2013–14 to 14 percent in TE 2023–24, the expansion of high-value segments such as horticulture from 19.4 percent to 21 percent (MoSPI, 2023). This indicates a slow and uneven shift in cropped area from cereals to non-cereal crops, underlining structural rigidities within the agricultural system. In this context, crop diversification has emerged as a critical way for enhancing farmers' income, improving resource-use efficacy, and strengthening resilience to climate and market risks. However, diversification into horticulture alone does not promise higher income, as high-value crops persist to be vulnerable to yield variability, pest attacks, seasonality, and price variations. Against this background, technological interventions that boost productivity and stabilize output become vital. Protected cultivation through controlled environments such as polyhouses and shade-net houses characterizes one such technology-driven approach to improving farm productivity and profitability. This study explores the emerging role of protected horticulture in India, predominantly in the context of crop diversification and income augmentation.

Despite the growing demand for high-value agricultural products, the pace of diversification remains unequal across states. Some states such as Andhra Pradesh, Kerala, Tamil Nadu, Jharkhand, have accomplished relatively higher diversification levels, while others mostly those historically associated with the Green Revolution, such as Punjab and Haryana continue to display strong crop concentration in rice–wheat systems. These trends highlight the importance of policy interventions and technological innovations that can support the transition toward high-value agriculture.

Globally, protected cultivation has expanded rapidly as many countries are committed to improve agricultural productivity and guarantee year-round supply

of horticultural products. China with nearly 60 percent of the protected cultivation area worldwide leads the global landscape. In contrast to the widespread adoption of low-cost protected cultivation systems such as those seen in China, the high-tech polyhouse models of Israel and the Netherlands represent a more advanced, precision-driven evolution of controlled environment agriculture. In Israel, high-tech polyhouses are engineered to maximize resource-use efficiency under climatic stress, integrating drip irrigation, fertigation, automated climate control, and sensor-based monitoring to optimize inputs and stabilize yields. Similarly, in the Netherlands, protected cultivation has evolved into a highly sophisticated glasshouse-based system, characterized by fully automated environmental regulation, CO₂ enrichment, artificial lighting, and hydroponic production. These systems emphasize intensive management of crop conditions, enabling year-round production, higher productivity, and superior quality outputs. Together, they illustrate a shift from scale-driven, low-cost structures toward technology-intensive, knowledge-driven systems, where productivity gains are achieved through precision, innovation, and integration with advanced research and market ecosystems. In contrast, the embracing of protected cultivation in India remains relatively restricted, covering only a small proportion of the total cultivated area. However, the technology has been provided through government support programs such as the Mission for Integrated Development of Horticulture (MIDH) and the Centres of Excellence (CoE) with Indo-Israel and Indo-Dutch collaboration. These centres serve as key institutional platforms for promoting high-tech horticulture in India through demonstration, training, and technology dissemination. With 52 centres approved nationwide (36 operational and 16 under development), the programme initiated in 2012 through Indo-Dutch collaboration and further strengthened by partnerships with Israel and Netherlands focuses on improving productivity, quality planting material, and sustainable cultivation practices. These centres provide hands-on training across crops such as vegetables, fruits, and flowers, while showcasing advanced practices including protected cultivation, nursery management, and precision irrigation. The Indo-Israel CoEs, in particular, function as hubs for adapting Israeli technologies to Indian conditions, emphasizing intensive and resource-efficient farming. With a cumulative investment of around Rs. 5 billion, CoEs annually produce over 25 million quality vegetable seedlings and 0.38 million fruit plants, while training more than 1.2 lakhs farmers, thereby significantly contributing to capacity building and technology adoption in the horticulture sector.

The study emphasizes on coloured capsicum as a model crop to examine the economic viability of protected cultivation. Capsicum has emerged as one of the

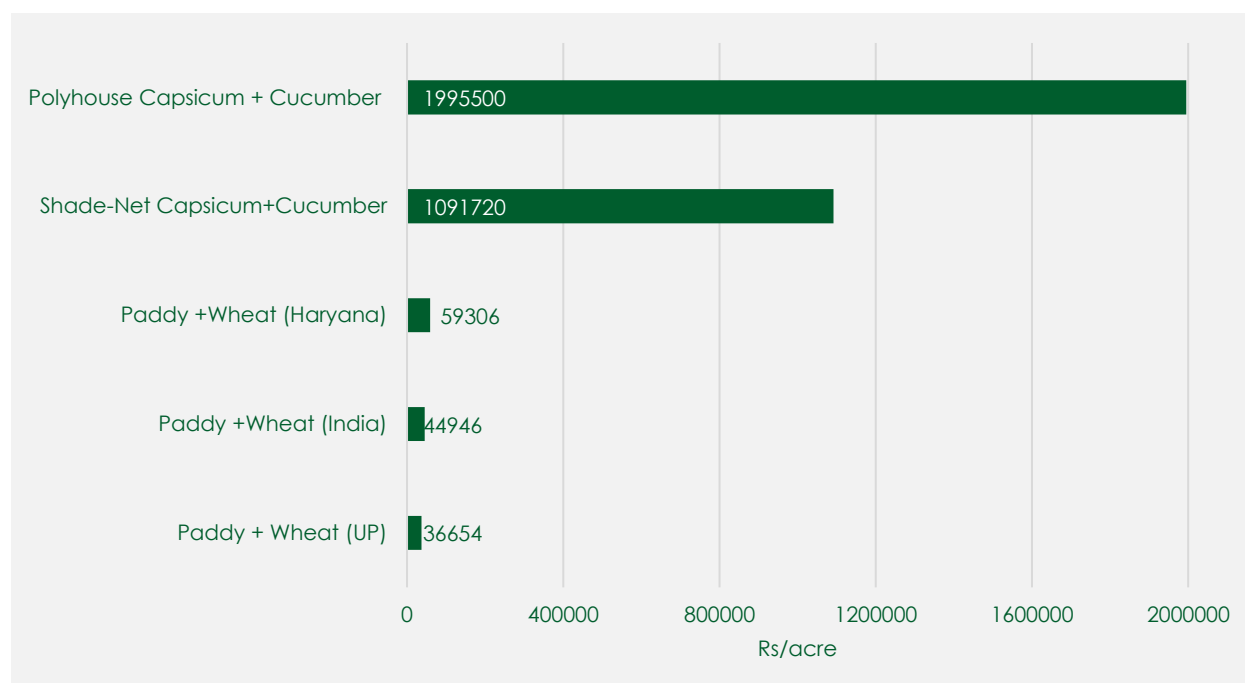
most successful crops grown under polyhouse settings due to its high market demand, adaptability to controlled environments, and potential for making higher returns per unit area. Over the past decade, the area under capsicum cultivation in India has increased considerably, accompanied by improvements in productivity and output. The majority of capsicum output in India comprises of green capsicum cultivated under open-field conditions, while coloured capsicum represents a comparatively small share of total output and is predominantly produced under protected cultivation systems such as polyhouses and shade-net structures. Red and yellow capsicums contain higher levels of vitamin C, vitamin A, and antioxidants than green capsicums. Under MIDH programmes, around 2.64 lakh hectares area has been brought under protected cultivation in the period of 2014-15 to 2022-23 indicating a penetration of less than 0.2 percent of net sown area (NSA) (Lok Sabha Starred Question, 2023). The growth has been motivated by technological innovations such as hybrid seeds, fertigation systems, drip irrigation, and upgraded crop management practices. Besides, rising urban demand for high-quality vegetables and the development of organized retail markets including online platforms have created new market opportunities for producers.

To examine the economic performance of protected cultivation, the study presents detailed case studies of capsicum cultivation under polyhouse and shade-net systems in Haryana and Uttar Pradesh. These states offer an exciting context for studying diversification because they are traditionally dominated by rice–wheat cropping systems but are gradually exploring high-value horticulture as an alternative pathway for income growth. Haryana benefits from proximity to major urban markets in the National Capital Region (NCR), while peri-urban clusters in Uttar Pradesh have started implementing protected cultivation technologies through the efforts of young agripreneurs and government support programs. The comparative analysis highlights how aspects such as market access, investment structure, and management practices impact the profitability and sustainability of protected horticulture systems.

The economic analysis shows that protected cultivation generates considerably higher yields and returns compared to traditional open-field farming systems. Polyhouse cultivation of capsicum can achieve significantly higher productivity due to controlled temperature, humidity, and pest management conditions. Higher productivity, combined with improved crop quality and the ability to produce off-season vegetables, allows farmers to attain better market prices. The following figure highlights the substantial profitability advantage of protected cultivation over the conventional paddy–wheat cropping system. Net returns from polyhouse

cultivation of capsicum and cucumber are estimated at around Rs. 19.95 lakhs per acre in a year, which is nearly 30 times higher than the paddy-wheat returns in Haryana (Rs. 59,306 per acre) and over 50 times higher than those in Uttar Pradesh (Rs. 36,654 per acre). Even in Haryana, where farmers benefit from an MSP-backed procurement system, returns remain significantly lower than those achievable in production of high value vegetable crops under protected cultivation. Moreover, relatively low-cost options such as shade-net houses also deliver strong financial performance, generating net returns of approximately Rs. 10.9 lakhs per acre.

Figure: Economic Returns: Protected Cultivation vs Traditional Farming, TE 2024-25



Source: Field Information and Cost of Cultivation data, Kharif and Rabi Report, CACP

Financial analysis, including investment appraisal and sensitivity analysis, recommends that despite high initial capital costs, protected cultivation projects can yield lucrative returns over the project life. The results are further supported by Monte Carlo simulation analysis, which validates that the internal rate of return (IRR) remains robust at 54 percent across a range of price, yield, and cost scenarios. Sensitivity analysis indicates that in the absence of government subsidies accompanied by unfavourable conditions (yield/price drop), the project's IRR undergoes a significant contraction, declining to approximately 25-35 percent. This underscores the project's high level of dependence on fiscal incentives to maintain its superior profitability profile. This indicates that bureaucratic inefficiency and systemic corruption might function as an informal tax, inflating the net initial

investment and delaying capital recovery, which significantly compresses the project's IRR.

Despite these positive economic outcomes, protected cultivation in India faces several challenges. One of the most significant blockades is the high initial investment required for building polyhouses and installing associated irrigation and fertigation systems. Although government subsidies decrease the financial burden, the technology remains capital intensive. Such systems are particularly well-suited to small landholdings, as they enable substantially higher returns per unit of land. However, their adoption is contingent upon access to adequate initial capital investment, which necessitates improved availability of institutional credit, particularly through formal banking channels. In addition, protected cultivation necessitates specialized technical knowledge for managing temperature of the structure, efficient nutrient application, and pest control. Limited technical training and inadequate extension support can therefore obstruct the success of these systems. Marketing limitations also pose significant challenges. Most farmers rely on intermediaries such as commission agents and wholesalers, which decreases their share in the consumer price. Moreover, fluctuations in market prices, seasonal demand patterns, and inadequate cold-chain infrastructure can affect profitability.

The findings of the study point towards important policy implications for scaling up protected horticulture in India. Strong institutional support instruments particularly access to affordable credit, better extension services, and training programs will be vital for empowering wider adoption among small and marginal farmers. Improving market linkages through farmer producer organizations (FPOs), and integration with organized retail platforms can help farmers reap a larger share of consumer prices. Investments in post-harvest infrastructure, including cold storage facilities, grading and packaging centres, and efficient transportation networks, will further enhance the efficiency of horticultural value chains. Finally, policy frameworks should encourage the development of region-specific protected cultivation models that account for local agro-climatic conditions, market demand, and resource availability.

Overall, the study concludes that protected cultivation embodies a promising pathway for promoting crop diversification and augmenting farmers' income in India. By allowing year-round production, improving yield stability, and facilitating integration with high-value markets, protected horticulture can contribute to a more resilient and commercially oriented agricultural system. However,

appreciating its full potential will require synchronized efforts involving technological innovation, institutional support, and market development. With appropriate policy interventions and investments, protected cultivation can perform a critical role in transforming Indian agriculture toward a more productive, sustainable, and income-enhancing sector.

Protected Cultivation of Capsicum: Success Stories

Polyhouse Cultivation	Polyhouse Cultivation	Shade Net Cultivation
		
<p>Location: Harikhera village, Mohanlalganj Block, Lucknow District, Uttar Pradesh</p>	<p>Location: Gaura village, Mohanlalganj Block, Lucknow District, Uttar Pradesh</p>	<p>Location: Sangoha Village, Karnal Block, Karnal District, Haryana</p>
<ul style="list-style-type: none"> ◆ Area under Cultivation: 3 acres ◆ Cost of Installation: Rs. 52 lakhs (Govt Subsidy 17 lakhs) @1 acre ◆ Yield: 35 tonnes/acre ◆ Net Return from Capsicum: Rs. 19.5 lakhs/acre ◆ Net Return (Adjusting for Annualized fixed cost): Rs. 16 lakhs/acre ◆ Net Return (first three years adjusting loan): Rs. 7.23 lakhs/acre 	<ul style="list-style-type: none"> ◆ Area under Cultivation: 2.5 acres ◆ Cost of Installation: Rs. 45.5 lakhs (Govt Subsidy Rs. 20.6 lakhs) @1 acre ◆ Yield: 24 tonnes/acre ◆ Net Return from Capsicum: Rs. 14.4 lakhs/acre ◆ Net Return (Adjusting for Annualized fixed cost): Rs. 11.9 lakhs/acre ◆ Net Return (first three years adjusting loan): Rs. 5.74 lakhs/acre 	<ul style="list-style-type: none"> ◆ Area under Cultivation: 3 acres ◆ Cost of Installation: Rs. 28 lakhs (Govt Subsidy Rs. 18 lakhs) @1 acre ◆ Yield: 12 tonnes/acre ◆ Net Return from Capsicum: Rs. 8.92 lakhs/acre ◆ Net Return (Adjusting for Annualized fixed cost): Rs. 7.92 lakhs/acre ◆ Net Return (first three years adjusting loan): Rs. 5.4 lakhs/acre



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