International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Fueling the Future: Government Push for High-Tech Greenhouse Farming in Kerala

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Abstract
This study analyses the distribution of government subsidies for high-tech greenhouse vegetable farming in Kerala from 2009–10 to 2019–20. A total of ₹26.4 crore was disbursed, with significant regional disparities—Wayanad received the highest share, while Idukki, despite having the most farms, ranked fourth due to the dominance of smaller units. Subsidy levels rose sharply in the early years, peaking at ₹856 per sq m in 2018–19, followed by a decline that coincided with reduced farm expansion. A notable negative correlation between farm size and subsidy per sq m was observed, influenced by high support for small-scale units under the Vegetable Development Programme (VDP). ANOVA results confirmed that greenhouse size significantly affects the subsidy received, with medium-sized farms benefiting the most. The findings highlight the importance of equitable and well-targeted subsidy policies to support sustained growth in high-tech agriculture.

Keywords: High-tech farming, Greenhouses, Subsidy

1.1 Introduction

High-tech farming, particularly greenhouse cultivation, has emerged as a promising alternative to traditional open-field agriculture. Although it offers numerous benefits—such as climate control, year-round cultivation, and protection from pests—it is significantly more expensive to adopt. The primary contributor to these high costs is the construction of greenhouses, which are enclosed structures covered with transparent materials such as glass or plastic. When covered with UV-stabilised polythene sheets, these structures are referred to as polyhouses, a form widely adopted worldwide due to its cost-efficiency and effectiveness (Nair et al., 2014).

Globally, more than 50 countries have embraced greenhouse cultivation as a commercial enterprise. China stands out with over 2.5 million hectares under greenhouse farming, while countries like Israel have used this technology to overcome adverse weather and water scarcity to meet their vegetable demands. According to Sabir et al. (2013), global greenhouse coverage amounts to approximately 623,302 hectares, of which only 402,981 hectares are used for vegetable production. Among the leading nations, China has 81,000 hectares of protected crop space, followed by the United States (70,400 ha), South Korea (47,000 ha), and Japan (36,000 ha).

India joined the greenhouse movement relatively late, with the first such structure built in 1988. By the year 2000, greenhouse cultivation had expanded to over 1,000 hectares and reached 5,730 hectares by 2012 (Gautam et al., 2016). States like Maharashtra, Uttarakhand, Karnataka, and Jammu & Kashmir have taken the lead in adopting this technology. Despite its advantages, Indian farmers have been slow to adopt greenhouse farming due to its high initial investment and risk factor. Recognising this hesitation, both the central and state governments have introduced various financial assistance programs to encourage adoption. The findings of Kumar et al., (2014) reveal that government subsidies significantly reduced the financial burden of initial investment, making it easier for farmers to adopt greenhouse technology.

According to the Planning Commission of India (2012), targeted financial and technical interventions are essential for scaling up modern agricultural practices. The National Horticulture Mission (NHM) and several state-specific initiatives provide subsidies of up to 75 percent of the standardised construction cost to reduce the burden on farmers. These incentives aim to make high-tech farming more accessible and viable, especially in regions like Kerala, where traditional agriculture is challenged by declining land availability, labour shortages, and climate unpredictability (Ashraf Panancheri, et al., 2022).

In recent years, Kerala's agricultural sector has undergone a gradual transformation through the adoption of high-tech farming methods such as precision agriculture, polyhouse cultivation, drip irrigation, and automation tools. To promote these advancements, the state government has launched a range of subsidy schemes. This study investigates the impact of these government subsidies on the adoption of high-tech farming in Kerala, drawing on empirical data from different districts. Through an analysis of subsidy distribution patterns and trends over time, the study assesses how financial support influences farmer participation in high-tech farming under greenhouses.

1.2 Research Methodology

This study adopts a mixed-methods approach, combining both primary and secondary data to analyse the distribution and effectiveness of government subsidies for high-tech greenhouse vegetable farming in Kerala during the period from 2009–10 to 2019–20. Secondary data regarding subsidy disbursement and farm statistics were collected from the Principal Agricultural Officers of all 14 districts in Kerala. To complement this, primary data were gathered through structured interviews and surveys conducted among 165 high-tech greenhouse farmers, selected from a population of 837 registered farmers across the state. The sample was chosen to ensure representation across districts and varying farm sizes. Descriptive statistics were employed to identify regional patterns and trends, while inferential tools such as ANOVA were used to examine the relationship between farm size and the level of subsidy received. Correlation analysis was also conducted to explore the association between farm size and subsidy per square meter. This methodological framework enabled a comprehensive evaluation of how subsidy policies have influenced the growth and distribution of high-tech greenhouse farming in Kerala.

1.3 Provision of Subsidy in Various Districts

The distribution of subsidies for high-tech greenhouse farming across Kerala reveals significant regional variations, reflecting differences in the adoption and promotion of this agricultural practice. While some districts have actively embraced greenhouse cultivation and availed substantial financial assistance, others have shown limited participation. Notably, Wayanad, Thiruvananthapuram, Ernakulam and Idukki have emerged as leading districts in establishing high-tech farms, benefitting from a larger share of the subsidy allocation. In contrast, districts such as Pathanamthitta, Kollam, and Kasaragod have seen relatively low levels of adoption. The following section provides a detailed breakdown of subsidy distribution and the number of greenhouse farms across various districts, offering insights into the spatial trends and policy outreach within the state.

Table 1 presents district-wise data on the adoption of greenhouse farming in Kerala, highlighting both the number of greenhouse farms established and the total amount of government subsidy disbursed in each district. This information provides valuable insights into the regional distribution and uptake of high-tech farming practices, as well as the extent of financial support extended to farmers under various subsidy schemes.

The table illustrates that a total of ₹26,39,77,937 was disbursed as subsidies across various districts in Kerala during the period from 2009–10 to 2019–20. Wayanad, despite having the second-highest number of greenhouse farms, received the largest share of the subsidy, followed by Thiruvananthapuram, Ernakulam, and Idukki. Interestingly, while Idukki ranks first in the number of farms, it ranks fourth in total subsidy received, primarily due to the predominance of smaller-sized farms in the district, which require lower investment per unit. On the other end of the spectrum, Kasaragod received the least amount of subsidy, followed by Pathanamthitta. The last column of the table presents the percentage share of total subsidies received by each district. The formatting of these percentages—bold or normal text—provides a visual cue: bold digits indicate districts that received a disproportionately higher share of subsidies relative to their number of farms, while normal digits represent districts where the share of subsidies is lower than the share of farms. This comparison highlights the uneven distribution and differential access to subsidy benefits across the state.

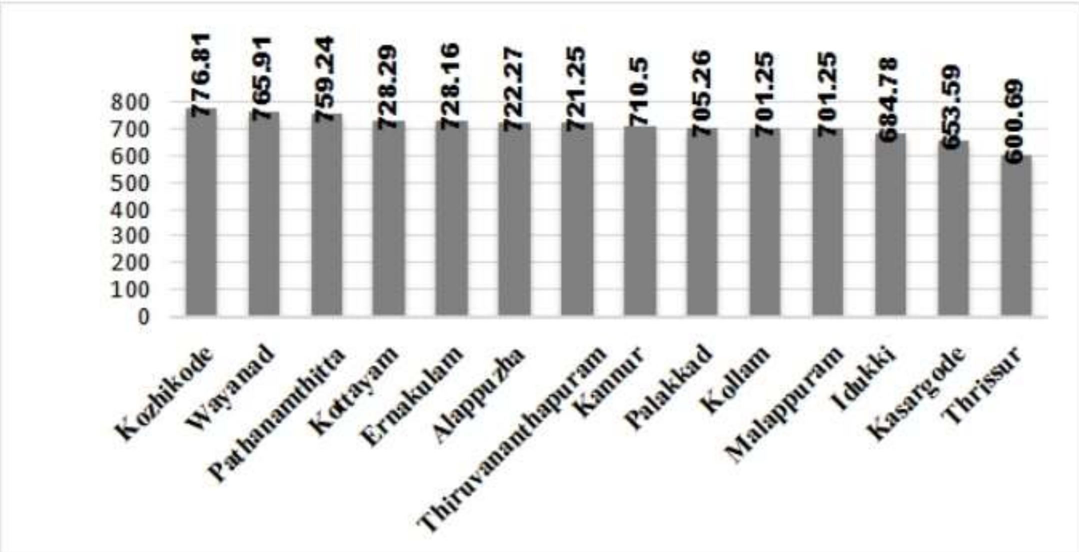
Table 1: District-wise Difference in the Provision of Subsidy

SL No	District	Number of Farms	Percent	Amount of Subsidy Given (₹)	Percent
1	Thiruvananthapuram	89	10.63	34369927	**13.02**
2	Kollam	32	3.82	14122820	**5.35**
3	Pathanamthitta	27	3.23	9714388	**3.68**
4	Kottayam	47	5.62	12037394	4.56
5	Alappuzha	35	4.18	11430245	**4.33**
6	Ernakulam	97	11.59	30410258	11.52
7	Idukki	112	13.38	30172678	11.43
8	Thrissur	71	8.48	14228411	5.39
9	Palakkad	40	4.78	13858842	**5.25**
10	Malappuram	61	7.29	16973781	6.43
11	Kozhikode	48	5.73	13172499	4.98
12	Wayanad	107	12.78	38540779	**14.60**
13	Kannur	41	4.90	21276622	**8.06**
14	Kasargode	30	3.58	3669293	1.39
Total		**837**	**100**	**26,39,77,937**	**100**

Source: Principal Agricultural Offices of Various Districts

In addition, an examination of the average amount of subsidy given per square meter of cultivation will help to determine the difference between the districts in this regard. Figure 4.2 demonstrates that the Kozhikode district received the highest subsidy (₹776), then Wayanad (₹765) and Pathanamthitta (₹ 759). Thrissur district received the lowest subsidy (₹600), then Kasaragod (₹ 653) and Idukki (₹ 684) districts. In this regard, the difference between the highest-subsidised Kozhikode and the lowest-subsidised Thrissur was about ₹ 176. There are only minor differences between the other districts, which are not specifically mentioned.

Figure 1: Subsidy (per sq m) in Various Districts



Source: Principal Agricultural Offices of Various Districts

1.4 Provision of Subsidy in Different Years since Inception

Since the inception of these initiatives in 2009–10, annual allocations have varied in response to policy priorities, budgetary provisions, and farmer participation rates. The following section presents a year-wise overview of the subsidies provided from 2009–10 to 2019–20, highlighting the government's sustained commitment to advancing protected cultivation technologies and enhancing agricultural productivity in the state.

Table 2: Provision of Subsidy for Farms Established in Different Years

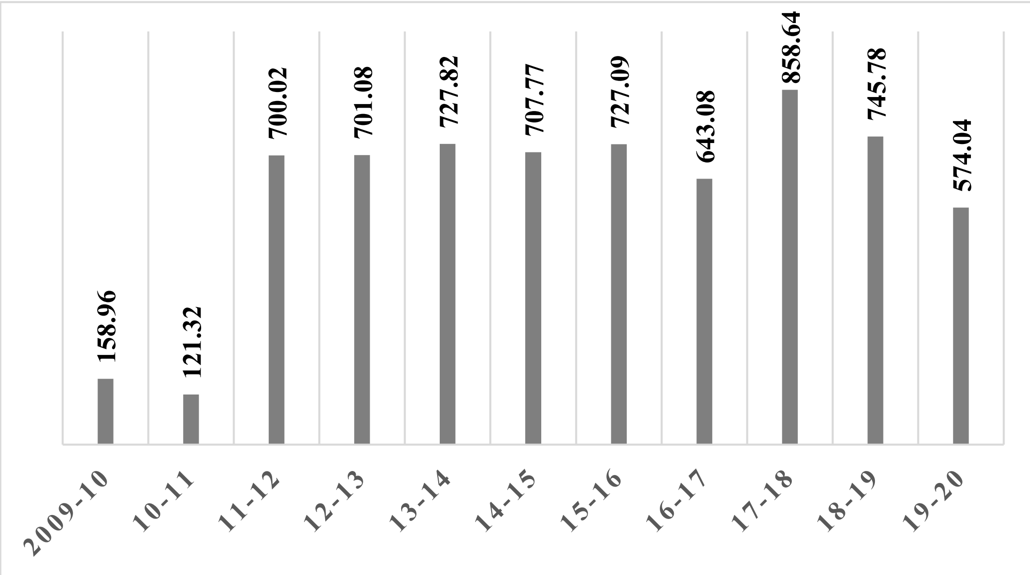
Year of Starting	Number of Farms	Percent	Subsidy Given (Rs)	Percent
2009-10	4	0.48	98001	0.04
2010-11	6	0.72	95612	0.04
2011-12	33	3.94	15787246	5.98
2012-13	129	15.41	32897807	12.46
2013-14	237	28.32	90494873	34.28
2014-15	176	21.03	59320067	22.47
2015-16	86	10.27	30484649	11.55
2016-17	37	4.42	11140371	4.22
2017-18	84	10.04	12689264	4.81
2018-19	40	4.78	10100726	3.83

2019-20	5	0.68	869321	0.33
Total	**837**	**100**	**26,39,77,937**	**100**

Source: Principal Agricultural Offices of Various Districts

Table 2 illustrates that 75 percent of total farms were established, and more than 80 percent of subsidies were paid only during the four years between 2012–13 and 2015–16. This indicates that the major contribution of farmers' entry into high-tech vegetable cultivation in the state occurred during this period. The last column of the table indicates the percentage of subsidies received by farmers each year. It can be seen that the highest proportion of subsidy was distributed in the year 2013-14 followed by 2014–15. On the other hand, the lowest proportion of subsidy was disbursed in the years 2009-10 and 2010-11, followed by 2019–20. The sector has expanded since 2012–13 with huge financial support from the government. But this speed could not be maintained later. It can be seen that by the year 2016–17, the sector had started facing a downturn. It can also be seen in the distribution of subsidies.

Figure 2: Subsidy Per sq m in Different Years



Source: Principal Agricultural Offices of Various Districts

Initially, the government provided very little financial support for the project. But then it increased tremendously. Figure 2 shows the average subsidy given for cultivation per square meter area for the period from 2009–10 to 2019–20. The subsidy, which was just Rs 158 in the first year, was reduced to Rs 121 the following year. It shall be noted that the number and area of farms were very limited during this period. However, by the year 2011–12, the subsidy level had quadrupled to ₹ 700 as compared to the initial period. This level was sustained with little fluctuation until 2015–16. During the same period, high-tech vegetable cultivation expanded extensively in the state in terms of both number and area. Although the subsidy amount peaked at ₹856 in 2018–19, it showed a declining trend over the following two years. Simultaneously, there was a noticeable reduction in both the number and area of newly established greenhouse farms. This trend indicates that government subsidies play a crucial role in promoting and sustaining the expansion of high-tech agriculture in Kerala.

1.5 Distribution of Subsidy among Various Sizes of Greenhouse Farms

The pattern of subsidy distribution among greenhouse farms in Kerala between 2009-10 and 2019-20 reveals significant variation based on the size of the cultivation area. Greenhouse units ranged from small-scale structures of less than 100 square meters to large-scale installations exceeding 1000 square meters. This classification provides insight into the government's approach to supporting farmers across different scales of operation. The following analysis highlights how subsidy allocation varied among these categories, reflecting policy priorities aimed at encouraging both marginal and commercial farmers to adopt high-tech farming practices.

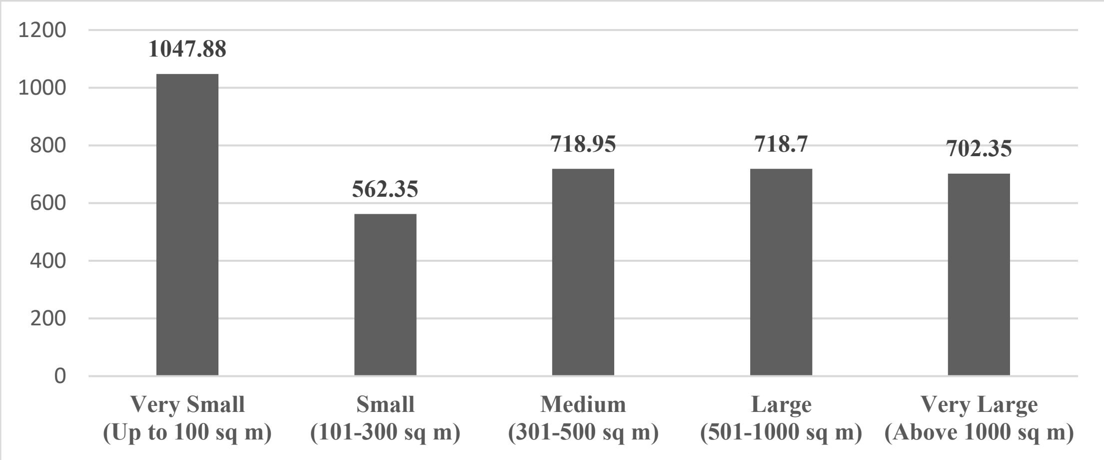
Table 3 indicates how the subsidy was distributed among farms of different sizes. Accordingly, the smallest section, which accounts for more than 20 percent of the total farms, received only 3 percent of the total subsidy. But for small (7.41%) and medium (52.8%) farms, it is 2.5 and 48.61 percent, respectively. On the other hand, in the cases of large farms (14.09%) and very large farms (5.37%), it is 24.91 percent and 20.98 percent, respectively. In short, about 46 percent of the total subsidy is spent on large and very large farms, which make up only 20 percent of the total farms. On the other hand, only 54 percent of the total subsidy has been spent on very small, small, and medium farms, which account for more than 80 percent of the total farms. This difference does not have much meaning, as the subsidy is given to some extent depending on the area of the farm. To know the depth, it is necessary to examine the rate at which the area per square meter is given.

Table 3: Distribution of Subsidy among Various Sizes of Greenhouse Farms

SL No	Size Category	Number of Farms	Percent	Total Subsidy in ₹	Percent of Subsidy
1	Very small (Up to 100 sq m)	170	20.31	7929497	3.00
2	Small (101-300 sq m)	62	7.41	6600067	2.50
3	Medium (301-500 sq m)	442	52.80	128326086	48.61
4	Large (501-1000 sq m)	118	14.09	65745786	24.91
5	Very Large (Above 1000 sq m)	45	5.37	55376501	20.98
Total		**837**	**100**	**26,39,77,937**	**100**

Source: Principal Agricultural Offices of Various Districts

Figure 3: Subsidy per sq m among Various Size Categories of GHs



Source: Principal Agricultural Offices of Various Districts

Table 4: Correlation Between Greenhouse Size and Subsidy

Spearman's rho		Size Category	Rank of Subsidy per sq m
Size Category	Correlation Coefficient	1	-0.074*
	p (2-tailed)		0.031
	N	837	837
*. Correlation is significant at the 0.05 level (2-tailed).			

Source: Author's estimation

Figure 3 specifies the subsidy per square meter on farms of various sizes. Accordingly, the highest amount of subsidy is given to very small units. The lowest amount of subsidy is for small units, and approximately the same level of subsidy is available for the other three categories, such as medium, large, and very large. The correlation between farm size and subsidies is given in table 4. Even though they are small, there is a significant negative correlation between farm size and the subsidy per sq m given to them.

The reason for the large subsidy scale in the very small units is that several units with 10, 20, and 40 sq m of area for producing vegetables for household consumption have been started in different districts as part of the government's Vegetable Development Programme (VDP). The level of subsidies in that programme was relatively high.

1.6 Subsidy Coverage in Greenhouse Construction Cost

This analysis explores the extent to which government subsidies contribute to the construction costs of greenhouses across different size categories. Using descriptive statistics, the study presents a clear picture of average subsidy proportions received by greenhouses ranging from very small to very large sizes, highlighting noticeable variations in the level of support. Medium-sized greenhouses were found to receive the highest and most consistent subsidy coverage, while smaller structures benefited less on average. To statistically validate these differences, an ANOVA (Analysis of Variance) test was conducted, revealing a significant variation in mean subsidy proportions across the five size groups, with a p-value of 0.009. This indicates that the size of a greenhouse plays a crucial role in determining the level of financial assistance received through subsidy schemes. Together, the descriptive and inferential analyses offer valuable insights into how subsidy distribution may be influenced by structural scale, informing future policy decisions and subsidy program designs.

Table 5: Subsidy Coverage in Greenhouse Construction Cost

Size Category of Greenhouses	Count	Mean Proportion	Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
Very Small (Below 100 sq m)	19	48.13	-0.72	4.27	38.66	55.63
Small (101-300 sq m)	11	37.00	0.23	5.34	25.26	46.52
Medium (301-500 sq m)	88	55.03	-0.03	1.53	52.16	58.44
Large (501- 1000 sq m)	30	55.03	-0.33	3.6	47.19	62.63
Very Large (Above 1000 sq m)	17	51.71	0.09	4.12	43.61	59.55
Total	**165**	**52.69**	**-0.1**	**1.38**	**49.77**	**55.47**

Source: Field Survey

Table 6: ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3765.887	4	941.472	3.521	.009
Within Groups	42787.352	160	267.421		
Total	46553.239	164			

Source: Author's estimation

Table 5 provides a detailed statistical comparison of how much of the greenhouse construction cost is met through government subsidies across different size categories, based on data from 165 greenhouses. On average, the overall subsidy coverage across all greenhouses is 52.69%, indicating that more than half of the construction cost is typically covered by the government. When comparing the size categories, medium-sized greenhouses (301–500 sq m) stand out, with the highest mean subsidy proportion of 55.03%, based on a robust sample size of 88, and a low standard error (1.53), which makes this estimate statistically reliable. Interestingly, large greenhouses (501–1000 sq m) also receive a similar average subsidy (55.03%), but with a higher standard error (3.6) and a smaller sample (30), suggesting more variability in subsidy distribution. Very large greenhouses (above 1000 sq m) show a slightly lower average subsidy at 51.71%, with higher uncertainty due to the small sample size (17) and a wider confidence interval (43.61% to 59.55%). On the other hand, very small greenhouses (below 100 sq m) receive a relatively modest average subsidy of 48.13%, and small greenhouses (101–300 sq m) receive the lowest subsidy, with only 37% of their construction cost covered, and a high standard error of 5.34 indicating significant variation or uncertainty. The difference in subsidy proportions may reflect policy focus, administrative ease, or cost-effectiveness in supporting mid-sized structures. Overall, the data suggests that medium-sized greenhouses are the most favoured in terms of consistent and substantial subsidy support. In contrast, both the smallest and largest greenhouses experience greater variation in the proportion of subsidies they receive.

The ANOVA results (Table 6) reinforce these observations, with a between-group sum of squares of 3765.887, an F-statistic of 3.521, and a significance level (p-value) of 0.009. Since the p-value is less than 0.05, the differences in mean subsidy proportions across the five size categories are statistically significant and not due to random chance. This implies that the size of a greenhouse does have a meaningful influence on the level of subsidy received. Overall, the data indicates that medium-sized greenhouses benefit the most from government subsidies, both in terms of the average proportion and the consistency of support, while other categories either receive less support or show greater variability, reflecting possible differences in policy priorities or implementation challenges.

1.7 Conclusion

This study demonstrates that government subsidies significantly contributed to the adoption of high-tech greenhouse farming in Kerala from 2009–10 to 2019–20. However, the distribution was uneven, with notable disparities across districts and farm sizes. Districts like Wayanad and Kozhikode received greater support, while others, including Kasaragod and Pathanamthitta, lagged behind. The mismatch between farm count and subsidy amount in regions such as Idukki reveals how smaller unit sizes can impact allocation patterns. The decline in subsidy levels after 2018–19 coincided with reduced farm expansion, indicating a strong link between financial support and growth momentum. Additionally, the negative correlation between farm size and subsidy per square meter—driven by policies favouring small-scale farms under the Vegetable Development Programme—and the ANOVA-confirmed advantage for medium-sized farms emphasise the need for nuanced policy design. To maximise impact, future subsidy strategies should aim for more equitable and size-sensitive allocation that supports both scalability and regional balance.

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