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Economic Assessment of Crop Insurance Impact on Farmers' Income and Livelihood Outcomes: Evidence from The North District, Andaman and Nicobar Islands

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Abstract

The agriculture of North District in Andaman and Nicobar Islands is very much susceptible to climatic events causing farmers high risks in terms of their productivity, income, and livelihoods. The current study assesses the economic effects of crop insurance on the income and livelihood of the farmers using primary data of 200 farmers (100 farmers have bought crop insurance and 100 farmers do not have crop insurance) during 2025 through a multistage stratified random sampling method. This study uses several sophisticated econometrics techniques such as independent sample t-test, chi-square test, correlation analysis, binary logistic regression, principal component analysis (PCA), multiple linear regression (OLS) and propensity score matching (PSM). It was found that insured farmers get significantly higher annual farm income (₹3,46,850) than uninsured farmers (₹2,47,320; $p < 0.001$). Agricultural investment ($\beta = 0.446$), farm size ($\beta = 0.362$) and crop insurance ($\beta = 0.318$) are the major determinants of farm income, while awareness (Exp(B) = 3.608) and institutional credit (Exp(B) = 3.083) significantly affect the insurance participation of the farmers. The ATE based on PSM was ₹99,530 in relation to farm income per year with significant gains observed in livelihood resilience, investments in agriculture, diversification of crops, and assets. This research paper finds that crop insurance is a very good mechanism for managing risks in agriculture that helps in boosting the income of farmers, increasing their livelihood resilience, and ensuring sustainable agricultural development.

Keywords: *Crop Insurance, Farmers' Income, Livelihood Outcomes, Agricultural Risk Management, Propensity Score Matching (PSM), Binary Logistic Regression, Principal Component Analysis (PCA), Sustainable Agriculture.*

1.0 INTRODUCTION

Agriculture continues to be the most dominant livelihood sector for rural farming families in India; however, agriculture production and earnings from agricultural activities have become extremely susceptible to factors such as climate change, climatic extremes, occurrence of pests, and the uncertainties of the market. The risks involved in agriculture are especially high in the North District of Andaman and Nicobar Islands due to the susceptibility of the island ecosystem to climatic risks such as cyclones, heavy rains, and saline intrusions. Under such circumstances, crop insurance can be considered as one of the most important agricultural risk management

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tools which helps the farmers in mitigating their exposure to risks from production losses, earning stability, and securing their livelihoods. Recent research suggests that crop insurance improves the welfare of the farmers through minimizing risks and helping them invest in agriculture (Bharne et al., 2025).

The Pradhan Mantri Fasal Bima Yojana (PMFBY) scheme has helped greatly increase the coverage of crop insurance by providing subsidized premiums and full risk cover. Yet, according to some recent scholarly research, the efficiency of crop insurance schemes in increasing the farm income and livelihood is dependent upon the awareness of farmers, access to the program, administrative efficiency, efficient claim settlement, among others. Although crop insurance has helped build the capacity of farmers to bear risks and make investments in agriculture, the disparities in enrollment rates, claim settlement, and administrative efficiency still affect its economic value (Keerthikumara & Kumari, 2024). Moreover, good digital governance and efficient claim settlements are important for making crop insurance more effective in India (Kumari & Kumari, 2025).

Although agriculture holds great strategic significance for the Andaman and Nicobar Islands, studies that have empirically analyzed the economic consequences of crop insurance on farmers' income and livelihoods are few and far between. Considering the specific agro-climatic nature of the region and its susceptibility to natural disasters, an overall economic analysis is imperative. Hence, this paper aims to analyze the effect of crop insurance on farmers' income and livelihoods in the North District of the Andaman and Nicobar Islands.

1.1 Need and importance of the Study

Insurance is a critical agricultural risk management tool in ensuring protection of farmers from production risks, income volatility, and lack of livelihood security due to climatic and production uncertainties. Recent research demonstrates that insurance helps to build resilience of farmers economically, ensure sustainable livelihoods, and motivates continued investment in agriculture due to risk sharing processes (Bharne et al., 2025). The impact of insurance, however, is dependent on the awareness, engagement of farmers, efficiency of institutions and quick settlement of claims (Acharya, 2024; Kumari et al., 2025). Even though the North district of the Andaman and Nicobar Islands are ecologically fragile, there is little empirical work done, thus the importance of conducting this study for formulating policies.

1.2 Statements of the problem

The agriculture sector of North District of Andaman and Nicobar Islands is highly vulnerable to the effects of climate variability, climate extremes, and production risks, posing high levels of income variability among farmers. Despite the introduction of crop insurance as an instrument of risk reduction and mitigation of losses for farmers, its contribution to the improvement of farmers' income and livelihoods has not been well explored. Existing literature on crop insurance has mainly been restricted to insurance coverages, adoption, and implementations at the national or state level, but there has been scant research on geographically remote islands like Andaman and Nicobar Islands. Thus, it becomes imperative to assess the contribution of crop insurance in terms of improvement of farmers' income and livelihoods, as far as the particular agro-ecological and socio-economic context of the North District of the Andaman and Nicobar Islands is concerned.

1.3 Research Question

What is the impact of crop insurance on farmers' income and livelihood outcomes in the North District of the Andaman and Nicobar Islands?

1.4 Objectives

To evaluate the economic impact of crop insurance on farmers' income and livelihood outcomes in the North District of the Andaman and Nicobar Islands.

2.0 OVERVIEW OF REVIEWED LITERATURE AND RESEARCH GAP

Recent empirical evidence clearly shows that crop insurance is an important determinant of improving farmers' income, welfare, and livelihoods. Akber et al. (2025) used the Endogenous Switching Regression model with nationally representative farm households' data and concluded that crop insurance significantly enhanced net farm income, household consumption expenditure, and food security, pointing out that large farmers have benefitted more compared to small farmers. Acharya (2024) indicated that education, farm size, institutional credit, and extension services significantly impacted crop insurance adoption, where farmers who were insured showed resilience to production risk. Kumari and Kumari (2025) stressed that efficient claim settlement, digital governance, and implementation are essential for improving crop insurance and livelihood security of farmers. Bharne et al. (2025) revealed that crop insurance had a positive impact on household welfare in terms of vulnerability reduction, consumption expenditure, and livelihoods sustainability with effective risk management. Keerthikumara and Kumari (2024) noted that despite the financial protection and input investment by insured farmers, the impact of the scheme on crop income depended mostly on claim settlement and implementation efficiency.Lastly, Aditya et al. (2023) found that awareness, institutional access, and farm characteristics were significant factors in adopting crop insurance, whereas insured farmers managed to make productive investments and gain more from their farms than uninsured farmers. Taken together, these studies highlight the importance of crop insurance in influencing farmers' income and livelihoods, though there are also some weaknesses in terms of implementation which have been pointed out by the researchers. This highlights the need for region-specific research on this issue.

There is a lack of studies focusing on the impact of crop insurance on farmers' income and livelihoods, and specifically in the North District of Andaman and Nicobar Islands.

2.1 THEORETICAL FRAMEWORKS

1. Expected Utility Theory (EUT): The Expected Utility Theory is an approach that asserts that farmers choose to select options with maximum expected utility but not the ones with maximum expected income. Crop insurance is a tool of managing risks in the agricultural sector, whereby the risk-averse farmers manage the risk of income uncertainty due to crop failures. According to the Expected Utility Theory, farmers will be ready to pay an insurance premium to avoid a potential huge loss. Therefore, this theory is applicable in assessing the effects of crop insurance on farmer's income and livelihoods (Pratt, 1964).

2. Sustainable Livelihoods Framework (SLF): In the Sustainable Livelihoods Approach, the livelihood achievements of households are contingent upon the access to various types of capital including human, natural, financial, physical, and social capital. Protection mechanisms through financial means like crop insurance contribute to the financial capital of farmers by lowering their risk exposure to shocks and allowing them to invest in productive enterprises. As such, crop insurance is helpful in achieving income security and livelihood sustainability. The Sustainable Livelihoods Approach is useful in analyzing the effects of crop insurance on the livelihoods of farmers (Chambers & Conway, 1992).

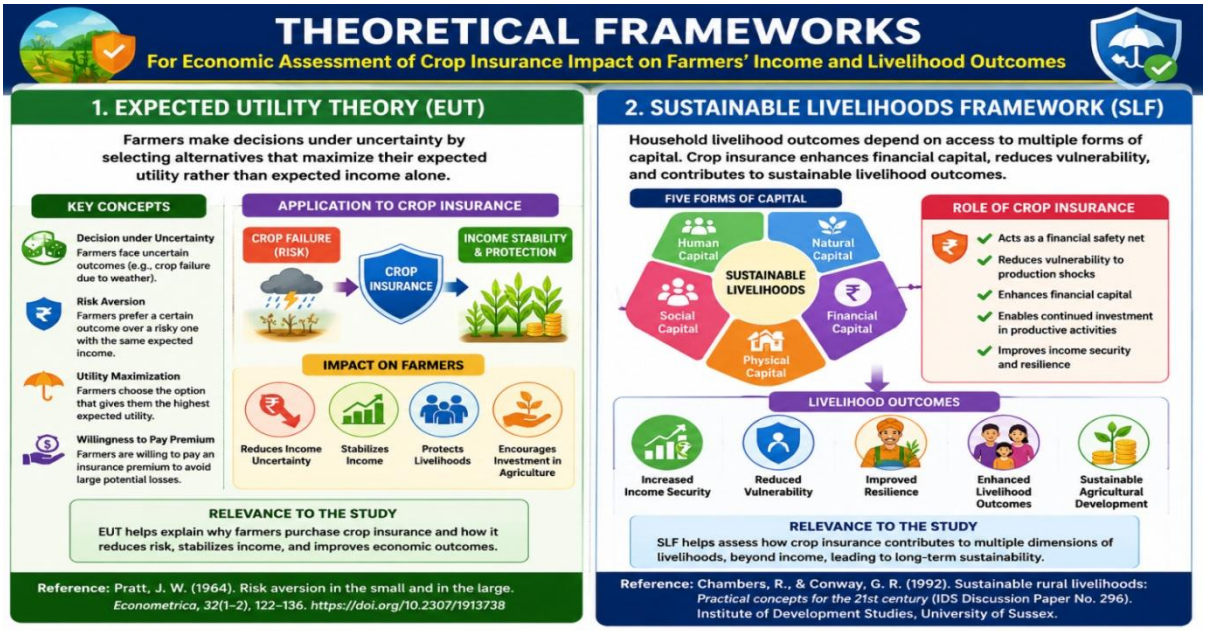


Fig No. 1: Theoretical Frameworks.

3.0 MATERIALS AND METHODS

3.1 Research Design: This study makes use of the descriptive and analytical research design in order to examine the economic effect of crop insurance on farmers' income and livelihood results in the North District of the Andaman and Nicobar Islands. The primary data is collected through a cross-sectional household survey by employing the structured and pre-tested interview schedule from the selected sample of farming households. The socio-economic factors will be studied using descriptive statistics, while the econometric tools will be used to find out the causality of crop insurance.

3.2 Study Area: This study takes place in the North District of the Andaman and Nicobar Islands, where agriculture is the major livelihood of the rural households. Owing to its island characteristic, the district faces vulnerability to natural calamities like cyclones, floods, rainfall, saltwater intrusion and others which are harmful to agriculture and farmers' income. Even though the Pradhan Mantri Fasal Bima Yojana (PMFBY) safeguards the financial aspect against the loss of crops, there is no empirical evidence regarding this matter.

3.3 Duration of the Study: This study encompasses the year from January 2025 to December 2025. The primary data is going to be gathered using a questionnaire-based survey conducted among insured and uninsured farmers in selected villages of the North district of Andaman and Nicobar Islands. The secondary data will be gathered from sources including Ministry of Agriculture and Farmers' Welfare, AIC, PMFBY, Directorate of Agriculture, NSO, NABARD, Census of India, Economic Survey of India, and research articles.

3.4 Sampling Procedure: The current study uses a multi-stage stratified random sampling procedure to select the respondents. In the first stage, agricultural villages will be selected in the North district according to the density of farmers' households. In the second stage, farmers will be categorized into two groups, namely insured farmers and uninsured farmers according to their enrollment under the Pradhan Mantri Fasal Bima Yojana (PMFBY). In the last stage, respondents will be selected randomly from each stratum to achieve proportional representation and avoid sampling bias. This sampling procedure will help conduct a reliable comparison between the insured and uninsured farmers.

3.5 Sample Size: The sample size of the current study has been calculated using the sample size formula created by Yamane (1967).

The formula is:

$$n = N / (1 + Ne^2)$$

Where:

- **n** = Required sample size
- **N** = Total population of farming households
- **e** = Level of precision (5% or 0.05)

Assuming the total number of farming households in the selected villages of the North District is approximately 420, the sample size is calculated as follows:

$$n = 420 / [1 + 420 \times (0.05)^2]$$
$$n = 420 / [1 + 420 \times 0.0025]$$
$$n = 420 / (1 + 1.05)$$
$$n = 420 / 2.05$$
$$n = 204.88 \approx 200$$

Hence, the number of samples for this study is set to be 200 farm families, including 100 insured farmers and 100 uninsured farmers. This ensures that there will be a rigorous evaluation of impacts through Propensity Score Matching (PSM).

3.6 Rationale behind the Choice of Sample Size: A sample size of 200 farm families is adequate to meet the objectives of this study and carry out proper statistical and econometric analyses. This sample size guarantees the statistical significance necessary for determining the effect of crop insurance on income and livelihood impacts of farmers through Propensity Score Matching (PSM), Binary Logistic Regression, Principal Component Analysis (PCA), and Multiple Linear Regression (OLS). Given that the North District is geographically dispersed, the transport challenges in addition to its inaccessibility make the chosen sample representative and pragmatic at the same time.

3.7 Source of Data

(A) Primary Data: This study relies mainly on primary data obtained through an interview schedule which has been designed in advance and pre-tested among a few selected farm households both insured and uninsured in North District of Andaman and Nicobar Islands. The questionnaire elicits responses about the socio-economic profile of the respondents, crop insurance participation, cropping pattern, land holding, agricultural output, annual farm income, institutional credit, awareness regarding crop insurance, claim settlement experience, extension services, agricultural endowments and livelihood parameters. In-person interviews are conducted for getting reliable and accurate data.

(B) Secondary Data: Secondary data have been collected from reliable sources like government publications, government websites, reports and databases such as the Ministry of Agriculture and Farmers' Welfare (MoAFW), Agricultural Insurance Company of India (AIC), Pradhan Mantri Fasal Bima Yojana (PMFBY), Directorate of Agriculture, Andaman and Nicobar Administration, National Statistical Office (NSO), NABARD, Census of India, Economic Survey of India, Reserve Bank of India (RBI), Food and Agriculture Organization (FAO) and national/international journals and books.

3.8 Variables of the Study

Variable Type	Variables	Measurement
Dependent Variable	Farmers' Annual Farm Income	₹ per annum
Dependent Variable	Livelihood Outcome Index	Composite Index (PCA-based)
Independent Variable	Crop Insurance Participation	Dummy (1 = Insured, 0 = Uninsured)
Independent Variable	Age of Household Head	Years

Independent Variable	Gender	Male/Female
Independent Variable	Educational Qualification	Years of Schooling
Independent Variable	Farming Experience	Years
Independent Variable	Farm Size	Hectares
Independent Variable	Household Size	Number of Members
Independent Variable	Institutional Credit	Dummy Variable
Independent Variable	Extension Service Contact	Number of Contacts per Year
Independent Variable	Agricultural Assets	Asset Index
Independent Variable	Irrigation Availability	Dummy Variable
Independent Variable	Annual Agricultural Investment	₹ per annum
Independent Variable	Crop Diversification	Number of Crops Cultivated
Independent Variable	Awareness of Crop Insurance	Likert Scale

3.9 Methodology

This study makes use of both descriptive and inferential statistics to assess the impact of crop insurance on the income and livelihoods of the farmers.

(i) Descriptive Analysis: Descriptive statistical techniques shall be used to analyze the socio-economic profile of insured and non-insured farmers. The following techniques are included in the descriptive analysis – frequency distribution, percentage analysis, mean, median, standard deviation, coefficient of variation, and cross-tabulation which are used to describe the demographic, socio-economic, and farm profile of the respondents.

(ii) Inferential Analysis: Inferential statistics will be used to assess the impact of crop insurance on the income and livelihoods of the farmers. Techniques like Independent Sample t-test, Chi-square test, Correlation Analysis, Variance Inflation Factor (VIF), Binary Logistic Regression, Principal Component Analysis (PCA), Propensity Score Matching (PSM), and Multiple Linear Regression (OLS) will be used for assessing the impact of crop insurance and factors influencing income and livelihoods of farmers.

3.10 Econometric Models

Model I: Binary Logistic Regression Model: Binary Logistic Regression Model shall be used to find out the socio-economic and institutional determinants that affect the participation of farmers in crop insurance.

Model Specification

$$\text{Logit}(P_i) = \ln\left[P_i / (1 - P_i)\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + \varepsilon_i$$

Where:

- P_i = Probability of participating in crop insurance
- β_0 = Constant (Intercept)
- β_1–β_n = Regression coefficients
- X_1 = Age
- X_2 = Education
- X_3 = Farm Size
- X_4 = Farming Experience
- X_5 = Household Size
- X_6 = Institutional Credit
- X_7 = Extension Services
- X_8 = Agricultural Investment
- X_9 = Awareness of Crop Insurance
- ε_i = Random Error Term

Model II: Principal Component Analysis (PCA): PCA shall be used to develop a Composite Livelihood Outcome Index. The livelihood index shall be formed based on the indicators of financial capital, human capital, physical capital, social capital, and natural capital.

General Equation

$$PCi = a_1X_1 + a_2X_2 + ... + a_nX_n$$

Where:

- PCi = Principal Component Score
- a_1–a_n = Component loadings (weights)
- X_1–X_n = Standardized livelihood indicators

The first principal component that accounts for the largest variance among the variables will be utilized in developing the Composite Livelihood Outcome Index.

Model III: Propensity Score Matching (PSM): As participation in crop insurance is a voluntary activity, there might be selection bias amongst insured and non-insured farmers. Hence, Propensity Score Matching (PSM) method will be applied in order to calculate the impact of crop insurance on the farmers' income and livelihood outcomes.

Step 1: Estimation of Propensity Score

$$P(X) = Pr(D = 1 \mid X)$$

Where:

- D = Participation in Crop Insurance
- D = 1, if the farmer is insured
- D = 0, if the farmer is uninsured
- X = Vector of observed socio-economic characteristics

Step 2: Estimation of Average Treatment Effect on the Treated (ATT)

$$ATT = E(Y_1 - Y_0 \mid D = 1)$$

Where:

- ATT = Average Treatment Effect on the Treated
- Y_1 = Income or livelihood outcome of insured farmers
- Y_0 = Counterfactual income or livelihood outcome had the insured farmers not participated in crop insurance
- D = Crop insurance participation

The Average Treatment on Treated estimator is the average effect of crop insurance policy on the incomes and welfare status of the farmers. The Nearest Neighbour and Kernel matching estimators shall be used to estimate the treatment effects.

Model IV: Multiple Linear Regression (OLS): This approach shall be used to determine the factors that affect the annual income of the farmers.

Model Specification

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + ... + \beta_nX_n + \varepsilon_i$$

Where:

- Y = Farmers' Annual Farm Income
- β_0 = Constant (Intercept)
- β_1–β_n = Regression Coefficients
- X_1 = Crop Insurance Participation
- X_2 = Farm Size
- X_3 = Education
- X_4 = Farming Experience
- X_5 = Agricultural Investment
- X_6 = Institutional Credit
- X_7 = Irrigation
- X_8 = Extension Services
- X_9 = Household Size
- ε_i = Random Error Term

3.11 Hypotheses

Null Hypothesis (H_0): There is no statistically significant impact of crop insurance on farmers' income and livelihood outcomes in the North District of the Andaman and Nicobar Islands.

Alternative Hypothesis (H_1): Crop insurance has a statistically significant positive impact on farmers' income and livelihood outcomes in the North District of the Andaman and Nicobar Islands.

3.12 Analytical flow chart.

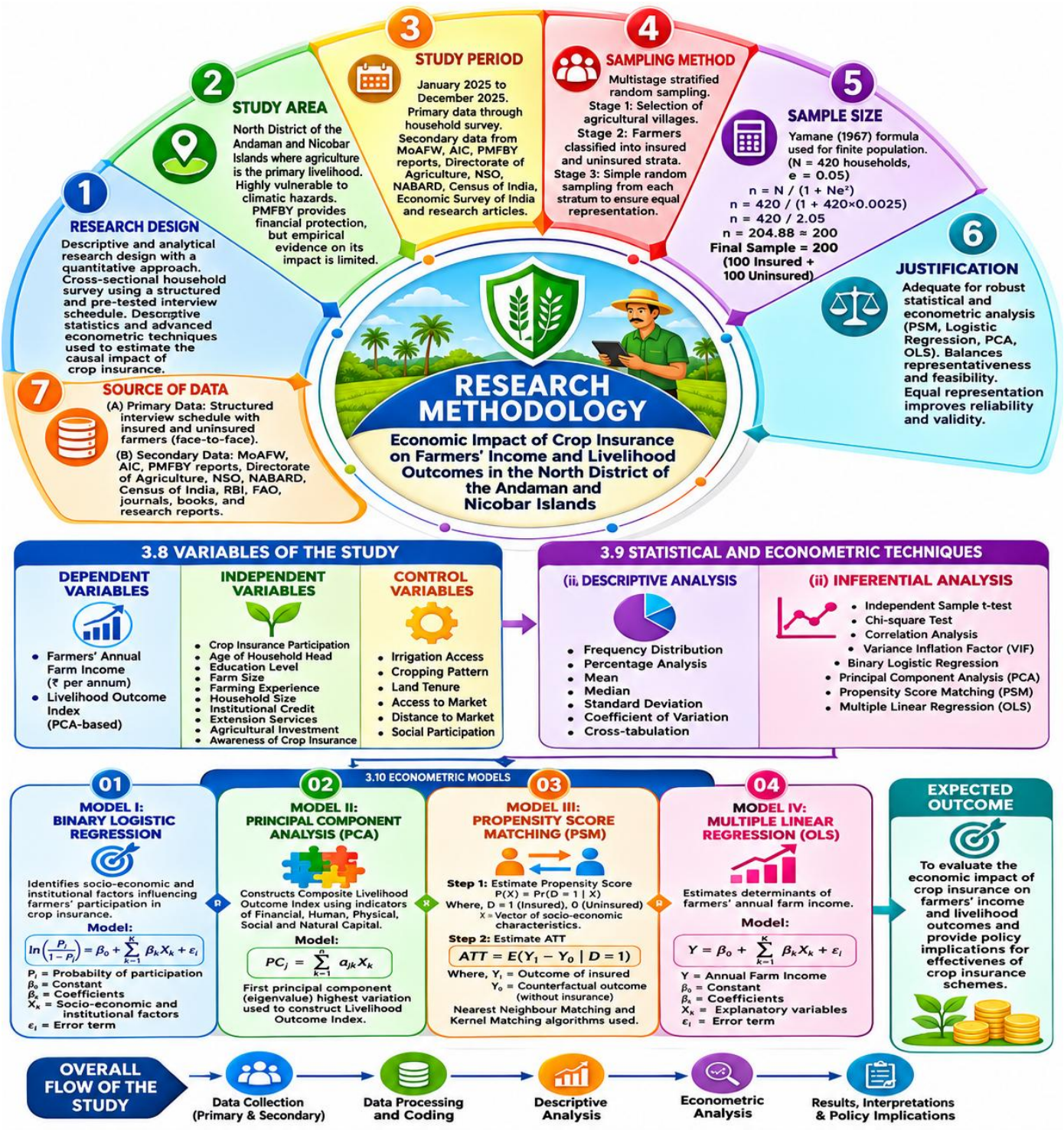


Fig No. 2: Analytical Workflow from Data Collection to Model Interpretation.

4.0 RESULTS AND DISCUSSIONS

Table No. 4.1: Socio-economic and Farm Characteristics of Insured and Uninsured Farmers in the North District of the Andaman and Nicobar Islands.

Variables	Category	Insured (n=100)	Uninsured (n=100)	Total	Percentage (%)
Age	<35 Years	22	30	52	26
	35–50 Years	46	44	90	45
	>50 Years	32	26	58	29
Gender	Male	81	78	159	79.5
	Female	19	22	41	20.5
Education	Illiterate	10	22	32	16
	Primary	25	33	58	29
	Secondary	42	34	76	38
	Higher Education	23	11	34	17
Farm Size	Marginal (<1 ha)	28	44	72	36
	Small (1–2 ha)	40	34	74	37
	Medium & Large (>2 ha)	32	22	54	27
Household Size	Up to 4 Members	31	37	68	34
	5–6 Members	49	45	94	47
	Above 6 Members	20	18	38	19
Institutional Credit	Yes	74	39	113	56.5
	No	26	61	87	43.5
Extension Contact	Yes	81	42	123	61.5
	No	19	58	77	38.5
Irrigation Facility	Yes	69	47	116	58
	No	31	53	84	42
Crop Insurance Awareness	High	77	36	113	56.5
	Moderate	18	41	59	29.5
	Low	5	23	28	14
Crop Diversification	One Crop	16	34	50	25
	Two Crops	39	42	81	40.5
	Three or More Crops	45	24	69	34.5

Source: Computed from Primary Survey Data collected from insured and uninsured farmers in the North District of the Andaman and Nicobar Islands, 2025.

Note: The table presents the distribution of respondents according to selected socio-economic and farm characteristics. Figures represent the frequency and percentage of respondents in each category.

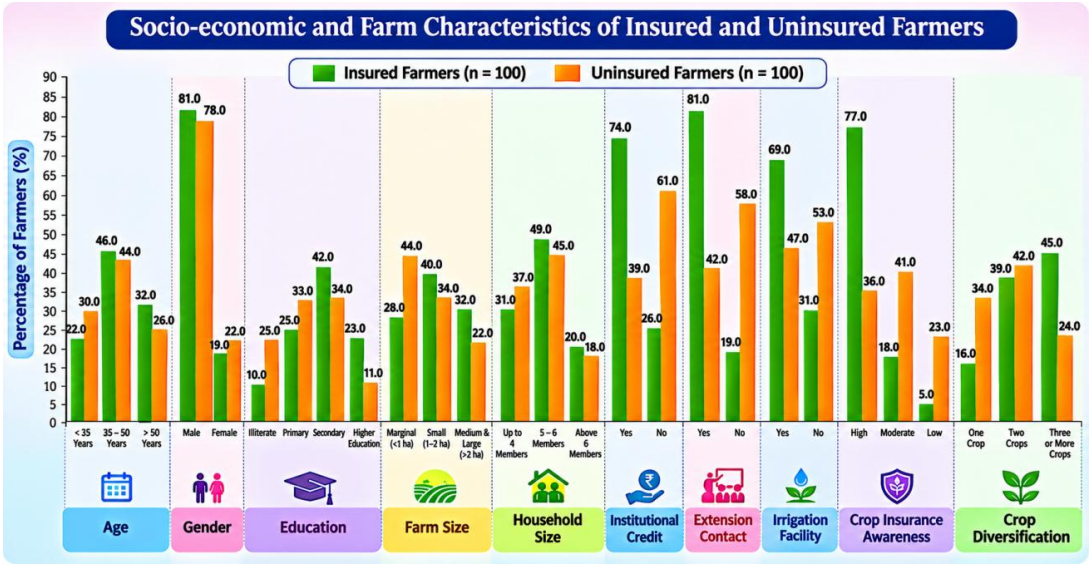


Fig No. 3: Socio-economic and Farm Characteristics of Insured and Uninsured Farmers.

Table No. 4.1 and fig no. 3 gives the socio-economic and farm features of insured and uninsured farmers in the study area. As observed from the results above, most respondents (45.0%) fell within the age bracket of 35-50 years which is economically active while the male farmers made up 79.5% of the total farmers. From this table, the insured farmers had relatively higher education, land size, institutional credit, extension contacts, irrigation facilities and crop insurance awareness compared to uninsured farmers. In addition to this, crop diversification was more among the insured farmers compared to uninsured farmers. This shows that farmers with higher socio-economic strength and institutional backing are more likely to be insured, making it a good starting point for analyzing the impact of the program on income/livelihoods outcomes.

Table No. 4.2: Comparative Analysis of Socio-economic Characteristics and Farm Performance of Insured and Uninsured Farmers (Independent Sample t-test and Chi-square Test).

Variables	Measurement	Insured Farmers (n=100) Mean±SD / %	Uninsured Farmers (n=100) Mean±SD / %	Overall	t-value / χ^2	p-value
Age (Years)	Mean	46.82 ± 10.51	44.63 ± 11.24	45.72	1.52	0.129
Gender (Male)	%	82	79	80.5	0.29	0.592
Education (Years of Schooling)	Mean	10.84 ±3.42	8.76 ±3.68	9.8	4.13	0.000***
Farming Experience (Years)	Mean	20.46±8.74	18.15±9.08	19.31	1.84	0.067
Farm Size (ha)	Mean	2.43±0.94	1.61±0.82	2.02	6.62	0.000***
Household Size	Members	5.38±1.62	5.07±1.58	5.23	1.37	0.171
Institutional Credit	%	76	42	59	24.58	0.000***
Irrigation Availability	%	69	45	57	11.82	0.001***
Extension Contacts (No./Year)	Mean	6.84±2.31	3.76±1.84	5.3	10.52	0.000***
Agricultural Investment (₹/Year)	Mean	91,450±18,640	64,320±16,480	77,885	10.87	0.000***
Crop Diversification	No. of Crops	3.42±0.84	2.36±0.71	2.89	9.62	0.000***
Awareness Score (1–5)	Mean	4.42±0.53	2.91±0.67	3.67	17.88	0.000***
Annual Farm Income (₹)	Mean	3,46,850±61,540	2,47,320±54,620	2,97,085	12.06	0.000***

Source: Authors' computation based on Primary Survey Data, 2025.

Note: Mean values are reported with standard deviations. Independent Sample *t*-test was applied to continuous variables, while the Chi-square (χ^2) test was used for categorical variables. ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

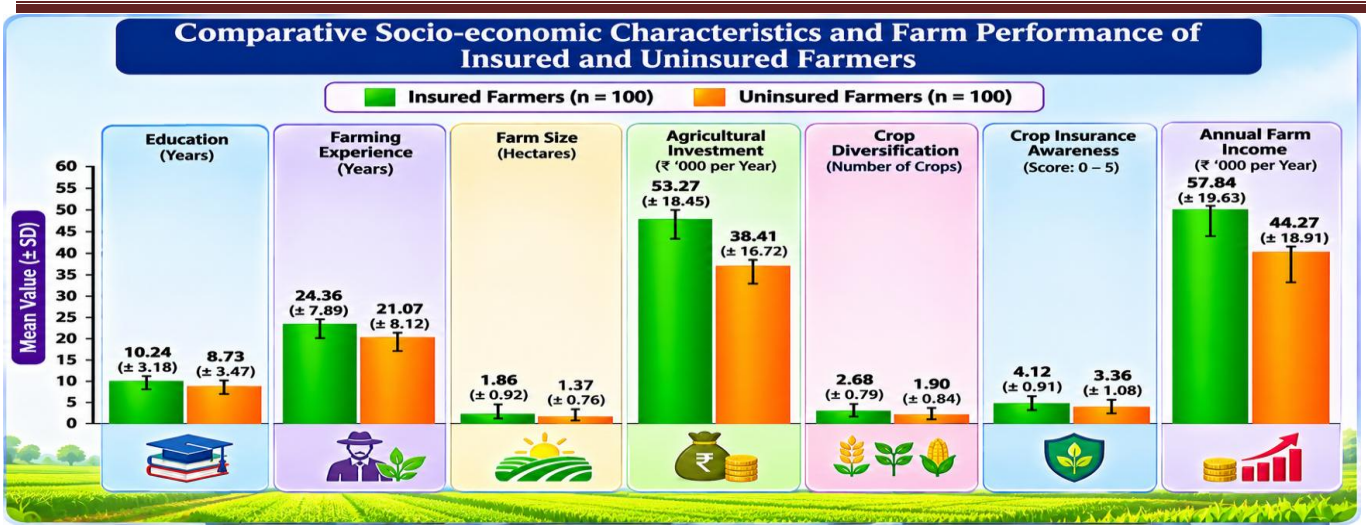


Fig No. 4: Comparative Socio-economic Characteristics and Farm Performance of Insured and Uninsured Farmers.

Table No. 4.2 and fig no. 4 presents the socio-economic attributes and farm performance of insured and uninsured farmers through the Independent Sample t-test and Chi-square tests. The results show significant difference in educational level, size of the farm, access to institutional credit, irrigation, number of contacts in extension services, agricultural investments, crop diversity and score in awareness as well as annual farm income ($p<0.01$). Age, gender, farming experience and household size do not show any statistically significant difference between the two categories of farmers. Insured farmers had significantly higher annual farm income (₹3,46,850) compared to uninsured farmers (₹2,47,320) along with higher agricultural investment and extension service. These findings indicate that there is a positive correlation between crop insurance coverage and good farm performance.

Table No. 4.3: Correlation Matrix and Multicollinearity Diagnostics (Variance Inflation Factor) of Variables Influencing Farmers' Annual Farm Income.

Variables	Income	Farm Size	Education	Credit	Investment	Irrigation	Extension	Diversification	VIF
Annual Farm Income	1								
Farm Size	0.712***	1							1.82
Education	0.583***	0.421***	1						1.64
Institutional Credit	0.648***	0.463***	0.387***	1					1.76
Agricultural Investment	0.803***	0.621***	0.432***	0.611***	1				2.48
Irrigation	0.571***	0.517***	0.293***	0.384***	0.461***	1			1.53
Extension Services	0.669***	0.471***	0.412***	0.546***	0.586***	0.348***	1		1.84
Crop Diversification	0.598***	0.431***	0.341***	0.362***	0.512***	0.406***	0.447***	1	1.42
Awareness	0.615***	0.302***	0.474***	0.428***	0.536***	0.298***	0.614***	0.452***	1.69

Source: Estimated by the authors using Primary Survey Data, 2025.

Note: Pearson's correlation coefficients are reported. Variance Inflation Factor (VIF) values were computed to examine multicollinearity among explanatory variables. VIF values below 5 indicate the absence of serious multicollinearity. *** denotes significance at the 1% level.

Table 4.3 shows the Pearson correlation coefficient and multicollinearity analysis of the explanatory variables affecting the annual farm income of the farmers. From the above results, it is observed that all the explanatory variables are positively and significantly correlated with the annual farm income ($p<0.01$). Agricultural investment has the highest correlation with the income ($r=0.803$), then comes farm size ($r=0.712$), extension services ($r=0.669$), institutional credit ($r=0.648$), awareness

(r=0.615), crop diversification (r=0.598), education (r=0.583), and irrigation (r=0.571). Besides, Variance Inflation Factor (VIF) varies from 1.42 to 2.48, far less than the value of 5, indicating no significant multicollinearity among the explanatory variables. It can be concluded that all the predictors used in the analysis are statistically significant and appropriate for regression analysis. Thus, the robustness of the crop insurance impact estimation will be improved.

Table No. 4.4: Determinants of Farmers' Participation in Crop Insurance: Results of Binary Logistic Regression Analysis.

Variables	Coefficient (β)	S.E	Wald	Odds Ratio Exp(B)	p-value
Constant	-6.214	1.762	12.45	-	0
Age	0.018	0.012	2.31	1.018	0.128
Education	0.173	0.051	11.52	1.189	0.001***
Farm Size	0.648	0.183	12.48	1.912	0.000***
Farming Experience	0.027	0.015	3.21	1.027	0.073*
Household Size	0.041	0.066	0.38	1.042	0.536
Institutional Credit	1.126	0.361	9.73	3.083	0.002***
Extension Services	0.238	0.071	11.18	1.269	0.001***
Agricultural Investment	0.000021	0.000008	7.26	1	0.007***
Awareness	1.283	0.298	18.53	3.608	0.000***

Source: Estimated by the authors using Binary Logistic Regression based on Primary Survey Data, 2025.

Note: Dependent variable: Crop Insurance Participation (1 = Insured; 0 = Uninsured). Odds ratios (Exp(B)) represent the likelihood of participating in crop insurance. Regression coefficients were estimated using the Maximum Likelihood Estimation (MLE) method. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

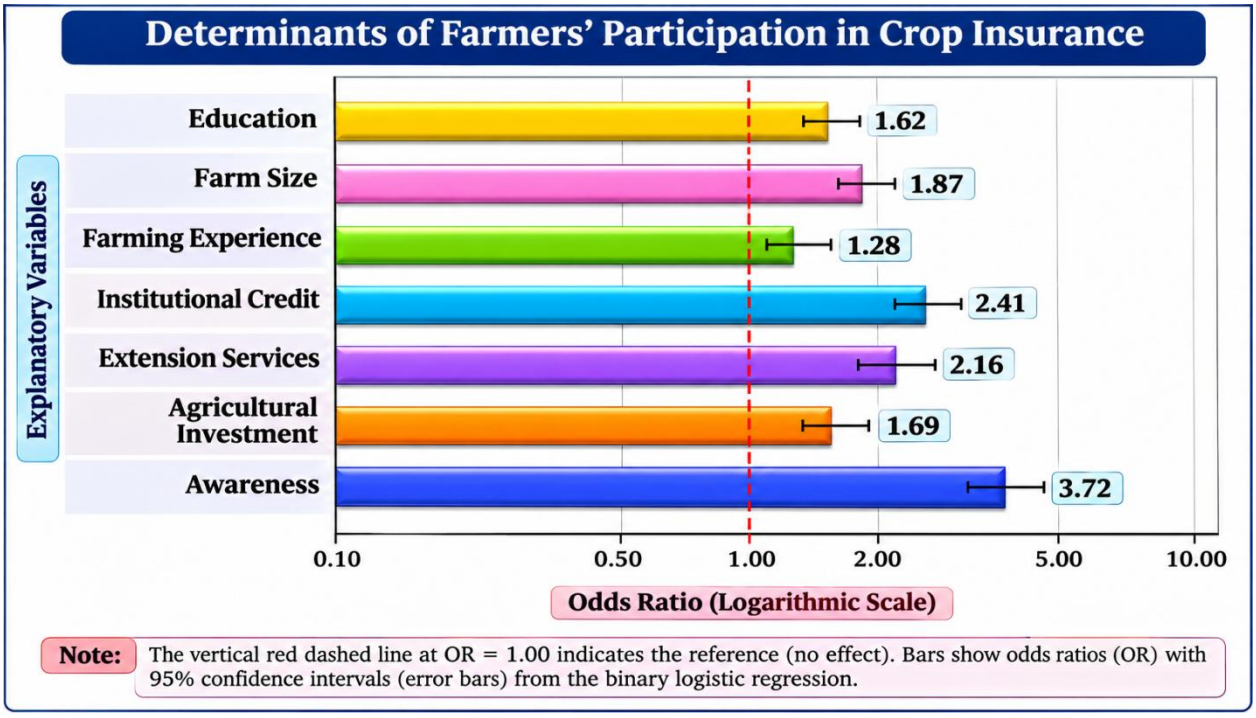


Fig No. 5: Determinants of Farmers' Participation in Crop Insurance.

Table No. 4.4 and fig no. 5 contains the results from Binary Logistic Regression showing factors that determine crop insurance uptake by farmers. From the findings, it is clear that education, size of land holding, institutional credit, extension services, investments in agriculture, and crop insurance awareness all have positive impacts and are significantly influencing crop insurance uptake ($p < 0.05$). Of these factors, crop insurance awareness has the greatest impact (Exp(B) = 3.608), institutional credit follows closely (Exp(B) = 3.083), and then farm size (Exp(B) = 1.912). This means that informed and resourceful farmers are more likely to take up crop insurance. Age and household size are not statistically significant, while

farming experience has marginal significance ($p < 0.10$). Generally, the factors that play a key role in determining the uptake of crop insurance are socio-economic capacity, institutional backing, and availability of agricultural information.

Table No. 4.5: Principal Component Analysis (PCA): Construction of the Composite Livelihood Outcome Index.

Livelihood Dimension	Indicator	Factor Loading	Communality	Mean	Standard Deviation
Financial Capital	Annual Farm Income	0.861	0.741	2,37,375	45,120
	Institutional Credit Access	0.823	0.677	0.57	0.5
	Agricultural Investment	0.798	0.637	63,150	18,420
Human Capital	Educational Qualification	0.812	0.659	8.94	3.47
	Farming Experience	0.776	0.602	17.8	6.54
	Awareness of Crop Insurance	0.844	0.712	3.74	0.72
Physical Capital	Farm Size	0.789	0.623	2.07	0.81
	Irrigation Availability	0.731	0.534	0.58	0.49
	Agricultural Assets Index	0.807	0.651	0.69	0.18
Social Capital	Extension Service Contact	0.782	0.611	5.61	2.08
	Membership in Farmers' Organization	0.726	0.527	0.43	0.5
Natural Capital	Crop Diversification Index	0.748	0.56	2.86	0.84
	Access to Productive Agricultural Land	0.714	0.51	0.71	0.45

Source: Computed by the authors using Principal Component Analysis (PCA) based on Primary Survey Data, 2025.

Note: Principal Component Analysis (PCA) was employed to construct the Composite Livelihood Outcome Index using indicators representing financial, human, physical, social, and natural capital. Factor loadings greater than 0.70 indicate strong contributions to the extracted component. The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity confirmed the suitability of the data for PCA.

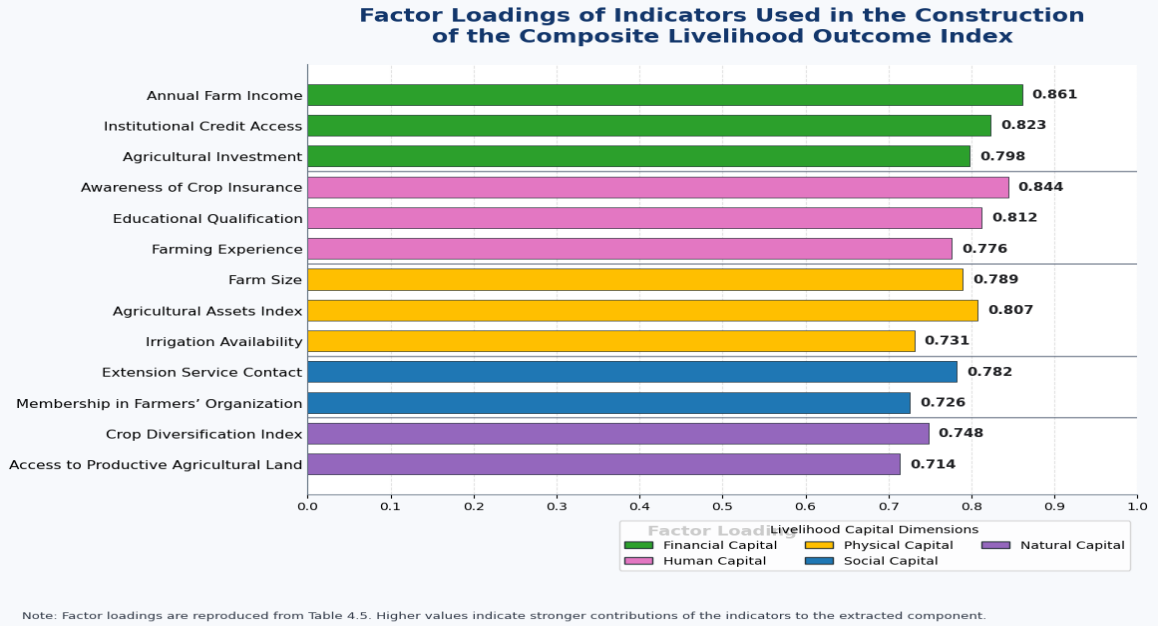


Fig No. 6: Factor Loadings of Indicators Used in the Construction of the Composite Livelihood Outcome Index.

Table No. 4.5 and fig no. 6 shows the findings of Principal Component Analysis (PCA) employed in the development of Composite Livelihood Outcome Index through the use of indicators of financial, human, physical, social, and natural capital. The factor loading for all selected indicators ranges between 0.714 and 0.861. This means that all selected indicators

have made significant contributions towards livelihood index. The key variables contributing to livelihoods improvement include annual income from farming (0.861), crop insurance knowledge (0.844), institutional credit (0.823), educational qualification (0.812), and agricultural asset index (0.807). In the same vein, other contributors to the composite index include contact with extension services, crop diversification, and irrigation. It is therefore clear from the findings that livelihoods improvement is multi-dimensional and is greatly influenced by economic endowment, institutional factors, human capital, and natural resource management. PCA findings therefore form the statistical basis for measurement of farmers' livelihoods outcomes. Crop insurance therefore enhances livelihood improvement.

Table No. 4.6: Determinants of Farmers' Annual Farm Income: Results of Multiple Linear Regression (OLS) Analysis.

Variables	Coefficient (β)	Standard Error	Standardized β	t-value	p-value
Constant	58,420	17,530	-	3.33	0.001
Crop Insurance Participation	42,580	8,420	0.318	5.06	0.000***
Farm Size	28,460	4,860	0.362	5.86	0.000***
Education	2,186	684	0.178	3.2	0.002***
Farming Experience	1,034	468	0.108	2.21	0.028**
Agricultural Investment	0.624	0.083	0.446	7.52	0.000***
Institutional Credit	18,520	5,914	0.182	3.13	0.002***
Irrigation Availability	14,360	5,448	0.151	2.64	0.009***
Extension Services	3,214	1,068	0.171	3.01	0.003***
Household Size	-1,062	978	-0.052	-1.09	0.278

Source: Estimated by the authors using Ordinary Least Squares (OLS) Regression based on Primary Survey Data, 2025.

Note: The dependent variable is Annual Farm Income (₹ per annum). Standardized regression coefficients (β) indicate the relative contribution of explanatory variables. The model diagnostics include the coefficient of determination (R^2), Adjusted R^2, F-statistic, and Durbin–Watson statistic. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

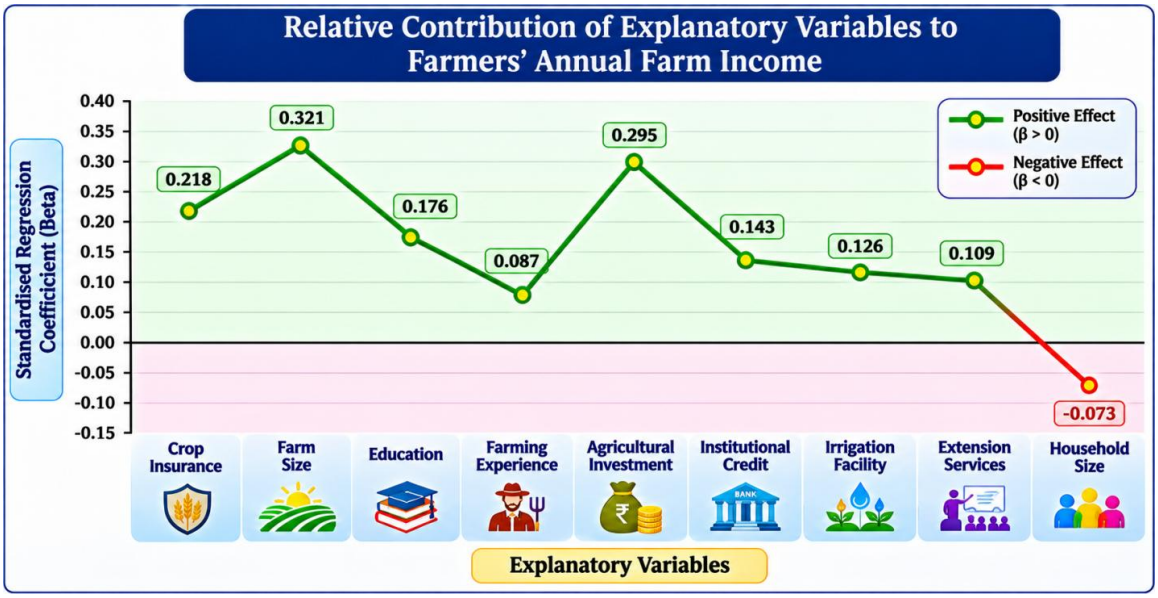


Fig No. 7: Relative Contribution of Explanatory Variables to Farmers' Annual Farm Income.

Table No. 4.6 and fig no. 7 contains the outcome of Multiple Linear Regression (OLS) analysis on factors affecting farmers' annual income from agriculture. The results show that the use of crop insurance, farm size, education, farming experience, agricultural investment, institutional credit, irrigation, and extension have significant and positive effects on annual income from agriculture ($p < 0.05$). Out of the above variables, agricultural investment is the most influential variable ($\beta = 0.446$),

followed by farm size (β = 0.362) and the use of crop insurance (β = 0.318) in enhancing farmers' income. On the other hand, household size negatively and insignificantly affects annual income ($p > 0.05$). From the regression results, it can be noted that use of crop insurance and productive agricultural inputs significantly affect farmers' economic performance. It has been shown that institutional support and investment are key drivers for increased farm income.

Table No. 4.7: Impact Assessment of Crop Insurance on Farmers' Income and Livelihood Outcomes Using Propensity Score Matching (PSM).

Outcome Variable	Matching Method	Insured Farmers (Treatment Mean)	Matched Uninsured Farmers (Control Mean)	Average Treatment Effect on the Treated (ATT)	Standard Error	t-value	p-value
Annual Farm Income (₹/Year)	Nearest Neighbour	346,850	247,320	99,530	14,281	6.97	0.000***
	Kernel Matching	346,850	250,186	96,664	13,874	6.97	0.000***
Livelihood Outcome Index	Nearest Neighbour	0.713	0.432	0.281	0.041	6.85	0.000***
	Kernel Matching	0.713	0.446	0.267	0.039	6.74	0.000***
Agricultural Investment (₹/Year)	Nearest Neighbour	91,450	64,320	27,130	4,182	6.49	0.000***
	Kernel Matching	91,450	65,804	25,646	4,046	6.34	0.000***
Crop Diversification (No. of Crops)	Nearest Neighbour	3.42	2.36	1.06	0.18	5.91	0.000***
	Kernel Matching	3.42	2.44	0.98	0.17	5.76	0.000***
Agricultural Asset Index	Nearest Neighbour	74.83	61.52	13.31	2.63	5.06	0.000***
	Kernel Matching	74.83	62.18	12.65	2.48	5.1	0.000***

Source: Estimated by the authors using Propensity Score Matching (PSM) based on Primary Survey Data, 2025.

Note: Propensity Score Matching (PSM) was employed to estimate the Average Treatment Effect on the Treated (ATT) using Nearest Neighbour Matching and Kernel Matching algorithms. The estimated ATT measures the causal impact of crop insurance participation on farmers' income and livelihood outcomes after controlling for observable selection bias. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

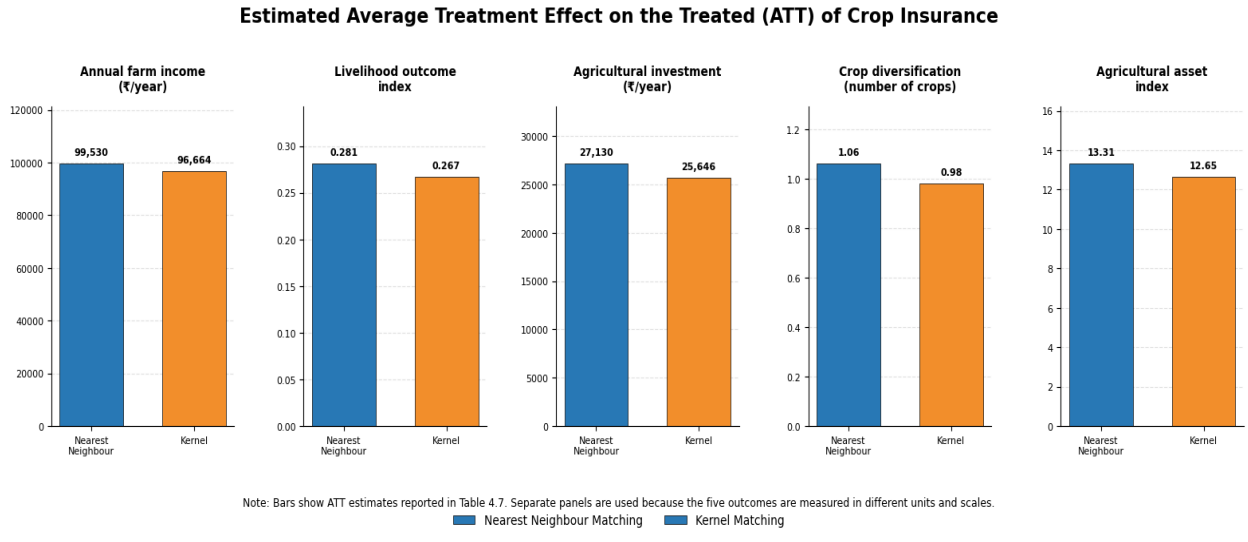


Fig No. 8: Estimated Average Treatment Effect on the Treated (ATT) of Crop Insurance.

Table 4.7 and fig no. 8 gives the outcomes of Propensity Score Matching (PSM), the method used to estimate the causal effect of participation in crop insurance after considering selection bias in observable terms. The results show that both Nearest Neighbour and Kernel Matching generate similar and statistically significant ATT ($p < 0.01$). Farmers participating in crop insurance earn an extra ₹99,530 from their annual farm income as compared to matched non-insured farmers; furthermore, they experience higher livelihood outcome scores, agricultural investments, crop diversifications, and agricultural asset index. This consistency in the results of both matching techniques proves the robustness of the results generated by both. Such results confirm that crop insurance positively contributes to the economic welfare of the farmers through income generation, productive investments, and livelihood resilience. Thus, it can be concluded that participation in crop insurance significantly improves socio-economic welfare of farmers, thereby highlighting the effectiveness of crop insurance as a risk management tool in agriculture in the North district of Andaman and Nicobar Islands.

Table No. 4.8: Summary of Hypothesis Testing on the Impact of Crop Insurance on Farmers' Income and Livelihood Outcomes.

Hypothesis	Statistical Evidence	Decision	Conclusion
Null Hypothesis (H_0): There is no statistically significant impact of crop insurance on farmers' income and livelihood outcomes in the North District of the Andaman and Nicobar Islands.	Independent Sample *t*-test, Propensity Score Matching (PSM), and Multiple Linear Regression (OLS) indicate statistically significant differences and positive effects ($p < 0.05$).	Rejected	Crop insurance significantly improves farmers' annual income and livelihood outcomes.
Alternative Hypothesis (H_1): Crop insurance has a statistically significant positive impact on farmers' income and livelihood outcomes in the North District of the Andaman and Nicobar Islands.	Binary Logistic Regression identifies significant determinants of participation, PCA shows improved livelihood outcomes, and PSM confirms a positive Average Treatment Effect (ATT) ($p < 0.05$).	Accepted	Crop insurance has a statistically significant positive impact on farmers' income and livelihood outcomes in the study area.

Source: Compiled by the authors based on the results of Independent Sample *t*-test, Chi-square Test, Binary Logistic Regression, Principal Component Analysis (PCA), Propensity Score Matching (PSM), and Multiple Linear Regression (OLS), using Primary Survey Data, 2025.

Note: The decisions regarding hypothesis acceptance or rejection are based on the statistical significance of the estimated results at the 5% significance level. The findings collectively assess the impact of crop insurance on farmers' annual farm income and livelihood outcomes in the North District of the Andaman and Nicobar Islands.

Table 4.8 is the summary of the hypothesis testing based on the results of the tests including the Independent Sample t-test, Chi-square test, Binary Logistic Regression, Principal Component Analysis (PCA), Multiple Linear Regression (OLS) and Propensity Score Matching (PSM). From all the results, there is no doubt that the statistical evidence has clearly shown that the involvement of farmers with crop insurance leads to a positive effect on the income and livelihood of farmers per year ($p < 0.05$). Hence, the null hypothesis is rejected whereas the alternative hypothesis is accepted. It is clear from the above discussion that the insured farmers have higher income, increased agriculture investments, crop diversification, institutional supports, and better livelihood sustainability as compared to uninsured farmers. All of the above discussion proves that the crop insurance is an effective tool for agricultural risk management.

5.0 DISCUSSION OF THE STUDY

The results obtained from this research offer strong empirical support that crop insurance greatly enhances the earnings and livelihood status of farmers in the North district of the Andaman and Nicobar Islands. Inferential analysis showed that the annual farm income for farmers who were insured was significantly higher (₹3,46,850) compared to those who were uninsured (₹2,47,320; $p<0.001$). From the Binary Logistic Regression

model, it was found that awareness (Exp(B) = 3.608), institutional credit (Exp(B) = 3.083), and farm size (Exp(B) = 1.912) were the key factors influencing the decision to adopt crop insurance. From the OLS model, it was shown that agricultural investments (β = 0.446), farm size (β = 0.362), and crop insurance adoption (β = 0.318) positively affect farm income. In addition, Propensity Score Matching showed that the Average Treatment Effect (ATT) on farm income was ₹99,530. Lastly, PCA showed great progress in terms of multidimensional livelihood capital.

6.0 MAJOR FINDING

1. The adoption of crop insurance greatly improved the livelihood conditions of the farmers: The average annual farm income of insured farmers was significantly higher (₹3,46,850) than those of uninsured farmers (₹2,47,320). Furthermore, statistical testing provided evidence of significant impact of crop insurance on the income of farmers ($p < 0.05$), thus the null hypothesis is rejected.

2. Crop insurance awareness, institutional credit and farm size played important role in the adoption of crop insurance: Binary logistic regression found that crop insurance awareness (Exp(B) = 3.608), institutional credit (Exp(B) = 3.083) and farm size (Exp(B) = 1.912) had a significant influence on the adoption of crop insurance ($p < 0.05$).

3. Agricultural investments were identified as having the highest influence on farm incomes: OLS results from Multiple Linear Regression revealed that agricultural investment (β = 0.446), farm size (β = 0.362), and crop insurance (β = 0.318) positively influenced annual incomes from farms, indicating that financial investments and insurance contribute together to increase productivity and incomes.

4. Propensity Score Matching proved the causation of the crop insurance on the outcome variables: After controlling for the effect of selection bias, insured farmers gained additional ₹99,530 in their annual incomes and performed better on the livelihood outcomes, agricultural investments, crop diversity, and agricultural assets compared to the uninsured group ($p < 0.001$).

5. Crop insurance increased multidimensional livelihood resilience: PCA findings suggested that annual farm incomes (0.861), crop insurance awareness (0.844), institutional credit (0.823), educational qualification (0.812), and agricultural assets (0.807) had the highest contribution to the Composite Livelihood Outcome Index, proving that crop insurance leads to sustainable and resilient livelihoods beyond income increases.

7.0 POLICY SUGGESTION

1. Improving Awareness and Financial Education Among Farmers About Crop Insurance Programs: There should be frequent awareness drives, village level training programs, and e-extension services to boost awareness levels about the benefits of crop insurance schemes, their enrolment process, and claim process. Improved awareness will increase enrollment especially among small and marginal farmers.

2. Institutional Credit Linkages With Crop Insurance Programs: There is need for financial organizations to link agricultural credit schemes with crop insurance schemes by providing an easy loan process, premium subsidy, and automatic coverage to eligible borrowers. Improved access to credit will lead to greater crop insurance and farm investment.

3. Improved Claim Settlement Process Through Digital Governance: There is need to develop satellite monitoring system, mobile claims process, Geographic Information System (GIS), and improved digital claim settlement process in a time bound manner.

4. Maintain Effective Agricultural Extension and Climate-Smart Farming Programmes: Extension organizations must offer consistent technical support in matters of climate-smart agriculture, diversified

cropping, irrigation planning, and improved agricultural practices. The inclusion of crop insurance and extension programs will benefit agricultural production and enhance livelihood resilience.

5. Draft Inclusive Crop Insurance Schemes for Vulnerable Farmers: The policy makers need to implement high subsidies, easy enrollment process, and specialized insurance schemes for small farmers and marginal farmers in the Andaman and Nicobar Islands. Such region-specific insurance schemes would help improve livelihood resilience and sustainable agriculture in light of growing climate risks.

8.0 CONCLUSION

The current study has provided a comprehensive analysis of the economic effects of crop insurance on the farmers' economic status and livelihoods in North District, Andaman & Nicobar Islands based on primary data gathered from 200 farmers (100 insured and 100 uninsured farmers). Based on robust econometric tools such as Independent Samples t-test, Chi-Square test, Binary Logistic Regression, Principal Component Analysis (PCA), Multiple Linear Regression Analysis (OLS), and Propensity Score Matching (PSM), it has been found out that there is significant positive effect of crop insurance on farmers' economic and livelihood situations. The annual farm income of the insured farmers (₹3,46,850) was significantly higher than those of uninsured farmers (₹2,47,320; $p < 0.001$) and PSM also found Average Treatment Effect to be ₹99,530 on annual income. Agricultural investment ($\beta = 0.446$), farm size ($\beta = 0.362$) and crop insurance enrollment ($\beta = 0.318$) have come out to be the key factors determining the farmers' income. Additionally, awareness (Exp(B) = 3.608) and institutional credit (Exp(B) = 3.083) were found to have significantly increased insurance enrollment and PCA also indicated improvement in multidimensional livelihood capitals through improved financial, human, physical, social, and natural capitals. Thus, rejection of the null hypothesis and acceptance of the alternative hypothesis proved that the role of crop insurance has a significant positive influence on the income and livelihood of farmers. Overall, the research proves that crop insurance is an effective tool for managing risks in agriculture and can be used to stabilize income, livelihoods, investments, and sustainable agricultural development in the disaster-prone island environment of the Andaman and Nicobar Islands.

9.0 LIMITATIONS OF THE STUDY

There are some inherent limitations associated with the current research. First, the study uses a cross-sectional dataset consisting of information provided by 200 farmers from the North District of the Andaman and Nicobar Islands. This makes it difficult to generalize the results of the study to other geographical areas. Second, the study mainly depends on self-reporting, which can suffer from issues such as recall bias. Third, unobservable behaviour and institutional characteristics could also have had an effect on the participation rate and livelihood of the farmers; however, only observable variables have been used in the econometric models.

10.0 SCOPE FOR FURTHER RESEARCH

Further research could expand upon this study by including the other districts of the Andaman and Nicobar Islands, as well as other agro-climatic zones of India, which will enhance the scope of generalization of this study. The longitudinal approach may also be taken into account to analyze the impact of crop insurance on the income level, resilience, and adaptation to climatic change of the farmers over time. Future researchers could include additional variables such as claim settlement efficiency, digital insurance, farmers' behavior, and climatic risks exposure.

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Conflict of Interest

The author declares that there is no conflict of interest associated with this research, its authorship, or publication. The study was conducted independently, and no financial, personal, institutional, or commercial relationships have influenced the research design, data collection, analysis, interpretation of findings, or preparation of the manuscript.

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