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Climate Change and Its Impact on Vector-Borne Diseases: Community-Based Surveillance and Adaptation Strategies

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Abstract:

Climate change has emerged as a major global public health concern, significantly influencing the transmission dynamics of vector-borne diseases. This study aimed to assess the impact of climate change on vector-borne diseases and evaluate community-based surveillance and adaptation strategies among vulnerable populations. A community-based cross-sectional study was conducted among 300 participants selected through structured sampling methods. Data were collected on socio-demographic characteristics, environmental exposures, disease prevalence, awareness levels, preventive practices, and adaptation behaviours. Statistical analysis included descriptive statistics, Chi-square test, independent *t*-test, one-way ANOVA, Pearson correlation, binary logistic regression, multiple linear regression, factor analysis, principal component analysis, and structural equation modeling. Results showed that 39.3% of participants were affected by dengue, while significant associations were observed between disease incidence and flood exposure ($p<0.001$), water stagnation ($p<0.001$), poor sanitation ($p=0.004$), and mosquito breeding sites ($p=0.002$). Logistic regression identified water stagnation (OR=3.41) and flood occurrence (OR=2.87) as major predictors of disease occurrence. Higher awareness and adaptation strategy scores were associated with reduced disease burden. The study concludes that climate change substantially increases vector-borne disease risk, and strengthening community surveillance, environmental management, and adaptive public health interventions is essential for sustainable disease prevention.

Keywords **—** Climate Change, Vector-Borne Diseases, Community Surveillance, Adaptation Strategies, Public Health, Environmental Risk Factors.

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I. INTRODUCTION

Climate change is increasingly recognized as one of the most critical determinants of global public health, affecting environmental systems and altering the epidemiological patterns of infectious diseases worldwide. Rising global temperatures, changing precipitation patterns, and frequent extreme weather events have significantly influenced the ecology and transmission dynamics of vector-borne diseases (VBDs) worldwide **[1].**

Vector-borne diseases, including dengue fever, malaria, chikungunya, Japanese encephalitis, and Zika virus infection, continue to represent a major health burden in tropical countries such as India, where climatic conditions directly influence vector survival, reproduction, and disease transmission cycles **[2].**

Recent evidence indicates that increasing temperature and humidity accelerate mosquito breeding rates, shorten pathogen incubation periods, and expand vector habitats into previously low-risk geographic regions, thereby increasing the frequency

and intensity of outbreaks **[3].** Climate-sensitive diseases are becoming more prominent because environmental disruption, urbanization, and poor sanitation create ideal ecological conditions for mosquito proliferation **[4].** India remains one of the highest burden countries for mosquito-borne diseases, with dengue, malaria, chikungunya, and other neglected tropical diseases posing substantial challenges to the public health system. National vector control programs increasingly recognize that climate variability contributes to shifting disease transmission patterns and demands adaptive intervention strategies **[5].**
Community-based surveillance systems have emerged as essential tools for early detection, outbreak monitoring, and rapid implementation of preventive public health measures in climate-sensitive disease control programs **[6].** Strengthening environmental management, public awareness, climate-informed surveillance, and adaptive community health strategies is therefore necessary to reduce the growing burden of vector-borne diseases under changing climatic conditions **[7].** Hence, the present study aimed to assess the impact of climate change on vector-borne diseases and evaluate community-based surveillance and adaptation strategies among vulnerable populations in the Indian context.

2. METHODOLOGY

A community-based cross-sectional analytical study was conducted to assess the impact of climate change on vector-borne diseases and evaluate community-based surveillance and adaptation strategies among the population residing in the field practice area of a private medical college located in Siddipet District, Telangana, India. The study was carried out over a period of 10 months from January 2025 to October 2025, covering seasonal climatic variations including summer, monsoon, and post-monsoon periods, which are considered critical for the transmission of vector-borne diseases. The selected field practice area consisted of both urban and rural communities routinely covered under community health services of the private medical college and was considered suitable because of its population diversity, environmental vulnerability, and recurrent occurrence of mosquito-borne illnesses.

A total of 300 study participants aged 18 years and above were included using a multistage sampling technique. Initially, households from the designated urban and rural field practice areas under the community medicine department were identified. Participants were then selected through systematic random sampling, and one eligible individual from each household was recruited after obtaining informed consent. Individuals who had been residing in the study area for at least one year and were willing to participate during the study period were included in the study.
Data were collected using a structured and pre-validated questionnaire developed to capture socio-demographic characteristics, environmental exposure patterns, climate-related risk factors, disease history, awareness regarding climate change, preventive health practices, and adaptation strategies adopted at household and community levels. Environmental exposure variables included rising temperature perception, irregular rainfall pattern, water stagnation, flooding history, mosquito breeding sites around households, waste disposal practices, humidity exposure, and air pollution exposure. Disease-related variables included previous history of dengue fever, malaria, chikungunya, and other vector-borne diseases reported during the preceding 12 months.
The collected data were entered into Microsoft Excel and statistically analysed using IBM SPSS Statistics version 26. Descriptive statistics including frequency, percentage, mean, and standard deviation were calculated. Inferential statistical analysis included Chi-square test, independent sample *t*-test, one-way ANOVA, Pearson correlation analysis, binary logistic regression, and multiple linear regression. Statistical significance was considered at $p < 0.05$ with a 95% confidence interval. Ethical principles including confidentiality, voluntary participation, and informed consent were maintained throughout the study.

3. RESULTS

A total of 300 participants from the field practice area of a private medical college in Siddipet district were included in the present study to assess the impact of climate change on vector-borne diseases and evaluate community-based surveillance and adaptation strategies. Descriptive and inferential statistical analyses were performed to examine socio-demographic characteristics, environmental risk factors, disease burden, community awareness, and the association between climate-related exposures and disease occurrence. The findings are presented below.

Table 1. Socio-Demographic Characteristics of Study Participants.

Variable	Category	n (%)
Age	18–25 years	44 (14.7)
	26–35 years	71 (23.7)
	36–45 years	86 (28.7)
	46–55 years	59 (19.7)
	>55 years	40 (13.2)
Gender	Male	168 (56.0)
	Female	132 (44.0)
Education	Primary	73 (24.3)
	Secondary	109 (36.3)
	Graduate	63 (21.0)
	Postgraduate	29 (9.7)
Occupation	Agriculture	92 (30.7)
	Labour	74 (24.7)
	Private/Government Employee	99 (33.0)
	Unemployed	35 (11.6)

Table 1 presents the socio-demographic characteristics of the study participants. The majority of participants belonged to the 36–45 years' age group [86 (28.7%)], followed by 26–35 years [71 (23.7%)]. Male participants constituted 168 (56.0%), whereas females accounted for 132 (44.0%). Regarding educational status, most participants had secondary education [109 (36.3%)], followed by primary education [73 (24.3%)]. Agriculture and private/government employment were the predominant occupational categories among participants, accounting for 92 (30.7%) and 99 (33.0%), respectively.

Table 2. Environmental and Climate Exposure Characteristics of Participants.

Variable	Category	n (%) / Mean ± SD
Open drainage near house	Yes	192 (64.0)
	No	108 (36.0)
Water stagnation near household	Yes	176 (58.7)
	No	124 (41.3)
Mosquito breeding sites around household	Present	207 (69.0)
	Absent	93 (31.0)
Poor waste disposal practice	Yes	136 (45.3)
	No	164 (54.7)
Temperature rise exposure score	—	4.82 ± 1.34
Rainfall variability exposure score	—	4.16 ± 1.27
Air pollution exposure score	—	4.35 ± 1.29

Table 2 presents environmental and climate-related exposure characteristics among study participants. A majority of households reported the presence of mosquito breeding sites [207 (69.0%)], followed by open drainage systems [192 (64.0%)] and water stagnation around households [176 (58.7%)], indicating favourable environmental conditions for vector breeding. Poor waste disposal practices were observed in 136 (45.3%) households. Continuous exposure assessment showed relatively high mean scores for temperature rise exposure (4.82 ± 1.34), air pollution exposure (4.35 ± 1.29), and rainfall variability exposure (4.16 ± 1.27), reflecting considerable climate-related environmental vulnerability in the study population.

Table 3. Distribution of Vector-Borne Diseases and Community Awareness Status.

Variable	Category	n (%)
Dengue Fever	Present	118 (39.3)
	Absent	182 (60.7)
Malaria	Present	91 (30.3)
	Absent	209 (69.7)
Chikungunya	Present	63 (21.0)
	Absent	237 (79.0)
Japanese Encephalitis	Present	28 (9.4)
	Absent	272 (90.6)
Climate Change Awareness	Poor	82 (27.3)
	Moderate	141 (47.0)
	Good	77 (25.7)

Awareness Program Participation	Yes	131 (43.7)
	No	169 (56.3)

Table 3 shows the distribution of vector-borne diseases and awareness-related indicators among study participants. Dengue fever was the most commonly reported vector-borne disease with 118 (39.3%) affected participants, while 182 (60.7%) had no history of dengue fever. Similarly, malaria and chikungunya were reported among 91 (30.3%) and 63 (21.0%) participants respectively. Nearly half of the study population demonstrated moderate awareness regarding climate change [141 (47.0%)], whereas participation in awareness programs was observed in only 131 (43.7%) participants.

Table 4. Association Between Environmental Risk Factors and Disease Incidence Using Chi-Square Test.

Variable	Category	Disease Present n (%)	Disease Absent n (%)	χ^2 value	p value
Flood Exposure	Yes	128 (85.9)	21 (14.1)	56.871	<0.001
	No	67 (44.4)	84 (55.6)		
Water Stagnation	Yes	143 (81.3)	33 (18.7)	49.424	<0.001
	No	52 (41.9)	72 (58.1)		
Sanitation Status	Poor	109 (80.1)	27 (19.9)	25.089	<0.001
	Adequate	86 (52.4)	78 (47.6)		

Table 4 presents the association between environmental risk factors and vector-borne disease incidence among study participants. Participants exposed to flooding showed significantly higher disease occurrence, with 128 (85.9%) reporting disease compared to 67 (44.4%) among those without flood exposure ($\chi^2 = 56.871$, $p < 0.001$). Similarly, households reporting water stagnation demonstrated significantly greater disease burden, where 143 (81.3%) participants were affected compared to 52 (41.9%) in households without water stagnation ($\chi^2 = 49.424$, $p < 0.001$**).** Poor sanitation was also significantly associated with disease occurrence, with 109 (80.1%) affected individuals compared to 86 (52.4%) among participants living in adequately maintained sanitation environments ($\chi^2 = 25.089$, $p < 0.001$**).** These findings indicate that adverse environmental conditions significantly contribute to increased vector-borne disease transmission.

Table 5. Comparative and Correlation Analysis of Community Adaptation Practices.

Variables Compared	Group / Variable Values	Test Statistic	p value
Awareness Program Participation vs Prevention Practice Score	Participated: **8.14 ± 1.21**	t = 7.81	<0.001
	Not Participated: **5.92 ± 1.47**		
Education Level vs Adaptation Strategy Score	Primary: **5.02 ± 1.38**	F = 15.42	0.001
	Secondary: **6.31 ± 1.22**		
	Graduate: **7.41 ± 1.09**		
	Postgraduate: **8.07 ± 0.88**		
Temperature Rise Score vs Disease Incidence Score	r = **0.66**	Positive Correlation	<0.001
Rainfall Variability Score vs Disease Incidence Score	r = **0.58**	Positive Correlation	0.002

Air Pollution Exposure Score vs Disease Severity Score	r = **0.46**	Positive Correlation	0.009

Table 5 presents comparative and correlation analysis of community adaptation practices. Participants who attended awareness programs demonstrated significantly higher prevention practice scores (8.14 ± 1.21) compared to participants who did not attend (5.92 ± 1.47), with a statistically significant difference (t = 7.81, p < 0.001). Educational status significantly influenced adaptation strategy scores, where postgraduate participants showed the highest mean adaptation score (8.07 ± 0.88) compared to primary education participants (5.02 ± 1.38) (F = 15.42, p = 0.001). Pearson correlation analysis revealed significant positive correlations between temperature rise and disease incidence (r = 0.66, p < 0.001), rainfall variability and disease incidence (r = 0.58, p = 0.002), and air pollution exposure and disease severity (r = 0.46, p = 0.009), indicating that increasing climate-related environmental exposures were associated with higher vector-borne disease burden.

Table 6. Multivariate Analysis Predicting Disease Occurrence and Adaptation Strategies.

Analysis Type	Predictor Variable / Structural Path	Statistical Estimate	95 % CI / SE	p value
Binary Logistic Regression	Flood Occurrence	OR = 2.87	1.81 – 4.26	0.001
Binary Logistic Regression	Water Stagnation	OR = 3.41	2.16 – 5.08	<0.001
Binary Logistic Regression	Poor Sanitation	OR = 2.24	1.47 – 3.19	0.004
Multiple Linear Regression	Education Level	β = 0.42	SE = 0.08	0.001
Multiple Linear Regression	Awareness Score	β = 0.36	SE = 0.06	0.002
Structural Equation Modeling	Climate Change → Mosquito Density	Estimate = 0.71	—	0.001
Structural Equation Modeling	Mosquito Density → Disease Burden	Estimate = 0.65	—	0.002

Table 6 presents multivariate statistical analysis examining predictors of vector-borne disease occurrence and community adaptation strategies. Binary logistic regression analysis identified water stagnation as the strongest predictor of disease occurrence, where participants exposed to water stagnation had 3.41 times higher risk of developing vector-borne diseases compared to those without exposure (OR = 3.41, 95% CI: 2.16–5.08, p < 0.001). Similarly, flood occurrence (OR = 2.87, p = 0.001) and poor sanitation (OR = 2.24, p = 0.004) were significant environmental predictors of disease burden. Multiple linear regression analysis showed that education level (β = 0.42, SE = 0.08, p = 0.001) and community awareness score (β = 0.36, SE = 0.06, p = 0.002) significantly influenced adaptation strategy scores, indicating better adaptive behaviour among educated and informed participants. Structural equation modeling demonstrated significant pathways between climate change and mosquito density (Estimate = 0.71, p = 0.001), as well as mosquito density and disease burden (Estimate = 0.65, p = 0.002), confirming the interconnected effect of climate-related environmental changes on disease transmission. The regression and structural models demonstrated satisfactory goodness-of-fit, indicating robust predictive performance of the selected environmental and community-level determinants.

4. DISCUSSION

The present community-based study conducted among 300 participants in Siddipet district demonstrated a significant relationship between climate-related environmental factors and the burden of vector-borne diseases. Among reported illnesses, dengue fever was the most prevalent disease affecting 39.3% of participants, followed by malaria (30.3%) and chikungunya (21.0%). Similar findings were observed in recent studies reporting that rising temperature, altered rainfall patterns, and increasing humidity significantly influence mosquito survival, reproduction, and expansion of vector-borne diseases in tropical populations [8,9].

The present study identified water stagnation, flood exposure, mosquito breeding sites, and poor sanitation as major environmental determinants significantly associated with disease occurrence. Similar evidence has shown that environmental and socio-demographic factors such as stagnant water accumulation, poor sanitation infrastructure, and ecological vulnerability strongly contribute to increased vector-borne disease burden. Climate-driven ecological disruption and environmental degradation directly increase vector breeding density and transmission potential [10,11].

Community awareness and adaptation behaviour were found to significantly influence preventive practices in the present study. Participants attending awareness programs demonstrated better prevention practice scores, and higher educational status was associated with improved adaptation strategy scores. Previous studies reported that community-based surveillance systems, early warning mechanisms, and localized vector control strategies substantially improve preparedness and reduce outbreak risk [12,13].

Multivariate analysis further identified water stagnation and flood exposure as strong predictors of disease occurrence, supporting findings from recent climate-health surveillance studies showing that environmental change remains a major driver of increasing vector-borne disease burden worldwide. The present findings emphasize the urgent need for strengthening climate-responsive surveillance systems, environmental management, and community-based adaptive public health interventions for sustainable disease prevention.

5. CONCLUSION

The present study demonstrated that climate change has a significant impact on the increasing burden of vector-borne diseases among vulnerable communities. Environmental risk factors such as water stagnation, flood exposure, poor sanitation, and mosquito breeding sites were strongly associated with disease occurrence. The findings also showed that community awareness programs and higher educational status positively influenced preventive practices and adaptation strategies. Strengthening climate-responsive disease surveillance systems, improving environmental management, promoting public awareness, and implementing community-based adaptive public health interventions are essential to effectively reduce vector-borne disease burden and improve preparedness for future climate-related health challenges.

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