Original Research Article

Determinants of agricultural land fallowing in Kerala, India: Insights and implications

ABSTRACT

Kerala's land use dynamics have undergone significant transformations, with increasing fallows emerged as a key concern amid changing land utilization patterns. The study explores key factors contributing to the fallowing of agricultural land in Kerala. The research was conducted across three districts selected based on implementation of fallow land development schemes representing the northern, central, and southern regions of the state. A total of 360 farmers were surveyed, comprising 180 farmers with owned fallow land and 180 beneficiaries of fallow land development schemes. Data were collected using a pretested interview schedule, developed through extensive literature review and expert inputs.

Factor analysis was employed to identify key determinants. Six major factors with eigenvalues greater than one were extracted, explaining 58.95% of the cumulative variance. These factors include perspectives on fallowing, socio-economic attributes, land use experience, risk contingencies, personal traits, and economic and agro-ecological features.

The findings highlight that perspectives on fallowing contribute the largest variance (21.96%), emphasizing the importance of farmers' perception on causes and consequences of fallowing. Socio-economic attributes (11.25%) underline the role of family size, subsidiary enterprises, land value, and wage rate in influencing land use decisions. Land use experience (9.06%) reflects farming experience and preceding crop cultivated. Risk contingencies (6.22%) emphasize challenges like wild animal attacks and distance of farm land from road. Personal traits (5.50%) comprise of age and personal reason for fallowing. Economic and agro-ecological features (4.96%) including income, extreme weather events and land fragmentation, also emerged as critical determinants.

The study provides a comprehensive understanding of the multi-dimensional factors driving agricultural land fallowing in Kerala, offering insights for policymakers and stakeholders to design targeted interventions to promote sustainable land use.

Keywords: Agricultural land fallowing, determinants of fallowing, Kerala, Land use dynamics, factor analysis

1. INTRODUCTION

Kerala, located in the southwestern region of India, is renowned for its distinctive geographical features and diverse land use patterns. Spanning an area of 38,863 square kilometers, the state is characterized by a complex mix of agricultural land, forests, water bodies, and urban spaces. The tropical climate, fertile soils, and an extensive network of rivers have historically supported a thriving agrarian economy, with rice, plantation and spices forming the backbone of Kerala's agricultural landscape.

Agricultural land use in Kerala is intricately tied to its demographic and cultural characteristics. With one of the highest population densities in India, high literacy rates, and significant outward migration, the state faces unique pressures in sustaining the farming sector. Kerala is having a highly dynamic history of land use. In recent decades, Kerala's land use dynamics have experienced significant transformations driven by urbanization, industrialization, and socio-economic changes [1]. Declines in cultivated land, accompanied by increases in built-up areas, have become prominent. Of growing concern is the alarming rise in fallow land, where previously cultivated plots are left idle due to various reasons [2]. Land use pattern in Kerala reported a shift in land use pattern in favour of barren and uncultivable land and fallow lands [3]. Rejula and Singh [4] observed that cultivable waste, fallow other than current fallow and current fallow recorded a positive growth in Kerala. Kerala stands third in growth of fallow land among different states in India [5].

Increasing fallow land is a multifaceted issue, shaped by various determinants, including economic, environmental, and demographic factors [6]. Ramasamy *et al.* [7] found that infrastructure and institutional factors, such as road density and access to institutional finance are the important determinants of the extent of fallow lands. According to Kumar and Harilal [8] extreme fragmentation of crop land has contributed to a shift to less labour-intensive crops and increased agricultural land fallowing in Kerala . A study by Meiyappan *et a*l. [9] found that factors contributing to increased fallow land are mainly associated with labor shortage, migration driven by new income opportunities, lack of infrastructure lack of access to capital, and crop land fragmentation. Jose and Padmanabhan [10] reported that reduced economic viability, labour shortage, and population pressure on the land are major drivers of land use change in Kerala.

The growing proportion of fallow land in the state over the years highlights the need to boost productivity on the remaining cultivable land by adopting modern agricultural practices. The government of Kerala has initiated programs such as *Subhiksha Keralam* to attain self- sufficiency in

food production through the utilization of cultivable fallow lands. Measures are undertaken to cultivate 25,000 ha of fallow land under the leadership of local self-government under the programme [11]

The evolving land use pattern poses critical challenges to Kerala's socio-economic and environmental stability. The reduction in cultivated land and the rise in fallow land raise concerns about food security, rural livelihoods, and the sustainability of natural resources. At the same time, these changes provide opportunities for innovative land use planning, sustainable development, and the revival of fallow lands through targeted interventions. Gaining insight into the underlying determinants of fallowing is crucial for shaping informed and effective policies.

2. MATERIAL AND METHODS

2.1 Objective

To delineate the determinants of agricultural land fallowing in Kerala

2.2 Methodology

2.2 Study area

The study was conducted in Kerala, which is divided into five Agro Ecological Zones (AEZs): coastal plains, midland laterites, foothills, high hills, and the Palakkad plains. For the purposes of this research, the Midland Laterite and High Hill zones were purposively selected due to their significant land area and high agricultural activity. Three districts of Kerala, coming under these AEZs namely Kasaragod, Thrissur, and Thiruvananthapuram, were chosen based on their active involvement in the fallow land development schemes. Within these districts, three panchayats were selected from both the Midland Laterite and High Hill AEZs. This resulted in the selection of a total of eighteen panchayats from the three districts. These panchayats provided a diverse sample, allowing for an in depth understanding of the various factors affecting fallow land dynamics across Kerala.

2.3 Sampling

From the selected eighteen panchayats, a total of 360 farmers were chosen for the study. The sample included two distinct groups, 180 control farmers who owned fallow land but had not participated in any fallow land development schemes, and 180 beneficiaries who were the beneficiaries of such schemes. The details of the farmers were collected from the Krishi bhavans of concerned panchayats.

2.4 Data collection

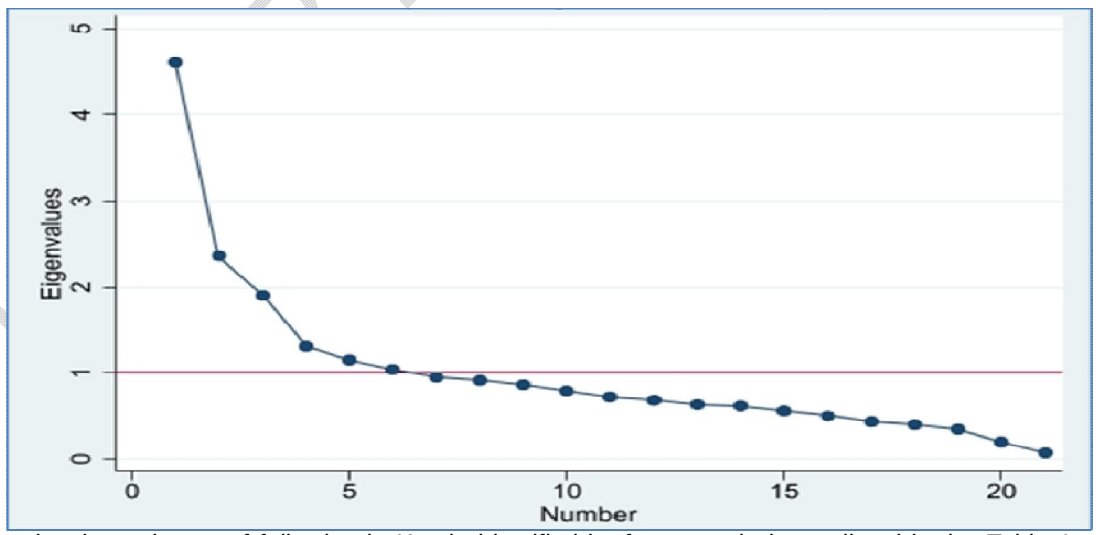
An interview schedule was prepared based on extensive literature review and expert opinion. To validate the interview schedule and ensure its reliability, it was pretested in a non-sample area within Kerala that exhibited similar agroecological and socio-economic conditions as the study locations. The final interview schedule was administered among 360 farmers across three selected districts of Kerala

2.5 Statistical method

The determinants of agricultural land fallowing in Kerala were identified through a factor analysis approach. Initially, a set of 36 variables, derived from a comprehensive literature review and expert input, were considered. These variables covered a broad range of socio-economic, environmental, and policy factors influencing fallowing. Following the analysis of correlations among these variables, 21 highly intercorrelated factors were selected for further examination. This reduction in variables aimed to distill the most influential determinants driving fallowing decisions. The factor analysis revealed six major factors with eigenvalues greater than one, which were identified as the primary determinants of agricultural land fallowing. These six factors together explained 60.95% of the cumulative variance, providing substantial insights into the key drivers behind the decision to leave land fallow. The use of factor analysis allowed for a robust and statistically sound understanding of how various factors interact and influence land use behaviors. The analysis was done using MS Excel and STATA 17.0

3. RESULTS AND DISCUSSION

The scree plot presented in Fig 1 illustrates that eigenvalues falls below one after the first six factors. This pattern indicates that these factors contribute significantly to explaining the variance within the dataset. Collectively, the first six factors account for a cumulative variance of 60.95%, demonstrating their ability to represent a substantial portion of the variability in the determinants of land fallowing.



The major determinants of fallowing in Kerala identified by factor analysis are listed in the Table 1.

Fig. 1 Scree plot showing determinants of fallowing

Within each factor, items with factor loadings above 0.3 were selected, and the factors were categorized as perspectives on fallowing, socio-economic attributes, land use experience, risk contingencies, personal traits, and economic and agro-ecological features.

Table 1. Determinants of agricultural land fallowing in Kerala (N=360)

Factor number	Factor	Items under the factor	Factor loading
1	Perspectives on fallowing	Perception on causes of land fallowing	0.414
2	Socio economic attributes	Perception on consequence of land fallowing	0.401
		Family size	-0.446
		Subsidiary enterprises	-0.430
		Land value	0.425
		Wage rate	0.414
		Social participation	-0.377
3	Land use experience	Farming experience	0.392
		Preceding crop cultivated	- 0.376
		Farming alienation	0.304
4	Risk contingencies	Wild animal attack	0.487
		Risk orientation	-0.393
		Distance from road	-0.378
5	Personal traits	Age	0.436
		Personal reason fallowing	0.370
6	Economic and agro-ecological factors	Incidence of extreme weather conditions	0.452

3.1 Perspectives on Fallowing

This factor accounts for the largest portion of variance (21.96%), highlighting that farmers views on the causes and consequences of fallowing are significant determinants. For instance, those who see issues like labor shortages or profitability challenges as unavoidable may deprioritize farming. Similarly, farmers who perceive minimal negative consequences of fallowing are more likely to leave their land idle. These findings align with studies by [12, 13].

3.1.1 Perception on causes of land fallowing

Table 2 presents the distribution of respondents based on their perceptions of the causes of land fallowing. The data indicates that beneficiaries of fallow land schemes generally hold a more moderate view on the causes behind land fallowing than do fallow land owners. This difference may be attributed to beneficiaries' involvement in schemes designed to reduce fallowing, which might lessen their sensitivity to the underlying causes. Conversely, fallow land owners have a slightly higher percentage in the high perception category (24.44 %). Overall, the perception of fallowing causes tends toward a medium level.

Table 2 Distribution of respondents based on perception on causes of land fallowing

Perception on causes of and fallowing	Fallow	Beneficiaries	Overall
Low	26 (14.44)	58 (32.22)	84(23.33)
Medium	110 (61.11)	103 (57.22)	213 (59.16)
High	44 (24.44)	19 (10.55)	63 (17.5)

Table 3 shows the distribution of respondents based on their perceptions of the consequences of land fallowing. The data reveals a difference in perception between fallow landowners and beneficiaries of fallow land schemes regarding consequences of fallowing. Beneficiaries are more inclined to view the consequences as moderate. This may reflect the assistance they receive through the schemes, which could help them in mitigating negative effects associated with land fallowing.

In contrast, a significant proportion (28.88 %) of fallow landowners have high perception on consequences of fallowing, likely because they experience these impacts more directly. Overall, the majority (58.61 %) of farmers in Kerala, regardless of their group, have medium level of perception on consequences of land fallowing. The lower percentage of high-perception among beneficiaries

suggests that fallow land schemes may be effective in managing or alleviating the negative effects of land fallowing

Table 3 Distribution of respondents based on perception on consequences of land fallowing

perception on consequences of land fallowing	Fallow	Beneficiaries	Overall
Low	33 (18.33)	32 (17.77)	65 (18.05)
Medium	95 (52.77)	116 (64.44)	211 (58.61)
High	52 (28.88)	32 (17.77)	84 (23.33)

3.2 Socio-economic attributes

Socio-economic attributes explain 11.25% of the variance. It reflects the impact of socio-economic conditions on land use choices, including family size, subsidiary enterprises, land value, wage rate, and social participation. Large families often have more labor available, which can decrease fallowing. Subsidiary enterprises also discourage fallowing. High land values, however, tend to increase fallowing due to potential alternative uses, such as real estate. The speculative trend around urban areas in Kerala encourages landowners to leave land idle while awaiting better prices. High wage rates similarly make it financially challenging for small farmers to hire labor, often leading to fallowing. Social participation supports active farming, as knowledge exchange and resource-sharing reduce fallowing through collective practices. These findings are consistent with [14].

3.2.1 Subsidiary enterprises

Table 4 presents the distribution of farmers based on subsidiary enterprises. It is clear that dairy and poultry farming are the main subsidiary enterprises for farmers in Kerala, with 43.33 % and 28.88 % of farmers involved in these activities, respectively. Both fallow landowners and scheme beneficiaries exhibit significant participation in dairy and poultry farming, indicating these as key sources of supplementary income. Scheme beneficiaries, in particular, show a broader range of involvement in subsidiary enterprises, including goat rearing (17.78 %), pisciculture (12.22 %), and mushroom cultivation (5.56 %).

Table 4 Distribution of respondents based on subsidiary enterprises

Subsidiary enterprises	Fallow	Beneficiaries	Overall
Dairy	88 (48.88)	68 (37.78)	156 (43.33)
Goat	9 (5.00)	32 (17.78)	41 (11.38)
Poultry	53 (29.44)	51 (28.83)	104 (28.88)
Piggery	20 (11.11)	17 (9.44)	37 (10.27)
Apiculture	6 (3.33)	7 (3.89)	13 (3.61)
Pisciculture	15 (8.33)	22 (12.22)	37 (10.27)
Mushroom	1 (0.56)	10 (5.56)	11 (3.05)
Others	0	2 (1.11)	2(0.56)

3.2.2 Family size

The data presented in Table 5 shows that the majority of farmers in Kerala, have family sizes ranging from 3 to 6 members. This aligns with the findings of [15]. The most common family size is 3 to 4 members, accounting for 52.22 %, followed by 5 to 6 members, which makes up 38.05 %. This pattern indicates that nuclear or moderately sized families are predominant among farmers in the state. Beneficiaries of fallow land schemes tend to have slightly larger families compared to fallow landowners, with 40.00 % of farmers having 5-6 family members and 8.88 % having more than 6 members.

Table 5 Distribution of respondents based on family size

Family size	Fallow	Beneficiaries	Overall
upto 2	6 (3.33)	3 (1.66)	9 (2.5)
3 to 4	99 (55.00)	89 (49.44)	188 (52.22)
5 to 6	65 (36.11)	72 (40)	137 (38.05)
>6	10 (5.55)	16 (8.88)	26 (7.22)

3.2.3 Social participation

A notable proportion (28.88 %) of scheme beneficiaries exhibit high levels of social participation, compared to only 10.00 % of fallow landowners. This higher level of involvement among beneficiaries suggests they are more engaged in community organizations, local groups, and social networks offering farmers support, resources, and knowledge-sharing. These findings align with [16] research.

Medium social participation is most common among both fallow landowners (80 %) and beneficiaries (61.67 %), indicating that a majority of farmers in both groups maintain a moderate level of involvement in social activities. Overall, 70.83 % of the combined sample falls into the medium participation category.

Table 6 Distribution of respondents based on social participation

Social participation	Fallow	Beneficiaries	Overall
Low	18 (10)	17 (9.44)	35 (9.72)
Medium	144 (80)	111 (61.67)	255 (70.83)
High	18 (10)	52 (28.88)	70 (19.44)

3.2.4 Wage rate

Table 7 presents the distribution of respondents based on wage rates. The data reveals that the majority of respondents earn more than 600 rupees per day, which is significantly higher than the national average of 361.52 rupees per day. Kerala stands out as the highest wage-paying state in India. The largest proportion of both fallow landowners and beneficiaries fall within the wage range of 651-700 rupees per day. For fallow landowners, this range includes 27.78 %, while for beneficiaries, it includes 48 individuals (26.67 %). In total, 98 people (27.22 %t) fall into this wage bracket, making it the most common wage range in the state. Wages exceeding 900 rupees per day are paid by 30 fallow landowners (16.67 %) and 24 beneficiaries (13.33 %), which accounts for 15.00 percent of the total sample. This indicates that a significant portion of the population in this study pays higher wages. The findings are consistent with the study by [17].

Table 7 Distribution of respondents based on wage rate

Wage rate	Fallow	Beneficiaries	Overall
Up to 600	21 (11.67)	8 (4.44)	29 (8.05)
601-650	23 (12.78)	40 (22.22)	63 (17.50)
651-700	50 (27.78)	48 (26.67)	98 (27.22)
701-750	21 (11.67)	15 (8.33)	36 (10.00)
751-800	12 (6.67)	17 (9.44)	29 (8.05)
801-850	9 (5.00)	10 (5.56)	19 (5.27)
851-900	14 (7.78)	18 (10.00)	32 (8.88)
>900	30 (16.67)	24 (13.33)	54 (15.00)

3.2.5. Land value

The land value percentage reported by the respondents is presented in Table 8. The table shows that the majority of fallow landowners reported land values exceeding one lakh percent. Only 36.11 %of fallow landowners reported values below one lakh, while 52.78 %of scheme beneficiaries reported land values below one lakh.

Table 8 Distribution of respondents based on land value

Land value per cent	Fallow	Beneficiaries	Overall
<1 lakh	65 (36.11)	95 (52.78)	160 (44.44)
1-2 lakh	54 (30.00)	50 (27.78)	104 (28.88)
2.1-3 lakh	22 (12.22)	24 (13.33)	46 (12.77)
3.1 to 4 lakh	18 (10.00)	10 (5.56)	28 (7.77)
4.1 to 5 lakh	8 (4.44)	1 (0.56)	9 (2.05)

>5 lakh	12 (6.67)	0	12 (3.33)

This suggests that a substantial portion of fallow land is situated in areas with relatively higher land prices. Such land may have potential for alternative uses, such as commercial or residential development, especially with the increasing demand for land in economically prosperous regions of Kerala. This trend may also reflect that many fallow landowners possess property in peri-urban or semi-urban areas, where land values have risen due to urbanization and infrastructure development. Similar trends were reported by [18,19].

3.3 Land use experience factors

This factor explains 9.06% of the variance, including farming experience, preceding crop cultivated, and farming alienation. Experienced farmers may leave land fallow, often due to repeated losses or advanced age. The type of crop previously grown also influences land use decisions, with labor-intensive or less profitable crops, like paddy, leading to higher fallowing. Farming alienation, or a farmer's detachment from agriculture, can also contribute to fallowing.

3.3.1 Farming experience

The data given in Table 9 shows that more than half of the respondents (53.05 %), including 51.66 % of fallow landowners and 54.44 %of scheme beneficiaries, have more than 25 years of experience. The moderate experience group, with 11 to 25 years of experience, also makes up a significant portion of respondents (29.16 %). The relatively low percentages of farmers in the 6 to 10 years and up to 5 years' experience categories indicate that there is limited entry of new and young farmers into agriculture in Kerala. These findings are supported by the study conducted by [20].

Table 9 Distribution of respondents based on farming experience

Farming experience	Fallow	Beneficiaries	Overall
Upto 5 years	4 (2.22)	2 (1.11)	6 (1.66)
6 to 10 years	35 (19.44)	23 (12.77)	58 (16.11)
11 to 25 years	48 (26.66)	57 (31.66)	105 (29.16)
Above 25 years	93 (51.66)	98 (54.44)	191 (53.05)

3.3.2 Preceding crop cultivated

A significant proportion of respondents (72.22 %) cultivated paddy before fallowing, with 66.66 %of fallow landowners and 77.77 %of scheme beneficiaries reporting that paddy was the major crop grown before fallowing in Kerala. This high percentage indicates that paddy fields are particularly susceptible to fallowing, possibly due to the labor-intensive nature of paddy cultivation or the high input costs involved. The vulnerability of paddy fields to fallowing has been highlighted in previous studies [21].

Rubber was the second most commonly cultivated crop before land was left fallow, with 29.44 % of fallow landowners and 12.77 % of beneficiaries indicating that their land was previously used for rubber cultivation. The trend of leaving rubber plantations fallow in Kerala is a concerning issue. Once a profitable crop for Kerala's farmers, rubber has encountered difficulties in recent years, prompting many farmers to abandon their plantations. Rubber prices have fluctuated significantly over the past decade, often staying below profitable levels for small and medium-sized farmers. Global competition and the rise of synthetic rubber have reduced the demand for natural rubber, making its cultivation less viable. Additionally, rubber tapping is labor-intensive and requires skilled workers, but Kerala has seen a decline in the availability of agricultural labor. The shortage of skilled tappers, coupled with high labor costs, has made it difficult for rubber plantation owners to maintain and harvest their crops, leading many to leave their plantations uncultivated. Many rubber plantations in Kerala also have aging trees with declining productivity. Replanting is costly and requires years of waiting for new trees to begin producing latex. Given these challenges, some farmers prefer leaving the land fallow rather than investing in replanting. These findings align with the research by [22].

A small number of farmers (1.11 %t) cultivated cashew and 1.66 % cultivated arecanut before fallowing, particularly in Kasaragod district. Many cashew plantations in Kasaragod were established decades ago, and the trees have now reached an age where their productivity naturally declines. Rejuvenating these plantations through replanting is expensive and requires several years of waiting before new trees begin producing nuts. The high initial investment and delayed returns discourage farmers from replanting, leading to more cashew land being left fallow. This trend was also reported by [23,24].

The fallowing of arecanut plantations may be attributed to recurring pest and disease issues affecting arecanut palms. Kasaragod has experienced frequent outbreaks of diseases like yellow leaf disease, bud rot, and arecanut leaf spot disease, which damage arecanut trees and often result in reduced yields. The challenges faced by arecanut farmers in Kerala, including the risk of disease spread and associated losses, have made leaving the land fallow a more financially sensible option. This was also reported by [25].

Table 10 Distribution of farmers based on crop grown before

Crop grown before	Fallow	Beneficiaries	Overall
Paddy	120 (66.66)	140 (77.77)	260 (72.22)
Rubber	53 (29.44)	23 (12.77)	76 (21.11)
Banana	2 (1.11)	1 (0.56)	3 (0.833)
Cashew	0	4 (2.22)	4 (1.11)
Arecanut	1 (0.56)	5 (2.77)	6 (1.66)
Trees	0	4 (2.22)	4 (1.11)
Others	4 (2.22)	3 (1.66)	7 (1.94)

3.3.3 Farming alienation

The data presented in Table 11 shows that most farmers in Kerala experience medium to low levels of alienation from farming. However, a notable proportion, particularly among fallow landowners, experience high alienation (20.55 %), indicating a potential risk of further fallowing if interventions to re-engage these farmers are not introduced. Beneficiaries of fallow land schemes seem less alienated than fallow landowners, with 29.44 % experiencing low levels of alienation and 56.11 % experiencing medium levels. This suggests that such schemes help retain farmers' interest in agriculture.

Table 11 Distribution of farmers based on farming alienation

Farming alienation	Fallow	Beneficiaries	Overall
Low	34 (18.89)	53 (29.44)	87 (24.16)
Medium	109 (60.55)	101 (56.11)	210 (58.33)

High	37 (20.55)	26 (14.44)	63 (17.50)

3.4 Risk factor

Contributing to 6.22% of the variance, this factor highlights wild animal attacks as a significant concern in fallow decisions. Additionally, risk-averse farmers are more likely to leave land fallow, while proximity to roads can increase fallowing due to opportunities for real estate development.

3.4.1 Incidence of wild animal attack

The distribution of farmers based on wild animal attacks is shown in the Table 12. Wild boars (38.05 %) and peacocks (19.44 %) are the most commonly reported animals causing damage. Monkeys (16.33 %t) and porcupines (10.22 %) pose a moderate threat to farmers. Attacks by elephants (8.05 %) and Indian giant squirrels (5.55 %) are less frequently reported, although elephants, in particular, can cause significant damage when they encroach upon agricultural areas. There were also reports of attacks by other wild animals, such as deer. These findings are consistent with the research by [26].

Table12 Distribution of farmers based on incidence of wild animal attack

Incidence of wild animal attack	Fallow	Beneficiaries	Overall
Wild boar	71 (39.44)	66 (36.67)	137 (38.05)
Elephant	13 (7.22)	16 (8.88)	29 (8.05)
Monkey	29 (16.11)	30 (16.67)	59 (16.33)
Porcupine	22 (12.22)	15 (8.33)	38 (10.22)
Peacock	30 (16.66)	40 (22.22)	70 (19.44)
Indian giant squirrel	10 (5.55)	10 (5.55)	20 (5.55)
Others	4 (2.22)	3 (1.66)	7 (1.94)

3.4.2 Risk Orientation

The table 13 presents the distribution of respondents based on their risk orientation. The majority (58.33 %) of scheme beneficiaries have a medium level of risk orientation, followed by 26.11 % with a high-risk orientation. This suggests that individuals with moderate to high risk tolerance are more likely to engage in the scheme. Among fallow landowners, the medium risk orientation category is also the most common (46.11 %), similar to beneficiaries. However, there is a higher proportion of low-risk oriented individuals (33.33 %) compared to beneficiaries, indicating that risk-averse landowners may be less likely to participate in the scheme. Farmers who are risk-averse may prefer leaving land fallow to avoid potential losses. Overall, the trend shows a predominance of medium-risk oriented farmers in Kerala (52.22 %), followed by low-risk (24.44 %) and high-risk oriented farmers (23.33 %). These findings align with the research by [27].

Table 13 Distribution of respondents based on risk orientation

Risk orientation	Fallow	Beneficiaries	Overall
Low	60 (33.33)	28 (15.56)	88 (24.44)
Medium	83 (46.11)	105 (58.33)	188 (52.22)
High	37 (20.26)	47 (26.11)	84 (23.33)

3.4.3 Distance from road

The table reveals that the majority (55.00 %) of fallow landowners have land located within 500 meters of a road, suggesting that lands closer to roads are more prone to fallowing. In contrast, only 38.89 % of scheme beneficiaries have land within this distance from the road. Overall, the majority of respondents across the three districts have land situated within 500 meters of a road.

Table 14 Distribution of farmers based on distance from road

Distance from road	Fallow	Beneficiaries	Overall
<500 m	99 (55.00)	70 (38.89)	169 (46.94)
0.501-1 km	54 (30.00)	66 (36.67)	120 (33.33)
1.1-1.5 km	22 (12.22)	16 (8.89)	38 (10.56)
1.6-2 km	5 (2.77)	23 (12.78)	28 (7.77)
>2	5 (2.78)	0	5 (1.38)

3.5 Personal Factors

Explaining 5.50% of the variance, this factor includes age and personal reasons for fallowing. Older farmers are more likely to fallow land, often due to health concerns or reduced interest in active farming.

3.5.1 Age

The table indicates that the majority of farmers in Kerala are middle aged, comprising 57.50 % of the respondents. A significant portion, 40.27 %, falls into the old age category, while only 2.22 % of farmers are classified as young. This suggests that the farming population in Kerala is aging. The results are consistent with the findings of [28], with a similar trend observed among both fallow landowners and scheme beneficiaries.

Table 15 Distribution of farmers based on age

Age	Fallow	Beneficiaries	Overall
Young (<35 years)	6 (3.33)	2 (1.11)	8 (2.22)
Middle (35-60 years)	99 (55.00)	109 (60.56)	207 (57.50)
Old (>60 years)	75 (41.67)	70 (38.89)	145 (40.27)

3.5.2 Personal reason for fallowing

The Table 16 presents the personal reason for fallowing, highlighting that economic, labor, and water-related challenges are the primary factors driving fallowing. For fallow landowners, profitability is a major concern, with 43.33 % citing lack of profit as a reason for fallowing, followed by water shortage at 17.78 %. Scheme beneficiaries, who may be more inclined to cultivate, report greater difficulties with labor availability (33.33 %t) and water shortage (23.88 %). These findings align with the work of [14].

The removal of senile crops is another significant cause of fallowing, with a higher percentage of beneficiaries (17.22 %) citing this reason compared to fallow landowners (6.11 %). This reason was primarily reported by farmers who had previously cultivated rubber. Rubber plantations face unique challenges in replanting due to high initial costs and fluctuating rubber prices. If replanting is not financially viable or market conditions are unfavorable, landowners may choose to leave the land fallow instead of investing in new rubber saplings. Both fallow landowners and beneficiaries reported a similar proportion (2.77 %) of fallowing due to health issues.

Crop loss due to pests and diseases is minimally reported (1.38 %), with only a small number of respondents from each group affected. The issue of "owners out of station" is reported solely by fallow landowners (4.44 %), possibly reflecting absentee ownership.

A very small percentage (0.83 %) reported unfavorable soil conditions, with no fallow landowners affected and only a few beneficiaries reporting the issue. This suggests that soil quality is not a significant obstacle to cultivation. Water stagnation appears to be a minor concern (0.83 %), with only a few individuals from each group impacted, indicating that the problem may be limited to specific areas or types of land. Additionally, an identical 5 % of respondents in each group cited various unspecified factors as reasons for fallowing.

3.6 Economic and agro-ecological Factor

This factor accounts for 4.96% of the variance and includes extreme weather events, income levels, and land fragmentation. Frequent weather events like floods or droughts can make farming unpredictable, increasing fallowing. Higher agriculture income provides farmers the resources to continue farming. Additionally, fragmented landholdings can make farming inefficient, prompting more land to be left fallow.

3.6.1 Income

The majority (43.33%) of farmers fall within the 0.5–1 lakh income range, indicating moderate earnings for a significant portion of Kerala's agricultural community. Specifically, 45 percent of fallow landowners and 41.67 % of beneficiaries report annual incomes in this range. A notable percentage of farmers earn more than 1 lakh annually, with 29.44 % of fallow landowners and 47.22 % of beneficiaries in this category. Overall, 38.33 % of respondents have annual incomes exceeding 1 lakh.

A smaller proportion of farmers earn less than 0.5 lakh annually. Among fallow landowners, 25 %fall into this category, while only 11.11 % of beneficiaries do. Overall, 18.05 % of farmers earn less than 0.5 lakh annually. This suggests that beneficiaries of development schemes tend to have slightly higher income levels compared to fallow landowners.

The income distribution shows that fallow land development scheme beneficiaries generally report higher income levels than fallow landowners. This may reflect the impact of the schemes in improving

beneficiaries' economic well-being or their pre-existing financial stability, which could enable them to take better advantage of such schemes.

Table 16 Distribution of farmers based on contingent causes of fallowing

Contingent causes of fallowing	Fallow	Beneficiaries	Overall
Health issues	5 (2.77)	5 (2.77)	10 (2.77)
Unavailability of labour	33 (18.33)	60 (33.33)	93 (25.83)
Crop loss due to pest and diseases	2 (1.11)	3(1.67)	42 (11.67)
Unfavourable soil conditions	0	3 (1.66)	3(0.83)
No profit	78 (43.33)	25 (13.88)	103 (28.61)
Water shortage	32 (17.78)	43 (23.88)	75 (20.83)
Water stagnation	2 (1.11)	1 (0.55)	3(0.83)
Senile crop removed	11 (6.11)	31 (17.22)	42 (11.67)
Owners out of station	8 (4.44)	0	8(2.00)
Others	9 (5.00)	9 (5.00)	18 (5.0)

Table 17 Distribution of farmers based on income

Income	Fallow	Beneficiaries	Overall

<0.5 lakhs	45 (25.00)	20 (11.11)	65 (18.05)
0.5 -1 lakhs	81 (45.00)	75 (41.67)	156 (43.33)
>1 lakhs	53 (29.44)	85 (47.22)	138 (38.33)

3.6.2 Incidence of extreme weather conditions

Heavy wind is the most frequently cited extreme weather condition, affecting 25 % of fallow landowners and 24.44 % of beneficiaries, with an overall incidence of 24.72 %. This suggests that wind damage is a significant issue for agricultural land in Kerala, potentially harming crops and discouraging continued cultivation.

Drought appears to be a major concern, impacting 22.78 % of fallow landowners and 21.66 % of beneficiaries. This indicates that water scarcity is a common challenge among farmers in Kerala, likely affecting agricultural productivity and leading to land fallowing.

Flooding has affected both groups, with 18.33% of fallow landowners and 10.55 % of beneficiaries citing it as a reason for fallowing, resulting in an overall rate of 14.44 %. This suggests that while floods are significant, they are not the primary weather-related cause of land fallowing in Kerala.

Landslides are a less common issue, reported by 5.55 % of fallow landowners and 6.66 %of beneficiaries, resulting in an overall rate of 6.11 %. Although less frequent, landslides may still pose a localized risk in certain hilly or mountainous areas.

The significant impact of heavy winds and drought highlights the need for climate-resilient agricultural practices in Kerala, such as drought-tolerant crops, windbreaks, and improved water management. Interventions to mitigate these weather-related risks could help reduce land fallowing and enhance agricultural productivity in the state. Additionally, flood and landslide management efforts are crucial in vulnerable areas to support sustainable land use and encourage cultivation.

Table 18 Distribution of farmers based on incidence of extreme weather conditions

Incidence of extreme weather conditions	Fallow	Beneficiaries	Overall
Flood	33 (18.33)	19 (10.55)	52 (14.44)
Drought	41 (22.78)	39 (21.66)	80 (22.22)

Heavy wind	45 (25.00)	44 (24.44)	89 (24.72)
Land slide	10 (5.55)	12 (6.66)	22 (6.11)

3.6.3 Land fragmentation

The data reveals the distribution of land holdings among respondents, highlighting the extent of land fragmentation in Kerala. The majority (36.68 %) of farmers own two plots, followed by 26.38 percent who own three plots. Fifteen percent of respondents own four plots, and a smaller proportion (10.56 percent) report owning more than four plots. This pattern indicates a prevalent trend of small and fragmented land holdings, as also noted by [14].

For policymakers, the key challenge is to create strategies that address land fragmentation, such as promoting land consolidation, supporting collective farming initiatives, or encouraging land management practices that cater to small, fragmented plots.

Table 19 Distribution of farmers based on land fragmentation

No of plots	**Fallow**	**Beneficiaries**	**Overall**
1	20 (11.11)	22 (12.22)	42 (11.66)
2	66 (36.67)	65 (36.11)	131 (36.38)
3	40 (22.22)	55 (30.56)	95 (26.38)
4	27 (18.00)	27 (15.00)	54 (15.00)
>4	18 (10.00)	20 (11.11)	38 (10.56)

4. CONCLUSION

This study provides a comprehensive analysis of the factors influencing fallowing in Kerala, highlighting a complex interplay of perspectives, socio-economic conditions, land use experiences, risks, and personal traits and economic and agro-ecological features. Farmer perceptions of the causes and consequences of fallowing significantly influence land use decisions. Labor shortages, profitability challenges, and perceived minimal negative impacts encourage fallowing, particularly among non-beneficiaries. However, beneficiaries of fallow land schemes demonstrate moderate perceptions, reflecting the mitigating effects of such interventions.

Socio-economic factors like family size, subsidiary enterprises, land value, wage rates, and social participation shape fallowing tendencies. Larger families and active subsidiary enterprises discourage fallowing, whereas high land values and wage rates promote it. Beneficiaries, with higher social participation and engagement in diverse enterprises, demonstrate reduced fallowing rates.

Experienced farmers often fallow land due to previous losses or the challenges associated with specific crops like paddy and rubber. High labour and input costs, coupled with market challenges, render these crops susceptible to fallowing. Beneficiaries, supported by schemes, show relatively less farming alienation. Risks such as wild animal attacks and economic uncertainty further influence fallowing. Farmers closer to roads often leave land idle, possibly awaiting better real estate opportunities. Beneficiaries, exhibiting moderate to high-risk tolerance, tend to continue cultivation.

Aging farmers and challenges such as profitability concerns, water scarcity, and labor shortages are key drivers of fallowing. Farming alienation also contribute to fallowing. Extreme weather events, fragmented landholdings, and income levels also play a role in fallowing decisions. Beneficiaries of fallow land schemes tend to demonstrate better resilience against these challenges, often due to the financial and structural support provided by the schemes.

The findings of the study underscore the necessity of targeted interventions to address the socio-economic, ecological, and psychological dimensions of fallowing. Strengthening fallow land development schemes is essential, with an emphasis on expanding their reach and tailoring interventions to address challenges associated with crops like paddy and rubber, which are highly susceptible to fallowing due to input costs and market risks. Promoting crop diversification, especially into high-value and climate-resilient crops like fruits, spices, and medicinal plants, can enhance profitability and reduce the likelihood of land abandonment.

Labor shortages, a critical driver of fallowing, can be addressed through mechanization support by establishing rural machinery hubs and fostering community-based labor-sharing models. Improving irrigation infrastructure and promoting water conservation techniques such as micro-irrigation and rainwater harvesting can mitigate water scarcity challenges. Risks from wild animals and extreme weather events should be managed through protective measures, insurance schemes, and compensation mechanisms to reduce farmers' vulnerabilities. Policies discouraging speculative landholding near roadsides and incentivizing active agricultural use of such lands are also crucial to address the issue of idle lands awaiting real estate opportunities. Addressing farming alienation and the aging farmer population through awareness campaigns, skill development, and youth engagement programs is essential to rejuvenate interest in agriculture.

GIS-based tools should be employed for monitoring fallow land trends, enabling precise and data-driven interventions. Continued research into the socio-economic and ecological impacts of fallowing will help refine policies and ensure effective fallow land management in Kerala, contributing to sustainable agricultural development and improved livelihoods.

Disclaimer (Artificial intelligence)

NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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