EPRA International Journal of Agriculture and Rural Economic Research (ARER)- Peer-Reviewed Journal
Volume: 13 | Issue: 8 | August 2025 | Journal DOI: 10.36713/epra0813| Impact Factor SJIF(2025): 8.733| ISSN: 2321 – 7847

ECONOMIC VIABILITY OF GREENHOUSE VEGETABLE FARMS IN KERALA

Dr. Ashraf Panancheri
Associate Professor of Economics, Government College Malappuram, Kerala
(Affiliated to the University of Calicut)

Article DOI: https://doi.org/10.36713/epra23791
DOI No: 10.36713/epra23791

ABSTRACT--

Greenhouse vegetable farming has emerged as a promising solution for enhancing agricultural productivity and addressing climatic uncertainties, particularly in ecologically sensitive states like Kerala. This study evaluates the ***annual economic performance and viability*** *of greenhouse vegetable farms in Kerala, using detailed cost and return data from 165 units established between 2009–10 and 2019–20. Employing standard farm management cost accounting methods (A1, B1, C2, C3) and applying non-parametric statistical tests (Kruskal–Wallis H and Pearson Chi square test), the analysis explores the profitability dynamics across five greenhouse size categories. The findings reveal that although economies of scale significantly reduce unit costs, a majority of greenhouses operate at a loss, even under subsidised conditions. Profitability is highest among large greenhouses (501–1000 sq. m), while very small units (≤100 sq. m) face severe economic inefficiencies. The results underline that despite policy support, greenhouse cultivation in Kerala faces major challenges in achieving financial viability, particularly for smallholder farmers. This highlights the need for integrated interventions combining financial aid, capacity building, and collective farming models to improve long-term sustainability.*

KEYWORDS: *Greenhouse Farming, Economic Viability, Protected Cultivation, Economies Of Scale, Subsidy Impact*--

1. INTRODUCTION

The growing demand for high-quality, residue-free vegetables and the need for year-round cultivation have led to the increasing popularity of greenhouse farming in India, particularly in ecologically sensitive and agriculturally significant states like Kerala. Greenhouse vegetable cultivation, by creating a controlled microclimate, offers a viable alternative to open-field agriculture by ensuring higher productivity per unit area, improved input efficiency, and better resistance to climate variability (Kumar et al., 2020; Singh & Kumar, 2016). In Kerala, where landholdings are generally fragmented and average farm size is declining, protected cultivation methods such as polyhouses and naturally ventilated greenhouses are being promoted to enhance farm-level income and productivity (Government of Kerala, 2022).

The economic viability of greenhouse farming, however, remains dependent upon various factors, including the size of the unit, capital and operational costs, choice of crops, yield levels, and market access. Comprehensive cost analysis frameworks such as Cost A1 (which includes all direct cash and kind expenses), Cost B1 (A1 + rental value of owned land + interest on fixed capital), Cost C2 (B1 + imputed value of family labour), and Cost C3 (C2 + 10% managerial cost) are critical in assessing the financial sustainability of such enterprises (Commission for Agricultural Costs and Prices, 2021).

In Kerala, greenhouse farming has been extensively supported through state and centrally sponsored subsidy schemes, particularly under the Mission for Integrated Development of Horticulture (MIDH). Despite the growing number of units, particularly in districts like Wayanad, Palakkad, and Idukki, the profitability and cost-efficiency across different sizes of greenhouses—from very small (<100 sq. m) to very large (>1000 sq. m)—are yet to be systematically analysed.

This study aims to assess the economic feasibility of greenhouse vegetable farms in Kerala by analysing costs and returns. It evaluates per kilogram production costs, average revenues, and profitability margins, using the standard farm management cost accounting methods. The findings are expected to provide critical insights for policymakers, extension agents, and prospective greenhouse farmers in designing cost-effective, scalable, and sustainable models of protected cultivation in Kerala.

RESEARCH PROBLEM

The endurance of any economic activity—whether industrial, commercial, or agricultural—depends fundamentally on its ability to generate profit. No enterprise can be sustained in the long term if it continually operates at a loss. Greenhouse vegetable cultivation, though technologically promising, is a capital-intensive and management-sensitive activity that demands continuous inputs of both financial and human resources (Singh & Kumar, 2016). In Kerala, the practice of protected cultivation has expanded over the past decade, supported largely by government subsidies under schemes such as the Mission for Integrated Development of Horticulture (MIDH) and state-level initiatives (Government of Kerala, 2022).

While agricultural scientists have extensively explored the technical feasibility of greenhouse cultivation—highlighting yield improvements, input-use efficiency, and year-round production potential—there remains a significant knowledge gap in the economic assessment of this farming system (Kumar et al., 2020). The viability of greenhouse vegetable cultivation must not only be assessed in terms of biological performance but also in terms of its financial sustainability across different farm sizes and support scenarios.

This issue becomes particularly relevant in Kerala, where greenhouse farming has been promoted among small and marginal farmers, often without a detailed understanding of the cost-return dynamics. Although all the greenhouses studied were established with government subsidies, this research investigates the actual profitability of these farms under both subsidised and hypothetical non-subsidised conditions, using detailed farm-level cost accounting—including A1, B1, C2, and C3 costs—across different greenhouse size categories (very small to very large). In the absence of reliable profitability standards and size-specific economic analysis, farmers and policymakers alike lack the necessary evidence to make informed decisions on the long-term viability of greenhouse farming in the state. Thus, the core research problem addressed in this study is: "What is the economic viability of greenhouse vegetable cultivation in Kerala across different greenhouse sizes and how does profitability differ under subsidised and non-subsidised cost conditions?" This analysis is vital to determine whether greenhouse farming is a financially sustainable option in the long term, beyond its initial establishment support.

2.OBJECTIVES

1. To evaluate the annual cost and revenue structure of greenhouse vegetable farms in Kerala across different size categories.
2. To assess the economic viability and profitability of greenhouse cultivation under both subsidised and non-subsidised scenarios.
3. To analyse the relationship between greenhouse size and financial performance using cost accounting and non-parametric statistical methods.

3. METHODOLOGY

3.1 Study Area and Period

The present study was conducted in the state of Kerala, where greenhouse vegetable cultivation has been actively promoted since the late 2000s under various government-supported schemes. The study, conducted during 2021–22, is based on data collected greenhouse units established across various districts of the state with government subsidies during the period 2009–10 to 2019–20.

3.2 Sampling Design

From the total population of 837 greenhouses, a stratified random sampling technique was adopted to ensure proportionate representation across different districts and greenhouse size categories. Based on this approach, 165 greenhouse units were selected as the representative sample. The greenhouse units were categorised by size into the following five groups: very small: below 100 sq. m, small: 101–300 sq. m, medium: 301–500 sq. m, large: 501–1000 sq. m and very large: above 1000 sq. m. This classification enabled a comparative analysis of cost structures and profitability across scales of operation.

3.3 Data Collection

Primary data were collected through detailed field surveys conducted using a pre-tested structured questionnaire. Interviews were held with greenhouse farmers to obtain accurate estimates of capital investment (initial and recurring), operational costs (labour, inputs, electricity, etc.,) gross and net revenues and output (in kg) and price realisation.
The data collection focused on actual experiences over at least one full production cycle, and where available, multi-year averages were used to smooth variability.
Cost elements were recorded under the following standard categories based on agricultural cost accounting practices in India:

- Cost A1: All paid-out costs in cash and kind, including hired labour, seeds, fertilisers, plant protection chemicals, electricity, irrigation, etc.
- Cost B1: A1 + interest on fixed capital + rental value of owned land
- Cost C2: B1 + imputed value of family labour
- Cost C3: C2 + 10% management cost (to account for entrepreneurial risk and effort)

Revenue was calculated on both per greenhouse unit and per kilogram of output basis. Profits were estimated using cost and revenue figures.

3.4 Data Analysis

Quantitative data were processed and analysed using descriptive and inferential statistical techniques with the help of statistical software such as SPSS and MS Excel. The key steps of analysis included:

- **Descriptive Statistics**: Mean, median, variance, and standard deviation of cost, revenue, and profit across different greenhouse size categories.
- **Comparative Analysis:** Preliminary data diagnostics, including skewness, kurtosis, and the Shapiro–Wilk test, indicated that the distribution of key economic variables—namely cost, revenue, and profit—was not normally distributed across the sample. Therefore, non-parametric statistical tests were employed to assess differences across groups, as these methods do not assume normality and are robust for ordinal and skewed data.

The following non-parametric test were applied:

- **Kruskal–Wallis H Test**: This test was used to determine whether there were statistically significant differences in the median values of cost, revenue, and profit among the five greenhouse size categories (very small, small, medium, large, and very large.
- **Pearson $\chi 2$ Test:** This test was used to verify the association between size of the farm and profitability.

All statistical analyses were conducted at a 5% level of significance ($p < 0.05$) using SPSS and Excel.

3.5 Presentation of Results

The findings of the analysis were systematically presented using tables and charts to facilitate interpretation and policy relevance. Comparative profitability across unit sizes and crops was visualised to highlight the most viable models of greenhouse vegetable farming under Kerala's agroeconomic conditions.

4. RESULTS AND DISCUSSION

4.1 Cost of Greenhouse Vegetable Cultivation without Subsidy

The cost of production is a fundamental indicator in assessing the economic feasibility and efficiency of agricultural enterprises. In the context of protected cultivation, particularly greenhouse-based vegetable production, estimating the average cost per unit output provides more meaningful insights than considering total expenditure. This is especially relevant when evaluating the viability across greenhouses of different sizes and scales of investment.

In the present analysis, the average cost of producing one kilogram of vegetables has been estimated for greenhouses of varying sizes—small, medium, large and very large—based on the standardised cost concepts A1, B1, C2, and C3, as defined by the Commission for Agricultural Costs and Prices (CACP). This analytical framework enables a systematic comparison of cost efficiency across different scales of greenhouse operations, thereby offering valuable insights into the potential for economies of scale and identifying which categories demonstrate relatively better per-unit cost competitiveness. Cost estimation of greenhouse vegetable cultivation without taking into consideration of subsidy given by the government revealed the social cost of the practice.

Volume: 13 | Issue: 8 | August 2025 | Journal DOI: 10.36713/epra0813| Impact Factor SJIF(2025): 8.733| ISSN: 2321 – 7847

The findings, presented in Table 1.1, highlight the estimated average cost per kilogram under each cost concept for the respective greenhouse categories. These estimates provide an empirical basis for evaluating the economic sustainability of greenhouse vegetable cultivation and offer critical inputs for shaping future policy interventions, investment strategies, and technology adoption in the protected cultivation sector.

Table 1.1: Average Production Cost per Kilogram of Vegetables (A1, B1, C2, and C3) by Greenhouse Size Category (Without Subsidy)

SL No	Size of GH	Number	Average Cost	Average Cost	Average Cost	Average Cost
1	Very Small (Up to 100 sq. m)	19	52.07	62.42	107.06	117.77
2	Small (101 - 300 sq. m)	11	100.38	116.89	140.46	154.5
3	Medium (301-500 sq. m)	89	63.59	71.39	80.64	88.70
4	Large (501-1000 sq. m)	30	53.37	62.76	67.25	73.97
5	Very Large (Above 1000 sq. m)	16	50.76	57.37	60.95	67.04
All		165	61.60	70.45	83.34	91.6

Source: Primary Data

Table 1.2 Hypothesis Test Summary

	Null Hypothesis	Test	Significance	Decision
1	The distribution of average A1 cost is the same across categories of farm size	Independent Samples Kruskal-Wallis Test	0.121	Retain the null hypothesis
2	The distribution of average B1 cost is the same across categories of farm size		0.120	Retain the null hypothesis
3	The distribution of average C2 cost is the same across categories of farm size		0.000	Reject the null hypothesis
4	The distribution of average C3 cost is the same across categories of farm size		0.000	Reject the null hypothesis

Asymptotic significances are displayed. The significance level is 0.05

Table 1.1 presents the average cost of vegetable production per kilogram under four cost categories—A1, B1, C2, and C3—across five greenhouse size classifications, without accounting for any subsidies.
The analysis reveals a distinct pattern of cost reduction with increasing greenhouse size.

- Very Small Greenhouses (≤100 sq. m) report the highest unit costs across all cost categories, with Rs. 52.07 (A1), Rs. 62.42 (B1), Rs. 107.06 (C2), and Rs. 117.77 (C3). This reflects limited economies of scale, higher relative fixed costs, and lower productivity per unit area.
- Small Greenhouses (101–300 sq. m) show even higher absolute costs than very small ones (e.g., C3 cost is Rs. 154.50), indicating possible inefficiencies due to sub-optimal scale without proportionate yield or cost benefit.
- Medium-sized Greenhouses (301–500 sq. m) demonstrate a significant cost advantage with a sharp decline in unit costs (e.g., C3 at Rs. 88.70), likely benefiting from better scale economies and more efficient resource utilisation.
- Large Greenhouses (501–1000 sq. m) and Very Large Greenhouses (>1000 sq. m) exhibit further reduction in costs, with very large units showing the lowest average costs across all categories (e.g., C3 at Rs. 67.04). This confirms the cost-efficiency of larger greenhouse operations, attributable to fixed cost dilution and improved operational practices.

The average across all greenhouse sizes for 165 observations confirms the trend: Rs. 61.60 (A1), Rs. 70.45 (B1), Rs. 83.34 (C2), and Rs. 91.60 (C3). The narrowing gap between A1 and C3 costs in larger greenhouses emphasises the role of scale in minimising indirect and imputed costs. These findings underscore the economic viability of upscaling greenhouse operations. Policy recommendations may focus on incentivising larger greenhouse structures or cooperative models for small-scale farmers to collectively realise scale economies and reduce per-unit costs of production.

Table 1.2 summarises the results of non-parametric hypothesis tests (Kruskal-Wallis Test) conducted to examine whether the distribution of average costs per kilogram of vegetable production—classified under four cost categories (A1, B1, C2, and C3)—differs significantly across different greenhouse size categories.

- For A1 and B1 cost categories (which reflect direct and capital-related paid-out costs), the p-values (0.121 and 0.120, respectively) exceed the conventional 5% significance level. Thus, we fail to reject the null hypotheses, indicating that the distribution of these costs does not significantly differ across greenhouse size categories. This suggests that basic input costs remain relatively consistent regardless of greenhouse scale.
- In contrast, for C2 and C3 cost categories (which incorporate imputed costs such as rental value of land and managerial charges), the p-values are both 0.000, indicating statistically significant differences in cost distributions across different greenhouse sizes. Therefore, the null hypotheses are rejected. This reflects that larger greenhouses enjoy clear cost advantages when accounting for opportunity costs and managerial effort, consistent with the earlier observed trend of declining average costs in larger structures.

These results emphasise the importance of scale in determining comprehensive production costs. While direct costs remain relatively uniform, indirect and imputed costs vary significantly by size, reinforcing the need for policies that promote scalability and capacity building among greenhouse farmers to achieve cost competitiveness and long-term viability.

4.2 Cost of Greenhouse Vegetable Cultivation with Subsidy

Greenhouse vegetable cultivation is a capital-intensive farming practice that involves significant upfront investment in infrastructure, including the construction of protected structures, installation of drip irrigation systems, and procurement of climate control technologies. To promote the adoption of this high-technology agriculture, both the Central Government, through the National Horticulture Mission (NHM), and various State Governments, through the State Horticulture Missions (SHM), have implemented substantial subsidy schemes. These schemes typically cover up to 50–75% of the construction cost, depending on the size of the greenhouse, location, and specific state-level policies (Government of India, 2022; NHM Guidelines, 2021).

These subsidies play a critical role in reducing the financial burden on farmers during the initial phase of investment. Capital subsidies significantly enhance the affordability and attractiveness of greenhouse farming among small and medium-scale cultivators by lowering entry barriers and encouraging risk-taking in high-value horticulture. Similarly, a study by Prakash et al. (2020) in Maharashtra highlighted that access to capital subsidies was a decisive factor influencing farmers' adoption of protected cultivation, with subsidy availability significantly increasing the proportion of farmland allocated to greenhouse farming.

The availability of subsidies not only reduces the net construction cost but also impacts the calculation of annualised fixed costs, thereby improving the economic viability indicators such as cost-benefit ratios, payback periods, and internal rates of return (IRR). Moreover, subsidy support for protected cultivation has demonstrated considerable multiplier effects in rural areas—boosting farm income, generating year-round employment, and promoting diversification into high-value crops (Thakur et al., 2021).

In this context, the present study estimates the annual cost structure of greenhouse vegetable cultivation under subsidised conditions, taking into account the reduced initial investment borne by the farmers. The detailed cost estimates under different cost concepts (A1, B1, C2, and C3) are presented in the following table, reflecting how government support mechanisms alter the economic landscape of protected cultivation.

Table 2.1 presents the average cost of vegetable production per kilogram under subsidized conditions across five categories of greenhouse sizes. The cost analysis is segmented into four standard cost concepts—**A1**, **B1**, **C2**, and **C3**—which together provide a comprehensive view of both direct and imputed production expenses. The analysis is based on a sample of 165 greenhouses, stratified by size.

The average cost per kg of vegetables across all greenhouse sizes under subsidised conditions is: A1: ₹49.88, B1: ₹58.74, C2: ₹71.62 and C3: ₹78.79. This indicates that while subsidies lower fixed and capital costs, substantial differences remain when imputed costs are accounted for.

- Very Small Greenhouses (≤100 sq. m) report the highest costs under C2 and C3 (₹90.17 and ₹99.19, respectively), despite subsidies. These structures typically suffer from lower economies of scale and less efficient resource utilisation.

- Small Greenhouses (101–300 sq. m) surprisingly show the highest absolute costs overall, particularly for A1 (₹89.14) and C3 (₹142.14). This suggests that despite receiving subsidies, their cost-efficiency remains lower, possibly due to sub-optimal input-output ratios or underutilization of space.
- Medium (301–500 sq. m), Large (501–1000 sq. m), and Very Large (>1000 sq. m) Greenhouses demonstrate a consistent decline in average cost per kg across all cost categories. The Very Large greenhouses show the lowest costs (C3 at ₹54.12), highlighting the benefit of economies of scale, efficient use of subsidy, and lower relative fixed costs.

Compared to the cost structure without subsidy, this subsidised cost structure shows a significant reduction, particularly in capital-intensive categories (B1, C2, and C3). For example, the C3 cost for Very Large greenhouses without subsidy was ₹67.04, but dropped to ₹54.12 with subsidy—showing the tangible impact of government financial support.

The data reinforce that greenhouse scale plays a critical role in cost efficiency, even when subsidies are applied. While the subsidy reduces initial capital burden across all categories, the relative benefit is maximised in larger structures, where fixed costs can be better distributed over higher output. Policymakers should therefore consider mechanisms to encourage group ownership models, farmer cooperatives, or incentives for scale expansion to help smaller farmers access such benefits more effectively.

Moreover, Table 2.2 illustrates that these differences in average costs were statistically significant except for cost B1 at the level of significance of 0.05.

Table 2.1 Average Cost: A1, B1, C2 and C3 per kg among Different Sizes of Greenhouses with Subsidy

SL No	Size of GH	Number	Average Cost A1 Rs.	Average Cost B1 Rs.	Average Cost C2 Rs.	Average Cost C3 Rs.
1	Very Small (Up to100 sq. m)	19	35.19	45.53	90.17	99.19
2	Small (101 - 300 sq. m)	11	89.14	105.65	129.22	142.14
3	Medium (301-500 sq. m)	89	52.67	60.47	69.72	76.69
4	Large (501-1000 sq. m)	30	42.43	51.81	56.31	61.94
5	Very Large (Above 1000 sq. m)	16	39.01	45.62	49.2	54.12
All		165	49.88	58.74	71.62	78.79

Source: Primary Data

Table 2.2 Hypothesis Test Summary

	Null Hypothesis	Test	Significance	Decision
1	The distribution of average A1 cost with subsidy is the same across categories of size of farms	Independent Samples Kruskal-Wallis Test	0.045	Reject the null hypothesis
2	The distribution of average B1 cost with subsidy is the same across categories of size of farms		0.072	Retained the null hypothesis
3	The distribution of average C2 cost with subsidy is the same across categories of size of farms		0.000	Reject the null hypothesis
4	The distribution of average C3 cost with subsidy is the same across categories of size of farms		0.000	Reject the null hypothesis

Asymptotic significances are displayed. The significance level is 0.05

Table 2.2 presents the results of the Kruskal–Wallis H Test, a non-parametric statistical method used to assess whether the distributions of different cost categories (A1, B1, C2, and C3) differ significantly across various greenhouse size categories in the context of subsidised cultivation. This method is particularly appropriate when data do not meet the assumptions of normality, which is common in cost and production studies involving heterogeneous farm units (Conover, 1999).

1. **A1 Cost** (direct paid-out cost): The test result (p = 0.045) shows a significant difference in the distribution of A1 costs across greenhouse sizes, suggesting that even direct input costs (like seeds, fertilisers, and labour) vary with scale, despite subsidy. This may reflect differences in input use efficiency and crop management intensity among farms of different sizes.
2. **B1 Cost** (A1 + interest on owned capital): With a non-significant p-value (0.072), the test fails to reject the null hypothesis. This implies that the capital cost structure, when adjusted for subsidies, is more uniform across sizes. The subsidy support appears to standardise capital investments, making them less sensitive to farm size in relative terms.
3. **C2 and C3 Costs** (which include imputed costs): Highly significant results (p = 0.000 for both) indicate strong differences in opportunity costs and managerial returns across different sizes. These imputed components reflect the value of owned land, fixed capital, and managerial effort. Larger greenhouse operations benefit from cost dilution due to higher output, which enhances cost efficiency—this is consistent with documented economies of scale observed in the floriculture industry (Schumacher & Marsh, 2003). This also aligns with observations that C3 costs decrease significantly in larger greenhouses, leading to improved profitability and higher returns on investment.

These findings are grounded in cost theory and farm efficiency models, particularly those that emphasise the role of scale in reducing average costs. According to Neoclassical Production Theory, the long-run average cost (LRAC) curve tends to decline as farm size increases, owing to the more efficient use of both fixed and variable inputs. This is particularly relevant in greenhouse farming, where capital-intensive investments (e.g., structures, irrigation) are amortised more effectively in larger units (Ellis, 1993; Hayami & Ruttan, 1985).

Subsidies, while effective in lowering barriers to entry, do not completely neutralise the cost disparities arising from scale advantages. This supports the argument that subsidies must be coupled with extension services, training, and collective farming models to maximise efficiency, especially for smallholder and marginal farmers.

4.3 Annual Average Profitability of Greenhouse Vegetable Farms

This part attempts to analyse the cost and revenue dynamics of greenhouse vegetable cultivation by examining the annual average revenue, average cost (C3), and average profit per kilogram of output across various greenhouse sizes, under the condition of government subsidies. The goal is to assess whether the scale of operation influences economic outcomes and to understand the sustainability of greenhouse farming in the current policy environment.

Table 3 presents a comparative analysis of average revenue, average cost (C3), and average profit per kilogram of output across different sizes of greenhouses under a subsidy regime. The data is categorised into five groups based on the greenhouse size, ranging from very small (up to 100 sq. m) to very large (above 1000 sq. m), along with an overall average for all sizes combined. This analysis highlights the economic performance of greenhouse farming when financial support is provided, aiming to assess the viability of vegetable cultivation under greenhouses at various scales.

Table 3: Average Revenue, Cost (C3), and Profit per Kilogram of Output for Different Greenhouse Sizes under Subsidy Support

SL No	Size of GH	Average Revenue Per kg Rs.	Average Cost C3 Per kg Rs.	Average Profit per kg Rs.
1	Very Small (Upto100 sq. m)	44.45	99.19	--54.74
2	Small (101 - 300 sq. m)	63.76	142.14	-78.38
3	Medium	48.03	76.69	-28.66

	(301-500 sq. m)			
4	Large (501-1000 sq. m)	47.78	61.94	-14.16
5	Very Large (Above 1000 sq. m)	38.9	54.12	-15.22
All		47.73	78.79	-31.06

Source: Primary Data. Negative sign shows average loss

According to the table, even with subsidy support, greenhouses of all sizes incur negative profits because the average cost per kilogram of output exceeds the average revenue. Due to high costs compared to revenue, very small and small greenhouses are the least profitable, losing Rs. 54.74 and Rs. 78.38 per kg, respectively. While large and very large greenhouses exhibit the smallest losses (Rs. 14.16 and Rs. 15.22), medium-sized units perform marginally better, with a dropped loss of Rs. 28.66 per kg, indicating increased cost efficiency at larger scales. Despite subsidies, greenhouse cultivation is generally not economically viable, although economies of scale provide some benefit. The average loss across all sizes is Rs. 31.06 per kg.

4.4 Profit and Loss Analysis of Greenhouse Vegetable Farms

Table 4 provides a detailed analysis of the relationship between greenhouse size and economic performance, specifically focusing on the number of units operating at a profit or loss under the C3 cost framework with government subsidy support. The data, derived from primary sources, categorises greenhouses into five size groups and examines the proportion of units that are profit-earning versus loss-making. This classification offers insights into how scale influences financial viability in protected cultivation. A Pearson chi-square test is applied to assess the statistical significance of the observed variation across size categories, helping to determine whether greenhouse size plays a decisive role in determining profitability.

Table 4: Profit and Loss Analysis by Greenhouse Size under Subsidised C3 Cost

Sl No	Size Category	Profit Earning	Loss Making	Total	Test
1	Very Small (Upto100 sq. m)	2 (10.5)	17 (89.5)	19	Pearson χ^2 11.887 df. 4 Prob. 0.018
2	Small (101 - 300 sq. m)	4 (36.4)	7 (63.6)	11	
3	Medium (301-500 sq. m)	36 (40.4)	53 (59.6)	89	
4	Large (501-1000 sq. m)	17 (56.7)	13 (43.3)	30	
5	Very Large (Above 1000 sq. m)	4 (25)	12 (75)	16	
All		63 (38.2)	102 (61.8)	165	

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

Table 4 reveals a clear association between greenhouse size and profitability under subsidised C3 cost conditions. Very small greenhouses (≤ 100 sq. m) show the highest level of unprofitability, with only 10.5% of units earning a profit, while 89.5% incur losses. Small greenhouses (101–300 sq. m) perform slightly better but still see a majority (63.6%) operating at a loss. Medium-sized units (301–500 sq. m) show modest improvement, with 40.4% profitability. Large greenhouses (501–1000 sq. m) stand out as the only category where the majority (56.7%) of units are profitable, indicating better economic viability at this scale. Interestingly, very large greenhouses (> 1000 sq. m) do not sustain this trend, with only 25% profitability, suggesting that increasing size alone does not ensure better outcomes and may introduce inefficiencies. Overall, 38.2% of all 165 greenhouses earned profits, while 61.8% faced losses. The Pearson chi-square test ($\chi^2 = 11.887$, df = 4, p = 0.018) confirms a statistically significant relationship between greenhouse size and profitability, underscoring the role of scale in influencing economic performance.

4.5 Cost and Revenue Dynamics of Profit-Making vs. Loss-Making Greenhouses

This section examines the underlying financial factors that differentiate profit-making greenhouses from loss-making ones. By comparing the cost structures and revenue levels of both categories, the analysis seeks to identify whether higher production costs or lower revenue realisation primarily contribute to financial losses. Understanding this distinction is essential for formulating effective policy interventions and management strategies to enhance the economic viability of greenhouse farming.

As previously stated, C3 is a broad definition of cost that encompasses all forms of costs associated with farming, including paid-out costs, the imputed value of own resources, and managerial costs. When this cost is taken into account, only 38 percent of greenhouses made a profit, while the remaining 62 percent lost money, as shown in Figure 1. In other words, just one-third of the greenhouses were financially viable when all costs were included.

Figure 1: Share of Greenhouses Operating at Profit vs. Loss

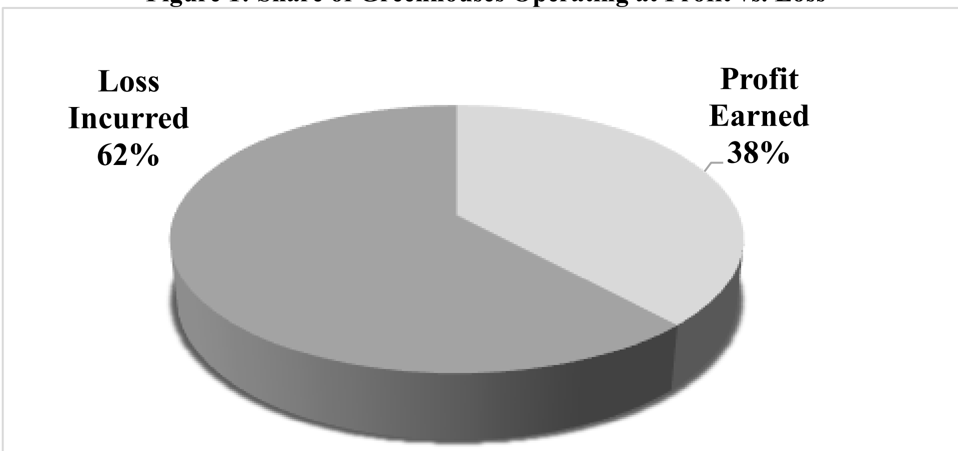

Table 5: Average Revenue, Cost (C3), and Profit per sq. m by Greenhouse Size (with Subsidy)

SL No	Size of GH	Average Revenue Per sq. m Rs.	Average Cost C3 Per sq. m Rs.	Average Profit per sq. m Rs.	Minimum Profit Per sq. m Rs.	Maximum Profit Per sq. m Rs.
1	Very Small (Upto100 sq. m)	302	630	-328	-1015.67	58.16
2	Small (101 - 300 sq. m)	397	392	5	-502.87	541.83
3	Medium (301-500 sq. m)	395	423	-28	-581	792.26
4	Large (501-1000 sq. m)	344	398	-54	-2053	399.64
5	Very Large (Above 1000 sq. m)	244	307	-63	-283.21	136.96
All		360.5	429	-68.5	-2053.84	792.26

Source: Primary Data

Table 5 presents a comparative analysis of average revenue, cost (C3), and profit per square meter for greenhouses of various sizes, factoring in subsidies. Overall, the data reveals that most greenhouse categories operate at a loss, with only the small-sized greenhouses (101–300 sq. m) showing a marginal average profit of ₹5 per sq. m. Very small (≤100 sq. m), medium (301–500 sq. m), large (501–1000 sq. m), and very large (>1000 sq. m) greenhouses all incur losses on average, with the highest average loss seen in very small units (₹328 per sq. m). Although medium-sized units showed potential for high profitability (maximum profit of ₹792.26), their average performance remains negative. Large and very large greenhouses, despite expected economies of scale, failed to break even. The higher profit marked for small greenhouses is due to their higher involvement in the seedling production in addition to vegetable production.

The wide range between minimum and maximum profits in each size category points to significant variability in performance, suggesting that profitability is not solely determined by greenhouse size. Factors such as management practices, market access, and input efficiency likely play a more crucial role. The overall average for all units combined shows a loss of ₹68.5 per sq. m, indicating that even with subsidies, most greenhouses struggle to be financially viable under current conditions.

5. MAJOR FINDINGS

Major findings of the study can be summarised as follows.

- **Operational Scale Matters:** Unit cost analysis indicates a strong inverse relationship between greenhouse size and cost per kilogram, with very large greenhouses (C3: ₹67.04/kg) showing significantly lower costs compared to very small units (C3: ₹117.77/kg).
- **Profitability Trends:** Only 38.2% of all greenhouses reported profits; large greenhouses (501–1000 sq. m) were the most viable (56.7% profitable), whereas very small units (≤100 sq. m) were the least viable (only 10.5% profitable).
- **Effect of Subsidies:** Government subsidies helped reduce capital and total costs across all sizes, but were not sufficient to ensure profitability. Even with subsidies, the average loss per kilogram was ₹31.06.
- **Farm Size and Profitability:** A Pearson chi-square test confirmed a significant relationship ($p = 0.018$) between greenhouse size and profitability. On a per square meter basis, only small greenhouses (101–300 sq. m) showed marginal profitability (₹5/sq. m), while other categories, especially very small units, reported heavy losses (up to ₹328/sq. m).
- **Variability in Profit:** Large variation in profitability within size categories suggests that factors beyond size—such as management, market linkage, and diversification (e.g., seedling production)—play critical roles in determining financial outcomes.

6. CONCLUSION

The study concludes that greenhouse vegetable farming in Kerala, despite its technological promise and policy support, remains largely economically unviable under current conditions, particularly for very small and small-scale units. Economies of scale significantly improve cost efficiency, with large-sized greenhouses demonstrating the best financial outcomes. However, subsidies alone are insufficient to overcome the structural cost disadvantages faced by smaller units. The results highlight a clear need for multi-dimensional support mechanisms that go beyond subsidies—such as farmer training, cooperative production models, efficient marketing channels, cultivation of high-value vegetables and input cost rationalisation. Future interventions must also focus on building managerial capacity and improving access to high-value markets in order to make greenhouse farming a sustainable and scalable livelihood option in Kerala.

Acknowledgement

This study forms a part of my doctoral research work. I am deeply grateful to my Research Supervisor Dr. Sanathanan Velluva, Associate Professor and Head (Retd.), and Co-guide Dr. Shiby M Thomas, Associate Professor and Head, PG and Research Department of Economics, St. Joseph's College (Autonomous), Devagiri, Calicut, for their invaluable guidance, critical insights, and continuous support throughout this research. Their mentorship played a vital role in shaping the direction and quality of this study.

REFERENCES

1. *Commission for Agricultural Costs and Prices. (2021). Price policy for Kharif crops for the marketing season 2021–22. Government of India.*
2. *Conover, W. J. (1999). Practical nonparametric statistics (3rd ed.). Wiley.*
3. *Ellis, F. (1993). Peasant economics: Farm households and agrarian development (2nd ed.). Cambridge University Press.*
4. *Government of India. (2022). Guidelines for Mission for Integrated Development of Horticulture (MIDH). Ministry of Agriculture and Farmers Welfare.*
5. *Government of India. (2025). MIDH operational guidelines 2025. Ministry of Agriculture and Farmers Welfare. https://nhb.gov.in/writereaddata/082825102800 MIDH%20 Guideline% 2025.pdf*
6. *Hayami, Y., & Ruttan, V. W. (1985). Agricultural development: An international perspective. Johns Hopkins University Press.*
7. *Kerala State Horticulture Mission. (n.d.). Protected cultivation (scheme details). State Horticulture Mission, Government of Kerala. Retrieved August 11, 2025, from https://shm.kerala.gov.in/scheme-details/*
8. *Kumar, M., Sirohi, H. S., Singh, B., Tomar, B. S., & Singh, A. K. (2020). Effect of insect-proof net house on flowering and seeds quality of cucumber (Cucumis sativus). Indian Journal of Agricultural Sciences, 90(6), 1202–1204. https://doi.org/10.56093/ijas.v90i6.104802*

9. *National Horticulture Board. (2021, May 26). Operational guidelines: Horticulture cluster development programme. Ministry of Agriculture & Farmers Welfare, Government of India. https://nhb.gov.in/pdf/CDPProgrammeGuidelines.pdf*
10. *Prakash, P., Kumar, P., Kar, A., & Singh, A. K. (2020). Status and impact of protected cultivation of horticultural crops in Maharashtra. Indian Journal of Horticulture, 77(3), 518–526. https://doi.org/10.5958/0974-0112.2020.00075.4*
11. *Schumacher, S. K., & Marsh, T. L. (2003). Economies of scale in the floriculture industry. Journal of Agricultural and Applied Economics, 35(3), 497–507. https://doi.org/10.22004/ag.econ.43145*
12. *Singh, B., & Kumar, M. (2006). Techno-economic feasibility of Israeli and indigenously designed naturally ventilated greenhouses for year-round cucumber cultivation. Acta Horticulturae, 710, 535–538. https://doi.org/10.17660/ActaHortic.2006.710.67*
13. *Thakur, N., Sharma, R., Giridhar, B. J., Kumar, S., Shilpa, A., Sharma, A., & Klate, A. (2021). Socio-economic impact assessment of protected cultivation: Income, employment and livelihood advancements for farmers. Journal of Agricultural Development and Policy, 31(2), 139–147. https://www.researchgate.net/publication/381165142_Socio-Economic_Impact_Assessment_of_Protected_Cultivation_Income_Employment_and_Livelihood_Advancements_for_Farmers*