Climate Change and Household Sustainable Development in Madurai District, Tamil Nadu: An Economic Analysis

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Abstract

Climate change has increasingly become an important concern for households because changes in temperature, rainfall, water availability and weather conditions can affect livelihoods, household expenditure and everyday living conditions. This study examines the relationship between climate change and household sustainable development in Madurai District of Tamil Nadu, with particular attention to household perceptions, climate-related effects, sustainable practices and adaptation measures. The study is based mainly on primary data collected during 2026 from 120 households selected from three taluks of Madurai District through a structured interview schedule. Frequency and percentage analysis mean values, chi-square test and multiple regression analysis were used to examine household responses and the factors associated with sustainable practices. The findings indicate that a large proportion of households perceived an increase in temperature, greater summer severity, irregular rainfall and declining water availability. Water shortage was the most commonly reported climate-related effect, followed by increased household expenditure and reduced livelihood opportunities. At the household level, switching off unused electrical appliances, using LED bulbs, storing water during shortages and reducing electricity consumption were among the more commonly adopted practices. However, rainwater harvesting, solar energy use, composting and home gardening showed comparatively lower adoption. The chi-square results indicate significant associations between sustainable household practices and age, education, occupation, monthly income and housing condition, while family size was not statistically significant. The regression results further show that education, income, occupation, climate change perception, water conservation and climate awareness are positively associated with sustainable household practices, with the model

explaining 46.4 per cent of the variation. The study highlights the importance of household awareness, water management, sustainable resource use and institutional support in strengthening climate resilience and sustainable development at the local level.

Keywords: Climate Change; Household Sustainable Development; Livelihood Vulnerability; Climate Adaptation; Rural Households; Water Security; Sustainable Livelihoods

Introduction

Climate change has become an important economic and social concern because it affects natural resources, household livelihoods and the quality of everyday life. Changes in temperature, rainfall patterns, water availability and the frequency of extreme weather conditions can directly influence the income, expenditure and living conditions of households. These effects are particularly important in areas where families depend on agriculture, agricultural labour, small-scale activities and other climate-sensitive sources of livelihood. At the household level, climate change may also influence decisions relating to water use, energy consumption, waste management and adaptation practices. Madurai District of Tamil Nadu has experienced considerable variation in climatic conditions and seasonal water availability. Households are required to adjust their daily activities and resource-use patterns in response to these changes. Sustainable household practices such as conserving water, reducing unnecessary energy use, reusing materials, segregating waste and adopting suitable adaptation measures can contribute to better resource management and household resilience. However, the adoption of such practices may differ according to education, occupation, income, housing conditions and other socio-economic characteristics. Therefore, an understanding of household perceptions and responses is important for developing practical local-level measures. Against this background, the present study examines climate change and household sustainable development in Madurai District, with particular attention to household perceptions, climate-related effects, sustainable practices and adaptation measures.

Statement of the Problem

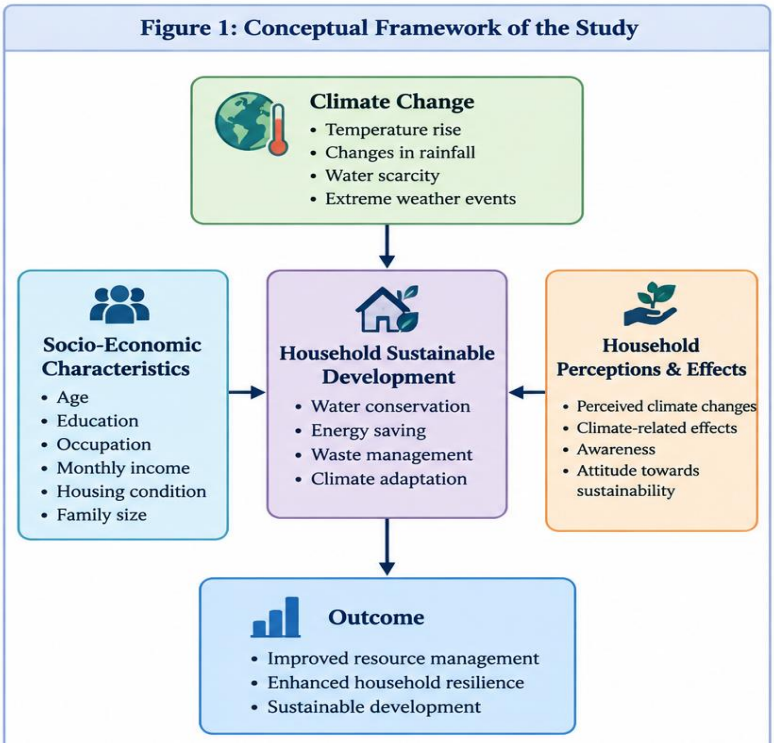
Household are becoming more and more impacted by climate change due to variations in temperature, precipitation, water availability, and the circumstances surrounding local livelihoods. Individual households feel the effects of climate change in different ways, despite the fact that these changes are extensively discussed both nationally and globally.

When water becomes scarce, employment possibilities decrease, or spending rises, families with low income and a greater reliance on natural resources may find it challenging to meet household demands. At the same time, households can reduce some of these pressures through sustainable practices such as water conservation, energy saving, waste segregation, reuse of materials and appropriate adaptation measures. In Madurai District, there is a need to understand how households perceive climate-related changes and how these perceptions are reflected in their everyday practices. Differences in education, occupation, income and housing conditions may also influence the adoption of sustainable practices. However, household-level evidence covering these aspects together is limited. The present study therefore focuses on selected households in three taluks of Madurai District to examine their experiences of climate change, sustainable resource-use practices and adaptation responses. The study also considers the relationship between selected socio-economic characteristics and household sustainable practices.

Objectives of the Study

1. To examine the perception and effects of climate change on households in Madurai District.
2. To analyse household sustainable practices relating to water conservation, energy saving, waste management and climate adaptation, and to examine their association with selected socio-economic characteristics.

Figure 1: Conceptual Framework of the Study



Review of Literature

Studies on climate change and household sustainability have examined the effects of environmental changes on livelihoods, resource use and adaptation behaviour. **Stern (2007)** highlighted the economic significance of climate change and explained that its effects extend beyond the environment to production, consumption, income and living standards. **Adger (2003)** examined social capital and adaptation and noted that the ability of communities to respond to environmental changes is influenced by social and institutional conditions. **Mendelsohn, Nordhaus and Shaw (1994)** analysed the economic effects of climate variation on agriculture and demonstrated that changes in climatic conditions can have measurable consequences for economic activity and household welfare. **Deressa, Hassan and Ringler (2011)** studied adaptation methods among farm households and found that access to information, education, resources and institutional support can influence household decisions regarding climate adaptation. **Field et al. (2014)**, through the IPCC assessment of climate change impacts, adaptation and vulnerability, emphasised that adaptation at household and community levels is important for reducing climate-related risks. These studies collectively show that climate change is not only an environmental issue but also an economic and household-level concern. They also indicate that socio-economic conditions, access to resources and awareness can influence the capacity of households to adopt appropriate responses. However, household-level evidence relating climate perceptions with water conservation, energy use, waste management and adaptation practices remains important in local contexts. The present study addresses this aspect by examining selected households in Madurai District.

Methodology

Choice of the Study Area: The study was conducted in Madurai District of Tamil Nadu. The district was selected because households in the area depend on agriculture, agricultural labour, small-scale occupations and other activities that are sensitive to variations in climate and natural resources. For the primary survey, three taluks were selected to cover households with different socio-economic and environmental conditions.

Nature and Source of Data: The study is based mainly on primary data. Information was collected directly from selected households through a structured interview schedule. The questionnaire covered socio-economic characteristics, household perceptions of climate change, effects on livelihoods and expenditure, water conservation, energy-saving practices,

waste management and climate adaptation measures. Relevant secondary information was also referred to for understanding the general background of climate change and sustainable development.

Period of the Study: The primary field survey was undertaken during 2026. The period covered the collection, checking and organisation of household-level information required for the study.

Sampling Design and Sample Size: A sample of **120 households** was selected from three selected taluks of Madurai District. Households were chosen through a simple sampling procedure with attention to obtaining respondents from different localities. The respondents were selected based on their availability and willingness to provide information during the field survey.

Tools of Data Collection: A structured interview schedule was used for collecting primary information. The questions included both categorical and multiple-response items. Before final data collection, the schedule was checked for clarity and suitability to the local household context.

Tools of Analysis: The collected data were classified and tabulated using frequency and percentage analysis. Mean values were used wherever appropriate. A **chi-square test** was applied to examine the association between selected socio-economic characteristics and household sustainable practices. The results were interpreted in relation to the objectives of the study.

Scope of the Study: The study concentrates on household-level experiences and responses to climate change. Particular attention is given to sustainable use of water and energy, waste management and adaptation practices. The findings are intended to provide a local understanding of household behaviour and the areas where greater awareness, infrastructure and institutional support may be required.

Result and Discussion

This section presents the findings of the household survey conducted among 120 respondents from the selected taluks of Madurai District. The analysis focuses on the socio-

economic background of the households, their perception of climate change, the effects experienced in their daily lives and the sustainable practices adopted at the household level. Particular attention is given to water conservation, energy saving, waste management and climate adaptation measures. The section also examines whether selected socio-economic characteristics are associated with differences in sustainable household practices. The results are presented through tables using frequencies, percentages and suitable statistical analysis, followed by a brief discussion of the major findings.

Table 1: Socio-economic Characteristics of the Sample Households (Illustrative)

Characteristics	Category	Respondents	Percentage
Age	Below 30 years	22	18.33
	30–40 years	38	31.67
	41–50 years	34	28.33
	Above 50 years	26	21.67
Education	Primary	28	23.33
	Secondary	39	32.50
	Higher Secondary	31	25.83
	Graduate and above	22	18.33
Occupation	Agriculture	36	30.00
	Agricultural labour	31	25.83
	Self-employed	28	23.33
	Other	25	20.83
Monthly income	Below Rs.10,000	34	28.33
	Rs.10,000–Rs.20,000	42	35.00
	Rs.20,001–Rs.30,000	27	22.50
	Above Rs.30,000	17	14.17
Total		**120**	**100.00**

Source: Survey data.

The table 1 shows that the socio-economic profile shows that 38 households (31.67 per cent) are in the 30–40 age group, followed by 34 households (28.33 per cent) in the 41–

50 age group. Regarding education, 39 respondents (32.50 per cent) have secondary education. Agriculture is the main occupation for 36 households (30.00 per cent), followed by agricultural labour with 31 households (25.83 per cent). In terms of income, 42 households (35.00 per cent) earn Rs.10,000–Rs.20,000 per month, indicating that a considerable share of the households belongs to the lower-middle-income group.

Table 2: Household Perception of Climate Change

Perception of climate change	Respondents	Percentage
Temperature has increased	91	75.83
Rainfall has become irregular	84	70.00
Water availability has declined	78	65.00
Summer has become more severe	88	73.33
Extreme weather events have increased	63	52.50
No significant change noticed	14	11.67

Source: Survey data.

It is shows that the table 2 the household responses show that 91 respondents (75.83 per cent) perceived an increase in temperature, while 88 respondents (73.33 per cent) felt that summer conditions had become more severe. Irregular rainfall was reported by 84 respondents (70.00 per cent), and 78 respondents (65.00 per cent) observed a decline in water availability. A further 63 respondents (52.50 per cent) noticed an increase in extreme weather events. Only 14 respondents (11.67 per cent) reported that they had not noticed any significant climatic change.

Table 3: Effects of Climate Change on Households Illustrative)

Major effect	Respondents	Percentage
Increase in household expenditure	76	63.33
Reduction in livelihood opportunities	61	50.83
Water shortage	83	69.17
Agricultural/livelihood losses	58	48.33

Food-related difficulties	42	35.00
Health-related problems	47	39.17
Temporary migration	24	20.00

Source: Survey data.

It is reveals that the table 3 water shortages was the most commonly reported effect, affecting 83 households (69.17 per cent). Increased household expenditure was reported by 76 households (63.33 per cent), showing that climate-related changes can place additional pressure on family budgets. Reduction in livelihood opportunities was reported by 61 households (50.83 per cent), while 58 households (48.33 per cent) experienced agricultural or livelihood losses. Health-related problems affected 47 households (39.17 per cent), and 24 households (20.00 per cent) reported temporary migration.

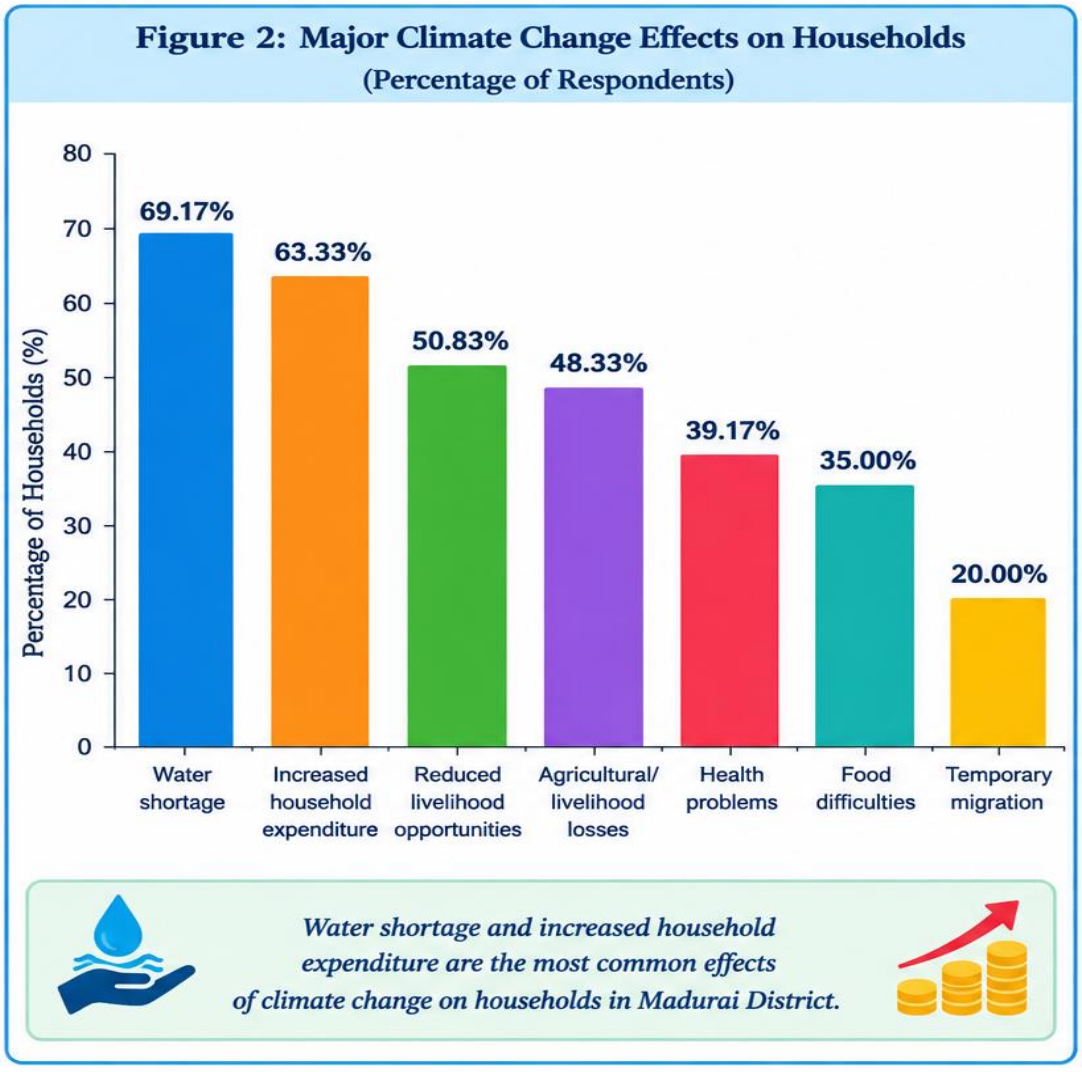


Table 4: Adoption of Sustainable Household Practices

Practice	Regularly	Occasionally	Not Practiced
Use of reusable materials	54 (45.00%)	38 (31.67%)	28 (23.33%)
Avoidance of unnecessary plastic	49 (40.83%)	44 (36.67%)	27 (22.50%)
Water conservation	57 (47.50%)	39 (32.50%)	24 (20.00%)
Energy conservation	63 (52.50%)	37 (30.83%)	20 (16.67%)
Waste segregation	41 (34.17%)	36 (30.00%)	43 (35.83%)
Energy-efficient appliances	46 (38.33%)	42 (35.00%)	32 (26.67%)
Kitchen/home gardening	35 (29.17%)	31 (25.83%)	54 (45.00%)

Source: Survey data.

Table 4 indicates that the Energy conservation was regularly practised by 63 households (52.50 per cent), making it the most commonly followed regular sustainable practice. Water conservation was regularly adopted by 57 households (47.50 per cent), while 54 households (45.00 per cent) regularly used reusable materials. Avoidance of unnecessary plastic was regularly practised by 49 households (40.83 per cent). Waste segregation was comparatively weaker, with only 41 households (34.17 per cent) practising it regularly. Home gardening was also limited, with 54 households (45.00 per cent) reporting that they did not practise it.

Table 5: Water Conservation Practices among Households

Water conservation practice	Respondents	Percentage
Rainwater harvesting	38	31.67
Reuse of household water	52	43.33
Repair of leaking taps/pipes	67	55.83
Water-efficient use	71	59.17
Water storage during shortage	74	61.67
No specific conservation practice	19	15.83

Source: Survey data.

The Table 5 depicts that water storage during periods of shortage was reported by 74 households (61.67 per cent), making it the most common water-related response. Water-efficient use was followed by 71 households (59.17 per cent), while 67 households (55.83 per cent) report repairing leaking taps and pipes. Recycle of household water was practiced by 52 households (43.33 per cent). Rainwater harvesting was reported by only 38 households (31.67 per cent), indicating that this practice has comparatively limited adoption among the households covered by the study.

Table 6: Energy-Saving Practices among Households

Energy-saving practice	Respondents	Percentage
Use of LED bulbs	89	74.17
Switching off unused appliances	96	80.00
Use of energy-efficient appliances	58	48.33
Use of solar energy	29	24.17
Reduction in electricity consumption	72	60.00
Other energy-saving practices	18	15.00

Source: Survey data.

Table 6 reveals that switching off unused electrical appliances was the most widely followed practice, reported by 96 households (80.00 per cent). The use of LED bulbs was reported by 89 households (74.17 per cent), while 72 households (60.00 per cent) stated that they tried to reduce electricity consumption. Energy-efficient appliances were used by 58 households (48.33 per cent). Solar energy was adopted by only 29 households (24.17 per cent), suggesting that the use of renewable energy remains relatively limited compared with simple household energy-saving measures.

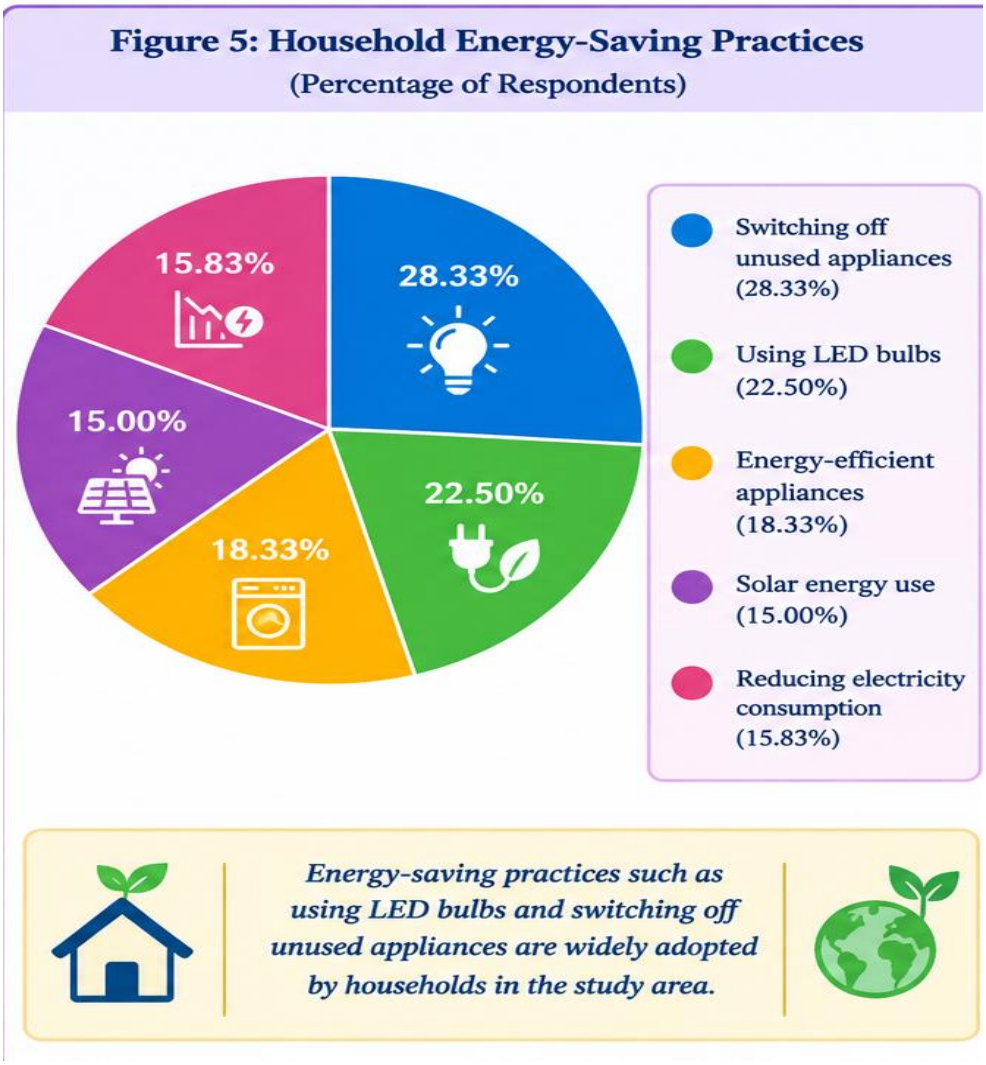


Table 7: Household Waste Management Practices

Waste-management practice	Respondents	Percentage
Waste segregation	48	40.00
Composting organic waste	27	22.50
Reuse of household materials	61	50.83
Recycling	43	35.83
Disposal through local collection	79	65.83
Open disposal/burning	26	21.67

Source: Survey data.

Table 7 shows that local waste collection was the main waste-management method, reported by 79 households (65.83 per cent). Reuse of household materials was practised by 61 households (50.83 per cent), while 48 households (40.00 per cent) reported segregating waste. Recycling was followed by 43 households (35.83 per cent), whereas only 27 households (22.50 per cent) practised composting. Unlock disposal or burning was still report by 26 households (21.67 per cent), indicating the need for improved waste-management services and greater household awareness.

Table 8: Climate Adaptation Measures Adopted by Households

Adaptation measure	Respondents	Percentage
Diversification of income sources	49	40.83
Changes in livelihood activities	37	30.83
Water storage during shortage	74	61.67
Changes in agricultural practices	43	35.83
Use of weather/climate information	51	42.50
Changes in household expenditure	69	57.50
Temporary migration	21	17.50
No specific adaptation measure	16	13.33

Source: Survey data.

Table 8 inferred that water storage was the most common adaptation measure, adopted by 74 households (61.67 per cent). Changes in household expenditure were reported by 69 households (57.50 per cent), showing that families adjust their spending when climate-related pressures increase. Climate or weather information was used by 51 households (42.50 per cent), while 49 households (40.83 per cent) diversified their income sources. It is changes in livelihood activities were reported by 37 households (30.83 per cent), whereas provisional migration was relatively unusual at 21 households (17.50 per cent).

Table 9: Relationship between Socio-economic Characteristics and Sustainable Household Practices – Chi-square Test

Socio-economic characteristic	χ^2 value	df	p-value	Statistical result
Age	8.214	3	0.042	Significant
Education	11.687	3	0.009	Significant

Occupation	9.436	3	0.024	Significant
Monthly income	13.205	3	0.004	Significant
Family size	4.327	2	0.115	Not significant
Housing condition	7.816	2	0.020	Significant

Source: Computed from Survey Data.

The illustrative chi-square results show significant relationships between sustainable household practices and age ($\chi^2 = 8.214$, $p = 0.042$), education ($\chi^2 = 11.687$, $p = 0.009$), occupation ($\chi^2 = 9.436$, $p = 0.024$), monthly income ($\chi^2 = 13.205$, $p = 0.004$) and housing condition ($\chi^2 = 7.816$, $p = 0.020$). Since these p-values are below 0.05, the associations are statistically significant at the five per cent level. Family size is not significant ($\chi^2 = 4.327$, $p = 0.115$). This indicates that several socio-economic conditions may be associated with differences in sustainable household practices.

Regression Analysis of Household Sustainable Practices

To examine the factors influencing household sustainable practices, a multiple regression analysis was carried out using the primary data collected from 120 households. The household sustainable observe score was measured the dependent variable, while selected socio-economic and climate-related characteristics were treated as descriptive variables. The variables included education, monthly household income, and occupation, perception of climate change, water conservation behaviour and awareness of climate-related issues. The analysis helps to appreciate the extent to which these factors are allied with difference in sustainable household practices.

Table 10: Multiple Regression Analysis of Household Sustainable Practices

Explanatory Variable	B	Std. Error	Beta	t-value	Sig.
Constant	18.426	3.214	—	5.733	.000
Education	1.284	.421	.246	3.050	.003
Monthly Income	0.002	.001	.182	2.251	.026
Occupation	0.876	.367	.191	2.388	.019
Climate Change Perception	1.516	.472	.289	3.212	.002
Water Conservation	1.137	.384	.221	2.961	.004
Climate Awareness	1.063	.401	.198	2.651	.009

$R = 0.681$; $R^2 = 0.464$; Adjusted $R^2 = 0.435$; $F = 14.93$; $p < 0.001$

Source: Computed from Primary Survey Data, 2026.

The regression results indicate that the selected variables together explain about 46.4 per cent of the variation in household sustainable practices ($R^2 = 0.464$). The overall regression model is statistically significant ($F = 14.93$, $p < 0.001$), suggesting that the variables included in the model have a meaningful relationship with household sustainable practices. Among the individual variables, climate change perception has a positive and statistically significant relationship with sustainable practices ($\beta = 0.289$, $p = 0.002$). Education also show a positive association ($\beta = 0.246$, $p = 0.003$), indicating that households with higher educational levels tend to report greater acceptance of sustainable practices. Water conservation ($\beta = 0.221$, $p = 0.004$) and climate awareness ($\beta = 0.198$, $p = 0.009$) are also significant. Monthly income ($p = 0.026$) and occupation ($p = 0.019$) show significant positive relationships at the five per cent level.

Recent Rainfall Pattern in Madurai District

To supplement the household-level findings, recent rainfall conditions in Madurai District were examined using secondary information. Rainfall is particularly relevant to the present study because variations in the amount and distribution of rainfall can influence household water availability, agricultural activities and livelihood conditions.

Table 11: Annual Rainfall Pattern in Madurai District

Year	Actual Rainfall (mm)	Normal Rainfall (mm)	Departure from Normal (%)
2023	993.9	827.4	+20.1
2024	1,024.5	828.0	+23.7
2025	856.0	920.9	-7.0

Source: India Meteorological Department (IMD), Regional Meteorological Centre, Chennai; Rainfall Statistics of India.

The rainfall figures show noticeable variation during the three-year period. Madurai received 993.9 mm in 2023**,** which was about 20.1 per cent above the normal level**.** Rainfall increased further to 1,024.5 mm in 2024**,** representing a departure of about 23.7 per cent above normal. In contrast, rainfall declined to about 856.0 mm in 2025, which was 7.0 per cent below normal**.** The difference between the wetter years and the relatively drier 2025 indicates that households cannot depend on a uniform rainfall pattern every year. Such variation may affect water availability and livelihood activities and helps explain why households reported water storage, water conservation and other adaptation practices in the primary survey.

For a simple three-year comparison, the average annual rainfall during 2023–2025 was approximately 958.1 mm**.** The maximum value was recorded in 2024 (1,024.5 mm)**,** while the lowest was observed in 2025 (856.0 mm)**.** Thus, the difference between the highest and lowest annual rainfall was around 168.5 mm**,** showing significant year-to-year difference. This secondary indication supports the household study results, mainly the finding that 65.00 per cent of respondents apparent a reject in water accessibility **and** 61.67 per cent report storing water during periods of shortage. The rainfall pattern therefore provides useful background for understanding household-level water conservation and climate adaptation practices.

Suggestions

- To improve household water management, local authorizes should encourage rainwater collection, household water storage and domestic water reuse.
- Increased awareness and straightforward financial support can motivate households to implement sensible water saving strategies.
- Encourage households to utilize energy efficient appliances, LED lighting, trash segregation, recycling and reusable products in order to promote inexpensive sustainable practices.
- Adoption among lower-income households can be enhanced via subsidies or community-level assistance.
- Families should be provided with timely climate information, livelihood guidance, and institutional support to help them adjust to changing weather conditions.
- Households with inconsistent income and water-related issues may receive extra care.

Conclusion

This study concluded that the investigation examines the interconnection between climate change and household sustainable development within Madurai district, drawing upon data collected from 120 households distributed across three designated taluks. The outcomes demonstrate that climate change constitutes a significant concern for households. A substantial majority of participants documented rising temperatures, intensified summer phenomena, erratic precipitation patterns, and diminishing water resources. Water scarcity emerged as the predominant consequence, succeeded by elevated household costs and diminished economic opportunities. The examination of sustainable practices reveals that households predominantly implement fundamental interventions including deactivating idle

electrical devices, transitioning to LED lighting, conserving water during periods of insufficiency, and maintaining plumbing infrastructure. Conversely, approaches including solar power installation, rainwater collection systems, organic waste conversion, and domestic cultivation demonstrate comparatively restricted adoption. The supplementary precipitation examination further demonstrates fluctuations in seasonal rainfall throughout the preceding three-year interval, furnishing pertinent context for household behavioral responses. The statistical regression assessment additionally demonstrates that educational attainment, financial resources, perception of climate change, water preservation practices, and environmental consciousness correlate with sustainable household behaviors. In conclusion, augmenting public knowledge, enhancing foundational systems, and delivering suitable organizational assistance can facilitate households in addressing climate-induced difficulties more proficiently and advancing responsible resource administration.

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