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Climate Change And Health Care Management: A Household Level Study In Kerala

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Abstract: At the Global level climate change and natural disaster forced to displace around 30 million people from their shelters, of which natural disaster became the prime reason for this displacement. In India, around 13 million people died as result of adverse health condition resulting from poor living environment and this accounts one in fourth of total death reported at the world level. Climatic factors and poor environment contributes more than hundred diseases and injuries at world level. The current changes in climatic conditions have serious and multiple impacts on society, economy, and population, which are only recently being recognized. These changes result in increased needs for health services, prevention of climate related diseases, etc., and that is why the health experts are paying close attention to prevention of diseases related to climatic factors. Impact of climatic conditions on human health is not only set by the frequency and intensity of extreme meteorological and hydrological processes but also by the previous health condition and the anxiety with respect to possible disaster damages and consequences. Even though Kerala ranked one of the best states in India as per NITI Ayog's States Energy and Climate Index; it is highly susceptible to natural disasters like floods, land sliding etc. due to its geographical condition. This paper indicate a strong link between communicable disease burden of the state and community awareness and engagement in managing their health in adverse environmental changes, emphasizing the crucial role of education and awareness and active participation of the general public to mitigate and adapt adverse climatic changes.

Index Terms **-** Climate Change Adaptability, Healthcare Management, Communicable Diseases, Healthcare Expenditure of Kerala, Household Healthcare

I. INTRODUCTION

The Earth's climate has been experiencing significant natural transformations for centuries. Climate change is defined as a statistically significant alteration in either the average state of the climate or its variability, lasting for an extended duration, typically decades or more. Presently, extreme weather events, including storms, floods, and droughts, are occurring with greater frequency and intensity, impacting millions globally. This phenomenon poses a serious threat to global water and food security, agricultural supply chains, and numerous coastal and urban areas. A recent report from the World Bank indicates that climate change could potentially drive over 100 million individuals back into poverty within the next fifteen years. According to the Global Risk Report 2024 by the World Economic Forum, environmental risks are projected to dominate the overall risk landscape for the next decade. Notably, one-third of global respondents identified extreme weather as the primary risk factor affecting the world.

Climate change may have various impacts, but most commonly observed negative effects on human health are seen as rise in illnesses and deaths. The World Health Organization (WHO) estimates that between 2030 and 2050, climate change is expected to cause approximately 2,50,000 additional deaths per year, resulting from malnutrition, malaria, diarrhea and heat stress. India is a highly populous country, undergoing industrialisation, with large scale rural to urban migration, chaotic, unplanned urbanization,

depletion of forest cover and requirement of high energy demand makes it more vulnerable to adverse impacts of climate change. As evident from various literatures worldwide, the health effects may occur either due to direct or indirect causes of climate change or extremes of weather.

Human beings have historically demonstrated a remarkable capacity to adapt to a wide range of climatic conditions. This adaptability is a hallmark of our species. However, climate change will challenge this ability. Navigating the continuous, unpredictable, and potentially violent impacts of climate change may differ significantly from the long-term adaptability of humans have made in the past. Nevertheless, confronting this challenge is unavoidable. A certain degree of climate resilience is essential. While emphasising the importance of cutting greenhouse gas emissions, the international response to climate change now puts equal emphasis on adaptation and mitigation. While humans have a strong track record, adaptation does not happen automatically. Effective adaptation requires knowledge, planning, coordination and foresight. The decisions required can be intricate and multifaceted. This makes adaptation an interesting economic problem. Issues of climatic change mitigation and adaptation can be fruitfully addressed only when there is an equitable distribution of the global carbon emission measures and resources among different countries, otherwise the burden falls heavily upon developing and developing countries. Climatic resilient construction and Infrastructure development and climatic financing is imperative to address the mitigation and adaptation measures to ensure sustainable development and intergenerational equity.

II. REVIEW OF LITERATURE

Climate change impacts vary across sectors, regions, and time scales, resulting in both positive and negative externalities. Poorer regions tend to experience more negative impacts, highlighting climate change as an issue of justice (Arrow et al., 1996; Banuri et al., 1996). The effects of climate change have both short-term and long-term implications, with sector sensitivity being crucial in the short term and vulnerability changes becoming more significant over time (Fankhauser et al., 1999).Li et al. (2019) conducted a spatial-temporal analysis of national vulnerability from 1996 to 2008 across 171 countries. They found that global vulnerability is increasing, with an average rise in the vulnerability index of 0.30 per cent points. Crimmins et al. (2016) highlighted that multiple health threats due to climate change, identifying disproportionately vulnerable populations in the United States. Toloo et al. (2014) emphasized that vulnerability to climate events depends on environmental, social-psychological, and demographic factors, as well as health status, lifestyle, attitudes, perceptions, preparedness, and resilience. They called for improved interdisciplinary collaboration and communication among stakeholders to mitigate health impacts. A one degree increase in global mean temperature can affect mortality due to vector-borne diseases (McMichael et al., 2018). Margherita et al. (2012) noted that significant disparities in climate change impacts between developing and rich countries, with major impacts concentrated in Sub-Saharan Africa and Asia.

Mirza (2011) analyzed flooding impacts, concluding that a 2°C rise in global mean temperature could be considered "dangerous climate change" for Bangladesh and South Asia, with cascading effects on millions of lives and regional economies. Bowen and Friel (2012) identified that poor, low-lying, and underdeveloped regions face the greatest threats but also have the greatest potential for cost-effective gains from appropriate action. Frederik (2019) emphasized the role of economic unions in managing risks and building resilience to climate impacts. Hainesa et al. (2006) analysed the 2003 European heat wave, concluding that even high-income countries can be adversely affected. They recommend public health strategies and improved surveillance for adaptation, as well as reducing fossil fuel use and increasing renewable energy technologies to mitigate climate change and improve health. The Paris Agreement, 2015addressed climate change through mitigation (reducing greenhouse gas emissions) and adaptation (investing in climate resilience).Recent studies (Markandya et al., 2014; Kahn, 2016; Massetti and Mendelsohn, 2015) emphasize adaptation as an autonomous reaction by private actors. Heal and Millner (2014) noted that higher uncertainty in adaptation outcomes compared to mitigation efforts. Ramesh et al. (2011), Bhattacharya et al. (2006), and Sumana et al. (2006) studied the impacts of climate change on malaria transmission in India, emphasizing the importance of considering non-climatic factors in assessing malaria vulnerability. This review highlights the complex and multifaceted nature of climate change impacts, emphasizing the need for both global and localized approaches to vulnerability assessment, mitigation, and adaptation strategies. It underscores the disproportionate effects on developing regions and vulnerable populations, while also noting that even developed countries are not immune to severe climate impacts. The case study of Kerala provides insights into region-specific challenges and potential solutions, particularly in the context of a developing economy with unique environmental characteristics.

III. METHODOLOGY

Kerala ranked the second best state as per NITI Ayog's States Energy and Climate Index published in 2022. The study employs a mixed-methods approach, incorporating both primary data gathered through surveys and interviews and secondary data from Directorate of Health Services (DHS), Government of Kerala, and Kerala State Disaster Management Authority (KSDMA). Household level climate change adaptive health care practices are analysed by collecting information form six major municipal corporations in Kerala. 180 sample households were selected for this purpose. This data sheds light on public attitudes towards their health care management.

IV. RESULTS AND DISCUSSION

Kerala is particularly susceptible to natural disasters and the evolving climatic conditions due to its coastal location and the steep gradients of the Western Ghats. The region is vulnerable to various natural hazards, including cyclones, monsoon storm surges, coastal erosion, rising sea levels, tsunamis, floods, droughts, lightning strikes, landslides (debris flows), land subsidence (resulting from tunnel erosion or soil piping), and earthquakes. KSDMA's State Disaster Management Plan identifies 39 types of known hazards that could become catastrophic without adequate preparedness and risk reduction strategies (KSDMA, 2016).

Kerala has a humid tropical climate, the dominant climatic phenomena being the South-West (June to September) and the North-East (October to December) monsoons. The former is more significant producing 80 per cent of the total annual rainfall. Kerala has an average annual precipitation of 3000 mm, with about 90 per cent of the rainfall occurring during the six monsoon months. The high intensity monsoon storms heavy discharges in all the rivers and result in severe floods, making floods the most common of natural hazards that affects the State (table.1)

Table 1. Area Vulnerable to Hazards in Kerala

Hazards	No of Taluks prone	Susceptible area (km2)	Population exposed
Landslides	50	5619.7	2799482
Floods	75	6789.5	7795816
Coastal Hazards	24	289.7	313205

Source : KSDMA, 2016

Nearly 14.8 per cent of the State is prone to flooding and the proportion is as high as 50 per cent for certain districts. Landslides are a major hazard along the Western Ghats in Wayanad, Kozhikode, Idukki and Kottayam districts (as seen in the weather led disaster that occurred in 2018, 2019 and 2024). More than 50 per cent of Kerala's land area is moderately to severely drought susceptible. Kerala anticipates the effects of global climate change to bring an increase in extreme rainfall and with it the probability of urban flooding during the north-east monsoon period, a water shortage during peak summer months, along with a subsequent increase in urban temperature, and a potential increase in coastal erosion along the highly populated coastline due to rising sea-levels. The impacts of climate change are aggravated by lack of adaptive capacity of people and the State to floods, droughts, and mudflows are expected to increase in both frequency and severity.

4.1 Climate Change and Health Impacts in Kerala

Climate sensitive illnesses are on increase due to climate change and extremes of weather either through direct or indirect impact. Climate affects social and environmental determinants of health like –clean air, safe drinking water, sufficient food and secure shelter. Climate change may negatively affect human health through a number of ways, but the commonly experienced are increased frequency and intensity of heat waves, rise in heat related illnesses and deaths, increased precipitation, floods and droughts, costing lives directly. High temperature is known to increase the level of 'ground level ozone' and other 'climate altering pollutants' other than carbon dioxide, which further exacerbate cardio-respiratory and allergic diseases and certain cancers. Beside these, there is increase in transmission and spread of infectious diseases, changes in the distribution of waterborne, food borne and vector-borne diseases and effects on the risk of disasters and malnutrition.Table.1 provides an overview of the incidence and mortality associated with communicable diseases in Kerala spanning the years 2011 to 2022. It details the total cases reported, the corresponding deaths, and the mortality rate per 1,000 cases for each year.

Table.2 Communicable Disease reported in Kerala

year	Total Cases (C)	Total Death (D)	Mortality rate per cases (D/C)*1000
2011	2201585	139	0.0631
2012	2781925	107	0.0385
2013	3475750	126	0.0363
2014	3196094	128	0.0400
2015	3253445	161	0.0495
2016	3231197	130	0.0402
2017	4020427	454	0.1129
2018	3547350	308	0.0868
2019	3506750	234	0.0667
2020	1556686	105	0.0675
2021	1724847	158	0.0916
2022	3815635	468	0.1227

Source: Directorate of health Services, Govt. of Kerala

Throughout the observed period, the number of reported cases exhibited variability, with an overall upward trajectory from 2011 to 2017. A marked decline in cases was noted in 2020, likely attributable to the COVID-19 pandemic and the resultant lockdown measures. The mortality figures also displayed fluctuations, with significant increases recorded in 2017 and 2022. The mortality rates per 1,000 cases, while showing some variation, remained relatively low on the whole. The regression co efficient that shows the relationship between total death (dependent variable) and total number of cases (independent variable) is statistically significant with p value 0.02 and the result says that on an average, the rate of change of death rate is one out of 10000 reported cases.

Following the decline in 2020, case numbers appear to be reverting to levels seen prior to the pandemic. It is plausible that this upward trend will persist, potentially reaching or surpassing the figures recorded in 2017-2018 in the forthcoming years. The recent rise in deaths, particularly in 2022, raises concerns and may be influenced by factors such as the emergence of new disease variants or alterations in healthcare capacity. The overall increase in case numbers over the years may be attributed to several factors, including enhanced reporting mechanisms, population growth, or shifts in disease prevalence. The significant reduction in cases during 2020 likely reflects the effectiveness of COVID-19 containment strategies, which may have inadvertently curtailed the transmission of other communicable diseases. The recent uptick in mortality, especially in 2022, necessitates further scrutiny, as it may be linked to the strain on healthcare systems due to the pandemic or the rise of more virulent disease variants. Despite the observed fluctuations, the generally low mortality rates indicate that Kerala's healthcare infrastructure has been relatively successful in managing communicable diseases. The resurgence of case numbers post-2020 suggests that as COVID-19 restrictions were lifted, other communicable diseases began to circulate more extensively once again.

These patterns underpins the necessity for sustained attention to disease monitoring, preventive measures, and the enhancement of healthcare systems to effectively address the persistent challenges presented by communicable diseases in Kerala. Over the years, trend prediction of morbidity and mortality related to communicable diseases in Kerala shows an upward movement. On an average 234123 cases are increasing over the years but the realised mortality is much lesser compared to the cases. Over the years the rate of increment in death related to communicable disease is 22 per year (table.3)

Table.3 Prevalence of Communicable Diseases in Kerala

Name of Diseases	2019		2020		2021		2022		2023 Up tp august 31	
	C	D	C	D	C	D	C	D	C	D
Dengue Fever	4651	14	2722	22	3251	27	4468	58	8902	35
Malaria	656	1	267	1	309	1	438	0	272	4
Confirmed Chikunguniya	109	0	558	0	334	0	66	0	20	0
Leptospirosis	1211	57	1039	48	1745	97	2482	121	1228	52
Scrub Typhus	579	14	423	8	438	6	727	24	329	8
HINI	853	45	58	2	1	0	94	11	834	49
Fever (OP)	2862375	51	1265782	0	1463517	0	3285392	6	1951773	6
Fever (IP)	60080		18879		12458		25257		30568	60080
Measles	199	1	76	1	3	0	183	0	739	0
Chickenpox	29583	20	14959	3	3457	2	9927	14	18311	4

Source: Directorate of health Services, Govt. of Kerala, 2021 C- Case, D- Death

Dengue fever cases have increased significantly in 2023, with 8,902 cases reported up to August 31, compared to 4,468 in the entire year of 2022. Leptospirosis cases and deaths have been consistently high, with a peak in 2022 (2,482 cases and 121 deaths). Malaria cases have generally decreased from 2019 to 2023, but there's a slight increase in deaths in 2023. Chikungunya cases peaked in 2020 but have since declined significantly. H1N1 (swine flu) cases have fluctuated, with a significant increase in 2023 (834 cases and 49 deaths up to August 31). Fever cases (both outpatient and inpatient) show high numbers, with a notable decrease during 2020-2021, possibly due to COVID-19 lockdowns and precautions. Measles cases have increased dramatically in 2023, with 739 cases reported up to August 31, compared to 183 in the entire previous year.

4.2 Prevalence of Waterborne diseases in Kerala

Vector-borne diseases are linked to the environment by the ecology of the vectors, and of their hosts, including humans. Several factors, such as seasonality, proximity to breeding grounds, vector density, biting rates, and proportion of infectious mosquitoes, contribute to the spread of mosquito-borne diseases (Agarwal et al., 2012). Kerala is prone to waterborne diseases due to dearth of safe drinking water at coastal and tribal area. Kerala health department is undertaking a programme called ‘Jagratha’ for prevention of communicable diseases from 2017 onwards.

Table.4 Prevalence of Waterborne Diseases in Kerala

Year		Hepatitis A	Cholera	Typhoid	ADD (Diarrhoea)
2019	Case	1620	9	27	544027
	Death	7	0	0	6
2020	Case	464	2	16	250788
	Death	2	0	0	1
2021	Case	114	1	30	238227
	Death	0	0	0	3
2022	Case	231	0	55	466211
	Death	2	0	0	2
2023	Case	326	24	78	350037
	Death	2	0	0	2

Source: Directorate of health Services, Govt. of Kerala, 2021

The number of cases and deaths for waterborne diseases from 2019 to 2023 is shown in table no.4. Acute Diarrheal Disease (ADD) is the most prevalent waterborne disease, with hundreds of thousands of cases each year. However, the number of cases decreased significantly in 2020 and 2021, possibly due to improved hygiene practices during the COVID-19 pandemic. Hepatitis cases have decreased dramatically from 1,620 in 2019 to 326 in 2023. Cholera cases are very low, with only 9 cases in 2019 and no cases in 2023. Typhoid cases are relatively low but showed an increase from 16 cases in 2020 to 78 cases in 2023.

Deaths from waterborne diseases have generally decreased over the years, with only 2 deaths (from ADD) reported in 2023.

4.3 Government's health expenditure in Kerala

Kerala government's health expenditure in Kerala from 2018-19 to 2022-23 highlights that Total health expenditure has increased from ₹ 7,859.06 crore in 2018-19 to ₹ 13,198.94 crore in 2021-22, a significant rise of about 68 per cent.

Table.5 Investment in Health and Family welfare (₹ in crore)

Yeasr	Total Government Health Expenditure plan expenditure	Total Government Health Expenditure Non plan expenditure	Total health expenditure	Total government expenditure	% of health expenditure to total govt expenditure	GSDP in crore at constant prices	% of health expenditure to GSDP
2018-19 (Acc)	2623.26	5235.8	7859.06	120069.82	6.55	554228.31	1.42
2019-20 (Acc)	2911.60	5292.21	8203.81	114384.94	7.17	559194.18	1.47
2020-21 (Acc)	4287.34	5657.63	9944.97	138884.49	7.16	512076.08	1.94
2021-22 (Acc)	5363.70	7835.24	13198.94	163225.53	8.09	573591.46	2.30
2022-23(BE*)	3836.32	7255.57	11091.89	173587.51	6.39		

Source: Directorate of health Services, Govt. of Kerala *Budget Estimate

The percentage of health expenditure to total government expenditure has increased from 6.55 per cent in 2018-19 to 8.09 per cent in 2021-22, showing increased priority for health.The percentage of health expenditure to GSDP (Gross State Domestic Product) has also risen from 1.42 per cent in 2018-19 to 2.30 per cent in 2021-22, indicating a growing share of the economy dedicated to health. There's a slight decrease in budgeted expenditure for 2022-23 compared to the previous year, which might be worth investigating.

4.4 Climate related health care management at the household level

Climate related health care management at the household level is analysed by eliciting information from 180 households in Kerala, 30 households were selected randomly from 6 municipal corporations in Kerala. Humans are far better than other species in adapting climate variability if it adversely affects up on his health condition. Knowledge and understanding the surrounding, planning and co-ordination, climate resilient activities, restoration measures are taken by human by themselves automatically when he face a severe threat from the existing environment. Lack of awareness and absence of strong intervention acts as a gap between degradation and restoration measures. This gap can be filled by the effective and fruitful intervention by the government authorities. The following information gives a detailed picture on how an average Keralite makes his health care management in accordance with the change in adverse climatic condition in Kerala.

The data is based on a sample of 180 households, with percentages indicating the proportion of households adopting each practice. Overall, the table shows a range of adaptive practices that households are implementing to address climate change impacts, with a strong focus on water safety, personal health, and environmental cleanliness.

Table.6 Factor Analysis of Climate Change Adaptable Practices at Household Level

Factor	Category	No. of household	% to total
Water Safety Measures and Management	Ensure safe drinking water in all season	168	93.33
	Drinking boiled water	165	91.67
	Chlorinated well	80	44.44
	Drought management measure during summer	55	30.56
	Usage of water purifier	37	20.56
	Water quality check conducted	35	19.44
Heat/ Cold Protection measures	Using cotton material to wear	120	66.67
	Using blankets in winter	113	62.78
	Using umbrella	109	60.56
	Restricted to go outside during summer	49	27.22
	Usage of Air Cnditioner during summer	46	25.56
	Usage of sun cream	39	21.67
perception regarding health, hygiene and Health practices	Own health perception- Good	168	93.33
	Own health perception- Bad	15	8.33
	Suffering any diseases	12	6.67
	Washing hands with soap	158	87.78
	Covid Vaccination	144	80
	Vaccination of children	133	73.89
	Drink plenty of water	102	56.67
	Following diet plan suitable to climate	58	32.22
	Having a health insurance	45	25
Environmental Management	Mosquito prevention measures	153	85
	Cleaning premises	143	79.44
	Keeping waste container	139	77.22
	Facilitating proper drainage	60	33.33
	Water logging prevention	55	30.56
Total Sample households		180	100.00

Source: Primary data collected from six municipal corporations, Kerala, 2019

Major findings of the primary study explains that, with respect to the Water Safety Measures, 93.33 per cent of households ensure safe drinking water in all seasons, 44.44 per cent use chlorinated wells and Other measures include drought management, use of water purifiers, and water quality checks. Regarding Climate Change Precautions adopted by sample households, 66.67 per cent use cotton material for clothing, 62.78 per cent use blankets in winter, 60.56 per cent use umbrellas to avoid heavy heat and temperature and other precautions include restricting outdoor activities in summer and using air conditioning during summer period. Healthy Interventions include drinking boiled water, 91.67 per cent, 87.78 per cent practice hand washing with soap, 73.89 per cent vaccinated their children, 56.67 per cent drink plenty of water during summer and 32.22 per cent follow climate-suitable diet plans. With respect to Clean Environment Initiatives: 85 per cent take mosquito prevention measures, 79.44 per cent clean their premises, 77.22 per cent keep waste containers and Other initiatives include facilitating proper drainage and addressing water logging

Water Safety and Management emerges as a crucial factor, with the highest participation rates. This suggests that households prioritize access to safe drinking water as a primary climate change adaptation strategy. Heat Protection Measures form another significant factor, reflecting the importance of adapting to increasing temperatures. Hygiene and Health Practices are widely adopted, showing an understanding of the link between climate change, health, and hygiene. Environmental Management practices are also prevalent, demonstrating awareness of the broader ecological impacts of climate change at the household level. These factors highlight the multifaceted approach households are taking to adapt to climate change, focusing on immediate health and safety concerns (water and hygiene), personal comfort (heat and cold protection), and broader environmental issues. It's quite evident that knowledge, awareness and improved

health care facilities helped Keraliltes to mitigate most of the issue related to climatic variability. In addition to individual effort, effective mechanism adopted by the Kerala Government like Suchitwa mission, Haritha Keralam, Plastic Ban, Green Army, Carbon neutral initiatives etc to mitigate climate variability also well appreciated. But still there exist wide gap between private public adaptability mechanisms. Direct and indirect cost of adaptation, mal adaptation etc. also poses severe bottlenecks.

V. CONCLUSION

Kerala has been increasing its investment in health, which may be contributing to better management of some diseases. Vector-borne diseases like dengue and leptospirosis remain significant challenges, with increasing cases in recent years. The COVID-19 pandemic likely influenced the patterns of other diseases, with notable decreases in some communicable and waterborne diseases in 2020 and 2021. While some diseases show improving trends (like malaria and waterborne diseases), others (like dengue and measles) have seen recent spikes that warrant attention. The state's 'Jagratha' program for preventing communicable diseases may be having some positive effects, but continued efforts are clearly necessary. These trends suggest a need for continued investment in public health infrastructure, disease surveillance, and preventive measures, particularly for vector control and water sanitation. Sustainable development is the level of development sustaining limited resources necessary to satisfy the wants of the future generations on earth. It is an approach for economic planning that attempts to promote economic growth by maintaining the quality of the environment for future. The state of Kerala has gone through as well as still faces a lot of natural and manmade environmental degradations and disasters. Climate change can be considered as an indirect effect and also a reason of these environmental degradations. Even though, Kerala government has taken various initiatives to protect the environment and safeguard the health and life of people, the fool proof implementation of these measures and hundred per cent co-operations from the local people also very important. A positive attitude towards protecting and safe guarding health and life in this changing environment and adverse climatic condition has to be developed by each one. The subject environmental studies and health care needs to be incorporated and made mandatory from early classes and various environmental protection programmes should be practiced. If we don`t give adequate consideration for the environment now, our future generation will face only environmental disasters and related health hazards.

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