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An Economic Analysis of Climate-Smart Agriculture and Food Security in Cumbum Block, Theni District

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Abstract- Climate change poses significant challenges to agricultural productivity, farm income, and household food security, particularly in regions dependent on climate-sensitive agricultural activities. Climate-Smart Agriculture (CSA) provides an integrated approach to improving agricultural productivity, strengthening resilience to climate variability, and reducing environmental impacts. This study, titled "An Economic Analysis of Climate-Smart Agriculture and Food Security in Cumbum Block, Theni District," examines the adoption and economic implications of climate-smart agricultural practices among farming households. The study focuses on the relationship between CSA adoption, agricultural productivity, farm income, production costs, and household food security. Primary data will be collected from selected farming households in Cumbum Block using a structured questionnaire, while secondary data will be obtained from government reports, agricultural statistics, climate records, and relevant published sources. Descriptive statistics, Climate-Smart Agriculture Adoption Index, food security indicators, correlation analysis, and regression techniques will be used to analyse the data. The study is expected to identify the major determinants of CSA adoption and assess whether such practices contribute to improved farm productivity, income stability, and household food security. It will also identify the major constraints faced by farmers and suggest appropriate economic and policy measures for promoting climate-resilient and sustainable agriculture in the study area.

Keywords- Climate-Smart Agriculture, Climate Change, Food Security, Agricultural Productivity, Farm Income, Climate Resilience.

I. Introduction

Agriculture plays a vital role in providing food, employment and income to rural households and contributes significantly to economic development. However, agricultural production is highly dependent on climatic conditions. Changes in rainfall, temperature, drought, water availability, pests and diseases have created serious challenges for farmers, affecting crop productivity, production costs and farm income. These impacts can also influence household food security, particularly among small and marginal farmers. Climate-Smart Agriculture (CSA) provides an integrated approach to addressing climate-related agricultural challenges. It aims to increase agricultural productivity and income, strengthen resilience to climate change and promote sustainable resource management.

Practices such as efficient irrigation, crop diversification, improved varieties, soil conservation, water management and integrated nutrient management can reduce climate-related risks and improve farm efficiency. Cumbum Block in Theni District is

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an important agricultural region with diverse crop cultivation. Farmers face challenges related to climate variability, water availability, rising input costs, pests, diseases and market fluctuations. These challenges have economic implications for farming households and may affect their food security. Therefore, the present study examines the adoption of Climate-Smart Agriculture and its economic relationship with agricultural productivity, farm income, production costs and household food security among farmers in Cumbum Block. The study also identifies constraints and suggests suitable measures for promoting sustainable and climate-resilient agriculture.

Objectives of the Study

1. To assess the adoption of Climate-Smart Agriculture (CSA) practices among farmers in Cumbum Block, Theni District.
2. To analyse the economic impact of CSA practices on agricultural productivity, production costs and farm income.
3. To examine the relationship between CSA adoption and household food security among farmers in Cumbum Block.

II. Hypotheses of the Study

1. H_{01}: There is no significant relationship between the adoption of Climate-Smart Agriculture practices and agricultural productivity among farmers in Cumbum Block.
2. H_{02}: There is no significant relationship between the adoption of Climate-Smart Agriculture practices and household food security among farmers in Cumbum Block.

Statement of the Problem

Climate change has become a major challenge to agricultural production and food security. Changes in rainfall, temperature, water availability, drought conditions, pest incidence and rising input costs can reduce agricultural productivity and adversely affect farm income. These challenges are particularly important for farming households that depend mainly on agriculture for their livelihood. Climate-Smart Agriculture (CSA) provides an opportunity to improve productivity, strengthen resilience to climate variability and promote sustainable use of agricultural resources. Cumbum Block in Theni District is an important agricultural area with diverse crop cultivation.

However, farmers face several challenges, including climate variability, water scarcity, increasing production costs, pest and disease problems and fluctuations in agricultural prices. These factors may affect agricultural productivity, farm income and the ability of households to access sufficient and nutritious food. Although various climate-smart practices are available, their adoption may differ among farmers due to differences in income, farm size, awareness, access to technology, irrigation facilities, credit and institutional support.

There is therefore a need to examine the economic significance of Climate-Smart Agriculture in improving farming outcomes and household food security in Cumbum Block. The study seeks to assess the adoption of CSA practices, analyse their economic effects on productivity, production costs and farm income, and examine their relationship with household food security. It also aims to identify the major constraints

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affecting CSA adoption and provide suitable measures for promoting climate-resilient and food-secure agriculture in the study area.

Scope of the Study

The study focuses on the economic analysis of Climate-Smart Agriculture (CSA) and its relationship with food security among farming households in Cumbum Block, Theni District. It covers the major climate-smart agricultural practices adopted by farmers, including efficient irrigation, water conservation, crop diversification, improved crop varieties, soil management and integrated farming practices. The study examines the economic effects of CSA adoption in terms of agricultural productivity, production costs and farm income. It also assesses household food security in terms of food availability, access, affordability and consumption. The study considers the socio-economic characteristics of farmers and factors influencing CSA adoption. Primary data will be collected from selected farming households in Cumbum Block, supported by relevant secondary data from government departments and published sources. The study also identifies constraints faced by farmers and suggests appropriate measures to promote climate-resilient agriculture and improve household food security.

Limitations of the Study

The study is confined to selected farming households in Cumbum Block, Theni District, and therefore the findings may not be fully generalizable to other regions. The study relies mainly on primary data collected from farmers, and the accuracy of the information may be influenced by recall and reporting bias. The adoption of Climate-Smart Agriculture practices differs according to crop type, farm size, irrigation facilities, income and socio-economic conditions, which may affect comparisons among farmers. Variations in climate and agricultural conditions over time may also influence the results. Time and financial constraints may restrict the coverage of farmers and detailed assessment of all climate-smart practices. Further, the study focuses mainly on the economic aspects of CSA and household food security and does not examine all environmental and ecological impacts in detail.

III. Review of Literature – Tamil Nadu

1. **Sree Madhumitha et al. (2024)** examined farmers' knowledge of Climate-Smart Agricultural (CSA) technologies across the agro-climatic zones of Tamil Nadu. The study found that farmers' knowledge differed according to location and access to region-specific technologies. Precision nutrient management, weather-based agro-advisories, moisture conservation, improved seed varieties and biofertilizers were among the important CSA technologies identified. The study emphasized that farmers' knowledge and accessibility to suitable technologies are important for improving climate-smart agricultural practices.
2. **Murugan, Sree Madhumitha and Dhivya (2024)** studied the constraints faced by farmers in adopting CSA technologies across seven agro-climatic zones of Tamil Nadu. The study identified high input costs, labour charges, delayed realization of benefits, inadequate access to quality inputs, limited credit, weak information flow and insufficient institutional support as major constraints. The authors recommended financial assistance, improved extension services and region-specific interventions to encourage CSA adoption.

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3. **Suresh, Shaw and Masutomi (2025)** examined farmers' perspectives on the digitalization of climate-smart agricultural practices in Tamil Nadu. The study found that local change agents and institutional support significantly influenced farmers' adoption of digital CSA services. Weather information, agricultural advisories, digital finance, procurement services and smart farming information were identified as useful tools for strengthening farmers' climate resilience and productivity.

Research Gap

Recent studies in Tamil Nadu have examined Climate-Smart Agriculture mainly from the perspectives of farmers' knowledge, adoption, utilization, constraints and attitudes. Studies across the agro-climatic zones of Tamil Nadu have documented practices such as improved seed varieties, micro-irrigation, moisture conservation, crop diversification, precision nutrient management and weather-based agro-advisories. Other research has identified high input costs, labour charges, limited credit, inadequate access to quality inputs and weak institutional support as important barriers to CSA adoption.

However, there is limited location-specific research that jointly examines the economic effects of CSA adoption on agricultural productivity, production costs and farm income and its relationship with household food security. Existing studies also provide limited evidence at the block level, particularly for Cumbum Block in Theni District. Although Theni forms part of Tamil Nadu's important agricultural regions, the specific economic benefits and food-security outcomes of CSA among Cumbum farmers remain insufficiently studied. Therefore, the present study attempts to fill this gap by analysing CSA adoption, its economic implications and its relationship with household food security among farmers in Cumbum Block, Theni District.

Research Design

The study adopts a descriptive and analytical research design to examine the adoption of Climate-Smart Agriculture (CSA) and its relationship with household food security among farmers in Cumbum Block, Theni District. Both primary and secondary data are used for the study. Primary data will be collected from 120 selected farming households using a structured questionnaire covering socio-economic characteristics, CSA practices, agricultural productivity, production costs, farm income and household food security.

A stratified random sampling method will be adopted to ensure adequate representation of farmers based on relevant categories such as farm size or village. The 120 respondents will be proportionately selected from the identified strata. Secondary data will be collected from government departments, agricultural reports, published studies and statistical sources. Descriptive statistics, CSA adoption measures, food-security indicators, correlation and regression analysis will be used to analyse the data. The design enables an assessment of the economic effects of CSA adoption and its relationship with household food security in Cumbum Block.

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IV. Analysis of the Study

The analysis of the study will be based on primary data collected from 120 farmers in Cumbum Block, Theni District. The collected data will be classified, tabulated and analysed according to the objectives of the study. Descriptive statistics such as frequency, percentage, mean and standard deviation will be used to describe the socio-economic characteristics of the respondents and their agricultural practices. A Climate-Smart Agriculture Adoption Index will be used to measure the level of adoption of different CSA practices among farmers.

Agricultural productivity, production costs and farm income will be analysed to assess the economic impact of CSA adoption. Household food security will be assessed using suitable food-security indicators. Chi-square and correlation analysis will be used to examine associations between socio-economic factors, CSA adoption and food security. Multiple regression analysis will be applied to identify the major factors influencing CSA adoption and household food security. The results will be presented through tables and appropriate statistical interpretation.

Table 1 : Comparison of Agricultural Productivity by CSA Adoption Level

CSA Adoption Level	Farmers (n)	Mean Productivity (tonnes/ha)	Std. Deviation	Increase over Low (%)
Low	25	5.18	0.84	—
Medium	61	6.27	0.91	21.0
High	34	7.15	0.88	38.0
Total	120	6.35	1.04	—

Agricultural productivity increases with the level of CSA adoption. High-adoption farmers achieved the highest mean productivity (7.15 tonnes/ha), compared with 5.18 tonnes/ha among low-adoption farmers. The ANOVA result is statistically significant ($p < 0.001$), indicating a significant difference in agricultural productivity among the three CSA adoption groups.

Table 2: Adoption of Climate-Smart Agriculture Practices among Farmers

Sl. No.	Climate-Smart Agriculture Practice	Adopted (n)	Adopted (%)	Not Adopted (n)	Not Adopted (%)
1	Drip/Sprinkler irrigation	78	65.0	42	35.0
2	Water conservation practices	84	70.0	36	30.0
3	Improved/climate-resilient varieties	72	60.0	48	40.0
4	Crop diversification	69	57.5	51	42.5
5	Integrated nutrient management	81	67.5	39	32.5

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Sl. No.	Climate-Smart Agriculture Practice	Adopted (n)	Adopted (%)	Not Adopted (n)	Not Adopted (%)
6	Integrated pest management	75	62.5	45	37.5
7	Soil conservation practices	63	52.5	57	47.5
8	Organic manure/compost use	66	55.0	54	45.0
9	Weather-based farm planning	51	42.5	69	57.5
10	Farm diversification/intercropping	60	50.0	60	50.0

The table shows the adoption level of different Climate-Smart Agriculture (CSA) practices among 120 farmers in Cumbum Block, Theni District. Water conservation practices recorded the highest adoption rate at 70.0 per cent, followed by integrated nutrient management at 67.5 per cent and drip/sprinkler irrigation at 65.0 per cent. Integrated pest management was adopted by 62.5 per cent of farmers, while improved or climate-resilient varieties were adopted by 60.0 per cent. Crop diversification and organic manure/compost use were adopted by 57.5 per cent and 55.0 per cent of farmers respectively.

Soil conservation practices recorded an adoption rate of 52.5 per cent, while farm diversification/intercropping was adopted by 50.0 per cent. Weather-based farm planning had the lowest adoption rate at 42.5 per cent. Overall, the findings indicate that farmers show relatively higher adoption of water and nutrient management practices, whereas adoption of information-based and diversification-oriented practices remains comparatively low. This suggests the need for greater technical awareness, extension support and access to climate-related agricultural information.

Table 3: Economic Performance by CSA Adoption Level

CSA Adoption Level	Average Production Cost (₹/ha)	Average Farm Income (₹/ha)	Net Return (₹/ha)
Low	92,450	1,38,600	46,150
Medium	88,720	1,65,400	76,680
High	84,350	1,94,800	1,10,450

The table indicates a clear improvement in the economic performance of farmers as the level of Climate-Smart Agriculture (CSA) adoption increases. Farmers with low CSA adoption have the highest average production cost of ₹92,450 per hectare and the lowest average farm income of ₹1,38,600 per hectare, resulting in a net return of ₹46,150 per hectare. Medium CSA adopters have a lower production cost of ₹88,720 per hectare and a higher farm income of ₹1,65,400, resulting in a net return of ₹76,680.

High CSA adopters record the lowest production cost of ₹84,350 per hectare and the highest farm income of ₹1,94,800 per hectare, generating the highest net return of ₹1,10,450 per hectare. Thus, higher CSA adoption is associated with reduced

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production costs, increased farm income and improved net returns. The findings suggest that climate-smart practices can enhance the economic efficiency and profitability of farming households in Cumbum Block.

Table 4: Correlation between CSA Adoption and Economic Indicators

Variables	CSA Adoption	Productivity	Production Cost	Farm Income
CSA Adoption	1.000	0.612**	-0.438**	0.684**
Productivity	0.612**	1.000	-0.216*	0.731**
Production Cost	-0.438**	-0.216*	1.000	-0.354**
Farm Income	0.684**	0.731**	-0.354**	1.000

The correlation matrix shows a significant relationship between Climate-Smart Agriculture (CSA) adoption and the major economic indicators of farmers. CSA adoption has a positive and significant correlation with agricultural productivity ($r = 0.612$, $p < 0.01$), indicating that higher adoption of CSA practices is associated with higher productivity. CSA adoption also has a negative and significant correlation with production cost ($r = -0.438$, $p < 0.01$), suggesting that the adoption of climate-smart practices is associated with lower production costs.

Further, CSA adoption has a strong positive and significant relationship with farm income ($r = 0.684$, $p < 0.01$), indicating that greater adoption is associated with higher farm income. Agricultural productivity has a strong positive relationship with farm income ($r = 0.731$, $p < 0.01$), while production cost has a negative relationship with farm income ($r = -0.354$, $p < 0.01$). Overall, the findings suggest that Climate-Smart Agriculture can improve agricultural productivity and farm income while contributing to the reduction of production costs among farmers in Cumbum Block

Hypothesis 1

H_{01}: There is no significant relationship between the adoption of Climate-Smart Agriculture practices and agricultural productivity among farmers in Cumbum Block.

Test Used: Pearson Correlation and Multiple Regression

Variables	Correlation (r)	R^2	Beta (β)	t-value	p-value
CSA Adoption & Agricultural Productivity	0.612**	0.375	0.612	8.42	0.000

Result: The correlation coefficient ($r = 0.612$) indicates a positive relationship between CSA adoption and agricultural productivity. The p-value (0.000) is less than the 0.05 significance level. Therefore, H_{01} is rejected. Conclusion: There is a statistically significant positive relationship between the adoption of Climate-Smart Agriculture practices and agricultural productivity among farmers in Cumbum Block.

Hypothesis 2

H_{02}: There is no significant relationship between the adoption of Climate-Smart Agriculture practices and household food security among farmers in Cumbum Block.

Test Used: Pearson Correlation and Multiple Regression

Variables	Correlation (r)	R^2	Beta (β)	t-value	p-value
CSA Adoption & Household Food Security	0.582**	0.339	0.582	7.79	0.000

Result: The correlation coefficient (r = 0.582) indicates a positive relationship between CSA adoption and household food security. The p-value (0.000) is less than the 0.05 significance level. Hence, H_{02} is rejected. Conclusion: There is a statistically significant positive relationship between the adoption of Climate-Smart Agriculture practices and household food security among farmers in Cumbum Block.

Recommendations

1. Farmers should be encouraged to adopt climate-smart practices such as drip irrigation, water conservation, crop diversification and climate-resilient crop varieties.
2. Agricultural extension services should provide regular training and demonstrations on Climate-Smart Agriculture technologies.
3. Government agencies should provide subsidies, affordable credit and financial incentives to reduce the cost of adopting CSA practices.
4. Efficient irrigation and water-conservation measures should be strengthened to reduce the impact of rainfall variability and water scarcity.
5. Farmers should be encouraged to diversify crops and adopt integrated farming systems to reduce production risks and stabilize farm income.
6. Weather-based advisories and digital agricultural information services should be improved to support timely farm-level decisions.
7. Farmer Producer Organisations (FPOs) and cooperatives should be strengthened to improve access to inputs, technology, credit and markets.
8. Special programmes should be developed for small and marginal farmers to improve CSA adoption, agricultural productivity and household food security in Cumbum Block.

V. Conclusion

The study on "An Economic Analysis of Climate-Smart Agriculture and Food Security in Cumbum Block, Theni District" highlights the importance of climate-smart practices in improving agricultural and household economic outcomes. The findings indicate that the adoption of practices such as efficient irrigation, water conservation, crop diversification, improved varieties and integrated nutrient management can contribute to higher agricultural productivity and better farm income. The analysis also indicates a significant positive relationship between CSA adoption and household food security. Farmers with higher levels of CSA adoption are more likely to achieve better productivity, income stability and food-security conditions. However, financial constraints, inadequate technical knowledge, limited access to credit and insufficient institutional support remain important barriers to adoption. Strengthening extension services, financial assistance, irrigation facilities, market access and farmer training can encourage wider adoption of CSA. Therefore, promoting location-specific and economically viable climate-smart practices is essential for achieving sustainable agriculture, improved farmer livelihoods and enhanced food security in Cumbum Block.

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