# From Bean to Income: Assessing the Financial Resilience of Kerala's Smallholder Coffee Farmers to Climate Change

**Shoukathaly C. M[1] & Dr. S. Kavitha[2]**

[1]*Ph.D. Research Scholar (Part-Time), PG & Research Department of Commerce*
*J.J. College of Arts & Science (A), Pudukkottai, Affiliated to Bharathidasan University*
*Tiruchirappalli, Tamil Nadu*

[2]*Professor, PG & Research Department of Commerce*
*J.J. College of Arts & Science (A), Pudukkottai, Affiliated to Bharathidasan University*
*Tiruchirappalli, Tamil Nadu*

Open Access

Manuscript ID: BIJ-2026-JAN-007

Subject: Commerce

Received : 13.09.2025
Accepted : 18.12.2025
Published : 31.01.2026

DOI:10.64938/bijri.v10n2.26.Jan007



**Abstract**

*The economic well-being of smallholder coffee farmers is particularly threatened by climate change, as their livelihoods are directly linked to climate conditions. This paper describes how smallholder coffee farmers in Kerala, India, are affected by climate change, particularly in financial terms, including the dimensions of risk and the factors that impact household income. Cross-sectional data were obtained from 420 farmers in Wayanad and Idukki, using a structured interview schedule and multistage random sampling. Three latent variables that had been the bases for the resilience of financial components, as (Financial Buffer & Risk Management, Institutional Support & Social Capital, Climate Change Smart Adaptive Practices ), were determined, and these factors explained 58.23 % of the cumulative variance from the exploratory factor analysis. According to the Multiple Linear Regression analysis, they were highly significant predictors for annual home income ($R^2 = .361, p < .001$), and Financial Buffers ($\beta = .452, p < .001$) as the strongest predictor. Furthermore, an Independent sample t-test further showed that the Arabica climate-sensitive coffee growers had reported substantially more severe effects of climate change than the Robusta coffee growers ($t (418) = 6.127, p <$ 001). 001). The paper suggests that the financial resilience of smallholder coffee farmers to weather variability is multifaceted, encompassing the need for enhanced financial safety nets, institutional support, and bolstering adaptive responses to protect household revenue. The holistic interventions based on these pillars should be the top priorities for policies in constructing climate-resilient, inclusive coffee systems.*

**Keywords: climate change, financial resilience, smallholder coffee farmers, Kerala, factor analysis, household income, climate-smart agriculture, agricultural finance, vulnerability, adaptation strategies**

## Introduction

Hundreds of thousands of smallholder farmers in the Global South depend on coffee for their survival and the health of sustainable rural communities. Coffee-growing in Kerala, India, predominantly carried out in the midlands and high ranges of Wayanad, Idukki, and some regions of Palakkad, has been a way of life and cultural heritage consecrated to millions of small-holding family farmers in India (Bhattacharya, 2022). But this critical stream of funds is facing an ever-growing and monumental risk from the universal threats of climate change. However, the complex agro-ecological synergy for C. arabica and C. robusta coffee is being disrupted due to climate change and temperature variability, as well as changes in precipitation (Jayakumar et al., 2021). Such environmental changes will have a bearing on farmer income, as they would automatically lead to A decrease in crop output. Rigorous occurrence of pests and diseases (eg, white stem borer and coffee berry borer), and a Decrease in bean quality (Mohan & Suresh, 2023).

Moreover, for these smallholder farmers, the economic welfare of their coffee trees represents the economic welfare of their lives. Smallholders react in a way that is dissimilar to estates, because smallholders have little reserves, so when there is a climatic shock, smallholders become very vulnerable. One bad monsoon (Prakash & Singh, 2022) or an early heat-wave—earlier in the heat-wave season causes a step back in a household's annual income-generating capacity, setting a family back down on the Socio-Economic Stair-Step, into more debt, less spending on education, health, future, and possible next crop inputs. This exposure is exacerbated by other factors, such as unstable international coffee prices, increasing production costs, and, in many cases, the absence of access to credit and resilient technologies (Narayanan & Kumar, 2022). Moreover, this confluence of pressures produces a kind of cycle of precarity, in which environmental risk is financial risk.

In this sense, it is deeply disconcerting that Cashman and Weathers (2017) treated the issue of financial resilience of smallholder coffee growers in Kerala as an ivory-tower exoteric exercise, and such policy challenges for sustainability and climate justice remain grossly unsatisfied. In this case, financial resilience is the ability of such farmers' homes to foresee, cushion, adjust, and rebound from climate-sensitive shocks (Mercy Corps, 2020). This comprises an examination of their coping strategies, formal insurance and credit access, adaptive climate-smart agriculture practices, and their relationship with the support of institutions. Biophysical effects of climate change on coffee are well-documented in other settings (Chemura et al., 2020). However, in India, there is a paucity of site-specific studies that empirically capture the quantitative and qualitative linkages between these changes and the monetary, health, and adaptive capacities of smallholder households in Kerala.

To the best of our knowledge this gap can be addressed by the present study, which critically interrogates the drivers behind the climate fragility and how it have been changing the economic security of the coffee smallholders of Kerala under the process "From Bean to Income". The climate data will be connected with socio-economic surveys to assess quantitatively the vulnerability to calculate the value of the adaptation currently adopted in WfW-vulnerable communities. The results will be used to advice policy makers, extension systems and financial institutions on precision interventions that can prevent the erosion of the income earning potential of those living on the edge to be most impacted by the extremities of the climate crisis.

## Need and Significance of the Study

The need for such analysis emerges with the potential dangerous projective nexus between three conditions: the hyper sensitivity of coffee to microclimatic variations; the socio-economic vulnerability of small-hold farming communities; and the horribly lopsided lack of predictability of regional or site specific climate impact studies for economies. While the biophysical impacts of climate change on coffee have been estimated globally (Läderach et al., 2017), the implications for on-farm income gains and losses for smallholder farmers in India remains unclear and unexplored. Kerala, where the coffee is a wild species, blessed with rich geography is known for its major presence of smallholders in its coffee growing community, which certainly justifies the urgency of the present study. This is also why the latter specific research recapitulated above is more than an academic exercise –- it is most crucial to provide some responses to an ever-deepening fine print to agrarian distress.

This study has multiple implications. First, so far as I can make out, and please show me some evidence if I am wrong, it is the only one of its kind (that addresses an important lacuna in the literature beyond mere agronomic-yield analyses) in establishing explicit, empirical, climates-variates/household-financial-wellbeing links. The Indian studies did not address the adaptation and specific financial coping-strategies of the farmer-level and, not based on their own preferences (Coffee Board of India, 2022), but generally focused on the national level production statistics and technical circumstances of cropping. This analysis will provide a nuanced discussion of financial resilience at the household level, including fluctuations in income stability, debt-accumulation, stress on savings capacity and investment in the capacity to adjust to technological change (Tumusiime et al., 2021). It is only this micro-level scrutiny that gives you a sense of the actual human cost of climate change."

Second, the results have important policy, and institutional, implications. Government of India and State Government of Kerala have implemented numerous climate-resilient agriculture and insurance schemes, including PMFBY (Pradhan Manri Fasal Bima Yojana) (Subramanian, 2023). However, the performance of such schemes on long term crops systems such as coffee, particularly in the situation of Kerala highlands have received less attention. The evidence of this is essential for assessing the current safety nets and how they fall short, and for creating better safety nets and strategies for stop-loss products like weather-indexed insurance, emergency credit lines, and grants-in-aid for building climate. Intelligent smart infrastructure (Osborne & Cutter, 2022).

The study has important policy implications on sustainable development of the rural economy in Kerala and food and livelihood security. War and coffee are the employment generator for almost all and to the sustenance of regional economy and even to that of migration (Vijayan, 2022). It will also thus be easier for actors in the "bean to income" value chain to identify financial break down hot spots that would help stakeholders such as FPOstoNGOs to design suitable interventions. In the final analysis, to enhance or strengthen financial resiliences of coffee smallholders ´´ is a euphemism for building social–ecological resilience´´, conserving a way of life based on coffee production and contributing to the associationalist objectives of sustainable and equitable development in the age of unpredictable climate.

**Statement of the Problem**

Coffee, a coffee smallholders-based crop commands with a control of 70% of the coffee growing area in India is facing existential risk on account of the anthropogenic climate change (Bhavani & Gopinath, 2022). In Kerala, a major coffee-producing state, they are experiencing directly the effects of a warming planet through unpredictable weather. The mass of scientific proof in favour of oubreak of the phenological patterns of coffee plants due to increased temperature, is simply phenomenal (Kumar & Singh, 2023; Mendez et al., 2020). However, despite the increasing coverage of biophysical impacts of extreme events, knowledge about how these shocks are being translated into financial and socio-economic realm at the level of smallholder household is inadequate.

At the core of the issue is how profoundly vulnerable these farmers are: They live at the intersection of ecological and economic precarity. Smallholdings are a business at the razor's edge of thin margins, smallholders have no capacity to absorb financial shock, contrast with large estates, which have some capital, as buffers (Sharma & Joshi, 2022). One crop failure due to climate can drive downward spirals of economic risk. with families experiencing lower annual income, savings depletion, and an increase in use of high-interest loans from informal sources, followed by the burden of debt on those families that have the potential to recover (Patel et al., 2021). Theis financial insecurity is further added to by systemic barriers, including limited availability of low-cost formal credit, access to weather-based insurance and low uptake and spread of high cost climate-resilient agriculture technology practices (Das, 2023).

Second, there is a large gap between macro-level climate models and on-the-ground financial facts. As long as policymakers are constructing generic adaptation pathways, the ways in which smallholder coffee families in Kerala adapt financially, manage risk, and make decisions are not being explored and little is known about them (Nair & Thomas, 2022). The issue is thus not one of climate alone, but of deficient, evidence-based, targeted financial and policy tools to generate the investment the world needs to be more resilient.

Thus there is an immediate requirement to identify the specific way through which the percolation of climate variability into the finances of the small coffee growers of Kerala is occurring in a systematic way. This study addresses the gap in empirical work regarding the relationship of specific climate stressors on measurable household-level financial outcomes, including volatile income, debt, and asset dissolution. Without this knowledge, interventions are liable to be mistargeted, ineffective, or not reach the most vulnerable of these groups, thereby posing a threat to the sustainability of the whole coffee-based livelihood in the zone.

## Literature Review

### Biophysical Impacts of Climate Change on Coffee

Significant material published to date in several coffee (Coffea arabica and Coffea canephora) producing countries has demonstrated the extreme climatic sensitivity of coffee. Studies have consistently found that warming, changing rainfall and a more variable climate are harming the growth, yield and quality of coffee beans. Especially Arabica coffee is sensitive to high temperatures within certain temperature ranges (18-22°C), long periods at temperatures >23°C speed up the ripening process, decrease the size of the beans and decrease the quality of the cup (Kath et al., 2020). This has been successfully modelled in other coffee-growing areas, including Latin America, where large reductions in the areas suitable for cultivation have been projected to occur under different climate change scenarios (Ovalle-Rivera et al., 2020). In the Indian situation, studies such as that of Coffee Board of India (2022) and other researchers including Jayakumar et al. (2021) has started to report on these same trends, which report increases in pest and disease incidences (e.g., white stem borer, coffee berry borer) due to warmer temperatures in traditional coffee growing areas (for example Kerala and Karnataka).

### Socioeconomic Vulnerability of Smallholder Farmers

At the same time, another line of literature addresses the inherent risk of smallholders in developing countries. Some argue that their susceptibility is due to their exposure to climate risk, sensitivity (reliance on agriculture) and low adaptive capacity (limited resources, credit and information) (Antwi-Agyei et al., 2021). Studies conducted in Africa and Asia have demonstrated that climate shocks usually lead smallholders to adopt negative coping strategies, such as selling assets, withdrawing children from school, or incurring high-interest debt, which ultimately weakens their long-term resilience (Tumusiime et al., 202214 2021, Singh et al., 202213 2022). In Kerala, the literature on agrarian distress has discussed increasing input prices, price fluctuations, and reliance on migrant labor without necessarily emphasizing climate change as a direct source of financial instability (Vijayan, 2022).

### Strategies to Adapt to Climate and to Strengthen Financial Resilience

Scholarship on adaptation examines the strategies farmers employ in response to climate change. These are generally grouped as: (i) record and plot level (on-farm) agronomic interventions (e.g., shade maintenance, soil conservation, changing cultivars), (ii) livelihood options (from off-farm), and (iii) financial risk manag (e.g., savings, insurance, credit) (Osborne & Cutter 2022). These strategies are very context-specific in terms of their efficacy. For example, although weather-index insurance is promoted as the silver bullet (see Ceballos et al. (2021), we find important problems in product design, basis risk (lack of correspondence between payout and actual loss), as well as low take-up rate among smallholders driven by trust and affordability issues. Climate-smart agriculture advocacy, as practiced in Kerala by government and NGO initiatives, is not backed by concrete action plans and few researches are done on the adoption, adaptation and the financial resilience (Nair & Thomas, 2022).

### Identified Research Gap

Not with standing the strong, and in some respects simultaneous, advancement of these three path of research two critical and interdisciplinary insufficiencies can be identified. Although a growing body of evidence indicates that coffee production is being negatively affected by climate change and that smallholders are (financially) vulnerable, there is a dearth of empirical household level research that directly links the two in the context of Kerala's coffee industry.

The majority of previous studies have one or more of the following shortcomings:

Siloed Approaches: There are Biophysical studies that measure yield loss, but fail to link it directly with the fiscal impact of such loss on income, debt and wellbeing of the cultivator. On the other hand, from a socioeconomic point of view the "climate" is referred as a general [endogenous or adaptive "climate"] risk factor on a global level without quantifying the specific share of financial distress from climate compared to other sources of distress such as market prices.

Lack of microeconomic data on finances—There is little granular research on the specific financial coping strategies that Kerala coffee smallholders use in dealing with the shock of climate (such as obtaining a loan, selling an asset, reducing expenditure on education/ health).

- Resilience Black Box: The concept of resilience is frequently discussed as a black box and is generally not operationalized and measured using specific financial instruments (e.g., income volatility, debt-to-asset ratio, saving rates) at the farmer level. We do not have a good sense of exactly what it is that makes one household more financially resilient to the same exact climate shocks and risks as another.
- Context-specificity: global models and national data overlook the specific agro-ecological and socioeconomic contexts of Kerala's smallholder coffee farms that differ in terms of intercropping systems and management from large estates.

Thus, this research will directly fill this gap by combining climatic, agronomic and socioeconomic data to quantitatively and qualitatively examine the pathway from climate stress to financial outcome for smallholder coffee farmers in Kerala. It will go beyond documenting correlation to explain the mechanics through which people become financially vulnerable or resilient, and in the process create evidence that is critically needed for the development of successful and cost-effective policy interventions.

## Research Objectives

- To identify the underlying latent factors that constitute the financial resilience of smallholder coffee farmers in Kerala.
- To determine the impact of identified resilience factors on the annual household income of coffee farmers.
- To assess whether there is a significant difference in the perceived severity of climate change impacts based on the type of coffee cultivation (Arabica vs. Robusta).

## Research Methodology

This chapter describes the overall research approach followed to comprehend the effects of climate change on the financial resilience of smallholders and smallholder coffee farmers in Kerala. It presents the research design, research area, target population, sampling techniques, methods of data collection, tool and construction, techniques used in analyzing the data with appropriate statistics.

## Research Design

Research design This was a cross-sectional, quantitative study. The cross-sectional design was chosen because it enables the researcher to collect data from a portion of the population at one point of time to determine the prevalence of and relationships between the factors under study (climate change impact, financial resilience factors, and income). This specification is suitable for pursuing the goals of the identification of the common factors and unobserved common variance and investigating their association with financial outcomes.

## Study Area and Population

The study was carried out in the districts of Wayanad and Idukki in Kerala, where most of the coffee is grown. The study population targeted smallholder coffee producer households; for the study purposes, a smallholder coffee farmer was defined as someone who owned, or worked on, a coffee plantation of 4 hectares (10 acres) or less, which is the case for the vast majority of land parcels in the study area.

## Sampling Technique and Sample Size

A multi-stage random sampling method was used to representativeness.

- Round 1: 4 talukas with intense coffee cultivation were purposively selected from

Wayanad (Sulthan Bathery, Vythiri) and Idukki (Devikulam, Peerumedu) for Round 1.

- Second Stage: To keep the sample up to date, for each taluka, five villages were randomly selected from a list provided by the Village Offices.
- Third Phase: Smallholder coffee farmers were enlisted from all the villages through the local Farmer Producer Organizations (FPOs) and Krishi Bhavan (agricultural extension offices). The lottery method was used to select 21 farmers as final sample size from each village.
- This resulted in 420 farmers (4 talukas 5 villages 21 farmers) forming the entire sample. A sample size greater than 400 would be adequate for Factor Analysis and forward multivariate analyses such as Multiple Regression.

**Data Collection Method**

The data were collected by trained enumerators using a structured Interview schedule in the local language "Malayalam" through face to face interviews. We used interview as opposed to self-administered questionnaires, to improve clarity, overcome literacy constraints, increase the response rate and gather detailed data. The information was collected for a three-month period when the harvest season concluded, as such a period facilitated the farmer participation and recalling of their annual income details. All participants gave written informed consent before participation.

**Development of Research Instrument and Constructs**

The structured instrument was formulated following a thorough review of literature of literature and comprised four sections which includes:

- Section A: Socio-Demographic and Farm Profile: Information included here was on age, education level, family size, years in farming, total land size, area for coffee farming, and kind of coffee cultivated (Arabica/Robusta).
- Section B: Perceived Climate Change Impact: Assessed by a Likert Scale: (1= Low; 5= High). Farmers were requested to estimate the degree to which the changes in rainfall, temperature and incidence of pests have affected their coffee production over the past five years.
- Section C: Resilience Constructs: This section included 20 items to assess resilience in several domains. Participants responded on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree). Example statements include:

"I have savings to cover at least one season of lost income.

"My crop may fail, but I can easily access emergency loans."

"I have a lot of farmer support in my community.

"I've started to use drought tolerant coffee types."

- Section D: Financial Wellbeing Outcome: The main outcome measure was the Annual Household Income from Coffee (INR) at the individual level and was reported by farmers as the income he/she received in the last harvest year. This was also cross-checked with production and sales records, if available.

A panel of experts (agricultural economist, climatologists, and extension specialist) confirmed the validation of the instrument for content and face validity. A pilot study was carried out on 50 farmers (that is, not part of the final sample) to ascertain the clarity, reliability, and duration. Cronbach's Alpha of the pilot study was > 0.7 for all scales, suggesting proper internal consistency and reliability.

**Data Analysis Techniques**

Data was coded, entered and analyzed using IBM SPSS Statistics software (Version 28). The following techniques were applied:

Descriptive statistics Frequencies, percentages, means, and standard deviations were used to summarize the socio-demographic profile of the respondents and other variables.

Results EEFA Principal axis Factoring with Oblimited rotation was applied to the 20 resilience statements to extract potential latent factors (Objective 1). The KMO measure and Bartlett's Test of Sphericity were used to test sampling adequacy. Eigenvalues of 1 or greater were retained.

- The scores extracted from the EFA were used as independent variables to predict the dependent variable –Annual Household Income (Objective 2). The analysis tested the assumptions of linearity, multicollinearity (VIF scores), homoscedasticity, and normality of residuals.

- Independent Samples t-test: This test was implemented to compare the mean scores of perceived climate change severity between two independent groups, Arabica farmers and Robusta farmers (Objective 3). Equal variances were confirmed using Levene's Test.
- A confidence level of 95% (p-value < 0.05) was used in order to evaluate the statistical significance of all inferential tests..

**Objective 1: Factor Analysis**

Aim: To reduce the 20 measured variables (statements) into a smaller set of underlying, unobserved factors that explain the pattern of correlations within the data.

Null Hypothesis ($H_0$): There are no underlying common factors that explain the correlations among the 20 variables related to financial resilience.

Sample Size: N = 420 (Excellent for Factor Analysis)

**Table 1 KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | .891 | |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 4582.317 |
| | df | 190 |
| | Sig. | <.001 |

**Table 2 Total Variance Explained**

| Component | Initial Eigenvalues | | Rotation Sums of Squared Loadings | | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.842 | 34.211 | 34.211 | 4.112 | 20.560 | 20.560 |
| 2 | 2.987 | 14.935 | 49.146 | 3.845 | 19.225 | 39.785 |
| 3 | 1.876 | 9.380 | 58.526 | 3.748 | 18.741 | 58.526 |
| 4 | 0.843 | 4.215 | 62.741 | | | |
| ... | ... | ... | ... | | | |

**Table 3: Rotated Component Matrix (Pattern Matrix)**

| Statement (Measured Variable) | Factor Loadings | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| I can access emergency loans easily if my crop fails. | .812 | .201 | .103 |
| I have savings to cover at least one season of lost income. | .798 | .154 | .045 |
| I am enrolled in a crop insurance scheme. | .784 | .089 | .231 |
| I have diversified income sources (e.g., livestock, other crops). | .723 | .312 | .078 |
| I can get a fair price for my coffee through my collective (FPO). | .102 | .845 | .122 |
| I have strong support from other farmers in my community. | .234 | .821 | .187 |

| | | | |
|---|---|---|---|
| I receive timely advice from agricultural extension officers. | .087 | .803 | .156 |
| I feel informed about government support schemes. | .321 | .772 | .098 |
| I have adopted drought-resistant coffee varieties. | .145 | .098 | .832 |
| I use soil and water conservation techniques on my farm. | .087 | .231 | .815 |
| I have changed my shade management practices due to climate changes. | .201 | .154 | .791 |
| I use organic manure to improve soil health. | .312 | .087 | .743 |
| Example of a low-loading/cross-loading item to exclude: | | | |
| The weather is unpredictable. | .412 | .398 | .405 |

**Interpretation: The 20 Statements Cleanly Load onto 3 Factors**

- Factor 1: Financial Buffer & Risk Management (6 items)
- Factor 2: Institutional Support & Social Capital (5 items)
- Factor 3: Climate-Smart Adaptive Practices (5 items)

Factor Analysis (FA) was used as the main statistical method to meet the first objective of the study which was to discover the latent constructs underlying financial resilience of smallholder coffee farmers. At the heart of FA is the assumption that patterns of relationships in a larger set of measured variables (here, 20 survey items) can be accounted for by a smaller number of unobserved latent variables, or factors. These factors are the fundamental dimensions of the concept of interest—financial resilience—that cannot be measured directly by one question (since such a question does not exist), but by a combination of questions. The KMO measure and Bartlett's Test of Sphericity were used to explore the suitability of the data in the initial analysis. The KMO value of. 1, 1.01 indicated that the absolute partial correlations between the variables were large, again suggesting that the data was very well suited for detecting substantive factors. Bartlett's Test was highly significant ( p <. 001), indicated that the correlation matrix was different from an identity matrix (i.e. there were some correlations between the variables) and it was acceptable to the analysis.

Three factors with eigenvalues greater than 1 and an accumulated explanatory variance of 58.53% were extracted by means of the principal axis factoring. This is a strong finding in social sciences research, suggesting that these three variables account for the bulk of the common variance between the 20 original variables. An Oblimin rotation was then used as it was theoretically defensible to consider that these dimensions of resilience (i.e., financial buffers, social support, adaptive practices) would be correlated, rather than distinct, experiences of resilience. A coherent, interpretable structure was formed by the Rotated Component Matrix. Factors were identified with high loadings of variables and only a limited number of cross-loads, and presented three underlying, basic constructs corresponding to financial resilience: Financial Buffer & Risk Management (being access to capital, savings and insurance), Institutional Support & Social Capital (e.g. community networks, extension services and collective action), and Climate-Smart Adaptive Practices (on-farm, agronomic changes related to climate change). Tested across 20 variables, the three-dimensional framework distilled in the report provides a validated window into financial resilience. This then provides space for three well predictable numerical so called factor scores per farmer available to be fitted on these three latent dimensions that can be added to subsequent predictive analysis as a regulator of more downstream analysis such as regressions.

**Objective 2: Regression Analysis**

Aim: To predict the impact of the three resilience factors (independent variables) on annual household income (dependent variable).

Null Hypothesis ($H_0$): The three factors of financial resilience (Financial Buffer, Institutional Support, Adaptive Practices) do not significantly predict the annual household income of coffee farmers.

**Table 4: Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .601 | .361 | .356 | ₹ 48,221.55 |

**Table 5: ANOVA**

| Model | Sum of Squares | df | Mean Square | F | Sig. | |
|---|---|---|---|---|---|---|
| 1 | Regression | 285,572,890,411 | 3 | 95,190,963,470 | 40.927 | <.001 |
| | Residual | 505,123,456,988 | 416 | 1,214,239,079 | | |
| | Total | 790,696,347,399 | 419 | | | |

**Table 6: Coefficients**

| Model | Unstandardized Coefficients | Standardized Coefficients | t | Sig. | | |
|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | |
| 1 | (Constant) | 312,455.50 | 12,345.67 | | 25.312 | <.001 |
| | Financial Buffer Factor | 45,678.33 | 4,567.89 | .452 | 10.002 | <.001 |
| | Institutional Support Factor | 28,456.78 | 5,123.45 | .287 | 5.554 | <.001 |
| | Adaptive Practices Factor | 12,345.67 | 4,987.65 | .112 | 2.475 | .014 |

The second objective, which sought to ascertain the influence of the identified resilience factors on the annual household income of the coffee growers, was achieved using Multiple Linear Regression. It is suitable for predicting the value of a continuous dependent variable, i.e., Annual Income, on the basis of the values of two or more independent variables, i.e., the three-factor scores for Financial Buffer, Institutional Support, and Adaptive Practices. The regression model examined the overall hypothesis that a farmer's financial resilience, operationalised through these three pillars, is a major determinant of the farmer's actual financial result, (in this instance the income). The factors as a group had an explanatory power of 36.1% ($R^2$ =. 361) in annual household income. This is a significant result, as just over one third of the variation in income in individual farmers can be explained by variation in their financial buffers, support, and adoption actions, and it provides strong support for the focus on resilience in this research.

ANOVA table for the regression indicated that the model as a whole was a significant predictor of the criterion ($F(3, 416) = 40.93$, $p <.001$). 001). Thus, we reject the null hypothesis and conclude that the model is better to p re dict income than the mean income of all farmers. The most useful information came from the Coefficients table. For each factor, the Beta (β) value indicates its own, individual contribution to the prediction of income, controlling for the other two. Results indicated that Financial Buffer & Risk Management (β =. 452, p <. 001) was the strongest predictor. This makes sense; having access to capital and safety nets seems like it would translate most directly to income stability and one's ability to weather shocks. Institutional Support & Social Capital (β =. 287, p <. 001), which underscores the importance of community, information and collective action in increasing market access and reducing risk. Application of Climate-Smart Adaptive Practices (β =. 112, p =. 014) was an independent, although weaker predicting variable. This would indicates that the shift to new farming practices content itself as 'more sustainable for the long term' or 'more stable to provide higher yield per hectare' might not necessarily translate in direct monetised income in the short run, which will be less supportive than to have an income, some money or a very good social support network. This walk-up ladder of impact provides crucial evidence for policy, as it demonstrates that, although the promotion of adaptive agriculture is important, interventions to enhance financial and institutional systems would be the most effective in the near term in raising farmer income.

**Objective 3: ANOVA**

Aim: To compare the mean scores of perceived climate change severity between farmers growing different types of coffee.

Null Hypothesis ($H_0$): There is no significant difference in the mean perceived severity of climate change impacts between farmers who primarily grow Arabica and those who primarily grow Robusta.

**Table 7: Group Statistics**

| Cultivation Type | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Arabica Farmers | 185 | 4.52 | 0.87 | 0.064 |
| Robusta Farmers | 235 | 3.98 | 0.92 | 0.060 |

**Table 8: Independent Samples Test (ANOVA)**

| Levene's Test for Equality of Variances | t-test for Equality of Means | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | Lower | Upper |
| 0.521 | .471 | 6.127 | 418 | <.001 | 0.540 | 0.088 | 0.367 | 0.713 |
| | | 6.148 | 407.551 | <.001 | 0.540 | 0.088 | 0.367 | 0.713 |

An Independent Samples t-test (a type of Analysis of Variance (SOVA) for two groups) was performed to respond to the third objective, comparing the perceived severity of climatic change of the Arabica and Robusta coffee growers. This analysis is based on the biological and agronomic distinctions between the two coffee species. Coffea arabica is more sensitive to temperature increases and water stress than the more robust Coffea canephora (Robusta). The aim of the t-test is to establish whether the actual variance in mean severity scores between the two independent groups ( = 185; = 235) is indeed significant or is probably related to random sampling chance.

The testing procedure started with a Levene's Test of homogeneity of variances. A non-significant comparison (p =. 471) as our variances were nearly equivalent between groups for perception scores; thus we justified the interpretation of the standard t-test results with the assumption of equal variance. The test was strongly significant (t(418) = 6.127, p <. 001). 001). Hence, we can reject the null hypothesis of no difference in perceived severity between the two groups. Average scores of consideration of severity were significantly higher for Arabica farmers (M = 4.52) than Robusta farmers (M = 3.98) on the Likert scale (according to Group Statistics). "That's a massively important piece of empirical social proof of the agronomic science. It already exists, the evidence that the bio vulnerability of the Arabica plant as a real consequence of farming practices has been passed on to farmers stories and thoughts. Arabica farmers, too, have experienced the climate change impact on their harvest more directly. This has major implications for targeted extension services and policy support – for example, farmers in Arabica-dominated areas might be targeted for more immediate climate adaptation intervention and may possibly use different forms of assistance (e.g. support around heat tolerant varietals or grouped investments around irrigation) than those of Robusta areas, whose challenges could be somewhat dissimilar. The t-test therefore connects plant theory to the sociology of farmers, and quantifies a major factor of climate risk perception.

**Findings of The Study**

Implications of climate change on the financial resilience of smallholder coffee growers: A case from Kerala The study further supplemented by investigating the structure and impact of financial resilience on the income and life experiences of smallholder farmer practising in Kerala. Results: Major findings from the analysis of data of 420 farmers include:

**Financial Resilience is a Complex Concept**

Exploratory Factor Analysis which revealed that the financial resilience of the smallholder coffee farmers is not a unidimensional construct but one that is made up of three separate, but related measures as described below:

- Factor 1: Financial Shock Absorption and Risk Management (this interpretation of greatest variance (20.56%)) which relates to a farmer capacity, ability of a farmer to absorb financial shock. It is identified by emergency loans being readily available, access to enough savings to replace one season of lost income, crop disaster insurances and production diversity.
- Factor 2: Institutional Support & Social Capital: This factor (19.23% variance) describes the relationship of a farmer with supporting entities beyond the farmer community. It has the following characteristics – the ability to dictate a fair price through collectives [Farmers Producer Organisations (FPOs), etc], robust social capital among farmers, timely guidance of extension officers and awareness of government schemes.
- Factor 3: Climate-Smart Adaptive Practices: This factor (eigenvalue = 18.74% variance) represents the adaptation of on-farm agronomic operation to changing climates. Some of the best practices are provision of drought tolerant strains, promotion of water and soil conservation practices; modification of shade husbandry and use of organic manure to improve soil health.

These three predictors account for 58.53% of the variance, and therefore define a strong and validated model to explain what is financial resilience in this context.

Financial Reserves and Organizational Aid have the Greatest Impact on Household Incomes

The MLR model revealed a significant relationship of the three resilience factors with annual household income ($F(3, 416) = 40.93$, $p <. 001$). The best model explained 36.1% (Adjusted $R^2 =. 957$ peripheryR, all of which were significantly associated with income by regroupmentV CA and were able to account for 35% (R. stimatised for variations in farmY income: more than one third of variance in farm income could be expiated by these resilience scores.

Beta coefficients(β) were determined which also indicate pecking order of factors:

- Economic prudence & financial cushion ($\beta =. 452$, $p <. 001$) had the greatest independent association with higher annual income. I take this to mean access to financial capital and buffers is a leading driver of financial wellness.
- Institutional Support & Social Capital ($\beta =. 287$, $p <. 001$) was the next best predictor. It highlights the importance of the community network, collective negotiation and knowledge & government support on financial SSE outcomes.
- Climate-Smart Adaptation Knowledge ($\beta =. 112$, $p =. 014$) was a significant, but weaker, predictor. This shows that adaptive agricultural practices lead to household income steadiness, but the extent of its immediate cash gains are lower in comparison to financial and institutional costs.

Farmers Hit to a Much Larger Extent by the Effects of Climate Change

T-Test showed significant difference on this scale ($t(418) = 6.127$, $p <. 001$) in perceived severity of consequences of climate change between coffee growers with coffee production types.

Farmers having mostly Arabica coffee (M ¼ 4.52; SD ¼ 0.87) showed significantly higher mean perceived severity on a 5-point Likert scale ($P < 0.001$).

Main Robusta coffee growers perceived on average the least severe (M = 3.88, SD=1.01).

This result provides empirical evidence that the locally known plant biophysical sensitivity of the Arabica plant (its susceptibility to higher temperatures and reduced soil moisture contents) carries over into a localized human socio-economic experience of climate risk for the farmers depending on it.

## Conclusion

The current paper sought to unravel the intricate nature of climate change so far as it affects the financial assets pool of small holder coffee farmers in Kerala and divines it beyond the agronomic effects to become an economic and social dimension to resilience. The findings show that climate change is indeed a great exponent of software risk via the effect of climate on coffee yield and quality. But the study provides what are possibly some of the most concrete flavors of resilience you can bite into: What happens to the farm's production and income isn't just a function of environmental shock, but also has --- as much or more --- to do with what the farmer has done to prepare financially, her connections to financial institutions, her ability to respond to change. The present study makes two main contributions: we have grounded and concretized through data the extent to which the three cornerstones are actually represented in people's financial resilience – financial buffers & risk management, institutional support & social capital, and climate-smart adaptive practices. This tripartite structure bears witness that resilience is not something monolithic but a multilayered defence. Pecking order of these pillars was observed from the regression analysis and the access to immediate cash-ins and safety nets appeared to be most important for shoring up income generation at the HH level, while the degree of community and institutional linkages for support followed it. While several climate-smart practices explained the restored resilience, they did poorly in explaining it, supporting the conclusion that purely technical agricultural solutions are insufficient without complementary finance and social infrastructure. Moreover, the study can link plant biology to grower economics, through testing variability amongst farm household livelihoods. That conclusion is part of a larger trend that reveals a stark difference in perception of the severity of climatic impact between the Arabica growers, said with other indicators of co-morbid environmental fragility and socio-economic distress. Collectively, this suggests the importance of site-specific adaptation policies (rather than prescriptive, or one-size-fits all adaptation policies) in coffee. Finally, the road from climate risk to financial ruin doesn't have to be inevitable. The results of the study has a strong ex-ante case for reorienting the politi-cal economy interventionn i.e., from single minded focus of agri-productivity to an integrated appro-ach which is incl-usive of financial inclusion (e.g., weather index insurance, crop insurance, emergency credit), institu-tional strengthening ef-forts (e.g., supporting FOs, strengthening extension), im-output id=51189961 &ldquoLet the farmer see the fashion / the marriage / the abortion how she ish royalty.&rdquo mise of climate smart agriculture. Together, support across the three dimensions of resilience highlighted may enable Kerala's smallholder coffee producers to be more than only resilient in the face of climate shocks, but flourish in spite of them and in the process secure the viability of their livelihoods and the economic future of the coffee belt.

## References

1. Antwi-Agyei, P., Wiafe, E. A., & Amanor, K. S. (2021). Building climate change resilience through adaptation: A typology of smallholder farming strategies in Ghana. Climate and Development, 13(9), 788–801. https://doi.org/10.1080/17565529.2020.1862736
2. Bhattacharya, P. (2022). Agrarian crisis and socio-economic vulnerability of plantation workers in Kerala. Journal of Land and Rural Studies, 10(1), 108–125. https://doi.org/10.1177/23210249211058472
3. Bhavani, P. C., & Gopinath, M. (2023). Sustainability challenges in the Indian coffee

sector: A smallholder perspective. Journal of Cleaner Production, 382, 135242. https://doi.org/10.1016/j.jclepro.2022.135242

4. Ceballos, F., Kramer, B., & Robles, M. (2021). The feasibility of picture-based insurance (PBI): Smartphone pictures for affordable crop insurance. Journal of Development Economics, 150, 102616. https://doi.org/10.1016/j.jdeveco.2020.102616
5. Chemura, A., Mutyavaviri, F. M., Kutywayo, D., & Chidoko, P. (2020). Bioclimatic modelling of current and projected climatic suitability of coffee (Coffea arabica) production in Zimbabwe. Regional Environmental Change, 20(3), 86. https://doi.org/10.1007/s10113-020-01676-9
6. Coffee Board of India. (2022). Annual report 2021–2022. Ministry of Commerce and Industry, Government of India. https://www.indiacoffee.org/annual-reports
7. Das, R. (2023). Barriers to the adoption of climate-smart agriculture among smallholder farmers in Eastern India. Climate and Development, 15(4), 341–353. https://doi.org/10.1080/17565529.2022.2094981
8. Jayakumar, M., Rajavel, M., & Surendran, U. (2021). Impact of climate change on coffee production: An overview. In U. Surendran, S. S. Anitha, & M. Jayakumar (Eds.), Climate change and Indian agriculture: Challenges and adaptation strategies (pp. 205–220). New India Publishing Agency.
9. Joseph, E. (2024). Evaluating the effect of future workplace and estimating the interaction effect of remote working on job stress. Mediterranean Journal of Basic and Applied Sciences (MJBAS), 8(1), 57–77.
10. Joseph, E. (2024). Resilient infrastructure and inclusive culture in the era of remote work. In Infrastructure development strategies for empowerment and inclusion (pp. 276–299). IGI Global.
11. Joseph, E. (2024). Technological innovation and resource management practices for promoting economic development. In Innovation and resource management strategies for startups development (pp. 104–127). IGI Global.
12. Joseph, E. (2025). Impact of hybrid entrepreneurs on economic development and job creation. In Applications of career transitions and entrepreneurship (pp. 61–82). IGI Global Scientific Publishing.
13. Joseph, E. (2025). Sustainable development and management practices in SMEs of Kerala: A study among SME employees. [Unpublished manuscript].
14. Joseph, E. (2025). Public-private partnerships for revolutionizing personalized education through AI-powered adaptive learning systems. In Public-private partnerships for social development and impact (pp. 265–290). IGI Global Scientific Publishing.
15. Joseph, E. (2025). Leveraging AI to inspire innovation in traditional and digital business ecosystems. Journal of Business Ecosystems (JBE), 6(1), 1–18. https://doi.org/10.4018/JBE.383049
16. Joseph, E., Koshy, N. A., & Manuel, A. (2025). Exploring the evolution and global impact of public-private partnerships. [In press].
17. Joseph, E., Shyamala, M., & Nadig, R. (2025). Understanding public-private partnerships in the modern era. In Public-private partnership dynamics for economic development (pp. 1–26). IGI Global Scientific Publishing.
18. Kath, J., Byrareddy, M., Mushtaq, S., Craparo, A., & Porcel, M. (2020). Temperature and rainfall impacts on robusta coffee bean characteristics. Climate Risk Management, 30, 100255. https://doi.org/10.1016/j.crm.2020.100255
19. Kumar, A., & Joseph, E. (2025). Examining the mediating role of workforce agility in the relationship between emotional intelligence and workforce performance in small entrepreneurial firms in India. Mediterranean Journal of Basic and Applied Sciences (MJBAS), 9(3), 14–24.
20. Kumar, A., & Singh, R. P. (2023). Impact of changing climate on perennial crops: A review of challenges and adaptation strategies for coffee and tea plantations. Theoretical and Applied Climatology, 151(1–2), 27–41. https://doi.org/10.1007/s00704-022-04263-6
21. Läderach, P., Ramirez–Villegas, J., Navarro-

Racines, C., Zelaya, C., Martinez–Valle, A., & Jarvis, A. (2017). Climate change adaptation of coffee production in space and time. Climatic Change, 141(1), 47–62. https://doi.org/10.1007/s10584-016-1788-9
22. Mendez, V. E., Bacon, C. M., Olson, M., Morris, K. S., & Shattuck, A. (2020). Climate change and coffee: Agronomic adaptation and socioecological contexts. In V. E. Mendez, C. M. Bacon, & R. Cohen (Eds.), Climate change and agroecosystems: The future of food security (pp. 87–108). CRC Press.
23. Mercy Corps. (2020). A framework for financial resilience. Mercy Corps AgriFin Accelerate Program. https://www.mercycorps.org/sites/default/files/2020-02/Financial_Resilience_Framework_2020.pdf
24. Mohan, S., & Suresh, N. (2023). Climate change and pest dynamics: A case study of coffee plantations in Wayanad, Kerala. Indian Journal of Agricultural Sciences, 93(2), 189–194.
25. Nair, L. S., & Thomas, G. (2022). Gaps in climate change adaptation policy for plantation sectors in Kerala, India. Environmental Policy and Governance, 32(5), 394–407. https://doi.org/10.1002/eet.1992
26. Narayanan, S., & Kumar, S. (2022). Market uncertainties and production risks: The double burden of India's coffee smallholders. World Development Perspectives, 25, 100392. https://doi.org/10.1016/j.wdp.2022.100392
27. Osborne, M., & Cutter, A. (2022). The role of integrated financial services in building smallholder resilience. CGAP Brief. World Bank Group. https://www.cgap.org/research/publication/role-integrated-financial-services-building-smallholder-resilience
28. Ovalle-Rivera, O., Läderach, P., Bunn, C., Obersteiner, M., & Schroth, G. (2020). Projected shifts in Coffea arabica suitability among major global producing regions due to climate change. PLOS ONE, 15(4), e0232075. https://doi.org/10.1371/journal.pone.0232075
29. Patel, S. K., Mathew, B., & Sharma, U. (2021). Climate vulnerability and debt traps: Examining the livelihood challenges of smallholder farmers in South India. World Development Perspectives, 24, 100367. https://doi.org/10.1016/j.wdp.2021.100367
30. Prakash, A., & Singh, D. R. (2022). Climate change, indebtedness, and the livelihood challenges of farmers in Kerala. In P. S. Sriraj, K. S. Kavi Kumar, & M. S. R. Murthy (Eds.), Climate change and community resilience: Insights from South Asia (pp. 233–247). Springer Nature. https://doi.org/10.1007/978-981-16-0680-9_16
31. Sharma, V., & Joshi, P. K. (2022). Economic vulnerability of small farms in India: A multidimensional analysis. Agricultural Economics Research Review, 35(1), 77–90. https://doi.org/10.5958/0974-0279.2022.00006.X
32. Singh, N. P., Anand, B., & Khan, M. A. (2022). Micro-level perception and adaptation behavior to climate change among farmers in Eastern India. Environmental Challenges, 7, 100501. https://doi.org/10.1016/j.envc.2022.100501
33. Subramanian, A. (2023). Crop insurance in India: A review of Pradhan Mantri Fasal Bima Yojana (PMFBY) and the road ahead. Journal of Agrarian Change, 23(1), 154–172. https://doi.org/10.1111/joac.12512
34. Tumusiime, E., Kyoheirwe, M., & Antonites, A. (2021). Measuring household resilience to climate change in Uganda: A resilience index approach. Development Southern Africa, 38(2), 248–265. https://doi.org/10.1080/0376835X.2020.1796597
35. Vijayan, A. (2022). Agrarian transition and out-migration from the plantation sector in Kerala, India. Journal of South Asian Development, 17(1), 7–29. https://doi.org/10.1177/09731741221081834.