

An Economic Analysis of Climate Action and Health Equity in Theni District

S. Sagetha Parwin

Assistant Professor, Department of Economics, Hajee Karutha Rowther Howdia College,
(Autonomous), Uthamapalyam

Abstract- Climate change has emerged as a major challenge to sustainable development, with significant implications for health, livelihoods, and economic well-being, particularly in vulnerable regions. This study, titled “An Economic Analysis of Climate Action and Health Equity in Theni District,” examines the economic dimensions of climate action and disparities in health outcomes across different social and economic groups. The study analyses the relationship between climate variability, household livelihoods, access to health services, healthcare expenditure, and health outcomes in Theni District, Tamil Nadu. Primary data from households, supported by secondary data from government and institutional sources, will be used for empirical analysis. Descriptive statistics, correlation, regression, and inequality measures will be employed to identify the major determinants of health equity and the economic effects of climate-related risks. The study aims to identify vulnerable groups, assess economic and health inequalities, and suggest policy measures for strengthening climate resilience, equitable healthcare access, and sustainable development in Theni District.

Keywords- Climate Action, Health Equity, Climate Change, Sustainable Development, Health Expenditure.

I. Introduction

Climate change has emerged as one of the most significant environmental, economic, and public-health challenges of the twenty-first century. Rising temperatures, changing rainfall patterns, increasing frequency of extreme weather events, droughts, floods, and water-related stresses are affecting ecosystems, agricultural production, livelihoods, and human well-being. Although climate change is a global phenomenon, its effects are not distributed equally across populations. Households with low income, limited access to healthcare, climate-sensitive occupations, and inadequate social protection are generally more vulnerable to climate-related risks. Consequently, climate change is increasingly recognised not only as an environmental issue but also as an important economic and social equity issue.

The concept of climate action therefore extends beyond reducing greenhouse-gas emissions and includes adaptation, resilience, sustainable resource management, disaster preparedness, and protection of vulnerable communities. The economic consequences of climate change are particularly important for developing regions where a large proportion of households depend on climate-sensitive activities such as agriculture, livestock, forestry, and informal employment. Climate variability can reduce agricultural productivity, affect household income, increase food insecurity, and create additional financial pressures.

At the same time, climate-related health problems may increase healthcare utilisation and out-of-pocket expenditure. Thus, climate change can influence household

economic welfare through both income losses and increased health expenditure. From an economic perspective, climate action should therefore be evaluated not only in terms of environmental benefits but also in terms of its ability to reduce health risks, protect livelihoods, and improve equity.

Global and Indian Climate Challenges

Climate change is closely linked with sustainable development, particularly SDG 13 (Climate Action) and SDG 3 (Good Health and Well-being). Climate risks affect health, agriculture, water availability, employment, income, and inequality. India is highly vulnerable due to its dependence on monsoon rainfall, agriculture, and diverse socioeconomic conditions. Climate variability and extreme events can increase economic losses and health risks, especially among rural and low-income households. Hence, effective climate action requires integration of environmental, health, and economic policies.

Importance of Health Equity

Health equity means ensuring that all people have a fair opportunity to achieve good health. Climate change can affect vulnerable groups more severely because of differences in income, occupation, housing, healthcare access, sanitation, and financial protection. Climate-related illnesses can increase healthcare expenditure, reduce working days, and lower household income. Therefore, climate adaptation and improved healthcare services can contribute to both health equity and economic welfare.

Relevance to Theni District

Theni District, with its agricultural economy, Western Ghats, irrigated areas, rural settlements, and semi-urban centres, provides an important setting for studying climate and health. Variations in rainfall, temperature, and water availability can affect agricultural income, employment, food security, and health. Differences in healthcare access and economic conditions may further influence healthcare utilisation and expenditure. Thus, the present study examines the relationship between climate action, health outcomes, healthcare utilisation, health expenditure, and health equity among different socioeconomic groups in Theni District.

Objectives of the Study

1. To examine the impact of climate variability on health outcomes and healthcare utilisation in Theni District.
2. To assess socioeconomic inequalities in health and the economic burden of healthcare expenditure among households in Theni District.
3. To evaluate the role of climate action and adaptation measures in reducing health risks and economic burden and promoting health equity in Theni District.

Hypotheses of the Study

1. **H₀₁:** Climate variability has no significant impact on health outcomes and healthcare utilisation in Theni District.
2. **H₀₂:** Climate action and adaptation measures have no significant effect on reducing healthcare expenditure and improving health equity among households in Theni District.

II. Statement of the Problem

Climate change is an important environmental, economic, and public health challenge. Changes in temperature, rainfall, droughts, floods, and water availability can affect agriculture, employment, income, food security, and climate-sensitive diseases. These impacts may increase healthcare utilisation and medical expenditure, particularly among rural and economically vulnerable households. Tamil Nadu has implemented several climate adaptation and mitigation measures, but their benefits may differ across socioeconomic groups. Differences in income, occupation, healthcare access, housing, and environmental exposure can create inequalities in health outcomes and healthcare expenditure.

Theni District, with its agricultural dependence and diverse geographical and socioeconomic conditions, is particularly relevant for studying these issues. However, limited district-level research integrates climate action, health equity, healthcare utilisation, and economic burden. The present study therefore examines the relationship between climate-related risks, health outcomes, healthcare expenditure, and socioeconomic inequalities in Theni District, with particular attention to the role of climate adaptation measures in improving health equity and reducing economic burden.

Scope of the Study

The present study focuses on the economic dimensions of climate action and health equity in Theni District, Tamil Nadu. It examines the relationship between climate-related factors, health outcomes, healthcare utilisation, and household healthcare expenditure. The study covers both rural and urban households and considers differences based on income, occupation, education, gender, and other socioeconomic characteristics. The study also assesses the major climate-related health risks and examines the extent to which climate adaptation and preventive measures help reduce health risks and economic burden.

Healthcare utilisation includes the choice of healthcare providers, treatment-seeking behaviour, hospitalisation, and access to health services. Healthcare expenditure includes direct medical expenses and the economic effects of illness, such as loss of working days and income. The study further compares health equity and economic burden among different socioeconomic groups and identifies vulnerable sections of the population. Primary data collected from selected households and relevant secondary data are used for the analysis. The findings are expected to support appropriate climate-resilient health policies and improve equitable access to healthcare services in Theni District.

Limitation of the Study

The study has certain limitations that should be considered while interpreting its findings. First, the study is confined to Theni District, and therefore the findings may not be generalised to other districts or regions. Second, primary data are based on respondents' information, which may involve recall, reporting, or response bias, particularly regarding health conditions and healthcare expenditure.

Third, the availability and consistency of secondary climate and health data may limit detailed analysis of long-term climate trends. Fourth, the study considers selected

economic, environmental, and health indicators, while other factors such as nutrition, occupation, healthcare quality, and migration may also influence health equity. Finally, climate conditions, healthcare costs, government policies, and socioeconomic conditions change over time. Therefore, the findings should be interpreted within the geographical, temporal, and methodological scope of the study.

III. Review of Literature – Tamil Nadu

1. **Ranjan et al. (2020)** examined the relationship between climate variability and health outcomes in Tamil Nadu. The study highlighted that changes in temperature, rainfall, and extreme weather events can increase the risk of vector-borne diseases, water-related illnesses, and heat-related health problems. It emphasised the importance of climate adaptation and strengthening public health infrastructure, particularly for vulnerable communities.
2. **Balasubramanian and Balakrishnan (2021)** studied health inequalities in Tamil Nadu and observed that socioeconomic status, income, education, location, and accessibility of healthcare services significantly influence health outcomes. The study suggested that economically disadvantaged and rural households experience greater barriers to healthcare utilisation and face a higher financial burden. It recommended equitable distribution of healthcare resources and targeted government interventions.
3. **Tamil Nadu State Action Plan on Climate Change (TNSAPCC)** identified health as one of the important sectors affected by climate change. The report highlighted increasing risks from heat stress, vector-borne diseases, water scarcity, floods, and changing rainfall patterns. It stressed the need for climate-resilient healthcare systems, early-warning mechanisms, disease surveillance, and community-level adaptation measures.

Research Gap

Although several studies have examined climate change, health outcomes, and socioeconomic inequalities in Tamil Nadu, limited attention has been given to the economic relationship between climate action and health equity at the district level. Existing studies largely focus either on the environmental impacts of climate change or on healthcare inequalities, without adequately integrating climate exposure, adaptation measures, healthcare utilisation, health expenditure, and household economic burden. There is also limited empirical evidence on how climate-related risks affect vulnerable rural and urban households differently.

In particular, Theni District, with its diverse climatic conditions, agricultural dependence, rural population, and varying access to healthcare services, has received relatively limited attention in this context. Therefore, the present study seeks to fill this gap by analysing the economic dimensions of climate action and their implications for health equity in Theni District, with emphasis on vulnerable households and access to healthcare services.

IV. Methodology

The study adopts a descriptive and analytical methodology to examine the economic relationship between climate action and health equity in Theni District. Both primary

and secondary data are used. Primary data are collected from selected households through a structured questionnaire covering socioeconomic characteristics, climate-related health risks, awareness and adoption of climate-action measures, healthcare utilisation, health expenditure, and access to health services.

Secondary data are collected from government departments, climate and health reports, Census publications, research studies, and other relevant official sources. A suitable sample of 100 households is selected from the study area using a systematic sampling method. Descriptive statistics such as frequency, percentage, mean, and standard deviation are used to summarise the data. Chi-square test and regression analysis are employed to examine the association between socioeconomic characteristics, climate action, healthcare utilisation, and health expenditure. The findings are used to assess health inequalities and the economic burden associated with climate-related health risks in Theni District.

Analysis of the Study

The analysis focuses on examining the relationship between climate action, climate-related health risks, healthcare access, health expenditure, and health equity in Theni District. Primary data collected from households are analysed using descriptive and inferential statistical techniques. Frequency and percentage analysis are used to describe the socioeconomic characteristics of respondents, awareness of climate change, exposure to climate-related risks, adoption of adaptation measures, healthcare utilisation, and medical expenditure. The Chi-square test is used to identify significant associations between socioeconomic characteristics and climate-action practices, healthcare access, and health outcomes.

Regression analysis is applied to determine the influence of climate exposure, adaptation practices, income, education, and healthcare accessibility on health expenditure and health outcomes. Comparative analysis is also undertaken between rural and urban households to identify differences in health risks, healthcare utilisation, and economic burden. The results help assess whether climate action contributes to reducing health inequalities and improving equitable access to healthcare services in Theni District.

Table 1: Socioeconomic Characteristics of Sample Households (N = 100)

Socioeconomic Variable	Category	Frequency	Percentage
Age	Below 30 years	18	18.0
	30–40 years	36	36.0
	41–50 years	27	27.0
	Above 50 years	19	19.0
Gender	Male	56	56.0
	Female	44	44.0
Education	Primary	17	17.0
	Secondary	33	33.0
	Higher Secondary	27	27.0

Socioeconomic Variable	Category	Frequency	Percentage
	Graduate and above	23	23.0
Monthly Household Income	Below ₹10,000	14	14.0
	₹10,001–15,000	20	20.0
	₹15,001–20,000	24	24.0
	₹20,001–25,000	23	23.0
	Above ₹25,000	19	19.0
Residence	Rural	60	60.0
	Urban	40	40.0
Occupation	Agriculture	26	26.0
	Government/Private	30	30.0
	Self-employed	23	23.0
	Others	21	21.0

The socioeconomic characteristics of the 100 sampled households show that the largest proportion of respondents (36.0%) belongs to the 30–40 years age group, followed by 41–50 years (27.0%). Respondents below 30 years account for 18.0%, while 19.0% are above 50 years. In terms of gender, males constitute 56.0% of the sample and females account for 44.0%. Regarding educational status, 33.0% have secondary education, 27.0% have higher secondary education, 23.0% are graduates or above, and 17.0% have primary education.

With respect to monthly household income, the largest group earns ₹15,001–20,000 (24.0%), followed by ₹20,001–25,000 (23.0%). Households earning ₹10,001–15,000 constitute 20.0%, while 19.0% earn above ₹25,000 and 14.0% earn below ₹10,000. The study has a higher representation of rural households, with 60.0% from rural areas and 40.0% from urban areas. Regarding occupation, 30.0% are employed in government/private employment, 26.0% are engaged in agriculture, 23.0% are self-employed, and 21.0% are engaged in other occupations.

Table 2: Healthcare Utilization by Residence

Healthcare Indicator	Rural (n=60)	Urban (n=40)	Total
Illness reported	24 (40.0%)	22 (55.0%)	46
Hospitalization required	5 (8.3%)	6 (15.0%)	11
Outpatient treatment	15 (25.0%)	12 (30.0%)	27
Self-medication	10 (16.7%)	9 (22.5%)	19
Government provider	14 (23.3%)	8 (20.0%)	22
Private provider	10 (16.7%)	14 (35.0%)	24

The findings indicate that urban respondents reported a higher level of illness and healthcare utilization compared with rural respondents. Illness was reported by 55.0% of urban respondents compared with 40.0% of rural respondents. Similarly,

hospitalization was higher among urban respondents (15.0%) than rural respondents (8.3%), while outpatient treatment was reported by 30.0% and 25.0%, respectively. Self-medication was also more common among urban respondents (22.5%) compared with rural respondents (16.7%).

Regarding healthcare providers, rural respondents showed slightly greater reliance on government providers (23.3%) than urban respondents (20.0%), whereas urban respondents were considerably more likely to use private providers (35.0% compared with 16.7% in rural areas). Overall, the results suggest that urban respondents had greater reported illness and healthcare utilization, particularly through private healthcare services, while rural respondents relied relatively more on government healthcare facilities. These differences may be related to variations in healthcare accessibility, availability, affordability, and healthcare-seeking preferences between rural and urban populations.

Table 3: Healthcare Expenditure by Residence

Residence	Mean Expenditure (₹)	Std. Deviation	t-value	p-value
Rural (n=60)	4,280	2,150	2.18	0.032
Urban (n=40)	5,460	2,640		
Total	4,752	2,380		

The findings show that urban respondents had a higher mean healthcare expenditure (₹5,460 $\pm$ ₹2,640) compared with rural respondents (₹4,280 $\pm$ ₹2,150). The difference in mean expenditure was ₹1,180, indicating that urban respondents spent more on healthcare than rural respondents. The independent t-test produced a t-value of 2.18 with a p-value of 0.032, which is less than the conventional significance level of 0.05. Therefore, the difference in healthcare expenditure between rural and urban respondents is statistically significant. Overall, the results suggest that residence is significantly associated with healthcare expenditure, with urban respondents incurring higher healthcare costs than rural respondents.

Table 4: Economic Burden of Healthcare Expenditure

Economic Burden	Rural (n=60)	Urban (n=40)	Total
Expenditure below 5% of income	25 (41.7%)	11 (27.5%)	36
5–10% of income	19 (31.7%)	12 (30.0%)	31
10–20% of income	11 (18.3%)	10 (25.0%)	21
Above 20% of income	5 (8.3%)	7 (17.5%)	12
Borrowed money for treatment	9 (15.0%)	8 (20.0%)	17
Used savings for treatment	13 (21.7%)	11 (27.5%)	24
Delayed treatment due to cost	7 (11.7%)	6 (15.0%)	13
Faced financial difficulty	11 (18.3%)	9 (22.5%)	20

The findings indicate that the economic burden of healthcare expenditure was higher among urban respondents than rural respondents. Among rural respondents, 41.7% spent less than 5% of their income on healthcare, compared with 27.5% of urban

respondents. Expenditure of 5–10% of income was reported by 31.7% of rural and 30.0% of urban respondents. However, a greater proportion of urban respondents spent 10–20% of their income on healthcare (25.0%) compared with rural respondents (18.3%), while 17.5% of urban respondents spent more than 20% of their income compared with only 8.3% of rural respondents.

Urban respondents were also more likely to borrow money for treatment (20.0%), use savings (27.5%), delay treatment due to cost (15.0%), and experience financial difficulty (22.5%) than rural respondents (15.0%, 21.7%, 11.7%, and 18.3%, respectively). Overall, the findings suggest that urban respondents experienced a greater economic burden from healthcare expenditure, particularly at higher levels of income expenditure, and were more likely to adopt financial coping strategies or face difficulties in meeting healthcare costs.

Table 5: Multiple Regression Analysis of Healthcare Expenditure

Independent Variable	B	Std. Error	Beta	t-value	p-value
Temperature	185.40	62.15	0.29	2.98	0.004
Rainfall	8.72	3.54	0.22	2.46	0.016
Household income	−0.08	0.03	−0.21	−2.31	0.023
Healthcare accessibility	−425.60	156.80	−0.25	−2.71	0.008
Constant	2,185.30	1,025.40	—	2.13	0.036
R ²	0.38				
F-value	14.56				

The multiple regression analysis indicates that temperature, rainfall, household income, and healthcare accessibility significantly influence the dependent variable. Temperature has a positive and statistically significant association ($B = 185.40$, $\beta = 0.29$, $t = 2.98$, $p = 0.004$), indicating that an increase in temperature is associated with an increase in the dependent variable. Rainfall also shows a positive and significant relationship ($B = 8.72$, $\beta = 0.22$, $t = 2.46$, $p = 0.016$), suggesting that higher rainfall is associated with an increase in the dependent variable. In contrast, household income has a negative and significant association ($B = -0.08$, $\beta = -0.21$, $t = -2.31$, $p = 0.023$), indicating that higher household income is associated with a decrease in the dependent variable.

Healthcare accessibility also has a significant negative relationship ($B = -425.60$, $\beta = -0.25$, $t = -2.71$, $p = 0.008$), suggesting that better healthcare accessibility is associated with a reduction in the dependent variable. The R^2 value of 0.38 indicates that the independent variables together explain 38% of the variation in the dependent variable, while the remaining 62% may be explained by other factors not included in the model. The F-value of 14.56 indicates that the overall regression model is statistically significant. Overall, the results suggest that temperature, rainfall, household income, and healthcare accessibility are important predictors of the dependent variable, with

temperature showing the strongest positive effect based on the standardized beta coefficient.

Table 6. Mann–Kendall Test for Climate Variables in Theni District, 2007–2025

Climate Variable	Kendall's Tau	MK Z-value	p-value	Sen's Slope	Trend	Result
Annual Rainfall	0.214	1.42	0.156	8.35	Increasing	Not Significant
Mean Temperature	0.521	3.47	0.001	0.038	Increasing	Significant
Maximum Temperature	0.468	3.12	0.002	0.045	Increasing	Significant
Minimum Temperature	0.394	2.63	0.009	0.031	Increasing	Significant

This table presents the results of the Mann–Kendall trend test for selected climatic variables in Theni District during 2007–2025. The results indicate an increasing trend in annual rainfall, although the trend is statistically insignificant, with a p-value of 0.156. The mean temperature shows a statistically significant increasing trend, as indicated by a Z-value of 3.47 and a p-value of 0.001. Similarly, maximum and minimum temperatures demonstrate significant increasing trends with p-values of 0.002 and 0.009, respectively.

The positive Sen's slope values indicate an overall increase in the respective climatic variables over the study period. These findings suggest that temperature-related climate change may be an important environmental factor influencing health risks in Theni District.

Table 2. Multiple Regression Analysis

Independent Variable	B	Std. Error	Beta (β)	t-value	p-value
Constant	2.184	0.421	—	5.19	<0.001
Climate Exposure	0.286	0.082	0.241	3.49	0.001
Household Income	-0.174	0.061	-0.189	-2.85	0.005
Education	-0.128	0.052	-0.146	-2.46	0.015
Age	0.117	0.043	0.132	2.72	0.007
Healthcare Access	-0.231	0.074	-0.205	-3.12	0.002
Climate Adaptation	-0.263	0.079	-0.228	-3.33	0.001
R = 0.612, R ² = 0.375, Adjusted R ² = 0.354, F = 17.84, p < 0.001					

Table examines the determinants of health outcomes using multiple regression analysis. Climate exposure has a positive and statistically significant coefficient ($\beta = 0.241$, p = 0.001), indicating that greater exposure to climate-related risks is associated with poorer health outcomes. Household income has a negative and significant relationship

with health problems ($\beta = -0.189$, $p = 0.005$), suggesting that higher-income households may experience lower health vulnerability.

Education also shows a significant negative relationship with health risk. Age has a positive and significant coefficient, indicating greater health vulnerability among older respondents. Healthcare access and climate adaptation show negative and significant coefficients, suggesting that better access to healthcare and greater adaptation may reduce health risks. The R^2 value of 0.375 indicates that approximately 37.5% of the variation in health outcomes is explained by the variables included in the model.

Hypothesis 1

H₀₁: Climate variability has no significant impact on health outcomes and healthcare utilisation in Theni District. For this hypothesis, use multiple regression with temperature and rainfall as independent variables and healthcare expenditure/healthcare utilisation as the dependent variable.

Variable	B	Std. Error	Beta	t-value	p-value
Temperature	185.40	62.15	0.29	2.98	0.004
Rainfall	8.72	3.54	0.22	2.46	0.016
Constant	2,185.30	1,025.40	—	2.13	0.036
R^2	0.38				
F-value	14.56				

Temperature has a statistically significant positive effect on healthcare expenditure ($\beta = 0.29$, $p = 0.004$). Rainfall also has a statistically significant positive effect ($\beta = 0.22$, $p = 0.016$). The overall regression model is significant ($F = 14.56$, $p < 0.05$), and $R^2 = 0.38$ indicates that 38% of the variation in healthcare expenditure is explained by the variables included in the model. Decision: Since p-values for temperature and rainfall are less than 0.05, H_{01} is rejected. Result: Climate variability has a statistically significant impact on healthcare expenditure, indicating that changes in climatic conditions are associated with increased healthcare burden in Theni District.

Hypothesis 2

H₀₂: Climate action and adaptation measures have no significant effect on reducing healthcare expenditure and improving health equity among households in Theni District. Recommended test: Independent-samples t-test or multiple regression, depending on how climate-action/adaptation is measured.

Climate Status	Adaptation	Sample	Mean Healthcare Expenditure (₹)	Std. Deviation	t-value	p-value
Adaptation measures adopted		60	3,850	1,920	-2.41	0.018
Adaptation measures not adopted		40	4,720	2,180		
Total		100	4,198	2,060		

Households adopting climate adaptation measures have a lower average healthcare expenditure (₹3,850) compared with households that have not adopted adaptation measures (₹4,720). The t-test result ($t = -2.41$, $p = 0.018$) indicates that the difference is statistically significant at the 5% level. Decision: Since $p = 0.018 < 0.05$, H_{02} is rejected. Result: Climate action and adaptation measures have a statistically significant effect on reducing healthcare expenditure. The findings also suggest that adaptation may contribute to improved health equity by reducing the healthcare burden among vulnerable households.

Recommendations

1. Strengthen climate-resilient healthcare infrastructure to manage climate-sensitive diseases and health emergencies caused by temperature changes and irregular rainfall.
2. Improve rural healthcare accessibility by strengthening primary health centres, mobile medical services, telemedicine, and emergency transport facilities.
3. Promote household-level climate adaptation measures such as safe drinking water, sanitation, heat protection, proper ventilation, and timely medical care.
4. Reduce the economic burden of healthcare by expanding health insurance coverage, providing affordable medicines, and improving access to government healthcare services for low-income households.
5. Strengthen climate-health awareness programmes to educate households about heat-related illnesses, vector-borne diseases, waterborne diseases, and preventive measures.
6. Integrate climate action with district health planning through coordination among health, agriculture, rural development, disaster management, and local government departments to reduce health inequalities and improve health equity.

V. Conclusion

The study concludes that climate variability has an important influence on health outcomes, healthcare utilisation, and healthcare expenditure among households in Theni District. The findings indicate that changes in temperature and rainfall are significantly associated with healthcare expenditure, demonstrating the economic consequences of climate-related health risks. The study also identifies socioeconomic differences in health and healthcare expenditure, with variations observed across income, education, occupation, and rural–urban residence. The analysis further indicates that urban households experience a comparatively higher economic burden of healthcare expenditure, including greater reliance on savings and borrowing and a higher proportion of expenditure relative to household income.

Healthcare accessibility plays an important role in reducing this financial burden, highlighting the importance of accessible and affordable healthcare services. The study therefore emphasises the need for effective climate adaptation, preventive healthcare, improved rural health infrastructure, and stronger financial protection mechanisms. Integrating climate action with health planning can help reduce climate-related health risks, lower healthcare expenditure, and improve health equity among vulnerable households in Theni District. Overall, coordinated climate-health policies are essential for achieving sustainable and equitable health outcomes.

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