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Economic efficiency, livelihood resilience and farmer-led innovation in protected cultivation: Evidence from open field comparisons

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Abstract

Protected Cultivation Technologies (PCT) have been increasingly recognized as sustainable, climate resilient and financially appealing alternatives to traditional open field farming methods. This study compares the socio-economic benefits and disadvantages associated with both systems; using primary data collected from adopters of PCT to analyse not just Livelihood Indicators, but also Economic Performance Indicators through Cost-Benefit Ratios. The findings indicate that on multiple levels, PCT outperforms open field systems with regard to income stability, net income generation, job creation, resource-use efficiency and risk mitigation. High capital costs, lack of access to specialized technical assistance, market and institutional barriers all inhibit early adoption of PCT. Although these impediments exist promotional efforts focused on developing innovative strategies specific to the region, as well as policy-driven solutions to increase the sustainability and scalability of PCT have been proposed by farmers. Therefore, while low cost and highly susceptible to risk, open field farming shall ultimately evolve from a traditional crop growing system to one driven by an economy based on resilience and commercial success; therefore policy-based interventions that alleviate barriers of entry are needed to facilitate distribution and widespread acceptance.

Keywords: Protected cultivation technologies, open field farming, socio-economic impact

1. Introduction

The agriculture system in India is primarily composed of small and semi-medium holdings. The agricultural community must now contend with an increasing number of challenges associated with climate variability, resource limitations, and fluctuating markets; therefore, instead of relying solely on the traditional open-field approach to farming, the use of protected-cultivation technology (PCT) in the form of polyhouses and shade-net systems is receiving significantly more attention through the National Horticulture Mission as a high-value, climate-resilient way to produce crops.

The use of protected-cultivation technology has enabled greater control over microclimatic conditions, resource-efficiency through reduced resource usage and increased ability to produce off-season crops. As a result, the use of protected-cultivation technology could increase farm incomes, create jobs, and build resilience among farmers that use this method of production in comparison to traditional open-field production. However, the adoption of protected cultivation in India has remained sporadic despite governmental support, because of costs associated with establishing and maintaining protected-cultivation systems, the complexity and technicality of protected cultivation, and the problems with access to financial and other resources that can facilitate the use of protected-cultivation systems. In India, there are currently very few empirical studies integrating the economic performance, socio-economic

impact and farmer innovation, as well as direct comparisons of the economic performance of protected-cultivation technology versus open-field production. The goal of the current study is to increase the understanding of the differences between the protected and open-field methods of producing crops in order to identify targeted policies and extension efforts to develop sustainable and inclusive agricultural intensification programs throughout India.

2. Socio-economic Influence of Protected Cultivation Technology Combined with Economic Performance - A Comparison with Open Cultivation

Socio-economic effects of protected cultivation technology were studied in relation to their economic efficiency and compared with conventional methods of open cultivations. Combining cost benefit analysis with socio-economic effects offers a complete perspective on the relative efficiency and sustainability of protected cultivation.

2.1 The Economics of Comparison

The economic analysis showed that although protected cultivation required higher initial expenditure, it had a better cost benefit ratio (CBR) than open cultivation. The farmers adopting protected cultivation received better gross and net returns per unit area due to enhanced productivity, quality improvement, and efficient pricing realization. Under protected cultivation, CBR was much greater than unity, which made it economically viable and profitable.

However, the CBR was lower in open cultivation, which was mostly just above unity due to greater susceptibility to climatic risks, pests, and prices. Although the fixed costs in open cultivation were lower, yield losses and reduced market prices caused decreased profitability.

Results indicate that although there are high setup costs for protected cultivations, there are continuous economic benefits, but the open cultivation method is still an unproductive and least-cost method of production.

2.2 Income Stability and Economic Security

Protected farming helped to ensure a stable source of money since the crops could always be grown regardless of the seasons, whether it is in the off-season when the demand is high. This source of money is evident in the cost-benefit ratio.

However, open-cultivation farmers faced income instability, as the earnings were highly dependent on the nature of the monsoons and the saturation levels in the markets. Even in years when they got favourable crops, the price crashes led to deteriorating Cost-Benefit ratio.

Therefore, protected cultivation assisted not only in increased income but also with respect to resistance to economic downturn, which remained an important socio-economic advantage for protected cultivation over open cultivation.

2.3 Employment Generation vis-à-vis Cost Efficiency

The use of protected cultivation methods created year-round job opportunities, thereby supplementing household income and making labour use efficiency better. The use of skilled labour in the management of nurseries, fertigation, pruning, and harvesting led to improved crop management, thereby positively impacting the cost-benefit ratio.

Open cultivation, on the other hand, provided seasonal job opportunities, which culminated in the underutilization of labour resources during the off-season. This impacted labour productivity, which, in turn, had an indirect effect on economic efficiency and profitability.

2.4 Risk Reduction and Economic Returns

This protected cultivation ensured a controlled environment that largely diminished the production risk factors related to the variability of rain and temperature variations and pest infestations. This diminished production risk improved the economic performance by mitigating the variability of the yield.

In open cultivation, there was a tendency towards increased exposure to abiotic and biotic stresses, and net returns were either negative or highly fluctuating. Such uncertainty reduced the effectiveness of the cost-benefit ratio, and the need for credit among the farmers increased.

2.5 Resource Use Efficiency and Cost Optimization

In protected crops, there was efficient use of land, water, and important inputs, thereby causing a decrease in costs per unit of product. Irrigation techniques, fertigation, and mulching techniques reduced wastage of inputs and increased efficiency of input use, hence improving the cost-benefit ratio.

Comparatively, the open cultivation systems were characterized by inefficient use of resource factors such as irrigation and nutrient application, resulting in higher variable costs and lower economic efficiency.

2.6 Socio-economic Empowerment

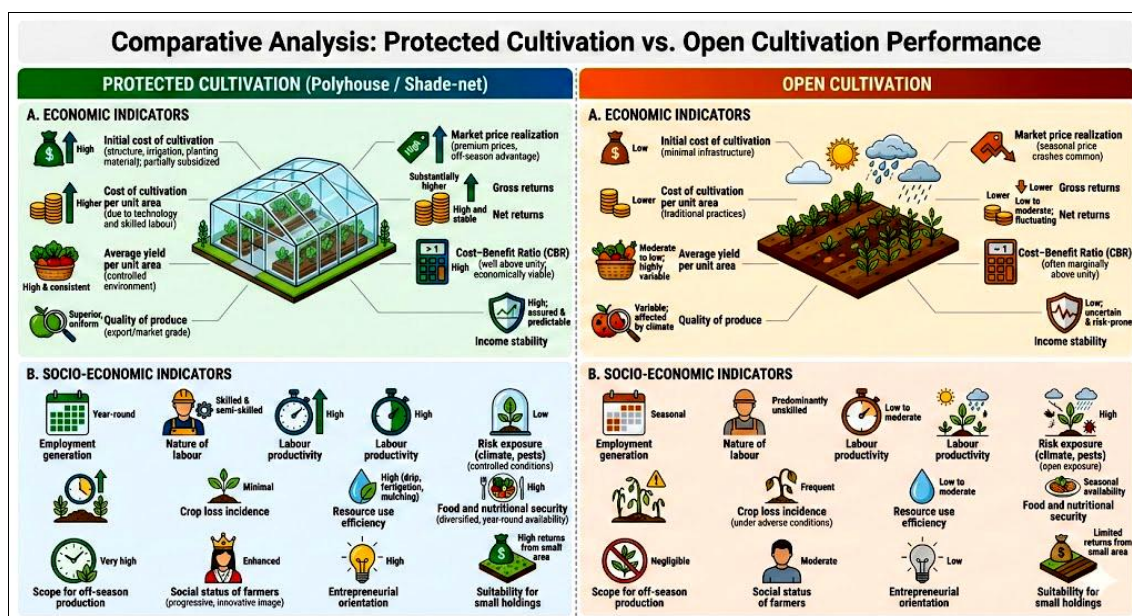
The increased profitability and favouring cost-benefit ratio of protected cultivation led to elevated socio-economic status as well as recognition in society for adopting farmers. The farmers adopting protected cultivation were considered progressive and enterprising, earning them the status of innovators or reference farmers. Open cultivation farmers, faced with the reduced profitability and economic risk, did not demonstrate much potential for re-investment and technological development.

Integrated Comparative Insight

Though open farming is less investment-oriented, its lower cost-benefit ratio, income volatility, and risks are constraints in socio-economic aspects. On the other hand, protected farming, being investment-oriented, ensures higher, sustainable returns, higher cost-benefit ratio, secured and continuous employment. The combination of socio-economic and economic analysis clearly defines protected cultivation as a financially feasible and socio-transformative crop system, thereby enabling farmers to shift from risk-constrained crop farming to risk-resilient, market-driven crop farming.

Comparative analysis

The advances made in the agriculture industry have established contrasting farming techniques: Protected Cultivation VS Open Field Cultivation. As seen in the infographic titled Comparative Analysis: Protected Cultivation vs Open Field Cultivation performance, the images in the quadrant vary. In the left section, coloured in green, protected cultivation refers to farming in poly houses, further illustrated with a greenhouse icon. On the right section, coloured in orange, open field cultivation refer to farming in a field with the sun and rain. The quadrant is further divided vertically into 2: A. Economic Indicators and B. Socio Economic Indicators, with an assortment of icons and short text serving to describe and rate each of the assessed factors.



Source: Field survey data, 2023-24 and Directorate of Horticulture, Government of Karnataka, 2020-21

On the protected side, including the greenhouse and polyhouse farming, there is a notable advantage created in the economy. As to the cultivation of crops, there is a higher return from the market with a cost benefit ratio higher than one in addition to stable high income. In the open section of the farming land with field crops, there is a lower economy created. Maintaining a high yield and stable income comes with high cost and operational input. In contrast, open field farming requires less operational input and cost. Although, in the economy created with open field farming a system of low income with highly variable yields is established, creating a lower cost.

3. Constraints in Adoption of Protected Cultivation Technologies: A Comparison with Open Cultivation

On top of that, the PCT adoption has been limited by a number of interconnected factors which, to a large extent, are non-existent or less severe in the open cultivation systems.

Firstly, among the constraints leading factors the high initial investment needed for setting up polyhouses or shade-net was the most significant one. In comparison to open cultivation, which is a low capital-intensive activity, PCT is highly capital-intensive at the very beginning. In addition to this, spending on the materials of irrigation and the fields themselves is also very significant. Even though the government subsidies only partially pay for this, small and marginal farmers still face delays and procedural complexities and hence are likely to be discouraged.

The second major problem was the lack of technical advice and local extension services. PCT is very technically intensive and calls for high precision in controlling environmental factors in a microclimate, fertigation and pests for example. Also, insufficient access to extension services and limited numbers of qualified personnel lead to an increase in the operational risk, especially during the first year of PCT adoption.

Farmers have acknowledged that the maintenance of structures is expensive and that their structures are deteriorating, mainly due to damage by the wind and aging

of the material. Such risks are minimal in open cultivation, where infrastructure dependence is low. On top of that, they point out a shortage of skilled labour and high labour costs as obstacles, while in open cultivation mostly the family labour is engaged.

Other constraints concerning the market like price volatility and lack of exclusive marketing channels for protected fruits and vegetables have double effects on farmers' decisions about adoption. Protected produce is harder to trace and therefore consumers cannot distinguish it easily which makes it challenging for fresh products to be sold even at higher prices.

To sum up, while open cultivation mainly faces climatic and biological risks, PCT is burdened with institutional, financial, and knowledge-intensive barriers which indicates the necessity of system-level interventions.

4. Farmers' Suggestions for Improving Adoption of Protected Cultivation Technologies

Farmers made sensible and policy-oriented suggestions for the wider adoption of PCT and its long-term sustainability, especially in comparison with the open mode of relatively self-managed cultivation.

Among the major recommendations was the improvement of subsidy coverage and the simplification of the procedures, particularly for small and marginal farmers. The respondents pointed out the necessity of timely disbursement and the provision of maintenance costs within the subsidy frameworks—a feature that is irrelevant in open cultivation but is very important for the sustainability of PCT.

Extension services can be improved if the staff is well trained, they receive technical support on the spot, and exposure visits are arranged. Farmers believe that if they are consistently capacitated there will be no need for dependence on trial-and-error method of learning which is the case in open cultivation where experiential knowledge predominates.

One more significant proposal was made concerning the creation of exclusive markets, assured procurement

mechanisms, and price incentives for protected produce. Farmers thought that without market differentiation, the economic benefit of PCT as compared to open cultivation is barely realized.

Moreover, the respondents acknowledged the significance of local repair services, input availability, and the existence of a pool of skilled labour which, they argued, would drastically reduce the occurrence of operational disruptions that are unique to protected systems.

Individually, these proposals reveal that although open cultivation can continue with minimal support from institutions, protected cultivation needs a facilitative ecosystem that includes finance, extension, infrastructure, and markets.

5. Conclusion

The comparative evidence highlight that protected farming dramatically surpasses open field systems in income stability, employment creation and climate resilience, which makes it a sustainable agricultural intensification pathway. But the speed and inclusiveness of adoption are limited by high entry costs, a management-intensive technology and institutional inefficiencies in extension, finance, and markets. Thus, a policy concerted effort is needed to scale up protected farming beyond capital subsidies to include credit access, extension support at the local level and skill development for farm labour. Moreover, integrating the products of the protected sector into differentiated and assured market channels will facilitate their uptake.

If strategies for protected farming were consistent with national horticulture and climate-resilience programmes, adoption by small and semi-medium farmers would be enhanced and the transition of protected cultivation from a niche intervention to a mainstream, economically viable and climate-resilient production system would be facilitated.

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