

Farmers' Adaptation to Climate Change in Wayanad: Practices, Constraints and Determinants

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Abstract

Climate change has become a major challenge to agriculture in Wayanad district of Kerala, where farmers face irregular rainfall, drought, flood, pest attack, and increasing uncertainty in cultivation. This study examines the adaptation practices adopted by farmers, the main constraints they face, and the factors influencing the extent of adaptation. The study is based on primary data collected from 100 farmers selected from the four development blocks of Wayanad. The primary survey was conducted during April and May 2024. Descriptive tools were used to analyse socio-economic conditions, adaptation measures, and key problems, while a Poisson regression model with robust standard errors was used to examine the determinants of adaptation. The findings show that farmers mainly depend on practical and locally feasible measures such as soil conservation, disease-tolerant varieties, mixed farming, replanting, and improved irrigation. However, adaptation remains constrained by financial difficulty, labour shortage, weak institutional support, and limited access to technology. The regression results show that irrigation access, credit access, climate knowledge, extension support, household income, and operational holding significantly improve adaptation. The study highlights the need for stronger financial, technical, and institutional support to strengthen climate resilience in agriculture.

Keywords: Climate change adaptation; farm-level adaptation; agricultural livelihoods; Wayanad; Kerala.

Introduction

Climate change has emerged as one of the most serious challenges facing agriculture across the world. Changes in temperature, rainfall pattern, and the frequency of extreme weather events have begun to affect agricultural production, food security, and rural livelihoods in many regions. Since agriculture depends directly on climate-sensitive natural resources such as land, water, and biodiversity, even small changes in weather conditions can create serious difficulties for farming communities. In this context, adaptation has become an essential response, particularly in developing countries where agriculture remains highly vulnerable to climatic uncertainty and rising weather extremes (IPCC, 2023; Nelson et al., 2009; Kurukulasuriya & Rosenthal, 2003).

The issue is especially important in India, where agriculture continues to play a crucial role in employment and livelihood security. A large share of cultivators are small and marginal farmers, and their capacity to withstand climatic stress is often limited. Irregular rainfall, drought, flood, pest attacks, and rising temperature can directly affect crop yield, farm income, and household stability. Earlier studies have shown that farmers adopt different strategies such as changing sowing dates, crop diversification, increasing irrigation, and adopting improved crop varieties in response to changing climatic conditions (Deressa et al., 2009; Sarker et al., 2013; Patel et al., 2023). At the same time, the ability to adapt is shaped by factors such as education, income, access to credit, institutional support, and availability of information (Maddison, 2007; Deressa et al., 2009; Maya et al., 2019).

Wayanad district of Kerala provides an important setting for examining these issues. Agriculture is one of the main sources of livelihood in the district, and the region is known for crops such as coffee, pepper, paddy, ginger, banana, cardamom, and arecanut. However, Wayanad has been increasingly experiencing erratic monsoon, drought, pest and disease outbreaks, landslides, and flooding, all of which have made farming more uncertain. The ecological and economic vulnerability of the district makes climate adaptation a matter of immediate concern. Studies conducted in Wayanad have already pointed to the increasing variability in rainfall, changing agro-ecological conditions, and the importance of local

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farming systems in building resilience (Gaetaniello et al., 2014; Kumar et al., 2022). Research has also shown that farmers in Wayanad display a relatively high level of awareness and adoption of climate-resilient practices, though significant challenges still remain (Anseera & Alex, 2019).

Within this broader discussion, farm-level adaptation assumes special importance. Since adaptation decisions in agriculture are ultimately taken at the level of the farmer or farm household, it is important to understand the socio-economic conditions, practical responses, and constraints that shape adaptation behaviour in specific local settings. Such an approach is particularly useful in agrarian and ecologically sensitive regions because it recognises that adaptation is not merely a technical matter but also a social, institutional, and livelihood issue. Earlier studies have underlined the importance of integrating local experience, inclusive governance, and institutional support in order to make agricultural adaptation more effective and sustainable (Wright et al., 2014; Jethi et al., 2016; Islam & Nursey-Bray 2017). In this sense, farm-level adaptation offers a useful framework for understanding how vulnerable farm households respond to climate stress in their own socio-economic setting.

Even though the literature on climate change and agriculture is expanding, an important gap remains. Many studies have examined climate variability, farmers' perception, and adaptation strategies in a general sense, while fewer studies have focused specifically on how farm-level adaptation operates at the local level in Wayanad. There is still limited district-specific evidence on the socio-economic background of farmers, the adaptation practices adopted by farm households, the constraints they face during adaptation, and the factors that shape successful adaptation efforts. Since adaptation is highly context-specific, such local-level analysis is necessary for developing effective and realistic policy responses (Gaetaniello, 2014; Anseera & Alex, 2019; Patel et al., 2023).

The present study contributes to the literature in three important respects. First, it integrates socio-economic characteristics, adaptation practices, major constraints, and the determinants of adaptation within a single farm-level analytical framework for Wayanad district. Second, it approaches adaptation not simply as a technical change in cultivation practices, but as a process shaped by access to resources, institutional support, information, and broader livelihood conditions. Third, by focusing on a climate-vulnerable agrarian district in Kerala, the study provides district-level evidence from a region where detailed empirical research on farm-level adaptation remains limited. In this way, the paper seeks to explain not only the nature of farmers' responses to climate stress, but also the conditions that facilitate or constrain adaptation at the farm level.

It is in this background that the present study examines farm-level adaptation to climate change among farmers in Wayanad district. The study seeks to analyse the socio-economic characteristics of farmers, document the adaptation strategies adopted by them, understand the major problems faced during adaptation, and identify the key factors influencing adaptation efforts. By doing so, the study attempts to contribute to the growing literature on climate adaptation in agriculture and to provide useful insights for strengthening resilience in a climate-vulnerable agrarian region.

Literature Review

Climate change is increasingly recognised as a major challenge to agriculture worldwide. Its implications are particularly serious in developing countries, where agricultural production remains closely dependent on rainfall, natural resources, and smallholder farming systems. A substantial body of literature has shown that rising temperatures, rainfall variability, drought, floods, and other extreme weather events have begun to affect crop productivity, food security, and rural livelihoods across different regions (IPCC, 2007; Nelson et al., 2009; Bandara & Cai, 2014). In this context, adaptation has assumed growing importance as a means of reducing agricultural vulnerability and strengthening livelihood security. Kurukulasuriya and Rosenthal (2003) argue that adaptation in agriculture must be understood not only in terms of farm-level adjustments, but also in relation to the broader policy and institutional support available to farmers. More recent assessments further confirm that climate-related risks to agriculture have intensified and that effective adaptation requires greater attention to local vulnerability, resilience, and enabling institutional conditions (IPCC, 2023).

One major theme in the literature is that the impact of climate change on agriculture is not uniform across regions. Though the broad challenge is global, its actual effects are shaped by local ecological, economic, and institutional conditions. This makes place-based studies highly important. In the case of Wayanad, existing studies point to a clear pattern of ecological

and agrarian vulnerability. Gaetaniello et al. (2014) observed that rainfall variability has had a stronger effect than temperature variability in shaping agricultural stress in the district. Gaetaniello (2014) also showed that climate change in Wayanad is closely linked with land-use change, agro-ecosystem transformation, and livelihood instability. Similarly, Muthulingam and Gopalsamy (2014) found that changes in rainfall pattern have affected agricultural practices, while farmers' responses often remain limited to short-term adjustments. These studies make it clear that climate change in Wayanad is not only an environmental problem, but also a problem of livelihood insecurity.

A second major theme in the literature concerns the different adaptation strategies adopted by farmers. Studies across countries show that farmers do not remain passive in the face of climate stress. They respond through crop diversification, changes in sowing and harvesting time, improved irrigation, use of tolerant varieties, soil and water conservation, and mixed farming practices. Deressa et al. (2009) found that farmers in Ethiopia adopted multiple strategies in response to climate variability, while Sarker et al. (2013) reported that most rice farmers in Bangladesh had already taken adaptation measures against drought and other climatic risks. Patel et al. (2023) also found that Indian farmers frequently respond through changes in sowing dates, crop types, and irrigation methods. These studies suggest that adaptation is already taking place at the farm level, though the form and intensity of adaptation differ across regions and production systems.

At the same time, the literature clearly shows that adaptation is shaped by more than climatic exposure alone. A third important theme is the role of socio-economic and institutional factors in influencing adaptation. Maddison (2007) showed that education has a significant role in enabling farmers to recognise and respond to climate change. Deressa et al. (2009) identified factors such as information, income, and resource access as important determinants of adaptation choice. Maya et al. (2019) also found that annual income, farm size, subsidies, electricity access, and extension support affect adaptive behaviour. Abid et al. (2016) similarly argued that farmers' risk perception and vulnerability condition their adaptive response. Thus, adaptation cannot be seen as a purely technical matter; it is also shaped by economic position, access to information, and institutional support.

This leads to another major issue in the literature, namely the importance of institutions and governance. A number of studies argue that the success of adaptation depends not only on individual effort but also on the wider institutional environment. Islam and Nursey-Bray (2017) showed that formal institutions play an important role in shaping place-based adaptive capacity in agriculture. Wright et al. (2014) argued that farm-level adaptation becomes more effective when linked with mainstream agricultural programmes and inclusive governance structures. Jethi et al. (2016) also stressed the need for community-centred and interdisciplinary strategies, especially in ecologically fragile agricultural regions. McCarl et al. (2016), from an economic perspective, further pointed out that adaptation requires supportive incentives, public investment, and correction of market failures. Together, these studies show that adaptation is not simply an individual response by farmers; it is also influenced by policy, institutions, and collective arrangements.

Within this wider discussion, farm-level adaptation has gained increasing importance because adaptation decisions in agriculture are finally taken at the level of the farmer or farm household. This approach helps to understand how farmers respond to climate stress through changes in crop choice, input use, irrigation, soil management, and other practical adjustments. At the same time, the success of farm-level adaptation depends on the wider institutional environment, including access to information, extension support, technology, and public policy. Kumar et al. (2022), in their study of the Kurichiya rice-farming system in the Western Ghats, demonstrated how culturally rooted and community-based farming practices can strengthen resilience. The literature thus suggests that adaptation becomes more meaningful and sustainable when it is locally grounded and socially embedded rather than imposed only through top-down technical measures.

Another recurring issue in the literature is the existence of strong barriers to adaptation. Financial constraints, lack of timely information, poor access to credit, inadequate institutional support, and weak technological access are repeatedly identified as major problems. Nasir et al. (2018) found that lack of information limited the range of adaptation strategies adopted by farmers. Kath and Kanagasabapathi (2020) reported that poor economic condition, low access to subsidies and loans, and lack of awareness about appropriate technology constrained adaptive action. Similar barriers were noted by Deressa et al. (2009). This shows that even when farmers are aware of climate risks, their ability to adapt remains limited unless supportive conditions are created.

Recent literature suggests that the study of agricultural adaptation in India is moving beyond a simple description of farm practices towards a closer examination of enabling conditions, institutional support, and the nature of adaptation itself (Datta et al., 2022; Vij et al., 2025). Recent reviews show that adaptation studies in India increasingly discuss incremental and transformative responses, while also pointing to important geographical and thematic imbalances in the literature (Datta et al., 2022; Vij et al., 2025). They further indicate that adaptation is shaped not only by climatic exposure, but also by access to information, institutional support, incentives, and policy design (Datta et al., 2022; Bahinipati et al., 2024). This wider perspective is relevant to the present study because it helps to interpret farm-level adaptation in Wayanad not simply as an individual farmer response, but as an outcome shaped by broader socio-economic and institutional conditions.

Although the literature provides useful insights, an important gap remains. Many studies discuss climate change and agriculture in a broad way, while others focus mainly on perception, adaptation choices, or policy issues in different regional settings. In the case of Wayanad, existing studies have examined rainfall variability, agro-ecosystem change, and local resilience practices, but there is still limited work that brings together farmers' socio-economic conditions, farm-level adaptation practices, adaptation constraints, and the factors influencing adaptation in one integrated framework. It is this gap that gives relevance to the present study, which seeks to understand how farm households in Wayanad are responding to climate change through farm-level adaptation.

Methodology

The present study is based on a field-level enquiry into farm-level adaptation strategies to climate change among agricultural households in Wayanad district of Kerala. The study is both descriptive and analytical in nature. It attempts to understand the socio-economic background of farmers, the adaptation strategies adopted by them, the major problems faced in the process of adaptation, and the factors influencing adaptation efforts. For this purpose, both primary and secondary data were used.

The study was conducted in Wayanad district, one of the important agrarian districts of Kerala, where a large section of the population depends on agriculture for livelihood. In recent years, the district has experienced several climate-related problems such as irregular rainfall, drought, flood, landslide, pest attack, and changes in seasonal pattern. These changes have created serious difficulties in cultivation and have made agriculture more uncertain. Since the study focuses on climate change adaptation in agriculture, Wayanad provides a suitable setting for examining the responses of farmers to climatic stress.

The study is based on both primary and secondary sources of data. Primary data were collected directly from farmers through a structured questionnaire with the help of the personal interview method. Secondary data were collected from books, journals, reports, and other published sources related to climate change, agriculture, and the economy of Wayanad district. The use of both sources helped to understand the issue from both conceptual and field-level perspectives.

The primary survey was conducted during April and May 2024 in the four development blocks of Wayanad district, namely Mananthavady, Kalpetta, Sulthan Bathery, and Panamaram. A random sample of 100 farmers was selected for the study, with 25 farmers chosen from each block. This helped to ensure representation from the major agricultural regions of the district. The personal interview method was found suitable because it made it possible to collect detailed information on the socio-economic characteristics of farmers, their farming experience, income, education, and the various adaptation practices followed by them in response to climate change.

The collected data were classified, tabulated, and analysed with the help of suitable statistical tools. Simple tools such as frequency and percentage were used to present the socio-economic profile of the respondents, the major adaptation measures adopted by them, and the important problems faced by them. To examine the factors influencing the extent of farm-level adaptation, the study used a Poisson regression model with robust standard errors. This model was considered appropriate because the dependent variable is the number of adaptation practices adopted by each farmer, which is a count variable. For comparison, an OLS model with robust standard errors was also estimated, and the broad pattern of results remained similar. However, Poisson regression was treated as the preferred specification for interpretation.

To identify the factors influencing the number of adaptation practices adopted by farmers, a parsimonious count-data model was specified. The dependent variable is the number of adaptation practices adopted by each farmer. In the

descriptive analysis, the study records all farmer-reported responses to climate stress. However, in interpretation a distinction is maintained between productive farm-level adaptation measures and distress-linked responses that arise under severe economic pressure. The explanatory variables initially considered were years of education, household income, farm experience, operational holding, knowledge about climate change, extension support, access to credit, irrigation access, and dependence on rain-fed agriculture. However, dependence on rain-fed agriculture was not included in the final model along with irrigation access because the two variables were found to be almost exact opposites in the dataset, which could create severe multicollinearity. Therefore, the final specification included years of education, household income, farm experience, operational holding, knowledge about climate change, extension support, access to credit, and irrigation access. The Poisson regression model estimated in the study is specified as follows:

$$\ln[E(Y_i | X_i)] = \beta_0 + \beta_1 \text{EDU}_i + \beta_2 \text{INC}_i + \beta_3 \text{EXP}_i + \beta_4 \text{LAND}_i + \beta_5 \text{KNOW}_i + \beta_6 \text{EXT}_i + \beta_7 \text{CREDIT}_i + \beta_8 \text{IRRIG}_i$$

Where:

Symbol	Definition
Y_i	Number of adaptation practices adopted by farmer i
EDU_i	Years of education
INC_i	Household income
EXP_i	Farm experience
LAND_i	Operational holding
KNOW_i	Knowledge about climate change
EXT_i	Extension support
CREDIT_i	Access to credit
IRRIG_i	Irrigation access

u_i = error term; Expected signs: Positive for EDU, INC, EXP, LAND, KNOW, EXT, CREDIT, and IRRIG

Findings and Discussion

The field data show that climate change adaptation in Wayanad is being carried out mainly by an ageing farming population with modest income and significant structural constraints (table 1). Out of the 100 respondents, 56 per cent were male and 44 per cent were female. A striking feature of the sample is its age structure. Nearly 68 per cent of the respondents belonged to the age group of 51 years and above, and the mean age was 59.68 years. This suggests that farming in the study area is increasingly carried forward by older farmers, while younger people appear to be moving away from agriculture. The respondents were not educationally deprived in a complete sense. About 73 per cent had high school education or above, though very few had higher education. Agriculture remained the principal occupation for most respondents, with 75 per cent depending on farming alone. At the same time, the income profile indicates that the majority of farmers were operating under financial constraints. More than half of the respondents reported an annual income below ₹2 lakh, and another 27 per cent fell in the ₹2–4 lakh category. Land ownership data also show that cultivation was based mainly on own land, though leased land also formed a significant share.

Table 1. Socio-economic Profile of Respondents

Indicator	Main result
Male respondents	56%
Female respondents	44%
Age 51-60	35%
Age 61-70	33%
Mean age	59.68 years
High school or above	73%
Farming as sole occupation	75%
Annual income below Rs 2 lakh	52%
Annual income Rs 2-4 lakh	27%
Own land under cultivation	254.08 acres
Leased land under cultivation	112.9 acres

Source: Compiled from the primary survey data collected in Wayanad during April–May 2024.

These socio-economic features are important for understanding adaptation. The predominance of older farmers may mean that practical farming experience is available among farmers in the study area, but it may also indicate weak generational renewal in agriculture. Similarly, while basic education levels are not very low, the low-income structure can directly reduce the capacity of farmers to adopt costly or technology-intensive adaptation measures. This becomes clearer in the next set of findings.

For analytical clarity, it is important to note that not all reported responses have the same character. Some responses, such as soil conservation, irrigation improvement, mixed farming, and tolerant varieties, are direct farm-level adaptation measures. A few others, especially sale of agricultural land, may reflect distress-induced adjustment rather than productive adaptation in the strict sense. They are included here because they were reported by farmers as responses to climate-related stress, but they are interpreted separately in the discussion.

The frequency distribution of adaptation measures (table 2) reveals that farmers rely more on low-cost and immediately feasible responses than on capital-intensive technological interventions. The highest reported measures include proper application of fertilizer, soil conservation, disease tolerant varieties, mixed farming, and replanting. These responses are largely management-oriented and can be undertaken within the existing farm structure. This suggests that adaptation behaviour is strongly influenced by affordability and operational convenience.

In contrast, the relatively low adoption of lift irrigation, drip irrigation, and construction of crop shed or greenhouse indicates weak penetration of advanced water-saving and protected cultivation technologies. Even though 51 farmers reported use of modern technology and machines, the near absence of greenhouse cultivation and the very low use of drip irrigation suggest that farmers are selective in adopting technology and tend to avoid highly capital-intensive measures. This reflects the role of financial constraints in shaping adaptive capacity.

The data also highlight two broader features of agrarian adjustment. First, diversification is significant, as seen in the widespread use of mixed farming, livestock expansion, and crop diversification. Second, the notable incidence of land sale suggests that farmer responses to climate stress do not always remain within the domain of productive adaptation. In some cases, they move into the domain of distress response. Therefore, the pattern of adaptation is best understood as constrained resilience, where farmers continue to respond to agricultural stress, but mainly through strategies that remain within their limited economic and institutional capacity.

Table 2. Frequency and rank of adaptation measures

Rank	Adaptation measure	Farmers using it	Level of use
1	Proper application of fertiliser	94	Very high
2	Soil conservation	91	Very high
3	Use of disease-tolerant varieties	81	Very high
4	Mixed farming	79	Very high
5	Gap filling / replanting	74	Very high
6	Use of drought-tolerant varieties	58	High
7	Increasing irrigation facilities	54	High
8	Introduction of modern technology and machines	51	High
9	Sale of agricultural land	50	High
10	Increasing number of livestock	47	Moderate
11	Delayed sowing	46	Moderate
12	Purchasing crop insurance	44	Moderate
13	Use of windbreak and shelterbelt	44	Moderate
14	Use of short-duration crops	38	Moderate
15	Crop diversification	34	Moderate
16	Organic farming	34	Moderate
17	Construction of farm pond	27	Moderate
18	Transplanting	26	Moderate
19	Alternative enterprise such as horticulture with the main crop	25	Moderate
20	Direct sowing	23	Low
21	Other income-generating activities (fisheries, cottage industries, etc.)	22	Low
22	Fallowing	10	Low
23	More investment	10	Low
24	Application of lift irrigation	8	Low
25	Application of drip irrigation	2	Low

26	Use of crop shed or greenhouse cultivation	0	Nil
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Source: Compiled from the primary survey data collected in Wayanad during April–May 2024. Note: This is a multiple-response table. One farmer may use more than one strategy. Therefore, the frequencies show how many farmers reported each measure, not mutually exclusive choices.

The ranked distribution of problems faced by farmers (table 3) presents a clear picture of the nature of agrarian stress in the study area. The table shows that the most serious constraint reported by farmers is lack of financial resources (82 farmers), followed closely by poor soil fertility and shortage of labour (80 farmers each). This ranking indicates that the main difficulties of farmers are not limited to one specific production issue. Rather, they arise from the combined effect of economic weakness, declining soil quality, and shortage of human labour. In other words, farmers are operating under conditions where both the resource base and the capacity to manage production have become constrained.

Another major problem reported by farmers is migration of youth (75 farmers). This particular problem goes beyond current farming difficulties and points towards a long-term structural issue in agriculture. When younger people move away from farming, the sector loses labour, continuity, and future sustainability. This also helps explain why shortage of labour has emerged as one of the highest ranked problems. Thus, the labour crisis in agriculture is not merely seasonal or temporary; it appears to be linked with broader social and demographic changes taking place in rural areas.

The table 3 also shows that poor support from local and national authorities on climate-related issues is reported by 69 farmers. This suggests that farmers do not view their difficulties as only individual or farm-level problems. A large section of them feel that institutional support is inadequate, especially in relation to climate stress. Similarly, lack of knowledge about modern farming (61 farmers) and unavailability of new technologies (60 farmers) are also reported by a substantial number of respondents. These findings indicate that farmers face not only material constraints, but also informational and technological limitations. Even where willingness to adapt may exist, the absence of proper guidance, extension support, and accessible technology may reduce their ability to respond effectively.

Water and land-related issues occupy a middle position in the ranking. Lack of water irrigation is reported by 58 farmers, while dispersed land parcels are reported by 52 farmers. These findings suggest that farming is affected by structural inefficiencies in the use and management of land and water resources. Fragmented landholding may raise the cost of cultivation and make efficient irrigation and farm management more difficult. Therefore, the problem is not simply shortage of natural resources, but also the way in which these resources are organised and accessed.

In contrast, lack of access to the market is reported only by 10 farmers, making it the least reported problem in the table. This is a notable result. It suggests that, in the present context, farmers do not consider market access to be their most immediate challenge. Their concerns are concentrated more on production constraints, financial scarcity, labour shortage, and weak institutional support. This means that improving market linkages alone may not be sufficient to strengthen agricultural sustainability unless these more basic constraints are addressed first.

The lower ranks of lack of knowledge about climate change (19 farmers) and poor access to climate monitoring information (15 farmers) may appear less serious in numerical terms, but they should not be ignored. These relatively lower values may not mean that climate-related knowledge is unimportant. Rather, they may indicate that farmers tend to identify immediate and visible problems such as finance, labour, and soil fertility more readily than information-based constraints. In practice, lack of climate knowledge and poor access to timely information can indirectly worsen other production problems.

Table 3. Major Constraints in Climate Change Adaptation

Rank	Problem	Number of Farmers	Percentage*
1	Lack of Financial Resource	82	82%
2	Poor soil fertility	80	80%
3	Shortage of labour	80	80%
4	Migration of youth	75	75%
5	Poor support from local and national authorities on climate-related issues	69	69%
6	Lack of knowledge about modern farming	61	61%
7	Unavailability of new technologies	60	60%
8	Inadequate irrigation facilities	58	58%
9	Dispersed land parcel	52	52%
10	Lack of knowledge about climate change	19	19%
11	Poor access to climate monitoring information	15	15%
12	Lack of access to market	10	10%

*Source: Compiled from the primary survey data collected in Wayanad during April–May 2024. *Percentage is shown on the assumption that the sample size is 100 farmers. Ranked by number of farmers reporting each problem*

Overall, the findings reveal that the problems faced by farmers are multi-dimensional, structural, and interrelated. The dominant issues are financial weakness, labour shortage, ecological stress, youth migration, and inadequate institutional support. This pattern shows that agrarian stress is not simply a matter of low rainfall or poor crop performance. It is rooted in a wider rural crisis where economic, environmental, demographic, and policy-related factors work together. The table strongly suggests that any meaningful intervention in agriculture must move beyond a narrow farm-production approach and address credit access, soil improvement, labour availability, technological extension, and climate-responsive institutional support in an integrated manner.

Determinant of Adaptation Practices to Climate Change

To examine the factors influencing the number of adaptation practices adopted by farmers (table 4), a parsimonious regression model was estimated by taking the total number of adaptation practices as the dependent variable. Since the dependent variable is a count measure, Poisson regression with robust standard errors was treated as the preferred specification. For comparison, an OLS model with robust standard errors was also estimated, and the broad pattern of results remained similar. In the final estimation, 99 usable observations were available. Dependence on rain-fed agriculture was not included together with irrigation access in the same model because the two variables were found to be almost exact opposites in the dataset, which could create severe multicollinearity.

The Poisson regression results show that irrigation access, access to credit, knowledge about climate change, household income, extension support, and operational holding have a positive and statistically significant association with the number of adaptation practices adopted by farmers. Among these variables, access to credit shows the largest effect in terms of incidence-rate ratio, while irrigation access appears as the most statistically robust predictor in the model. The coefficient of irrigation access is positive and statistically significant at the 1 per cent level. The incidence-rate ratio of 1.207 indicates that farmers with irrigation access are expected to adopt about 20.7 per cent more adaptation practices than farmers without irrigation access, other factors remaining the same.

Table 4. Poisson regression (robust standard errors)

Variable	Coefficient	IRR	Robust SE	p-value	Sig.
Years of education	-0.016	0.984	0.010	0.106	
Household income (Rs lakh)	0.018	1.019	0.008	0.019	**
Farm experience (years)	-0.001	0.999	0.003	0.682	
Operational holding (acre)	0.027	1.028	0.011	0.015	**
Knowledge about climate change (1=yes)	0.245	1.278	0.095	0.010	***
Extension support (1=yes)	0.139	1.149	0.068	0.042	**
Access to credit (1=yes)	0.335	1.398	0.125	0.007	***
Irrigation access (1=yes)	0.188	1.207	0.059	0.001	***

Poisson goodness-of-fit: Log likelihood = -251.26; Deviance = 92.32; Pearson chi-square = 85.19.

Access to credit is also found to be an important determinant of adaptation behaviour. It is positive and statistically significant at the 1 per cent level. The incidence-rate ratio of 1.398 suggests that farmers with access to credit are likely to adopt about 39.8 per cent more adaptation practices than those without such access. This indicates that financial capacity plays an important role in enabling farmers to undertake adaptation measures.

Knowledge about climate change also has a positive and statistically significant effect on adaptation. Farmers who reported knowledge about climate change were found to adopt more adaptation practices than those who lacked such knowledge. The incidence-rate ratio of 1.278 shows that climate-aware farmers are expected to adopt about 27.8 per cent more adaptation measures. This result indicates that awareness and understanding of climatic risk are important preconditions for adaptation at the farm level.

Extension support enters the model with a positive sign and remains statistically significant at the 5 per cent level. The incidence-rate ratio of 1.149 implies that farmers receiving extension support are likely to adopt about 14.9 per cent more adaptation practices than others. This finding underlines the importance of institutional guidance, technical advice, and official support in strengthening adaptive responses.

Household income also shows a positive and statistically significant relationship with adaptation. Although the magnitude of the coefficient is smaller compared to the dummy variables, the result still indicates that better-off households are in a stronger position to adopt more adaptation measures. Similarly, operational holding has a positive and significant effect, suggesting that farmers with a larger operated area have greater scope and flexibility to undertake adaptation practices.

On the other hand, years of education and farm experience do not emerge as statistically significant in the present specification. Their coefficients carry the expected interpretation only weakly, and the results suggest that formal schooling and farming experience alone may not be sufficient to explain differences in adaptation behaviour once resource access, irrigation, credit, and institutional support are taken into account.

Overall, the regression results indicate that adaptation at the farm level is influenced less by background demographic factors and more by practical enabling conditions. In particular, irrigation access, access to credit, knowledge about climate change, extension support, and economic capacity appear to be the key drivers of adaptation. Thus, the findings suggest that the strengthening of farm-level adaptation in Wayanad depends not only on farmers' individual effort, but also on improved access to water, finance, information, and institutional support.

Conclusion and policy implication

The study clearly shows that farmers in Wayanad are not passive in the face of climate change. They have already begun to respond through a variety of locally suitable adaptation practices such as proper application of fertiliser, soil conservation, use of disease-tolerant varieties, mixed farming, gap filling / replanting methods, drought-tolerant varieties, and improved irrigation arrangements. The findings suggest that the adaptive capacity of farmers remains limited, especially because adaptation is taking place under conditions of low income, labour shortage, weak institutional support, and inadequate access to technology. The farming population is also marked by low income, dependence on agriculture as the main occupation, and continued pressure on land and labour. These findings suggest that adaptation in Wayanad is real and active, but still limited by the weak economic and institutional condition in which farmers operate.

The study further shows that the main barriers to climate adaptation are not climatic alone. Farmers face serious problems such as lack of financial resources, poor soil fertility, shortage of labour, migration of youth, weak support from local and national authorities, lack of knowledge about modern farming, and poor access to new technologies and irrigation. The regression analysis shows that farm-level adaptation is influenced mainly by enabling conditions rather than by demographic background alone. Household income, operational holding, knowledge about climate change, extension support, access to credit, and irrigation access all show a positive and statistically significant relationship with the number of adaptation practices adopted by farmers. In contrast, years of education and farm experience do not appear to be statistically significant in the present model. This suggests that adaptation depends not only on individual awareness or experience, but more directly on access to water, finance, information, and institutional support.

Before turning to the policy implications, one limitation of the study needs to be acknowledged. In the descriptive analysis, all farmer-reported responses to climate-related stress were included in order to capture the full range of adjustments taking place at the farm level. However, some responses, particularly the sale of agricultural land, may not represent productive adaptation in the strict sense and may instead reflect distress-driven adjustment under conditions of economic pressure. These responses were retained because they formed part of the actual behaviour reported by farmers during the survey. Therefore, the findings should be interpreted with some caution, especially where the distinction between adaptation and distress response is not fully clear.

Seen in this light, the policy lesson of the study is quite clear. Climate adaptation in Wayanad should be approached not only as a matter of changing farm practices, but also as a question of livelihood security, public support, and institutional strengthening. Greater financial support is essential, especially in the form of timely credit, targeted subsidies, affordable crop insurance, and quick compensation for climate-related losses. Since delays in support weaken trust and discourage continued farming, prompt disbursal of assistance should be treated as a priority. Along with this, farmers need stronger extension support through regular training in climate-resilient agriculture, including improved crop varieties, water management, soil conservation, and the practical use of new technologies. Field-based demonstrations and local workshops can help make such support more effective.

There is also a strong case for improving local weather and climate information systems. Reliable and timely advisories on rainfall, temperature, pest risk, and seasonal changes can help farmers make better decisions regarding sowing, irrigation, and crop protection. The establishment of local weather stations and multiple communication channels for forecast dissemination would therefore strengthen adaptation planning at the farm level. At the same time, greater attention should be given to soil and water management, since poor soil fertility and irrigation problems were reported as major constraints. Measures such as farm ponds, water conservation, soil improvement, and support for organic and eco-friendly farming can strengthen long-term resilience while also reducing production risk.

The findings suggest that farm-level adaptation in Wayanad can become more effective only when local farmer efforts are supported by a stronger institutional environment. Support from agricultural departments, local bodies, climate-related programmes, and farmer-oriented agencies must become more regular, practical, and responsive to field realities. Since labour shortage and youth migration are also serious concerns, adaptation policy should aim not only at climate resilience, but also at making farming more economically viable and socially sustainable. Overall, the study suggests that the future of adaptation in Wayanad depends on combining local knowledge and farmer initiative with financial assistance, technological access, and active institutional support. Only such an integrated approach can improve the resilience of farm households under changing climatic conditions.

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