



TECHNO-ECONOMIC CONSTRAINTS OF GREENHOUSE VEGETABLE FARMING IN KERALA

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Abstract

This study examines the techno-economic constraints affecting greenhouse vegetable farming in Kerala, with the aim of analysing the key technical, economic, and market-related factors influencing its viability and sustainability. Despite policy support and the potential advantages of protected cultivation, greenhouse farming in the state faces persistent challenges that limit its performance and wider adoption. The research problem centres on understanding how these interrelated constraints—ranging from production inefficiencies to financial and market limitations—affect the overall feasibility of greenhouse vegetable cultivation.

The study is based on both primary and secondary data. A sample of 165 greenhouse farms was selected from a population of 837 units established between 2009–10 and 2020–21, using a stratified sampling method to ensure representation across different farm sizes and districts. Primary data were collected through structured interviews with farmers, while secondary data were obtained from institutional sources. Analytical tools such as ratio analysis and chi-square tests were employed, and results were presented using tables and charts.

The findings reveal that greenhouse farming is highly capital-intensive, with fixed costs forming the largest share of total cost, followed by labour and material costs. Contrary to expectations, labour costs remain substantial, indicating limited reduction in labour dependency. Debt burden increases significantly with farm size, and a majority of farmers receive prices below the cost of production, leading to poor profitability. Technical constraints such as pest infestation, low durability of materials, climatic stress, and shortage of skilled labour further reduce efficiency. Market-related issues, including price fluctuations and weak marketing systems, compound these challenges. Additionally, insurance coverage is extremely low, exposing farmers to high risks.

The study concludes that the combined effect of techno-economic constraints limits the sustainability and scalability of greenhouse vegetable farming in Kerala. Addressing these issues requires integrated interventions in technical support, market linkages, financial services, and risk management to enhance the long-term viability of the sector.

Keywords: *Greenhouse Farming, High-tech Farming, Techno-Economic Constraints, Protected Cultivation, Cost of Cultivation, Price Realisation.*

Introduction

Agriculture in Kerala is characterized by small and fragmented landholdings, high population pressure, and increasing vulnerability to climatic variability. In this context, the promotion of protected cultivation technologies such as greenhouse (polyhouse) vegetable farming has been considered a strategic intervention to enhance productivity, ensure year-round supply, and improve farmers' income. Greenhouse cultivation enables the control of environmental parameters such as temperature, humidity, and light, thereby reducing the adverse effects of biotic and abiotic stresses and allowing off-season



production of high-value vegetables (Lakshmi S. et al., 2017). As a result, it has been widely promoted under various government schemes in Kerala since 2009–10 as part of high-tech agriculture initiatives. Despite its theoretical advantages, the diffusion and performance of greenhouse vegetable farming in Kerala have not been entirely satisfactory. Although the technology has demonstrated potential for higher productivity and better crop quality, its adoption among farmers remains limited and uneven. Studies indicate that greenhouse farming in the state has failed to gain widespread acceptance, raising concerns about its long-term sustainability and economic viability (Panancheri A, 2023). The high initial investment, dependence on subsidies, and requirement of technical expertise pose significant entry barriers, particularly for small and marginal farmers.

From an economic perspective, the profitability of greenhouse vegetable farming in Kerala presents a mixed picture. While protected cultivation can enhance yields and improve resource-use efficiency, several studies reveal that a large proportion of greenhouse units operate under financial stress. Even under subsidised conditions, many farms struggle to achieve viable returns, with smaller units facing severe inefficiencies due to higher per-unit costs and lack of economies of scale (Panancheri A, 2025). Furthermore, disparities between expected and realised prices for major crops such as tomato, capsicum, and cabbage significantly undermine farm income.

Marketing and price realisation have emerged as critical constraints affecting the success of greenhouse farming. Evidence shows that although a majority of farmers can secure buyers, only a small fraction receive remunerative prices, while more than half sell their produce below cost-recovery levels (Panancheri A, 2025). This indicates that the problem is not merely technological inefficiency but also structural issues in marketing systems, supply chains, and price stabilisation mechanisms. In addition, inadequate extension support, labour constraints, and limited access to technical knowledge further exacerbate the challenges faced by farmers.

The concept of techno-economic constraints provides a comprehensive framework to analyse these issues by integrating both technological and economic dimensions. Technological constraints include issues related to design, maintenance, pest and disease management, and climate control, while economic constraints encompass high capital costs, operational expenses, credit access, and market uncertainties. The interaction of these factors determines the overall viability and sustainability of greenhouse vegetable farming systems.

Against this backdrop, there is a need for a systematic examination of the techno-economic constraints affecting greenhouse vegetable farming in Kerala. While existing studies have focused either on economic viability or technological aspects in isolation, a holistic analysis combining both dimensions is essential to understand the underlying causes of low adoption and performance. Such an analysis is crucial for designing effective policy interventions, improving support systems, and ensuring that the potential benefits of protected cultivation are translated into sustainable farm incomes.

Research Problem

Despite sustained policy support and institutional promotion, greenhouse vegetable farming in Kerala continues to face operational and economic difficulties that limit its sustainability. The persistence of technical constraints—including pest infestation, poor durability of greenhouse covering materials under humid climatic conditions, pollination issues, improper waste disposal, and shortage of skilled labour—affects the efficient functioning of protected cultivation systems. Reports of the Indian Council of Agricultural Research emphasise that the success of greenhouse technology in India is highly



dependent on skilled management and location-specific adaptations, which remain inadequate at the farm level (ICAR, 2016).

At the same time, economic constraints further weaken the viability of greenhouse farming. High initial investment and rising labour costs, combined with unstable market conditions, low price realisation, and lack of organised marketing systems, reduce profitability. Studies associated with Kerala Agricultural University indicate that many farmers are unable to recover costs consistently due to price fluctuations and high recurring expenses (Lakshmi S. et al., 2017). In addition, issues such as debt burden, inadequate subsidy support for operational costs, and absence of comprehensive insurance coverage increase financial risk and discourage sustained adoption (NABARD, 2018).

Although these constraints are individually documented, there is limited empirical evidence examining their combined techno-economic impact on greenhouse vegetable farming in Kerala. Hence, the research problem is to identify and analyse the major technical and economic constraints and evaluate their influence on the viability and sustainability of greenhouse vegetable farming in the state.

Objectives of the Study

1. To identify and analyse the major technical constraints affecting greenhouse vegetable farming in Kerala.
2. To examine the economic and market-related constraints and assess their impact on the viability and sustainability of greenhouse vegetable farming in Kerala.

Methodology

The study was based on primary data. The population consisted of 837 greenhouse vegetable farms established in Kerala during the period 2009–10 to 2020–21. From this population, a sample of 165 farms was selected using a stratified sampling technique, ensuring representation across all fourteen districts of the state as well as different size categories of greenhouse units.

Primary data were collected directly from the selected farmers through a structured interview schedule, covering technical, economic, and market-related aspects of greenhouse vegetable cultivation. For analysis, both descriptive and inferential statistical tools were employed. Ratio analysis was used to evaluate cost and return structures, while the chi-square test was applied to examine associations and differences across categories such as farm size and constraints faced. The results were systematically presented using tables and charts to facilitate clear interpretation.

Results and Discussion: Greenhouse technology in agriculture has the potential to help farmers adapt to unpredictable weather patterns caused by climate change. However, in Kerala, local farmers face challenges in successfully adopting and profiting from this method. The high cost of establishing and maintaining greenhouse systems, the lack of expertise and technical knowledge, and the scarcity of resources further exacerbate these challenges. Technical constraints include a lack of technical expertise, inadequate knowledge about greenhouse management practices, and limited exposure to climate control and crop optimisation. Economic constraints involve high upfront costs, labour costs, uncertain returns, and difficulty obtaining loans or financial assistance to invest in greenhouse infrastructure.

Technical Constraints

Pest Infestation: Pest protection is one of the major advantages of greenhouse vegetable farming. As a result, it is safer to consume foods that do not require as much cooking as vegetables because they do



not contain pesticides. However, according to this study, this feature was not totally present in Kerala greenhouse farming. Figure 1 indicates that 62 percent of all greenhouses have been infested. Only 38 percent of greenhouses were able to successfully grow vegetables without being harmed by pests.

Figure 1: Extent of Insect Attack

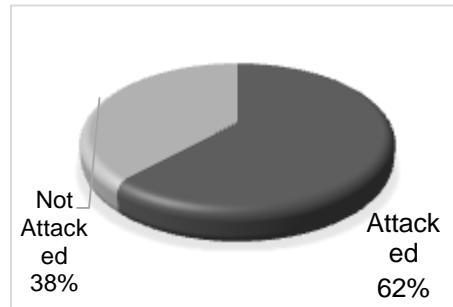


Table 1: Intensity of Pest Attack on Organic and Nonorganic Farms

Sl No	Nature of Farming	Intensity of Pest Infestation			Test
		No Pest Infestation	Pest Infestation	Total	
1	Nonorganic	24 (66.7)	12 (33.3)	36	Pearson $\chi^2(1) = 4.559$ $p = 0.033$
2	Organic	107 (82.9)	22 (17.1)	129	
Total		131 (79.4)	34 (20.6)	165	

Source: Primary Data

Table 1 illustrates the intensity of insect attacks on organic and non-organic farms. Accordingly, the intensity of pest attacks was comparatively higher on non-organic farms (33.3%) than on organic farms (17.1%). Crops were better protected against insect attack by the organic cultivation strategy than by the nonorganic one. Furthermore, this difference in infestation intensity between organic and non-organic farms was statistically significant ($p=0.033$).

Short Durability of Roofing and Side Covering Sheets

Polyethene sheets were used to cover the roofs and sides of all greenhouses in the state. Due to the state's unique climatic circumstances, it lasts only a few years. After that, it becomes a non-biodegradable waste that causes a slew of issues for farmers.

Table 2: Durability of Roofing Sheet of Various Sizes of Greenhouses

SL No	Size of GH	Average Durability in Years	Minimum Durability in Years	Maximum Durability in Years
1	Very Small (Up to 100 sq. m)	5.15	4	6
2	Small (101 - 300 sq. m)	4.63	4	6
3	Medium (301-500 sq. m)	4.99	2	9
4	Large (501-1000 sq. m)	5.26	3	10
5	Very Large (Above 1000 sq. m)	5.62	4	8
All		5.1	2	10

Source: Primary Data



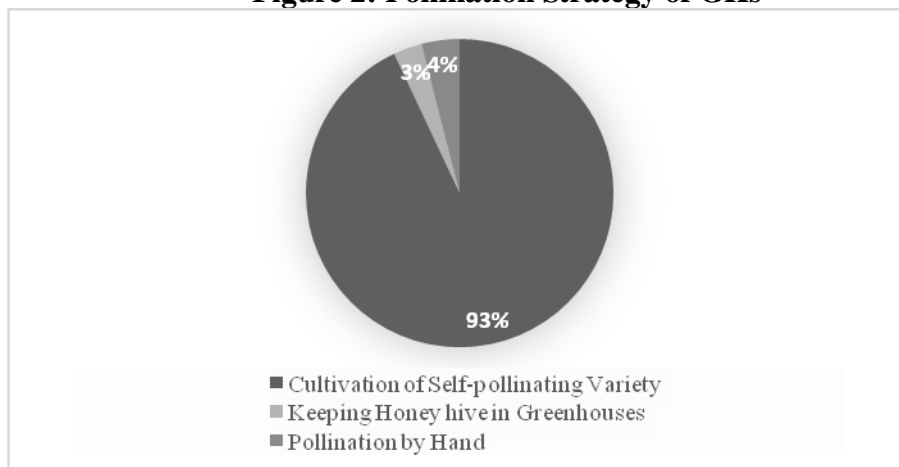
The durability of covering and roofing materials for greenhouses of various sizes is shown in Table 2. Accordingly, the average lifespan of all greenhouses was 5.1 years. Very large greenhouses had the best average durability (5.62 years), followed by large greenhouses, while small greenhouses had the worst (4.63 years). Large greenhouses have a maximum lifespan of ten years, whereas smaller greenhouses have a minimum lifespan of five years. Six months of continuous rain led to moss growth on the covering and roofing sheets, significantly reducing their lifespan.

Moss blockage on the roof and side-covering sheets has damaged approximately 99 percent of greenhouses. The inadequate sunlight entering the greenhouses has reduced productivity. Furthermore, 22.4 percent of greenhouse operators lacked a suitable strategy for clearing clogged moss and dust from the covers. The traditional and rudimentary approach of washing to clear the obstructed moss was used by the remaining 77.6 percent. Farmers, on the other hand, found this strategy prohibitively expensive to execute. In light of these challenges, many operators are now seeking innovative solutions to enhance the efficiency of their cleaning methods.

Pollination of Crops

Except for leafy vegetables like spinach, cabbage, and cauliflower, pollination is required for vegetable crop production. In greenhouses, various pollination methods are utilised. There are mechanical methods like vibrators and fans, as well as biological methods like beehive installation and manual pollination, as well as the production of self-pollinating cultivars. Figure 2 depicts the various methods used by Kerala greenhouse farmers to pollinate their crops. As a result, 93 percent of farmers chose self-pollinating kinds or crops that don't need pollination. Three percent of the remaining seven percent of farms used honey hives in the greenhouse for crop pollination, while four percent of farmers pollinated by hand. To avoid the pollination constraint, nearly all farmers cultivated self-pollinating crop varieties. As a result, only a small number of crops, such as yardlong beans, salad cucumbers, and spinach, were mostly grown in greenhouses in Kerala.

Figure 2: Pollination Strategy of GHs



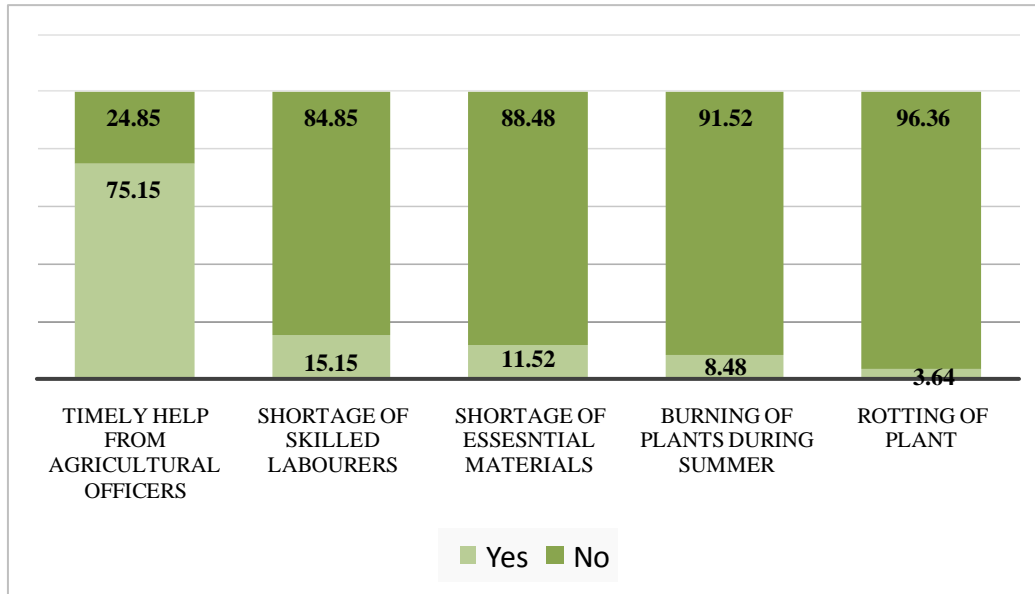
Other Major Technical Constraints of GH Vegetable Farming

In addition to the constraints discussed earlier, greenhouse vegetable cultivation in Kerala faces several other operational challenges. These include the lack of timely technical guidance and support from agricultural officers, the shortage of skilled labour and critical inputs, the incidence of plant scorching during the summer months, and plant rotting during the rainy season due to excess humidity. These



issues further aggravate production risks and reduce overall efficiency. The extent to which greenhouses are affected by these constraints is illustrated in Figure 3.

Figure 3: Proportion of GHs with Various Constraints



Source: Primary Data

Figure 3 shows that 24.85 percent of greenhouses did not obtain timely assistance from agriculture officers, whereas 75.15 percent did. The scarcity of skilled labour to do farm tasks was not severe. Only 15.15 percent of farmers were affected by the scarcity of skilled labour, while 84.85 percent were not. When compared to skilled labour, the intensity of the lack of essential materials was lower. 11.52 percent of farmers reported a lack of necessary resources for greenhouse vegetable cultivation. During the scorching summer, 8.48 percent of farmers experienced plant burnout. Plant rotting, on the other hand, was extremely low (only 3.64 percent) during the rainy season.

Economic Constraints

High Labour Cost

Generally, labour costs can be reduced considerably in greenhouse cultivation as many of the farm activities are being done through automation techniques. But in Kerala, a different picture can be observed. Table 3 presents the composition of annual cost (A1) across different sizes of greenhouse units, highlighting the relative share of fixed, labour, material, and interest costs. Examining the percentage distribution of each cost component provides insight into how cost structures vary with scale and the extent to which capital and operational expenses contribute to total cultivation costs in greenhouse farming.

Table 3: Components of Annual Cost (A1) of Various Sizes of Greenhouses with Subsidy

SL No	Size of GH	Number	Fixed Cost (Rs)	Labour Cost (Rs)	Material Cost (Rs)	Interest Cost (Rs)	Total Cost A1(Rs)
1	Very Small	19	4086	631	3752	00	8471



	(Up to 100 sq. m)		(48.3)	(7.45)	(44.30)	(0)	(100)
2	Small (101 - 300 sq. m)	11	16090 (30.28)	18000 (33.87)	16812 (31.64)	2227 (4.19)	53135 (100)
3	Medium (301-500 sq. m)	89	34412 (28.25)	36620 (30.06)	40390 (33.16)	10365 (8.5)	121787 (100)
4	Large (501-1000 sq. m)	30	90331 (40.67)	57316 (25.8)	51116 (23.01)	23333 (10.5)	222096 (100)
5	Very Large (Above 1000 sq. m)	16	132280 (32.4)	123125 (30.15)	78575 (19.24)	74287 (18.19)	408267 (100)
All		165	49356 (32.86)	43386 (28.88)	40253 (26.80)	17185 (11.44)	150180 (100)

Source: Primary Data. Values in parentheses are percentages of the row total

For very small greenhouses, fixed cost constitutes the largest share (48.3%), followed by material cost (44.30%), while labour cost is minimal (7.45%) and no interest cost is reported. This shows that initial structure-related expenses dominate at this scale.

In small units, the cost structure becomes more balanced, with labour cost (33.87%) forming the highest share, closely followed by material cost (31.64%) and fixed cost (30.28%), while interest cost remains relatively low (4.19%).

For medium-sized greenhouses, material cost accounts for the highest proportion (33.16%), followed by labour (30.06%) and fixed cost (28.25%), with interest cost contributing 8.5%. This indicates increasing operational expenses with scale.

In large units, fixed cost again becomes dominant (40.67%), while labour (25.8%) and material costs (23.01%) have relatively lower shares. Interest cost rises to 10.5%, reflecting higher capital involvement.

In very large greenhouses, the distribution is more even, with fixed cost (32.4%) and labour cost (30.15%) forming major shares, followed by material cost (19.24%) and a significantly higher interest cost (18.19%), indicating greater financial burden due to capital investment.

Overall, considering all farm sizes together, fixed cost accounts for the largest share (32.86%), followed by labour (28.88%) and material cost (26.80%), while interest cost (11.44%) forms the smallest component. This suggests that although capital investment remains significant, operational costs—especially labour—also constitutes a substantial portion of total costs in greenhouse farming.

Table 3 reveals the need for farm automation, which reduces labour costs in greenhouse cultivation by improving efficiency, consistency, and scalability. It minimises manual work through automated irrigation, fertigation, and climate control, while ensuring precise input use and uniform crop management. Simplifying complex tasks reduces dependence on skilled labour and enables efficient management of larger areas. Overall, automation enhances productivity, resource use, and the long-term sustainability of greenhouse farming.

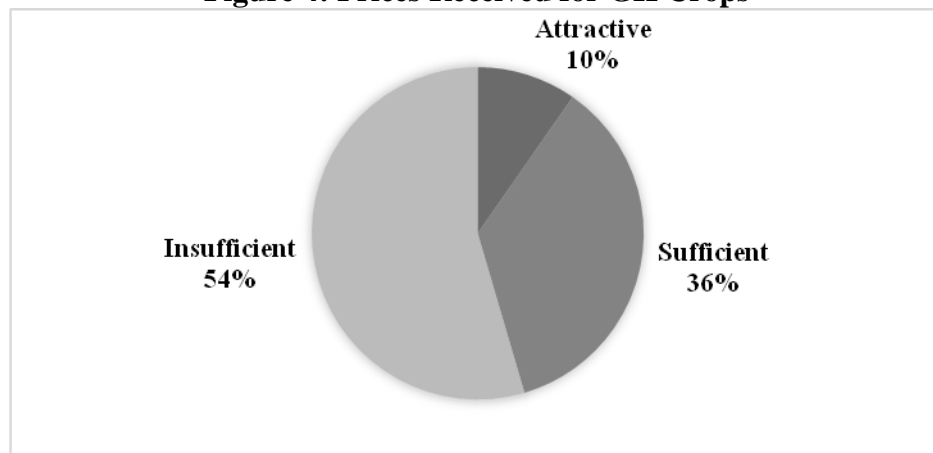
Insufficient Price of Outputs

Adequate pricing is essential for the long-term viability of any commercial venture. However, when compared with the cost of production per kilogram, the prices received by greenhouse farmers for



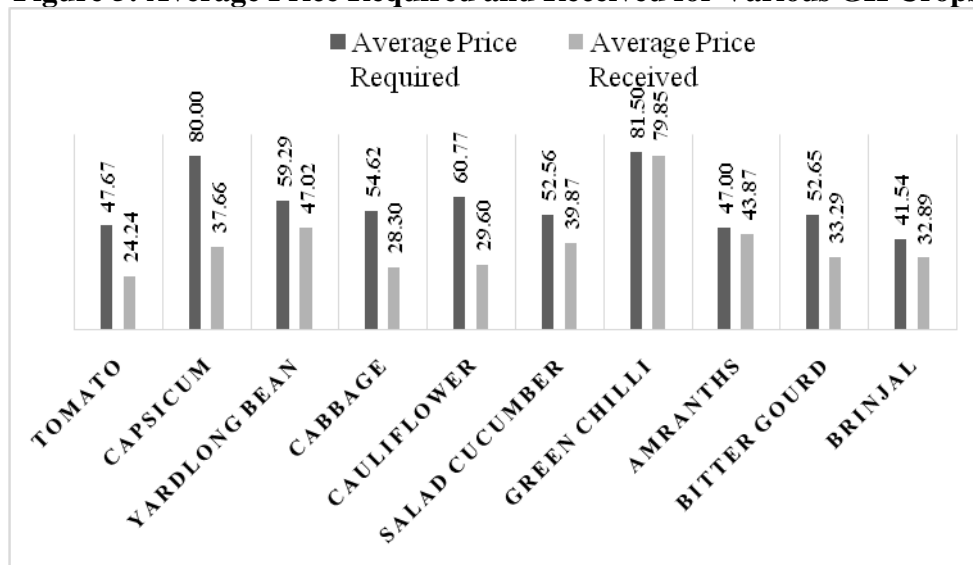
vegetable produce were largely inadequate. As illustrated in Figure 4, only 10 per cent of farmers obtained remunerative prices, while 36 per cent received just sufficient prices. A majority of farmers (54%) were compelled to sell their produce at prices below cost. Furthermore, as shown in Figure 5, almost all vegetable crops cultivated in greenhouses in Kerala were sold at prices lower than the required level for sustaining the enterprise. Crops such as tomato, capsicum, cabbage, and cauliflower were sold at nearly 50 per cent below the required price. Similarly, major crops like yardlong bean, salad cucumber, and bitter gourd fetched prices that were 20 per cent, 24 per cent, and 36 per cent lower, respectively, than the required levels. Green chilli was the only crop that came close to achieving the required price.

Figure 4: Prices Received for GH Crops



Source: Primary Data

Figure 5: Average Price Required and Received for Various GH Crops



Source: Primary Data

Debt Burden

The debt burden is usually a significant barrier for farmers. Greenhouse farmers are also not different, as the majority of them have taken out loans from a variety of sources to cover the high cost of building



greenhouses and installing various greenhouse amenities. Table 4 illustrates the intensity of debt burden among various sizes of greenhouses.

Table 4: The Intensity of Debt Burden among Different Sizes of Farms

Sl No	Size Category	Number of Farms	Average Debt per farm (Rs)	Average Debt per sq. m (Rs)
1	Very Small (Upto 100 sq. m)	19	00	00
2	Small (101 - 300 sq. m)	11	31318.18	158.40
3	Medium (301-500 sq. m)	89	148078.65	360.81
4	Large (501-1000 sq. m)	30	333333.33	395.49
5	Very Large (Above 1000 sq. m)	16	1061250.00	565.21
All		165	245509.00	331.89

Source: Primary Data

Table 4 shows a clear increase in debt burden with the size of greenhouse units. Very small farms report no debt, indicating either limited investment or reliance on own funds. However, from the small category onwards, both the average debt per farm and per square metre (sq. m) rise steadily.

Small farms have relatively low debt levels (₹31,318 per farm; ₹158.40 per sq. m), while medium farms show a sharp increase (₹1,48,079 per farm; ₹360.81 per sq. m), reflecting higher investment requirements. The debt burden becomes more pronounced in large farms (₹3,33,333 per farm; ₹395.49 per sq. m) and reaches its peak in very large units, with an average debt of ₹10,61,250 per farm and ₹565.21 per sq. m.

Overall, the average debt across all farms is ₹2,45,509 per farm and ₹331.89 per sq. m, indicating that greenhouse cultivation is capital-intensive, and larger units face significantly higher financial exposure.

Lack of Insurance for Greenhouses and Crops

It is critical to have insurance coverage for greenhouses and the crops grown in them in order to be protected from extreme weather. Kerala is one of the Indian states that is vulnerable to natural disasters, including floods, landslides, and storms. Crop failure and, as a result, financial loss for farmers are common as a result of extreme weather. Greenhouse farmers lose a lot of money because of the damage to their greenhouses and the crops they grow in them. Many greenhouses and the crops inside them were destroyed during the Ockhi cyclone in 2017, which hit areas like Thiruvananthapuram, Kollam, and Alappuzha. As a result of the severe damage caused by this natural disaster, a lot of farmers abandoned greenhouse farming. The primary cause was farmers' failure to insure greenhouses and crops. The following graphs show the lack of insurance among Kerala greenhouse vegetable farmers.



Figure 6: Insurance to GHs

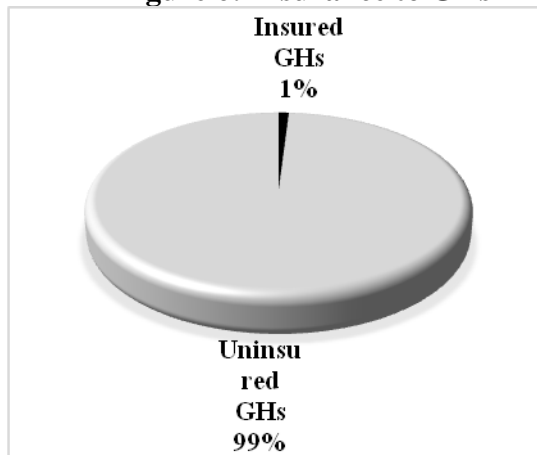
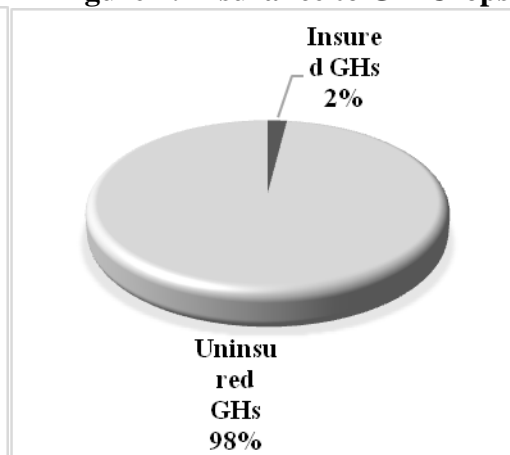


Figure 7: Insurance to GH Crops



Source: Primary Data

According to Figure 6, only 1 per cent of farmers insured their greenhouses against natural calamities and fire, highlighting a major gap in risk management for such high-cost structures. Figure 7 shows a similar pattern in the case of crop insurance, with only 2 per cent of farmers insuring the crops grown inside greenhouses. This indicates that insurance coverage among greenhouse vegetable farmers is extremely limited. The low adoption is mainly due to lack of awareness and the absence of suitable insurance schemes, which discourages farmers from insuring both their greenhouses and crops.

Major Findings

1. Greenhouse farming is affected by issues such as pest infestation, poor durability of materials, pollination problems, and climatic stresses like plant scorching and rotting.
2. The vast majority of greenhouse farmers (93%) avoided pollination challenges by cultivating self-pollinating crops or crops that do not require pollination, while only a small proportion used methods like beehives (3%) and manual pollination (4%).
3. Due to this strategy, greenhouse cultivation in Kerala is largely limited to a few crops such as yardlong bean, salad cucumber, and spinach.
4. Lack of skilled labour and inadequate extension services limit efficient greenhouse management.
5. The cost of cultivation in greenhouse farming is dominated by fixed costs (32.86%), followed by labour (28.88%) and material costs (26.80%), indicating a capital-intensive production system.
6. Contrary to expectations, labour cost remains a significant component across all farm sizes, accounting for nearly one-third of total costs, reflecting continued dependence on skilled labour.
7. The average debt per farm and per sq m. increases with the size of greenhouse units, with very large farms facing the highest financial burden.
8. A majority of farmers (54%) receive prices below the cost of production, while only a small proportion (10%) obtain remunerative prices, severely affecting profitability.
9. Major crops such as tomato, capsicum, cabbage, and cauliflower are sold at nearly 50% below the required price, while others like yardlong bean, cucumber, and bitter gourd also fetch significantly lower prices.
10. Only 1% of farmers insured their greenhouses and 2% insured their crops, exposing them to high production and financial risks.



11. The combined effect of techno-economic constraints limits the adoption, scalability, and sustainability of greenhouse vegetable farming in Kerala.

Limitations of the Study

The study is subject to certain limitations. It is primarily based on cross-sectional farm-level data collected from a sample of greenhouse units in Kerala, which may not fully capture temporal variations in costs, prices, and productivity. The findings rely on farmers' responses, which may involve recall bias or reporting inaccuracies. In addition, the analysis is limited to selected techno-economic variables and does not account for all external factors such as policy changes, climate variability, and market dynamics over time. Therefore, the results should be interpreted with caution while generalising beyond the study context.

Conclusion

The greenhouse vegetable farming in Kerala, despite its potential to enhance productivity, ensure year-round cultivation, and improve farm income, is constrained by a combination of interrelated technical and economic challenges. The analysis highlights that the cost structure is heavily burdened by high fixed, labour, and material costs, with labour expenses remaining significant even in a system expected to reduce labour dependence. The rising debt burden, especially among larger units, further intensifies financial vulnerability. At the same time, inadequate price realisation—where a majority of farmers receive prices below the cost of production—undermines profitability and discourages continued investment.

Technical constraints such as pest infestation, low durability of greenhouse materials, climatic stresses like plant scorching and rotting, and the shortage of skilled labour reduce operational efficiency and crop performance. These issues are compounded by limited access to timely technical guidance and extension support. Market-related challenges, including weak marketing systems and price fluctuations, further constrain income stability. Additionally, the near absence of insurance coverage for both greenhouses and crops exposes farmers to high risks, while insufficient support for recurring expenses limits long-term sustainability.

Taken together, these findings indicate that greenhouse farming in Kerala has yet to realise its full potential due to techno-economic constraints. Addressing these issues requires a comprehensive approach that includes improved technical support, the promotion of automation, stronger market linkages, accessible credit and insurance mechanisms, and policies that go beyond capital subsidies to support operational sustainability.

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