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Climate Change and the Rising Burden of Vector-Borne Diseases in East Africa: A Comprehensive Review

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Abstract: Climate change is intensifying the transmission and geographic spread of vector-borne diseases (VBDs) across East Africa, with distinct impacts in Kenya, Uganda, Tanzania, Ethiopia, Rwanda, Burundi, South Sudan, and Somalia. This review examines how rising temperatures, erratic rainfall, and extreme weather events are altering the epidemiology of malaria, dengue, Rift Valley fever (RVF), and leishmaniasis in the region. We synthesize recent country-specific data on disease trends, climate-vector interactions, and public health responses. Our analysis highlights the urgent need for integrated climate and health strategies tailored to each nation's vulnerability.

Keywords: climate change; vector-borne diseases; somalia; malaria; dengue

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1. Introduction

Vector-borne diseases (VBDs) are infections transmitted by vectors such as mosquitoes, ticks, and sandflies. In East Africa, VBDs pose a significant public health challenge, with diseases like malaria and dengue causing substantial morbidity and mortality. Climate change has emerged as a critical factor influencing the distribution and incidence of these diseases. Understanding the relationship between climate change and VBDs is essential for developing effective public health interventions.

Globally, rising temperatures have been linked to the expansion of VBDs into higher altitudes and latitudes. For instance, dengue fever has spread into temperate regions of Europe and North America, while malaria is re-emerging in highland areas of South America and Africa [1]. The Intergovernmental Panel on Climate Change (IPCC) projects that climate change will increase the population at risk of VBDs by up to 1 billion people by 2080, with the most significant impacts expected in low-income countries with weak health systems [2].

Africa bears the highest burden of VBDs globally, with malaria alone causing over 600,000 deaths annually, predominantly among children under five [3]. The continent's vulnerability is exacerbated by its tropical climate, limited healthcare infrastructure, and high population growth. East Africa, in particular, is a hotspot for climate-sensitive VBDs due to its diverse ecosystems, ranging from humid coastal regions to arid and semi-arid highlands. Recent studies indicate that the region has experienced a 1.0–1.5°C temperature increase since 1950, with projections suggesting a further rise of 2–4°C by 2100 [4].

2. Impact of Climate Change on Vector-Borne Diseases in East Africa

Climate variables such as temperature, rainfall, and humidity directly affect vector survival, reproduction, and distribution.

Temperature

Increased temperatures can accelerate the development of pathogens within vectors, shorten the extrinsic incubation period, and expand vector habitats to higher altitudes and latitudes. For instance, malaria transmission has been observed at higher elevations in the Ethiopian highlands due to rising temperatures [5].

Rainfall and Humidity

Changes in precipitation patterns can create new breeding sites for vectors. Excessive rainfall leads to stagnant water accumulation, while drought conditions may compel communities to store water in containers, both scenarios providing breeding grounds for mosquitoes [6].

3. Country-Specific Observations

Kenya

Kenya has experienced a 1.2°C temperature rise since 1985, with the most significant warming observed in the central highlands and arid northern regions [7]. These changes have facilitated the expansion of Anopheles gambiae and An. arabiensis into highland areas previously unsuitable for malaria transmission. A 2023 study in the Kenyan highlands documented a 47% increase in malaria cases since 2010, directly correlated with rising temperatures [8]. Additionally, erratic rainfall patterns, particularly during the long rains (March–May), have created temporary breeding sites for Aedes aegypti, leading to localized dengue outbreaks in coastal cities like Mombasa [9].

Uganda

Uganda's climate has warmed by 0.8°C since 1960, with the Lake Victoria basin experiencing the most rapid temperature increases [10]. This warming has shortened the extrinsic incubation period of Plasmodium falciparum in mosquitoes, contributing to sustained malaria transmission in endemic regions. In 2022, Uganda reported 12.8 million malaria cases, with new hotspots emerging in the Kabale Highlands [11]. Dengue fever is also becoming a growing concern, with Kampala reporting its first major outbreak in 2021. Urban heat islands and poor drainage systems have created ideal breeding conditions for Aedes aegypti, leading to recurrent dengue cases in the capital [12].

Tanzania

Tanzania has recorded a 1.1°C temperature increase since 1970, with significant impacts on VBD transmission [14]. Malaria prevalence remains high in the Lake and Coastal Zones, but recent studies indicate a southward expansion of Anopheles funestus due to changing rainfall patterns [15]. Zanzibar, once a malaria success story, has seen a resurgence of cases linked to higher nighttime temperatures and increased humidity [16]. Dengue fever is also emerging as a public health threat, with Dar es Salaam reporting 700 cases in 2022. The city's rapid urbanization and poor waste management have exacerbated Aedes breeding, particularly during the short rains (October–December) [17].

Ethiopia

Ethiopia's highlands have warmed by 1.3°C since 1950, leading to the re-emergence of malaria in areas previously considered low-risk [19]. A 2023 study in the Amhara Region documented a 60% increase in malaria cases since 2015, with An. arabiensis now detected at altitudes above 2,000 meters [20]. Visceral leishmaniasis (kala-azar) is also expanding into new areas, including the outskirts of Addis Ababa, due to warmer temperatures and changing sandfly (Phlebotomus spp.) habitats [21].

Rwanda and Burundi

Rwanda has experienced a 0.9°C temperature rise since 1981, with nighttime warming particularly pronounced [23]. This trend has extended the malaria transmission season in high-

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altitude regions like Musanze District, where cases increased by 30% between 2020 and 2023 [24]. Dengue fever is also emerging, with Kigali reporting its first outbreak in 2021. The city's urban heat island effect and inadequate drainage systems have facilitated Aedes aegypti proliferation [25]. Burundi faces similar challenges, with malaria cases spiking during intense short rains (September–December). The 2023 outbreak in Cibitoke Province resulted in over 50,000 cases, overwhelming local health facilities [26].

South Sudan

South Sudan is one of the fastest-warming countries in East Africa, with temperatures rising by 1.5°C since 1950 [27]. Extreme flooding in 2019–2023 created ideal conditions for RVF vectors (Culex and Aedes spp.), leading to outbreaks in Jonglei and Unity States. The 2022 epidemic caused 300+ human cases and 60 deaths. Malaria remains endemic, with 4.2 million cases reported in 2023. Flooding has displaced populations, increasing their exposure to mosquito bites in temporary shelters [29].

Somalia

Somalia is among the countries most vulnerable to the impacts of climate change, characterized by increasing temperatures, erratic rainfall patterns, and prolonged droughts. These climatic changes have significantly influenced the epidemiology of vector-borne diseases (VBDs) in the region. The country has experienced a gradual temperature increase of 1 to 1.5°C since 1991, contributing to the expansion of habitats suitable for disease vectors such as Anopheles and Aedes mosquitoes. This expansion facilitates the transmission of diseases like malaria and dengue fever into previously unaffected areas [30]. The 2021–2023 drought, the most severe in four decades, affected over 7.8 million people—approximately half of Somalia's population—and led to the displacement of more than one million individuals in 2022 alone. Such mass movements often result in overcrowded and unsanitary living conditions, creating ideal environments for the proliferation of disease vectors. Conversely, when rains occur, they are often intense and lead to severe flooding, particularly along the Juba and Shabelle rivers, causing widespread displacement and an increased risk of waterborne diseases [31].

4. Country-Specific Disease Trends and Data

Malaria

Malaria is the leading cause of morbidity and mortality in East Africa, with climate change exacerbating transmission in previously low-risk areas. Kenya reported 3.1 million cases in 2023, a 47% increase in highland regions since 2010 [30]. Uganda documented 12.8 million cases in 2022, with new transmission zones emerging in the Kabale Highlands [31]. Ethiopia's malaria cases reached 2.9 million in 2023, including outbreaks near Addis Ababa [32]. In Rwanda, malaria incidence in Musanze District rose by 30% from 2020 to 2023 due to warmer temperatures [33]. South Sudan recorded 4.2 million cases in 2023, with flooding displacing populations into high-risk areas [34]. Somalia reported 336,840 suspected malaria cases in 2022, with 11,550 confirmed positive cases. Although this represents an 11% decline compared to the previous year and a 61% decrease from 2020, the risk of outbreaks persists, especially during periods of flooding when stagnant water provides breeding grounds for mosquitoes [32].

Dengue Fever

Dengue fever is emerging as a significant public health threat in East Africa's urban centers. Kenya's Mombasa reported 1,200 cases in 2023, linked to coastal warming and Aedes aegypti proliferation [35]. Tanzania's Dar es Salaam documented 700 cases in 2022, with poor urban drainage exacerbating breeding sites [36]. Rwanda's first major dengue outbreak occurred in Kigali in 2021. Uganda has also reported sporadic dengue cases in Kampala, driven by urban heat islands [37]. The presence of Aedes aegypti, the primary vector for dengue, has been increasingly reported in areas

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where it was previously uncommon in Somalia, indicating a shift in vector distribution likely influenced by climate change [38].

Rift Valley Fever (RVF)

RVF outbreaks in East Africa are closely tied to extreme weather events. Kenya's 2023 outbreak in Isiolo County caused 120 human cases and 45 deaths following El Niño-induced floods [39]. South Sudan's 2022 epidemic in Jonglei State resulted in 300+ cases and 60 deaths, overwhelming local health facilities [40]. Tanzania and Ethiopia have also experienced RVF outbreaks linked to erratic rainfall. The 2021 outbreak in Morogoro Region (Tanzania) caused 85 cases [41], while Ethiopia's 2020 epidemic in Afar Region led to 120 cases [42].

Cholera

In 2023, Somalia reported a total of 15,554 suspected cholera cases, with 43 fatalities, resulting in a case fatality rate of 0.3%. Districts such as Belethawa, Afmadow, Dolow, and Daynile, which were directly impacted by flooding, reported the highest attack rates [33].

5. Public Health Responses and Challenges

Kenya

Kenya has established a Climate-Health Unit to integrate meteorological data into disease surveillance [46]. Larval source management programs in malaria hotspots have reduced transmission in some highland areas [47]. However, weak coordination between the health and environment sectors hampers effective response to climate-driven outbreaks.

Uganda

Uganda's dengue task force in Kampala has improved outbreak response [48]. Indoor residual spraying (IRS) in malaria-endemic districts has also shown success [49]. However, funding gaps limit the scalability of these interventions, particularly in rural areas.

Tanzania

Tanzania has invested in community-based vector control, including larviciding in urban areas [50]. Zanzibar's malaria elimination program has faced setbacks due to climate-related resurgence [51]. Strengthening cross-border collaboration with Kenya and Uganda is critical for managing transboundary outbreaks.

Ethiopia

Ethiopia's leishmaniasis control program focuses on endemic regions but lacks a national climate-disease surveillance system [52]. The 2020 RVF outbreak in Afar exposed gaps in veterinary-public health coordination [53].

Rwanda and Burundi

Rwanda has introduced malaria early warning systems in high-altitude regions [54]. Burundi's response to climate-sensitive outbreaks is hindered by limited healthcare infrastructure [55]. Both countries require increased funding for climate adaptation in health.

South Sudan

South Sudan's RVF response relies heavily on international partners due to weak health systems [56]. Conflict and displacement further complicate disease control efforts [57].

Somalia

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Somalia's healthcare infrastructure faces significant challenges, including inadequate funding, insufficient healthcare personnel, and limited access to medical supplies. These systemic issues hinder effective disease surveillance, prevention, and treatment efforts. Furthermore, ongoing conflicts and political instability divert attention and resources away from public health priorities, exacerbating the vulnerability of the population to climate-sensitive diseases. In response to these multifaceted challenges, Somalia has initiated efforts to enhance its climate resilience and public health capacity. The country formulated its first National Adaptation Programme of Action (NAPA) in 2013, aiming to integrate climate change considerations into national development planning [34]. Additionally, community-based projects focusing on water management and afforestation have been implemented to mitigate the impacts of drought and reduce vector breeding sites. However, these initiatives require sustained support and coordination to effectively address the complex interplay between climate change and vector-borne diseases in Somalia [35].

6. Recommendations

1. Strengthen climate-health surveillance with real-time data integration.
2. Expand vector control programs in high-risk areas, including urban centers.
3. Increase funding for climate-adaptive health policies.
4. Enhance regional collaboration through the East African Community (EAC).

7. Conclusion

Climate change is intensifying the burden of VBDs in East Africa, with distinct impacts across countries. Tailored, climate-informed strategies are urgently needed to mitigate this growing threat.

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