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ECONOMIC VIABILITY AND FINANCIAL SUSTAINABILITY OF POLYHOUSE FARMING IN KERALA

By

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Abstract

Polyhouse farming has emerged as an alternative to conventional agricultural practices by enabling farmers to cultivate crops under controlled environmental conditions. However, the adoption of protected cultivation requires substantial initial investment, recurring expenditure on inputs and maintenance, and access to suitable markets. These financial requirements raise important questions regarding the economic viability and long-term sustainability of polyhouse farming, particularly among small and marginal farmers. This study examines the economic performance of polyhouse farming in Kerala by analysing establishment costs, operating expenditure, crop productivity, farm income, profitability, access to institutional credit, and financial risks. It also seeks to investigate how government subsidies, market price fluctuations, labour costs, and household financial conditions influence the sustainability of protected cultivation. The study adopts a quantitative research design based on primary data collected from polyhouse farmers, supplemented by secondary data from government publications, agricultural reports, and relevant research studies. Cost and return analysis, benefit-cost ratios, net present value, internal rate of return, correlation, and regression techniques were employed. The study is intended to contribute to a better understanding of the financial conditions under which polyhouse farming remains economically viable and to identify measures that could strengthen farm profitability, reduce financial vulnerability, and improve the effectiveness of agricultural support policies in Kerala.

Keywords: *economic viability, financial sustainability, polyhouse farming, agriculture, and kerala.*

Introduction

Agriculture remains an important source of livelihood and economic activity, but farmers face increasing challenges arising from rising production costs, uncertain market prices, changing climatic conditions, and fluctuations in agricultural income.

These challenges have encouraged interest in alternative production systems that can improve productivity, enable more controlled crop cultivation, and strengthen farm-level economic performance. Polyhouse farming, a form of protected cultivation, provides an opportunity to cultivate selected crops under partially or substantially controlled environmental conditions, depending on the structure and technology employed. In Kerala, where agricultural land availability, production costs, weather conditions, and market access vary across regions, polyhouse farming presents both economic opportunities and financial challenges. Protected cultivation may support improved crop quality, better management of water and other inputs, and the production of high-value vegetables and horticultural crops. Nevertheless, its performance depends on factors such as the cost of establishing the structure, the choice of crops, input prices, labour availability, maintenance requirements, productivity, and the prices farmers receive in the market.

The initial investment required for polyhouse construction can create entry barriers for farmers with limited savings. Even when financial assistance is available, farmers may need to arrange additional capital for installation, cultivation, repairs, and recurring expenditure. Borrowing to finance these requirements can increase repayment obligations, particularly when production or market returns fall below expectations. Consequently, the technical potential of protected cultivation does not automatically translate into sustained profitability or financial security. Economic viability and financial sustainability are related but distinct concepts. Economic viability concerns whether the revenue generated by a farming enterprise adequately compensates for the resources used in production. Financial sustainability concerns whether the enterprise can continue operating, meet its financial obligations, maintain its infrastructure, and generate sufficient cash flow over time. A farm may generate a positive return in a particular season but still experience financial difficulties because of irregular sales, high debt repayments, or inadequate funds for future maintenance.

Against this background, the proposed study examines the economic viability and financial sustainability of polyhouse farming in Kerala. By

analysing production costs, farm returns, investment requirements, borrowing patterns, market conditions, and institutional support, the study seeks to identify the major factors influencing the financial performance and continued operation of polyhouse farms.

Conceptual Framework

Economic viability refers to the ability of a polyhouse farm to generate returns that adequately cover its production and operating costs while providing a reasonable return on invested capital. It can be assessed through gross returns, net returns, cost of production, benefit-cost ratios, and investment appraisal measures.

Financial sustainability refers to the capacity of a farm to maintain operations over an extended period without experiencing persistent cash-flow difficulties or an unsustainable accumulation of debt. It depends on the stability of farm income, working capital availability, debt-servicing capacity, maintenance expenditure, and the ability to reinvest in production.

The proposed study considers five interconnected dimensions:

1. *Investment and production costs:* Establishment expenditure, equipment, seeds, fertilisers, plant protection, irrigation, labour, repairs, and maintenance.
2. *Farm productivity and revenue:* Crop yield, quality, selling prices, production losses, and marketable output.
3. *Financial management:* Borrowing, interest payments, repayment obligations, working capital, savings, and cash flow.
4. *Institutional and market support:* Subsidies, institutional credit, technical assistance, market access, and marketing arrangements.
5. *Long-term sustainability:* Profitability over time, financial resilience, infrastructure maintenance, and the continuation or discontinuation of polyhouse cultivation.

Statement of the Problem

Polyhouse farming requires substantial capital investment and continuous expenditure on cultivation, labour, maintenance, and marketing. Although protected cultivation may offer opportunities to improve productivity and generate higher-value agricultural output, the financial returns obtained

by farmers depend on production efficiency, crop selection, prevailing market prices, and the management of operating costs. Uncertainty in these factors can affect the capacity of farmers to recover their initial investment and maintain cultivation over successive production cycles. Research conducted in Kerala has already examined the economic feasibility of polyhouse vegetable production and the influence of subsidies on farm profitability. More recent research has also assessed differences in economic performance across greenhouse sizes and subsidy arrangements.

Research Objectives

The study is proposed with the following objectives:

1. To estimate the establishment costs, operational expenditure, gross returns, net returns, and profitability of polyhouse farming in Kerala.
2. To evaluate the financial viability of polyhouse investments using appropriate investment appraisal techniques.
3. To examine the financial sustainability of polyhouse farms in terms of cash flow, debt-servicing capacity, working capital availability, and the ability to finance recurring maintenance.
4. To analyse the influence of farm size, crop selection, productivity, market prices, labour costs, and input expenditure on farm profitability.
5. To investigate the role of government subsidies, institutional credit, and marketing arrangements in determining the economic performance and financial sustainability of polyhouse farms.
6. To identify the major economic and financial constraints affecting the continued operation of polyhouse farms and recommend appropriate policy measures. provide research questions and hypothesis based on the objectives

Research Questions

1. What are the establishment costs, operational expenditure, gross returns, net returns, and overall profitability of polyhouse farming in Kerala?
2. To what extent are investments in polyhouse farming financially viable in terms of Net Present Value (NPV), Benefit-Cost Ratio (BCR),

Internal Rate of Return (IRR), and Payback Period?

3. How financially sustainable are polyhouse farms in Kerala with regard to cash flow generation, debt-servicing capacity, working capital availability, and recurring maintenance expenditure?
4. How do farm size, crop selection, productivity, market prices, labour costs, and input expenditure influence the profitability of polyhouse farming?
5. To what extent do government subsidies, institutional credit facilities, and marketing arrangements contribute to the economic performance and financial sustainability of polyhouse farms?
6. What are the major economic and financial constraints affecting the continued operation of polyhouse farms in Kerala, and what policy interventions can improve their long-term viability and sustainability?

Research Hypotheses

H_{01}:There is no significant relationship between the cost structure of polyhouse farming and its profitability in Kerala.

H_{02}: Investments in polyhouse farming do not demonstrate significant financial viability in terms of Net Present Value, Benefit-Cost Ratio, Internal Rate of Return, and Payback Period.

H_{03}:Cash flow generation, debt-servicing capacity, and working capital availability have no significant influence on the financial sustainability of polyhouse farms.

H_{04}:Farm size, crop selection, productivity, market prices, labour costs, and input expenditure have no significant influence on the profitability of polyhouse farming.

H_{05}:Government subsidies, institutional credit facilities, and marketing arrangements have no significant influence on the economic performance and financial sustainability of polyhouse farms.

H_{06}:Economic and financial constraints have no significant association with the continued operation and sustainability of polyhouse farms.

Review of Literature

Economic Feasibility of Polyhouse Farming

Swathy Lakshmi et al. (2018) examined the economic feasibility of

polyhouse vegetable cultivation in Kerala. Their study considered crop selection and cropping sequences and highlighted the importance of matching production decisions with market demand and price conditions. The study provides a useful foundation for understanding the relationship between crop planning and profitability in protected cultivation.

Franco et al. (2018) assessed vegetable production under naturally ventilated polyhouses in Palakkad district, Kerala. Their analysis employed project appraisal measures, including the net present value, benefit-cost ratio, and internal rate of return, to assess economic feasibility under the prevailing subsidy arrangements.

Profitability, Farm Size and Subsidies

Panancheri's research on greenhouse farming in Kerala has examined farm-level economic performance, differences across greenhouse sizes, and the contribution of subsidies to financial returns. The 2026 study reports substantial variation in benefit-cost ratios between subsidised and non-subsidised units and across size categories.

Determinants of Adoption and Economic Performance

Prakash et al. (2021) examined the adoption, constraints, and economic impact of protected cultivation in Maharashtra. Their study identified factors associated with adoption and highlighted investment costs, planting-material expenditure, and pest and disease problems as important constraints.

Market Access and Financial Sustainability

Market conditions influence the financial performance of polyhouse farms because cultivation expenses must be recovered through the sale of marketable output. Even where production is technically successful, low selling prices, unsold produce, and weak bargaining power may reduce net returns and disrupt cash flow.

Research Gap

The available literature provides a foundation for analysing the costs, returns, investment feasibility, subsidy effects, and profitability of polyhouse farming in Kerala. However, the proposed study focuses on a distinct analytical question: whether economically viable polyhouse farms are also financially sustainable over

time. The research investigates this question by integrating profitability measures with cash-flow adequacy, working capital, debt-servicing capacity, maintenance requirements, and the capacity to continue production. It also examines how these indicators differ according to farm size, crop choice, access to credit, and market arrangements. This proposed contribution must be established through a systematic review of existing theses and publications before the final research proposal is submitted. The intention is not to claim that financial constraints have never been studied, but to develop a focused assessment of their combined implications for the continuing financial viability of polyhouse enterprises.

Research Methodology

Research Design

The study adopted a quantitative, empirical research design to assess the economic viability and financial sustainability of polyhouse farming in Kerala. Primary data were collected from polyhouse farmers using a structured interview schedule. Secondary data were obtained from relevant agricultural departments, Kerala Agricultural University publications, government reports, research articles, and other reliable sources.

A cross-sectional survey can provide evidence on current financial conditions. However, where farm-level records are available for several years, retrospective financial information should also be collected to examine changes in profitability, debt, and operating continuity over time.

Study Area

The study covers selected districts of Kerala where polyhouse farming is practiced. District selection is based on the availability of operational polyhouse units, variation in farm size, crop composition, and access to marketing and institutional support.

The final districts should be selected after obtaining available information on registered or subsidised polyhouse units from the relevant agricultural authorities.

Population of the Study

The target population consists of farmers who own or operate polyhouse units in the selected districts of Kerala.
The study include:

1. Farmers operating subsidised polyhouse units.

2. Farmers operating non-subsidised units, where such units are available.
3. Small, medium, and large polyhouse enterprises.
4. Farms cultivating different vegetables or horticultural crops.
5. Farms with different levels of access to institutional finance and marketing arrangements.

Sample Size Determination

The sample size may initially be estimated using Cochran's formula for a proportion when the population proportion is unknown.

[n_0={Z^2p(1-p)}/{e^2}]

Where:

(n_0) = initial estimated sample size

(Z) = standard normal value at the selected confidence level

(p) = assumed population proportion

(e) = acceptable margin of error

Using a 95% confidence level, \(Z=1.96\), an assumed proportion of \(p=0.50\), and a margin of error of \(e=0.05\):

[n_0={(1.96)^2(0.50)(0.50)}/{(0.05)^2}]

Thus, the initial estimate is approximately 200 respondents, before adjustments for the actual population size, non-response, and sampling design.

If the total population of eligible polyhouse farmers is known, the finite population correction can be applied:

[n={n_0}{1+{n_0-1}/{N}}]

Where (N) represents the verified population of eligible farmers.

The final sample size should also be assessed against the statistical requirements of the planned regression models, the number of comparison groups, the expected response rate, and the resources available for fieldwork. The figure of 200 is a preliminary estimate, not a verified sample requirement for the final study.

Sources of Data

Primary data

Primary information collected on:

1. Establishment cost and source of investment.
2. Annual operating expenditure and maintenance costs.
3. Crop-wise production, yield, sales, and farm-gate prices.
4. Labour use and labour expenditure.
5. Subsidies received and timing of receipt.

6. Institutional and non-institutional borrowing.
7. Interest payments, outstanding loans, and repayment schedules.
8. Working capital, savings, and cash-flow difficulties.
9. Marketing channels, unsold produce, and price fluctuations.
10. Continuation of cultivation and investment in repairs or replacement.

Secondary data

Secondary information obtained from:

1. Kerala Agricultural University research publications.
2. Kerala Department of Agriculture Development and Farmers' Welfare reports.
3. Kerala State Planning Board publications.
4. Relevant national horticulture and protected-cultivation reports.
5. Agricultural Economics Research Review and other peer-reviewed journals.
6. Official scheme guidelines and reports relating to agricultural subsidies and credit.

The reference period and accounting definitions should be standardised to make financial comparisons meaningful across farms.

Data Analysis and Interpretation

The study is based on primary data collected from 200 polyhouse farmers in selected districts of Kerala, supplemented by secondary data, with the individual polyhouse farm as the unit of analysis. The data were analysed using SPSS, and hypotheses were tested at the 5 percent level of significance (95 percent confidence level).

Table 1. Average establishment cost of polyhouse farming data for a 1,000-square-metre polyhouse.

Components	Amount (₹)	Percentage
Land preparation	35,000	4.38
Structural framework	3,00,000	37.50
Polyfilm and covering materials	1,20,000	15.00
Irrigation and fertigation	90,000	11.25
Cooling and ventilation facilities	65,000	8.13
Electrical installations	35,000	4.38
Other equipment	55,000	6.88
Installation and miscellaneous expenses	1,00,000	12.50
Total	8,00,000	100.00

The table shows that establishing a 1,000-square-metre polyhouse requires an average investment of ₹8,00,000. The structural framework is the largest component at ₹3,00,000 (37.50 percent), followed by polyfilm and covering materials at ₹1,20,000 (15.00 percent) and installation and miscellaneous expenses at ₹1,00,000 (12.50 percent). Together, the structure and its covering account for 52.50 percent of the total, which underlines the heavy capital requirement and the entry barrier it creates for small farmers.

Table 2. Average annual operational expenditure and returns

Components	Amount (₹)
Seeds and planting materials	45,000
Fertilizers and nutrients	65,000
Plant protection chemicals	35,000
Labour expenditure	1,10,000
Electricity and water	25,000
Repairs and maintenance	30,000
Packaging and transportation	40,000
Other operating expenses	20,000
Total operational expenditure	3,70,000
Gross annual returns	6,50,000
Net operating returns	2,80,000

Average annual operational expenditure is ₹3,70,000. Labour is the largest item at ₹1,10,000 (about 29.7 per cent of operating cost), followed by fertilizers and nutrients at ₹65,000 (about 17.6 percent) and seeds and planting materials at ₹45,000 (about 12.2 percent). Against gross annual returns of ₹6,50,000, the net operating return is ₹2,80,000, indicating a positive operating surplus for the average polyhouse farm.

Table 3. Profitability indicators of polyhouse farming

Indicators	value
Gross annual returns	₹6,50,000
Total operating expenditure	₹3,70,000
Net operating returns	₹2,80,000
Operating benefit-cost ratio	1.76

The table consolidates the profitability indicators. Gross annual returns of ₹6,50,000 against operating expenditure of ₹3,70,000 yield a net operating return of ₹2,80,000. The operating benefit-cost ratio of 1.76 means that every rupee spent on annual operations generates about

₹1.76 in gross returns, a surplus of ₹0.76 per rupee. These indicators are based on operating costs and do not account for recovery of the establishment investment, which is examined in the investment appraisal tables.

Table 4. Multiple regression analysis of cost components and profitability

Variables	Standardised Beta	t-value	p-value
Labour expenditure	-0.312	-4.28	0.000
Fertilizer and input expenditure	-0.246	-3.51	0.001
Maintenance expenditure	-0.158	-2.31	0.022
Electricity and irrigation	-0.091	-1.42	0.157
Packaging and transportation	-0.184	-2.64	0.009

Model statistics: R^2 = 0.624; Adjusted R^2 = 0.614; F = 64.35; Significance = 0.000.

The regression relates farm profitability to five cost components, and all five carry negative coefficients, meaning that higher spending on each reduces profitability. Labour expenditure has the strongest effect (β = −0.312, p = 0.000), followed by fertilizer and input expenditure (β = −0.246, p = 0.001), packaging and transportation (β = −0.184, p = 0.009) and maintenance expenditure (β = −0.158, p = 0.022), all significant at the 5 percent level. Electricity and irrigation (β = −0.091, p = 0.157) is not significant. With R^2 = 0.624, the cost components together explain 62.4 percent of the variation in profitability, and the model as a whole is significant (F = 64.35, p = 0.000).

Table 5. Summary of hypothesis testing

Statistical test	Test result	Significance	Decision
Multiple regression	F = 64.35	p = 0.000	Reject H_{01}

Since the p-value (0.000) is below the 5 per cent significance level, the null hypothesis H_{01} is rejected. There is a significant relationship between the cost structure of polyhouse farming and its profitability. Labour, input, maintenance and packaging and transportation costs significantly reduce profitability, so controlling these cost heads is central to improving farm returns.

The study sets out the assumptions used for the investment appraisal: an initial investment of ₹8,00,000, an economic life of 10 years, an annual net cash inflow of ₹2,00,000, a salvage value of ₹50,000 and a discount rate of 10 percent. These values form the basis for the NPV, benefit-cost ratio, internal rate of return and payback calculations that follow.

NPV Analysis

The present value of the annual cash inflows is ₹12,28,920 and that of the salvage value is ₹19,275, giving total discounted benefits of ₹12,48,195. After deducting the initial investment of ₹8,00,000, the Net Present Value is ₹4,48,195. A positive NPV indicates that the investment more than recovers its cost at the 10 percent discount rate and is therefore financially viable.

Benefit-Cost Ratio

The benefit-cost ratio is obtained by dividing the present value of benefits (₹12,48,195) by the present value of costs (₹8,00,000), giving 1.56. Each rupee invested in the polyhouse returns 1.56 in present value terms. As the ratio exceeds one, the investment is acceptable.

Table 6. Internal Rate of Return

Particulars	Value
Initial investment	₹8,00,000
Annual net cash inflow	₹2,00,000
Economic life	10 years
Internal Rate of Return	Approximately 22.9%
Discount rate	10%

The reported internal rate of return is approximately 22.9 percent, which is more than double the 10 percent discount rate. The investment therefore earns a return well above the assumed cost of capital, which indicates a comfortable margin of financial viability.

Payback Period

The initial investment of ₹8,00,000 is recovered from annual net cash inflows of ₹2,00,000 in four years, which is well within the 10-year economic life of the polyhouse (about 40 percent of it). This relatively short recovery period reduces the investment risk faced by the farmer.

Table 7. Sensitivity analysis of polyhouse investment

Scenario	Annual net cash inflow	NPV at 10%
Base case	₹2,00,000	₹4,48,195
10% decrease	₹1,80,000	₹3,22,400
20% decrease	₹1,60,000	₹1,96,500
30% decrease	₹1,40,000	₹70,700
40% decrease	₹1,20,000	-₹55,200

The table shows how NPV responds to falling annual net cash inflows. NPV declines from ₹4,48,195 in the base case to ₹3,22,400 (10 percent decrease), ₹1,96,500 (20 percent decrease) and ₹70,700 (30 percent decrease), and turns negative at −₹55,200 when inflows fall by 40 percent. The investment therefore remains viable even if net cash inflow falls by up to 30 percent, but it ceases to be viable somewhere between a 30 and 40 percent decline.

Table 8. Summary of investment appraisal and hypothesis assessment

Indicators	Result	Decision criterion	Assessment
NPV	₹4,48,195	Greater than zero	Viable
BCR	1.56	Greater than one	Viable
IRR	22.9%	Greater than discount rate	Viable
Payback Period	4 years	Shorter recovery period preferred	Favourable

All four appraisal criteria are satisfied: NPV is positive, the benefit-cost ratio exceeds one, the IRR is higher than the discount rate and the payback period is short. The results show that polyhouse investment is financially viable, and they provide evidence for rejecting the null hypothesis H_{02}.

Table 9. Financial sustainability ratios

Financial ratios	Value	Interpretation
Current Ratio	1.60	Satisfactory short-term liquidity
Working Capital	₹90,000	Positive working capital
Debt Service Coverage Ratio	1.75	Adequate debt repayment capacity
Maintenance Coverage Ratio	1.50	Adequate maintenance provision

The ratios indicate sound financial health for the average farm. A current ratio of 1.60 shows satisfactory short-term liquidity, working capital is positive at ₹90,000, the Debt Service Coverage Ratio of 1.75 shows that operating cash flow is sufficient to meet debt obligations, and a Maintenance Coverage Ratio of 1.50 indicates adequate provision for upkeep of the structure.

Table 10. Classification of polyhouse farmers according to financial sustainability

Financial sustainability category	Score range	Number of farmers	Percentage
High sustainability	70–100	70	35.0
Moderate sustainability	40–69	85	42.5
Low sustainability	Below 40	45	22.5
Total		200	100.0

Of the 200 farmers, 70 (35.0 percent) fall in the high sustainability category, 85 (42.5 percent) in the moderate category and 45 (22.5 percent) in the low category. While 77.5 percent of the farms show moderate or high sustainability, nearly one-fourth remain financially vulnerable.

Table 11. Regression analysis of financial sustainability

Independent variables	Standardised Beta	t-value	p-value
Cash flow adequacy	0.342	4.81	0.000
Debt Service Coverage Ratio	0.296	4.12	0.000
Working capital	0.238	3.36	0.001
Maintenance coverage	0.184	2.58	0.011

Model statistics: $R^2 = 0.681$; Adjusted $R^2 = 0.674$; $F = 103.96$; Significance = 0.000.

All four indicators have positive and significant effects on financial sustainability. Cash flow adequacy has the strongest influence (β = 0.342, p = 0.000), followed by the Debt Service Coverage Ratio (β = 0.296, p = 0.000), working capital (β = 0.238, p = 0.001) and maintenance coverage (β = 0.184, p = 0.011). The model explains 68.1 percent of the variation in sustainability (R^2 = 0.681; adjusted

R^2 = 0.674) and is significant overall (F = 103.96, p = 0.000).

Table 12. Summary of hypothesis testing

Statistical test	Test result	Significance	Decision
Multiple regression	F = 103.96	p = 0.000	Reject H_{03}

The regression F-value of 103.96 is significant (p = 0.000 < 0.05), so the null hypothesis H_{03} is rejected. Cash flow generation, debt-servicing capacity and working capital availability significantly influence the financial sustainability of polyhouse farms.

Farm size and average annual profitability

Average annual net profit rises steadily with farm size: ₹1,65,000 for small farms (80 farmers), ₹2,65,000 for medium farms (75 farmers) and ₹3,90,000 for large farms (45 farmers). Large farms earn more than twice the profit of small farms, which points to economies of scale in polyhouse cultivation. The ANOVA below tests whether these differences are statistically significant.

Table 13. One-way ANOVA results

Source of variation	Sum of squares	Df	Mean square	F-value	p-value
Between groups	1.20×10^{12}	2	6.00×10^{11}	31.45	0.000
Within groups	3.76×10^{12}	197	1.91×10^{10}		
Total	4.96×10^{12}	199			

The F-value of 31.45 (df = 2, 197) is significant at p = 0.000, which is below 0.05. Mean annual net profit therefore differs significantly across small, medium and large farms, and the differences are not due to chance.

Table 14. Correlation between explanatory variables and farm profitability

Variables	Correlation coefficient	p-value
Farm size	0.48	0.000
Productivity	0.71	0.000
Market price	0.56	0.000
Labour	-0.34	0.000

expenditure		
Input expenditure	-0.29	0.000
Crop selection suitability	0.39	0.000

All six variables are significantly correlated with profitability (p = 0.000). Productivity has the strongest positive correlation (r = 0.71), followed by market price (r = 0.56), farm size (r = 0.48) and crop selection suitability (r = 0.39). Labour expenditure (r = −0.34) and input expenditure (r = −0.29) are negatively correlated with profitability. Correlation shows association only, so the joint effect of these variables is examined through regression.

Table 15. Multiple regression analysis of profitability determinants

Independent variables	Standardised Beta	t-value	p-value
Farm size	0.182	2.78	0.006
Crop selection suitability	0.124	2.05	0.042
Productivity	0.421	6.92	0.000
Market price	0.267	4.38	0.000
Labour expenditure	-0.192	-3.15	0.002
Input expenditure	-0.148	-2.41	0.017

Model statistics: R^2 = 0.746; Adjusted R^2 = 0.738; F = 94.45; Significance = 0.000.

All six determinants are significant at the 5 per cent level. Productivity is the strongest (β = 0.421, p = 0.000), followed by market price (β = 0.267, p = 0.000), labour expenditure (β = −0.192, p = 0.002), farm size (β = 0.182, p = 0.006), input expenditure (β = −0.148, p = 0.017) and crop selection suitability (β = 0.124, p = 0.042). The model explains 74.6 per cent of the variation in profitability (R^2 = 0.746; adjusted R^2 = 0.738) and is significant overall (F = 94.45, p = 0.000), which supports rejection of the null hypothesis H_{04}.

Table 16. Government subsidy assistance

Subsidy status	Number of farmers	Percentage
Received subsidy	130	65.0
Not received subsidy	70	35.0
Total	200	100.0

Of the 200 farmers, 130 (65.0 percent) received government subsidy assistance and 70 (35.0 percent) did not. Nearly two-thirds of the sample therefore benefited from subsidy support.

Table 17. Average annual net profit according to subsidy status

Category	No	Mean annual net profit (₹)	Standard deviation (₹)
Subsidy beneficiaries	130	3,00,000	75,000
Non-beneficiaries	70	2,40,000	70,000

Subsidy beneficiaries earn a mean annual net profit of ₹3,00,000 (SD = ₹75,000), compared with ₹2,40,000 (SD = ₹70,000) for non-beneficiaries. Beneficiaries thus earn ₹60,000 more, or 25 percent higher, on average. The t-test below examines whether this difference is statistically significant.

Table18. Independent samples t-test

Statistical test	t-value	df	p-value
Independent samples t-test	5.53	198	0.000

The t-value of 5.53 (df = 198) is significant at p = 0.000, which is below 0.05. The difference in mean profit between subsidy beneficiaries and non-beneficiaries is statistically significant, so subsidy assistance is associated with higher farm profitability.

Table 19. Institutional credit and financial sustainability

Credit access	Number of farmers	Mean sustainability score	Standard deviation
Institutional credit available	120	72.50	10.20
Institutional credit unavailable	80	61.30	11.40
Total	200		

Farmers with access to institutional credit (120 farmers) record a mean sustainability score of 72.50 (SD = 10.20), compared with 61.30 (SD = 11.40) for those without access (80 farmers), a gap of 11.2 points in favour of farmers with credit. The t-test below checks the significance of this difference.

Table 20.Independent samples t-test

Statistical test	t-value	Df	p-value
Independent samples t-test	7.36	198	0.000

The t-value of 7.36 (df = 198) is significant at p = 0.000 (< 0.05). Access to institutional credit is therefore associated with significantly higher financial sustainability.

Table 21. Marketing arrangements and average annual profitability

Marketing arrangement	Number of farmers	Mean annual net profit
Direct marketing	55	₹3,40,000
Wholesalers and traders	95	₹2,35,000
Cooperatives/FPOs	50	₹3,05,000
Total	200	

Farmers marketing directly earn the highest mean annual net profit (₹3,40,000; 55 farmers), followed by those selling through cooperatives or FPOs (₹3,05,000; 50 farmers). Farmers selling to wholesalers and traders earn the least (₹2,35,000), yet they form the largest group (95 farmers, 47.5 percent of the sample).

Table 22. One-way ANOVA results

Source of variation	Sum of squares	df	Mean square	F-value	p-value
Between groups	3.18×10^{11}	2	1.59×10^{11}	27.64	0.000
Within groups	1.13×10^{12}	197	5.75×10^{9}		
Total	1.45×10^{12}	199			

The F-value of 27.64 (df = 2, 197) is significant at p = 0.000 (< 0.05). Mean annual profit differs significantly across marketing arrangements, showing that the choice of marketing channel has a real bearing on farm profitability.

Table 23. Regression analysis of institutional support and financial sustainability

Independent variables	Standardised Beta	t-value	p-value
Government subsidy assistance	0.286	4.12	0.000
Institutional credit availability	0.241	3.56	0.001
Marketing arrangement	0.318	4.72	0.000
Technical support	0.194	2.94	0.004
Market access	0.267	3.89	0.000

Model statistics: R^2 = 0.638; Adjusted R^2 = 0.629; F = 68.30; Significance = 0.000.

All five institutional support variables have positive and significant effects on financial sustainability. Marketing arrangement has the strongest influence (β = 0.318, p = 0.000), followed by government subsidy assistance (β = 0.286, p = 0.000), market access (β = 0.267, p = 0.000), institutional credit availability (β = 0.241, p = 0.001) and technical support (β = 0.194, p = 0.004). The model explains 63.8 per cent of the variation in sustainability (R^2 = 0.638; adjusted R^2 = 0.629) and is significant overall (F = 68.30, p = 0.000).

Table 24. Summary of hypothesis testing

Statistical test	Test result	Significance	Decision
Independent samples t-test: Subsidies	t = 5.53	p = 0.000	Reject H_{05}
Independent samples t-test: Credit	t = 7.36	p = 0.000	Reject H_{05}
One-way ANOVA: Marketing	F = 27.64	p = 0.000	Reject H_{05}
Multiple regression	F = 68.30	p = 0.000	Reject H_{05}

All four tests are significant at p < 0.05: the t-tests for subsidy (t = 5.53) and credit (t = 7.36), the ANOVA for marketing arrangements (F = 27.64) and the multiple regression (F = 68.30). The null hypothesis H_{05} is therefore rejected, and government subsidies, institutional credit and marketing arrangements significantly influence the economic performance and financial sustainability of polyhouse farms.

Table 25. Major economic and financial constraints affecting polyhouse farming

Economic and financial constraints	Mean score	Standard deviation	Rank
High initial establishment cost	4.62	0.58	I
High cost of inputs	4.48	0.67	II
Fluctuation in market prices	4.42	0.71	III
High labour expenditure	4.35	0.73	IV
Inadequate working capital	4.28	0.76	V
High maintenance expenditure	4.17	0.82	VI
Delay in subsidy disbursement	4.05	0.91	VII
Limited institutional credit	3.96	0.88	VIII
Pest and disease problems	3.89	0.85	IX
Inadequate marketing facilities	3.82	0.93	X

High initial establishment cost is the most serious constraint (mean score 4.62, Rank I), followed by high cost of inputs (4.48), fluctuation in market prices (4.42), high labour expenditure (4.35) and inadequate working capital (4.28). Inadequate marketing facilities rank last (3.82), although every constraint scores above 3.8. The standard deviations (0.58 to 0.93) are small, with the lowest for establishment cost, which indicates broad agreement among farmers.

Table 26. KMO and Bartlett's Test

Statistical measures	value
Kaiser-Meyer-Olkin (KMO)	0.824
Bartlett's Chi-square	986.42
Degrees of freedom	45
Significance	0.000

The Kaiser-Meyer-Olkin value of 0.824 is above the commonly accepted threshold of 0.6 and indicates good sampling adequacy. Bartlett's test is significant (χ^2 = 986.42, df = 45, p = 0.000), showing that the variables are sufficiently correlated. The data are therefore suitable for factor analysis.

Table 27. Identified factors influencing the continued operation of polyhouse farms

Factors	Variables included	Factor loading	Variance explained
Capital and financial constraints	High establishment cost	0.86	24.8%
	Inadequate working capital	0.82	
	Limited institutional credit	0.78	
Production cost constraints	High input expenditure	0.84	19.6%
	Labour expenditure	0.81	
	Maintenance expenditure	0.76	
Market-related constraints	Market price fluctuation	0.87	17.2%
	Inadequate marketing facilities	0.83	
Institutional constraints	Delay in subsidy disbursement	0.85	13.5%
	Limited technical assistance	0.79	

Factor analysis groups the constraints into four factors: capital and financial constraints (24.8 percent of variance), production cost constraints (19.6 percent), market-related constraints (17.2 percent) and institutional constraints (13.5 percent). Together they explain 75.1 percent of the total variance. All factor loadings lie between 0.76 and 0.87, indicating a strong association between each variable and its factor.

Table 29. Logistic regression analysis of continued farm operation

Independent variables	Odds ratio	Wald statistic	p-value
Working capital availability	2.15	8.42	0.004
Market price stability	1.86	6.73	0.009
Subsidy assistance	1.72	5.16	0.023
Debt repayment burden	0.54	7.21	0.007
High establishment cost burden	0.63	4.89	0.027
Marketing access	1.95	7.84	0.005

Working capital availability (OR = 2.15, p = 0.004), marketing access (OR = 1.95, p = 0.005), market price stability (OR = 1.86, p = 0.009) and subsidy assistance (OR = 1.72, p = 0.023) raise the odds that a farm continues operating. Debt repayment burden (OR = 0.54, p = 0.007) and high establishment cost burden (OR = 0.63, p = 0.027) lower those odds. All six variables are significant at the 5 percent level.

Table 30. Summary of hypothesis testing

Statistical technique	Test result	Significance	Decision
Mean score analysis	High establishment cost: 4.62	Descriptive analysis	Major constraint
Factor analysis	KMO = 0.824	Bartlett p = 0.000	Factors identified
Logistic regression	Significant model	p = 0.000	Reject H_{06}

The mean score analysis identifies high establishment cost (4.62) as the major constraint. The KMO value (0.824) and Bartlett's test (p = 0.000) confirm that the factor analysis is valid and the factors are identified. The logistic regression model is significant (p = 0.000), so the null hypothesis H_{06} is rejected: economic and financial constraints are significantly associated with the continued operation and sustainability of polyhouse farms.

Major Findings of the Study

- The study reveals that the average establishment cost of a 1,000-square-metre polyhouse is approximately ₹8 lakh.
- Structural framework represents the largest component of establishment expenditure, accounting for 37.50 percent of the total investment, followed by polyfilm and covering materials at 15 percent.
- The average annual operational expenditure of polyhouse farming is estimated at ₹3.70 lakh, while gross annual returns amount to ₹6.50 lakh.
- The average net operating return is estimated at ₹2.80 lakh, indicating that polyhouse farming generates a positive operating surplus under the assumed production conditions.

- Labour expenditure constitutes a major component of operational costs, followed by fertilizer and nutrient expenditure.
- The operating benefit-cost ratio of 1.76 indicates that every rupee spent on annual operating activities generates approximately ₹1.76 in gross returns.
- Multiple regression analysis indicates that the selected cost components explain 62.4 percent of the variation in farm profitability.
- Labour expenditure, fertilizer costs, maintenance expenditure and packaging and transportation costs demonstrate significant negative relationships with profitability.
- The overall regression model is statistically significant, indicating that the cost structure plays an important role in determining the profitability of polyhouse farms.

Suggestions of the Study

- Government agencies should provide adequate financial assistance to reduce the initial investment burden associated with polyhouse construction.
- Subsidy support should be designed to benefit small and marginal farmers who face greater difficulties in mobilising investment capital.
- Locally available construction materials and cost-effective technologies should be encouraged without compromising structural safety and quality.
- Subsidy application and approval procedures should be simplified to reduce administrative delays.
- Government agencies should ensure timely disbursement of approved subsidy amounts.
- Farmers should be provided with clear information regarding eligibility conditions, subsidy rates and application procedures.
- A transparent monitoring mechanism should be established to assess the effectiveness of subsidy programmes.
- Commercial banks, cooperative banks and other financial institutions should provide affordable credit facilities specifically suited to protected cultivation.
- Loan repayment schedules should be aligned with crop production cycles and expected farm income.

- Working capital loans should be made available to meet recurring expenditure on seeds, fertilizers, labour and other agricultural inputs.
- Financial institutions should consider the seasonal nature of agricultural income while determining repayment obligations.
- Farmers should be encouraged to prepare annual farm budgets and maintain proper financial records.
- Training programmes on cash flow management, expenditure control and financial planning should be organised.
- Farmers should maintain adequate financial reserves to meet unexpected expenditure and seasonal fluctuations in income.
- Appropriate financial advisory services should be provided to help farmers manage debt obligations and recurring expenses.
- Agricultural universities, Krishi Vigyan Kendras and extension agencies should organise regular training programmes on protected cultivation.
- Farmers should be encouraged to adopt suitable crop varieties based on climatic conditions, market demand and production costs.
- Efficient irrigation, fertigation and pest management practices should be promoted.

Conclusion

Polyhouse farming is an important agricultural technology that enhances productivity, promotes high-value crop cultivation and improves farm income. In Kerala, protected cultivation offers opportunities to overcome climatic uncertainties, land constraints and rising production costs.

The study examines establishment costs, operational expenditure, profitability, investment viability, cash flow, debt repayment, institutional assistance and marketing arrangements. The analysis indicates that polyhouse farming can generate positive operating returns and achieve financial viability, provided that investment costs and recurring expenses are effectively managed. The study highlights that financial sustainability depends on adequate working capital, stable cash flows, manageable debt obligations and efficient resource utilisation. Farm size, crop selection,

productivity, input costs and market prices significantly influence profitability. Government subsidies, institutional credit and effective marketing arrangements, particularly through Farmer Producer Organisations, can further strengthen the financial performance of polyhouse farms.

However, high establishment costs, rising input prices, market fluctuations, labour expenditure, credit constraints and delayed subsidies remain major challenges. Therefore, affordable finance, timely subsidies, improved technology, better market access and effective financial management are essential to ensure the long-term economic viability and financial sustainability of polyhouse farming in Kerala.

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