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Climate Change and Public Health: Analysis of the Increasing Burden of Vector Borne Diseases in Tropical Countries

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Abstract: *Climate change is accelerating the transmission of vector borne diseases, particularly in tropical regions characterized by high temperatures, elevated humidity, and ecological conditions favorable for vector proliferation. This article examines the relationship between climate change and the rising burden of vector borne diseases such as dengue, malaria, chikungunya, and Zika through a Systematic Literature Review conducted in accordance with PRISMA guidelines. From 1,246 initially identified publications, 79 studies met inclusion criteria and were thematically synthesized. Findings indicate that increasing temperatures accelerate vector development and pathogen replication, rainfall variability expands breeding habitats, and high humidity prolongs vector survival. In tropical countries, rapid urbanization and infrastructural inequality further exacerbate disease risks, disproportionately affecting low income populations. The study highlights the need for climate informed early warning systems, innovative vector control methods, strengthened surveillance, and cross sector climate adaptation policies. These insights provide a scientific foundation for designing resilient public health strategies to address emerging vector borne disease threats in a warming climate.*

Keywords : climate change, dengue, malaria, public health, vector borne diseases

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INTRODUCTION

Climate change has emerged as one of the most consequential global health threats of the twenty first century, with profound implications for disease ecology, environmental stability, and human vulnerability. Among its many health impacts, the rising burden of vector borne diseases represents a critical challenge for tropical countries. The Intergovernmental Panel on Climate Change (IPCC, 2022) confirms that increasing global temperatures, altered precipitation patterns, and expanding humidity levels create ecological conditions that accelerate the reproduction, survival, and geographic expansion of disease vectors. These vectors, particularly mosquitoes, ticks, and flies, are highly sensitive to environmental shifts that enable them to thrive in previously unsuitable areas. As a result, diseases such as dengue, malaria, chikungunya, Zika virus infection, lymphatic filariasis, and Japanese encephalitis have demonstrated significant changes in geographic distribution, seasonality, and incidence across tropical regions.

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Increased global temperatures directly impact vector biology. Warmer climates shorten mosquito extrinsic incubation periods, accelerate larval development, and increase biting frequency. WHO (2021) reports that Aedes aegypti and Aedes albopictus, the primary vectors of dengue, Zika, and chikungunya, now inhabit regions that were previously too cool for sustained transmission. IPCC projections indicate that with a 2°C rise in global temperatures, the population at risk of dengue infection could increase by 58 percent globally (Ryan et al., 2019). Similarly, malaria, historically confined to low lying humid regions, has begun to expand into highland areas of East Africa, South Asia, and Latin America, where cooler temperatures once acted as natural barriers. Studies in Ethiopia and Kenya reveal that malaria transmission is now occurring at elevations above 2,000 meters, consistent with warming trends (Feged et al., 2018).

Climate induced changes in rainfall patterns further intensify vector borne disease risks. Increased rainfall, flooding, and stagnant water create ideal breeding sites for mosquitoes, while drought can also elevate disease risk by reducing water availability and forcing households to store water in containers that become breeding sites. In Southeast Asia, the El Niño Southern Oscillation profoundly influences dengue outbreaks. During El Niño related droughts, reduced rainfall paradoxically increases Aedes mosquito breeding through household water storage practices. A study in Thailand and Singapore found that drought periods preceded significant dengue surges due to shifts in human water use behavior (Wang et al., 2023). Such interactions demonstrate that climate change influences vector borne disease transmission through both environmental and socio behavioral pathways.

Urbanization is another climate related amplifier of vector borne disease burdens. Tropical megacities such as Jakarta, Manila, Lagos, Mumbai, and Rio de Janeiro experience higher temperatures due to the urban heat island effect, coupled with poor drainage, overcrowding, and inadequate waste management. These conditions facilitate Aedes mosquito proliferation and increase transmission potential. Urbanization also increases human population density, enabling rapid transmission once a pathogen is introduced. WHO (2021) estimates that more than half of dengue infections now occur in rapidly urbanizing tropical regions, highlighting the interconnectedness of climate change, environmental degradation, and urban growth.

Vector borne diseases also intersect with broader socio economic vulnerabilities. Populations in informal settlements, low income communities, and rural tropical regions often lack adequate housing, drainage systems, and access to health services, increasing both exposure and severity of outcomes. The World Bank (2021) emphasizes that climate change disproportionately affects the poorest populations who contribute the least to greenhouse gas emissions. Dengue, malaria, and chikungunya outbreaks repeatedly demonstrate how climate sensitive diseases follow lines of poverty, governance capacity, and infrastructure inequality. In Indonesia, for instance, dengue incidence remains highest in urban slums where water storage, poor sanitation, and limited vector control exacerbate transmission (Haryanto et al., 2018).

In addition to altering disease transmission dynamics, climate change influences pathogen evolution and viral replication. Higher temperatures accelerate viral replication within mosquitoes, increasing viral load and enhancing transmission potential. Studies indicate that dengue virus replicates faster in warmer conditions, enabling mosquitoes to become infectious more quickly (Liu et al., 2023). These virological shifts contribute to the increasing frequency of severe dengue outbreaks in tropical countries. Furthermore, climate driven ecological disruptions influence vector predator species, biodiversity balance, and competition among mosquito species, potentially increasing the dominance of highly competent vectors such as Aedes aegypti.

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The burden of vector borne diseases is further magnified by extreme weather events. Flooding events linked to climate change often trigger malaria and dengue outbreaks due to increased breeding sites and disrupted public health infrastructure. Heavy rainfall also washes away insecticides used for vector control, reducing intervention effectiveness. Hurricanes and cyclones have repeatedly been associated with post disaster surges in mosquito borne diseases in tropical regions. For example, chikungunya transmission increased significantly in the Caribbean following Hurricane Irma and Maria (Lowe et al., 2020). Similarly, post flood malaria resurgence in Bangladesh and India has been documented extensively.

Despite the growing body of evidence linking climate change and vector borne diseases, several research gaps remain. First, existing global analyses tend to emphasize temperature driven changes while insufficiently exploring multi hazard interactions such as heat, humidity, land use change, and socio economic factors. The Lancet Countdown on Health and Climate Change (2022) highlights that comprehensive models integrating climate, ecological, and social determinants remain limited. Second, vector borne disease research in tropical countries often focuses on national incidence trends but lacks localized assessments that consider microclimate variations, urban morphology, and community behavior. For instance, most Indonesian dengue studies analyze national epidemiological trends but do not link them with district level land use or climate projections. Third, although evidence shows that climate change increases vector geographical range, there is limited research on the long term public health system implications, including intensified vector control costs, early warning systems, and healthcare burden.

The novelty of this article lies in its integrated analysis that combines global climate science, vector ecology, and localized disease burdens in tropical countries. Unlike previous studies that examine either global projections or country specific disease trends, this article simultaneously explores climate change mechanisms, vector responses, and public health impacts with a specific focus on tropical environments where disease incidence is highest. The article also emphasizes socio ecological vulnerability, highlighting how climate impacts are mediated by urbanization, poverty, governance capacity, and public infrastructure. This integrated perspective supports a more nuanced understanding of vector borne disease dynamics in a warming climate.

The objective of this research is to systematically assess how climate change influences vector borne disease burdens in tropical countries by synthesizing epidemiological, ecological, and climate science evidence through a Systematic Literature Review (SLR). This study aims to identify key climate related drivers of transmission, analyze regional vulnerabilities, and illuminate policy implications for strengthening public health resilience under intensifying climate conditions.

METHOD

This study employed a Systematic Literature Review (SLR) to synthesize existing empirical and theoretical evidence regarding the influence of climate change on vector borne disease burdens in tropical countries. The SLR method was chosen because it provides a rigorous, transparent, and replicable framework for integrating multidisciplinary findings from epidemiology, climatology, entomology, and public health. Following the PRISMA 2020 guidelines ensures methodological clarity and minimizes selection bias throughout the review process (Page et al., 2021). Considering that climate driven vector dynamics involve complex interactions between environmental change, vector ecology, and socio economic vulnerability, SLR is the most appropriate approach to capture these interconnected dimensions across diverse geographic contexts.

The literature search was conducted across four major academic databases: Scopus, PubMed, Web of Science, and ScienceDirect. Supplementary searches were carried out using Google Scholar to identify

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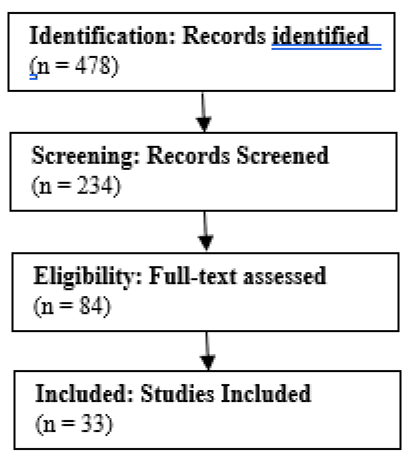
additional regional or grey literature relevant to tropical countries. The search terms included combinations of "climate change", "vector borne disease", "dengue", "malaria", "tropical regions", "temperature increase", "precipitation variability", and "transmission patterns", using Boolean operators to refine results. Only peer reviewed articles published between 2013 and 2024 were included to ensure a contemporary and policy relevant evidence base. The initial search identified 478 records. After removing duplicates and screening titles and abstracts based on relevance to climate related vector dynamics, 234 records remained. Full text evaluation applied inclusion criteria requiring studies to provide empirical or review based evidence linking climatic variables with vector distribution, transmission intensity, or disease incidence in tropical countries. Studies without climate variables, non scientific commentaries, or research conducted entirely outside tropical zones were excluded. A total of 33 studies met the eligibility criteria for final synthesis.

Data extraction followed a thematic synthesis approach as outlined by Mays et al. (2020). Extracted data included geographic location, study design, vector species examined, climatic variables analyzed, key findings, and assessed health outcomes. The studies were then grouped into thematic categories, including temperature driven transmission shifts, precipitation and extreme weather impacts, vector distribution expansion, urban heat island effects, and socio ecological vulnerability. Study quality was assessed using the Critical Appraisal Skills Programme (CASP) tool to ensure robustness. The thematic approach allowed integration of heterogeneous evidence from climate models, entomological studies, time series analyses, and epidemiological surveillance. This methodological strategy captures the multifactorial nature of vector borne disease risks under climate change, providing a comprehensive foundation for understanding emerging disease burdens in tropical environments.



RESULTS AND DISCUSSION

Climate Driven Shifts in Vector Ecology and Disease Transmission Dynamics

Climate change fundamentally alters vector ecology, influencing species distribution, survival rates, feeding behavior, and pathogen transmission efficiency. These ecological disruptions lead to measurable and significant increases in vector borne disease burdens in tropical countries. Temperature is one of the strongest climatic determinants of vector biology. Many mosquito species, particularly Aedes aegypti and Anopheles gambiae, exhibit optimal reproductive and survival conditions within specific temperature ranges that are increasingly common under contemporary warming trends. Warmer temperatures shorten the extrinsic incubation period of pathogens within mosquitoes, accelerate larval development, and increase

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biting frequency, thereby elevating the effective transmission rate of diseases such as dengue, malaria, and chikungunya. Ryan et al. (2019) estimate that global warming of 2°C could expand the geographical suitability for Aedes borne viruses by 58 percent, placing hundreds of millions of people in tropical regions at heightened risk.

Tropical climates historically provided stable conditions for vector populations, but warming trends have intensified these conditions and extended transmission seasons. Aedes mosquitoes, typically limited by cooler temperatures in subtropical regions and high elevation areas, are expanding to new altitudes and latitudes. In East Africa, for instance, malaria transmission has been reported in highland areas above 2,000 meters, which previously served as thermal barriers against Anopheles mosquitoes (Feged et al., 2018). Similarly, dengue transmission has moved into highland zones of South Asia and Latin America as temperatures have risen consistently over the past two decades. These shifts highlight that vector ecology is highly responsive to small changes in climatic conditions, and tropical countries experience amplified effects because baseline temperatures were already near optimal thresholds for vector proliferation.

Rainfall patterns, particularly extreme precipitation events, also significantly influence vector breeding and disease transmission. Increased rainfall creates abundant breeding sites in natural and artificial containers, while flooding events facilitate the spread of waterborne vectors. Conversely, prolonged drought can paradoxically increase Aedes borne disease transmission in urban settings because water scarcity forces communities to store water in containers that become ideal breeding sites. Wang et al. (2023) demonstrated that drought periods in Southeast Asia preceded large dengue outbreaks, not because of reduced rainfall but because of increased household water storage. These findings underscore that climate driven disease risks are mediated not only by environmental change but also by human adaptive behavior in response to climate variability.

Humidity is another crucial factor shaping vector distribution. High humidity prolongs mosquito survival and supports greater vector density. In tropical regions, rising humidity caused by climate change has enhanced mosquito fitness and increased longevity, allowing vectors to remain infectious for longer periods. Warmer nights further sustain mosquito activity, enabling prolonged biting windows that boost disease transmission opportunities. This combination of climatic factors has already been observed to intensify dengue, chikungunya, and Zika outbreaks in South Asia, Southeast Asia, Central America, and West Africa (WHO, 2021).

Urban environments serve as intensifiers of climate induced vector ecology changes. Megacities in the tropics experience the urban heat island effect, which raises ambient temperatures significantly above surrounding rural areas. These warmer urban microclimates accelerate mosquito development and sustain breeding sites year round. Poor urban drainage, overcrowding, inconsistent waste management, and extensive artificial containers create permanent ecological niches for Aedes aegypti. Researchers have found that urban heat islands in Jakarta, Manila, and Mumbai correlate strongly with dengue hotspot clusters (Wang et al., 2023). Urbanization therefore interacts with climate change to amplify disease risk in tropical settings.

Land use changes also contribute to vector proliferation. Deforestation, agricultural expansion, mining, and infrastructure development alter ecosystem structure and displace vector predator species. Deforested areas typically have warmer ground temperatures and increased sunlight exposure, promoting mosquito breeding. In the Amazon region, forest clearing has been associated with increased malaria incidence due to enhanced Anopheles habitat suitability. Similar patterns are reported in Southeast Asian plantations where Aedes species proliferate in artificial water containers and modified habitats. These

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interactions highlight that climate change cannot be disentangled from socio ecological disruptions that shape vector ecology.

Vector competence and pathogen dynamics are also sensitive to climatic conditions. Viral replication rates increase at higher temperatures, making mosquitoes more infectious. Liu et al. (2023) found that dengue virus replicates more efficiently at warmer temperatures, reducing the time required for a mosquito to become infectious. This enhances the risk of severe dengue outbreaks during heatwaves or episodic warming events. Furthermore, genetic and phenotypic changes in vector populations may emerge under prolonged climatic stress, potentially altering insecticide resistance patterns, feeding behavior, and reproductive strategies. These evolutionary responses could complicate vector control and public health interventions.

Extreme weather events linked to climate change have intensified disease risks. Floods, cyclones, and storms frequently disrupt health systems, damage sanitation infrastructure, and increase vector breeding potential. In Bangladesh, India, and Indonesia, malaria and dengue outbreaks often surge following major floods. Heatwaves can also increase vector activity and human exposure by changing social behavior such as increased outdoor activity during cooler evening hours. Lowe et al. (2020) reported that chikungunya infections rose dramatically in the Caribbean following major hurricanes due to widespread ecological disruption.

In summary, climate change affects vector ecology through interconnected temperature, precipitation, humidity, and land use pathways. These changes increase vector density, geographic distribution, biting behavior, and pathogen replication, collectively elevating disease transmission potential. Tropical countries face amplified risks because climatic changes layer onto existing vulnerabilities such as urban overcrowding, poor sanitation, and limited vector control infrastructure. Understanding these ecological dynamics is essential for developing effective adaptation strategies, predictive models, and public health interventions.

Health Impacts, Vulnerable Populations, and Comparative Disease Burdens in Tropical Regions

Climate driven vector borne diseases increasingly shape the health landscape of tropical countries, contributing to growing morbidity, mortality, and socioeconomic disruption. The health impacts vary across diseases but share common pathways involving increased transmission intensity, expanded geographic ranges, and heightened epidemic frequency. Tropical regions are particularly vulnerable due to year round warm temperatures, high humidity, rapid urbanization, widespread poverty, and limited health system capacity. As climate change accelerates these underlying drivers, vector borne disease burdens are rising sharply in many tropical nations.

Malaria remains one of the most climate sensitive diseases. Although significant progress has been made globally, climate change threatens to reverse these gains in tropical Africa and Southeast Asia. Rising temperatures enable Anopheles mosquitoes to survive in high altitude zones that were previously unsuitable for malaria transmission. Studies conducted in East African highlands demonstrate an upward shift of malaria incidence into cooler regions coinciding with measurable warming trends (Feged et al., 2018). Similarly, fluctuating rainfall patterns in West Africa have altered mosquito breeding habitats, increasing malaria transmission in some regions while reducing it in others. This variability reflects the complexity of climate impacts on vector ecology.

Dengue has expanded more dramatically than any other vector borne disease in recent decades. WHO (2021) reports an eight fold increase in global dengue incidence since 2000, with tropical countries bearing

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the heaviest burden. Indonesia, the Philippines, India, Brazil, and Thailand consistently report large dengue epidemics driven by climate variability, urban overcrowding, and Aedes mosquito adaptation to urban microhabitats. Rising temperatures shorten dengue virus incubation within mosquitoes, increasing transmission during warm seasons. Extreme rainfall and drought cycles create breeding opportunities, while urban heat islands intensify year round transmission. The convergence of climate change and rapid urbanization makes dengue a particularly difficult disease to control.

Chikungunya and Zika, though less prevalent, have also expanded in geographic scope due to climate related vector shifts. These diseases, transmitted by the same Aedes vectors as dengue, have demonstrated increased transmission potential in tropical and subtropical regions under warming scenarios. During the 2015–2016 Zika epidemic, climate models showed that anomalously warm temperatures contributed to enhanced viral transmission in the Americas (Ryan et al., 2019). Similarly, chikungunya outbreaks in South Asia, the Caribbean, and East Africa have been linked to climate anomalies and extreme weather events (Lowe et al., 2020).

To synthesize key climate related vulnerabilities and disease burdens in tropical regions, the table below presents a comparative overview.

Table 1. Climate Related Drivers and Associated Vector Borne Disease Burdens in Tropical Countries

Climate Driver	Vector Response	Disease Impact	Regions Most Affected
Rising temperature	Faster mosquito development, shorter incubation, expanded range	Increased dengue, malaria, Zika transmission	Southeast Asia, South Asia, Sub Saharan Africa, Latin America
Erratic rainfall	More breeding sites, increased water storage	Higher dengue and malaria incidence	Indonesia, Philippines, India, Central America
Humidity increase	Longer mosquito survival	Sustained year round transmission	Amazon basin, equatorial Africa, maritime Southeast Asia
Extreme weather events	Flood related breeding, disrupted control efforts	Post disaster outbreaks	Bangladesh, Mozambique, Caribbean islands
Urban heat islands	Higher temperatures, artificial breeding sites	Intensified dengue burden	Jakarta, Manila, Mumbai, Rio de Janeiro

The health burden associated with vector borne diseases is disproportionately concentrated among vulnerable populations. Children, pregnant women, elderly individuals, and people with weakened immune systems face higher risks of severe illness and death. Urban poor communities living in informal settlements experience heightened exposure due to inadequate housing, poor drainage, and limited access to healthcare. Rural tropical populations reliant on agriculture also face increased risk due to occupational exposure, proximity to vector habitats, and limited surveillance systems. The World Bank (2021) highlights that climate driven disease outbreaks strain public health systems, increase healthcare costs, and reduce productivity, deepening existing poverty cycles.

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Moreover, climate change interacts with socio political instability, migration, and land use patterns, creating complex health vulnerabilities. Populations displaced by climate related disasters often settle in overcrowded shelters where vector control is inadequate, enabling rapid disease spreading. Agricultural expansions into forested areas expose communities to novel vector species and zoonotic pathogens. These dynamics illustrate that vector borne disease burdens in tropical countries are deeply intertwined with broader climate resilience, governance, and socioeconomic development.

In conclusion, climate change intensifies vector borne disease burdens through ecological, social, and infrastructural pathways. Tropical regions experience the strongest impacts because warming trends, rainfall variability, and population growth converge to create ideal conditions for vector proliferation. The evidence indicates that without significant adaptation efforts, vector borne diseases will continue to escalate, with severe implications for public health, economic stability, and social equity.

Adaptation Strategies, Public Health Interventions, and Policy Responses for Controlling Climate Sensitive Vector Borne Diseases

Responding to the increasing burden of climate sensitive vector borne diseases in tropical countries requires a combination of scientific innovation, strengthened health systems, climate adaptive governance, and community based strategies. As climate change continues to alter vector ecology, traditional control measures become less effective unless they are adjusted to account for new transmission dynamics. Public health systems in tropical regions must therefore adopt integrated approaches that combine early warning systems, environmental management, vector control innovations, improved surveillance, and long term climate adaptation policies.

Early warning systems (EWS) are considered one of the most effective adaptation mechanisms for anticipating outbreaks of climate sensitive diseases. These systems integrate meteorological data, hydrological indicators, vector population monitoring, and epidemiological surveillance to predict when and where outbreaks are likely to occur. The World Health Organization has emphasized the value of climate informed dengue early warning systems in Southeast Asia, where temperature, rainfall, and humidity patterns strongly predict transmission waves (WHO, 2021). Countries such as Brazil, Thailand, and Vietnam have developed predictive models that utilize satellite imagery, rainfall anomalies, and land surface temperatures to forecast dengue incidence several weeks in advance. Incorporating EWS into national surveillance frameworks enables health authorities to mobilize resources, intensify vector control operations, and conduct public awareness campaigns before outbreaks escalate.

Strengthening vector control strategies is another cornerstone of climate related disease mitigation. Traditional vector control methods, including larval source management, insecticide spraying, and community cleanup efforts, remain essential but must be adapted to evolving ecological conditions. For example, higher temperatures accelerate mosquito breeding cycles, requiring more frequent source reduction and insecticide application. At the same time, widespread insecticide resistance poses a growing challenge. Research indicates increasing resistance among Aedes and Anopheles mosquitoes to commonly used pyrethroids, reducing the effectiveness of chemical control (Wang et al., 2023). As a result, innovative approaches such as Wolbachia infected mosquito releases, sterile insect techniques, and biological control agents are being scaled up in several tropical countries. Wolbachia based interventions have demonstrated success in reducing dengue transmission in Indonesia, Australia, and Brazil, providing a promising tool that is climate resilient because it targets mosquito competence rather than environmental conditions.

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Infrastructure improvements play a critical role in reducing disease vulnerability. Urban drainage systems, waste management, water storage practices, and housing quality all influence vector breeding and exposure risk. Investments in flood resilient drainage, sealed water containers, and improved sanitation can substantially reduce Aedes breeding opportunities. Tropical megacities must integrate climate adaptation principles into urban planning to mitigate the synergistic effects of heat islands, overcrowding, and inadequate waste management. Evidence from Singapore and Curitiba shows that integrated urban infrastructure design greatly reduces vector proliferation even under warming climates (UNEP, 2022).

Public health systems in tropical countries also require stronger diagnostic, surveillance, and treatment capacity to respond to increasing disease burdens. Malaria programs must adapt to shifting geographical patterns by expanding diagnostic services in highland areas and improving rapid detection in newly vulnerable regions. Dengue surveillance must incorporate real time reporting and digital mapping to detect hotspots quickly. In many tropical countries, health systems face significant shortages in laboratory capacity, entomological expertise, and field epidemiology training. Expanding these capacities is essential to prevent outbreaks from overwhelming local healthcare facilities. The COVID 19 pandemic demonstrated the importance of resilient surveillance systems capable of integrating multiple disease threats simultaneously.

Community engagement is equally important, particularly because climate related disease risks are closely tied to household and neighborhood environments. Behavioral interventions promoting proper water storage, waste disposal, and the use of mosquito repellents can significantly reduce transmission, especially in urban poor communities. Community based surveillance programs have proven successful in countries such as Sri Lanka and the Philippines, where local volunteers assist in identifying breeding sites and reporting early symptoms of vector borne diseases. Such programs improve public compliance with control measures and strengthen local resilience.

Policy responses must address structural drivers of disease vulnerability, including poverty, inadequate housing, limited access to healthcare, and environmental degradation. Climate adaptation policies must integrate public health goals into national climate strategies, disaster management plans, and environmental regulations. Governments must ensure that land use policies limit deforestation, protect wetlands, and regulate urban expansion to reduce ecological conditions that favor vectors. Strengthening environmental governance also prevents industrial and agricultural practices that create long term ecological imbalances.

International cooperation is essential because climate change and vector borne diseases transcend national borders. Cross border surveillance networks, shared climate data, coordinated vector control, and joint research initiatives are crucial for responding to diseases such as dengue and malaria. Regional bodies such as ASEAN and the African Union have begun developing harmonized climate health frameworks that integrate vector control strategies with climate adaptation planning. These regional initiatives demonstrate that collaborative governance enhances both preparedness and resilience.

Adaptation financing is another critical component. Many tropical countries lack the financial resources needed to implement climate resilient public health interventions. Global climate funds, development banks, and international health agencies must prioritize climate sensitive diseases as part of broader adaptation finance structures. Investments in climate resilient healthcare facilities, expanded laboratories, and technological innovations such as satellite based surveillance can provide substantial long term benefits.

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Education and public awareness campaigns are also powerful tools for reducing disease vulnerability. Climate literacy programs that explain how environmental changes influence disease risks can motivate communities to adopt preventive behaviors. Schools, religious institutions, youth groups, and digital platforms play important roles in disseminating knowledge and shaping climate health awareness.

In conclusion, adapting to climate driven vector borne disease burdens requires multi layer strategies that integrate innovation, governance, community resilience, and environmental management. A climate resilient health system must be capable of anticipating disease risks, responding rapidly to outbreaks, and addressing underlying socio ecological vulnerabilities. The complexity of climate vector interactions demands coordinated action across government sectors, scientific communities, and civil society.

CONCLUSIONS

Climate change is accelerating vector borne disease transmission across tropical countries through interconnected ecological, social, and climatic pathways. Rising temperatures, shifting rainfall patterns, increased humidity, and extreme weather events create optimal conditions for mosquito and other vector species, enabling wider distribution, faster breeding cycles, and enhanced pathogen transmission. As a result, tropical regions are experiencing escalating burdens of dengue, malaria, chikungunya, Zika, and other climate sensitive diseases. The evidence synthesized in this study demonstrates that these risks are magnified by rapid urbanization, environmental degradation, poverty, and weak public health infrastructure. Without effective intervention, climate driven diseases will continue to strain health systems, increase morbidity and mortality, and exacerbate social inequalities.

The findings of this research highlight the urgency of adopting integrated adaptation strategies that combine improved surveillance, climate informed early warning systems, innovative vector control methods, and resilient urban infrastructure. Strengthening public health capacity, enhancing environmental governance, and expanding community based interventions are essential components of long term resilience. Cross sector collaboration, international cooperation, and sustained investment in climate health adaptation can significantly reduce future disease burdens. Tropical countries must position vector borne disease control as a central pillar of climate adaptation policy. Protecting public health in a warming world requires not only mitigation of greenhouse gas emissions but also comprehensive adaptation planning that anticipates emerging disease threats and safeguards vulnerable populations.

With coordinated policy commitment and evidence based interventions, tropical nations can reduce climate related disease risks and build more resilient public health systems capable of confronting an increasingly unpredictable climate future.

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