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COMMENT

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Money for health: handling the costs of climate change to African health systems

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Abstract
The manifold impacts of climate change are also seen in the field of health in most countries. It is particularly so in Africa, whose health systems are amongst the most fragile in the world. This Commentary showcases the degree of vulnerability of the health systems of African countries to climate change, and describes some measures aimed at increasing their resilience to climate shocks. African health systems face significant challenges due to climate change, necessitating a comprehensive approach to enhance resilience.

Keywords Climate change, Health, Africa, Finances, Resilience

Introduction

African countries are particularly vulnerable to climate change due to various factors, including widespread poverty, recurrent political instability, and inadequate infrastructure, which hinder effective adaptation and mitigation efforts [1, 12, 13, 19]. Of particular concern is the fact that climate change also has a significant impact on African countries, affecting their economies, environments, and societies in profound ways [6, 24].

For instance, the economy of Africa countries heavily relies on agriculture, which is extremely vulnerable to climate variability [20]. Changes in temperature and precipitation patterns, as well as increased frequency of extreme weather events such as droughts and floods, can lead to crop failures and reduced agricultural productivity. This not only affects food security but also livelihoods, especially for smallholder farmers [4].

In addition, many African regions are experiencing changes in water availability due to climate change. Increased temperatures and changing rainfall patterns are affecting river flows and reducing the volume of water in lakes and reservoirs [16]. For example, Lake Chad has significantly shrunk over the past decades. This reduction in water resources leads to difficulties in agriculture, drinking water supplies, and hydropower generation [21].

Climate change can exacerbate resource scarcity, leading to migration and potential conflicts [8]. Many communities in Africa are already competing over diminishing water and land resources, leading to social unrest and even violent conflicts [10]. Changes in climate conditions also affect the habitats and survival of various wildlife species, leading to shifts in biodiversity across Africa. These changes can disrupt ecosystem services that many communities rely on for their livelihoods, such as fishing and ecotourism [18, 25].

The issues of water scarcity and biodiversity loss are increasingly intertwined with health outcomes and pose significant challenges to health systems worldwide.

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Access to clean and safe water is fundamental for maintaining public health, yet the exacerbation of water scarcity affects not only hydration but also sanitation and hygiene practices, leading to an increased burden of waterborne diseases. These diseases, such as cholera and dysentery, thrive in conditions where water is inadequately managed, particularly in vulnerable populations facing limited access to healthcare.

Biodiversity loss further compounds these challenges by disrupting ecosystems that provide essential services, including water filtration and regulation. Healthy ecosystems, rich in biodiversity, are vital for the natural purification of water sources. When species decline or ecosystems degrade, the capacity to filter pollutants diminishes, leading to the deterioration of water quality. This deterioration often results in harmful contaminants entering drinking water supplies, which can trigger outbreaks of illness and strain health systems tasked with managing these public health crises.

Moreover, the interconnection between biodiversity loss and water scarcity can lead to food insecurity, which has direct implications for health systems. Decreased biodiversity can negatively impact the resilience of food systems, leading to a reliance on monocultures that are less nutritious and more susceptible to disease. This can aggravate malnutrition, particularly in vulnerable communities, causing a wide range of health issues.

In light of these interconnected challenges, health systems must adopt a more holistic approach that integrates environmental health strategies. Promoting sustainable water management practices and conserving biodiversity are essential steps toward enhancing overall health outcomes. By addressing water scarcity and biodiversity loss together, governments can strengthen their health systems, improve resilience against emerging health threats, and ensure better health for future generations.

Many impacts are also seen in the field of health, a matter explored in the second part of this Communication. Addressing all these challenges requires comprehensive international cooperation and strong local governance to implement effective climate adaptation strategies [23].

The adverse effects of climate change on health, next to the human suffering, significantly affect the broader economy [11]. Productivity losses and increased health expenditure illustrate the need for greater investments in climate adaptation strategies, which may also support the economic growth of African countries and increase the wellbeing of their populations [4, 5].

Methods

This study employs a multidisciplinary approach to examine the impacts of climate change on the health sector in Africa, with malaria serving as a case study. We did a review of existing literature, an analysis of secondary data, and spatio-temporal mapping to identify patterns, challenges, and potential interventions. The literature review synthesises findings from peer-reviewed studies and reports from authoritative organisations such as the World Health Organization (WHO), focusing on the relationships between climatic variables (temperature, precipitation, and humidity) and climate-sensitive diseases, particularly malaria.

Secondary data from WHO reports on malaria (2010–2022) are analysed to assess trends in malaria incidence, treatment costs, and climatic factors. In addition, spatio-temporal mapping illustrates the distribution of climate-sensitive diseases across Africa, with a focus on malaria.

Additionally, the study evaluates adaptation strategies by examining best practices in climate-resilient health systems and community interventions. A gap analysis identifies resource deficits in health infrastructure, surveillance, and financing, thereby pinpointing the need for targeted investment. The study provides evidence-based recommendations for establishing climate-resilient health systems, promoting adaptation strategies, and mitigating the effects of climate change on health in Africa.

Climate change and health sector impacts

Climate change presents a great challenge to the health sector in Africa, impacting public health systems in multifaceted ways that necessitate urgent responses. The increased frequency and severity of climate-related events not only strain existing health services but also exacerbate health inequalities, disproportionately affecting the most vulnerable populations.

The health sector's vulnerability to climate change is driven by its direct impact on disease patterns, healthcare infrastructure, and resource availability. Climate variability contributes to the spread of infectious diseases, malnutrition, and non-communicable diseases through changes in temperature, precipitation, and extreme weather events. For instance, shifts in temperature and rainfall patterns influence the habitat suitability for the vectors of diseases such as malaria, dengue fever, diarrheal diseases, tuberculosis, typhoid fever, meningitis, schistosomiasis, yellow fever, malnutrition and Ischemic heart thereby modifying their geographic distribution and seasonality as showing in [22]. The distribution of these climate-infectious diseases vary spatially, temporally and Spatio-temporally (Fig. 1). Malaria, tuberculosis, and schistosomiasis show considerable prevalence rates across multiple countries due to their sensitivity to climate change.

Malaria, amongst the most sensitive diseases to climate change, represents a real threat for Africa, the link between climate and malaria in endemic regions has been established, most regions of Africa have climatic

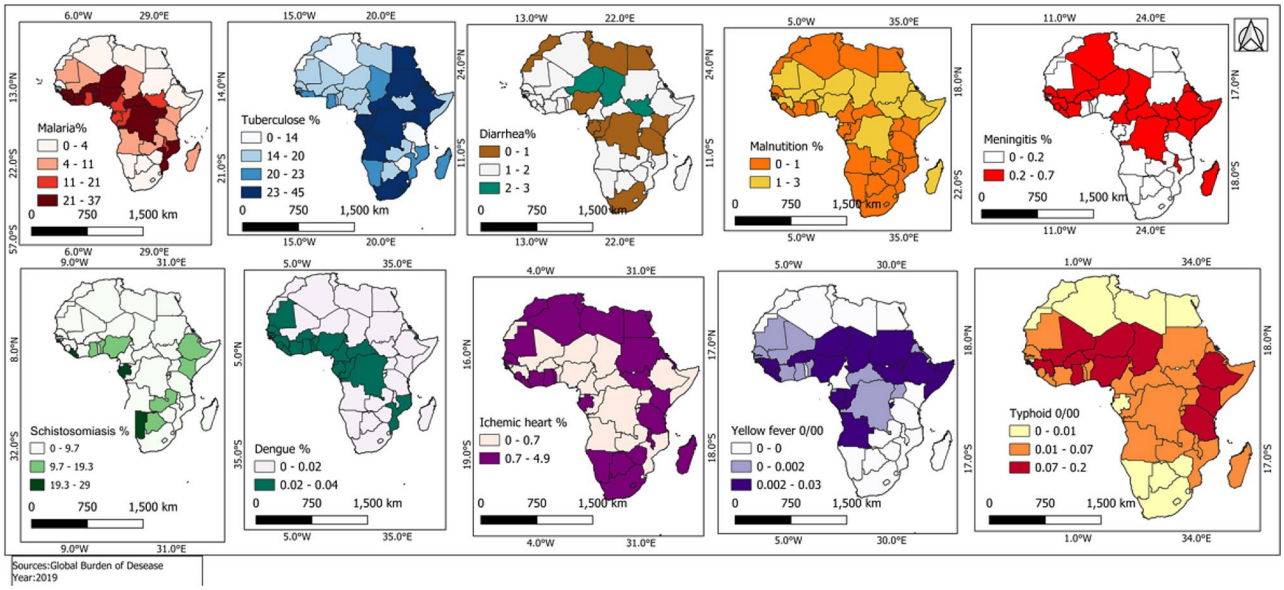

Fig. 1 Mapping of the ten most important climate change-related diseases in Africa

conditions which are favorable to the development of the Anopheles mosquito vector and the Plasmodium malaria parasite constitutes a real problem for the health sectors [15]. Africa does not have enough resources to deal with the effects of climate change, which makes him more vulnerable. Several additional resources are needed in terms of training sufficiently qualified health professionals, medical equipment, building more health centers and hospitals in areas where the most vulnerable populations are located [7]. The changing disease patterns, increased frequency of extreme weather events, and environmental degradation pose substantial challenges to health systems. Addressing these impacts requires a comprehensive and coordinated approach, integrating climate change adaptation and mitigation strategies into healthcare planning, resource allocation, and policy development. Building climate-resilient health systems and strengthening preparedness and response mechanisms are crucial to mitigate the adverse health effects of climate change on African populations.

Malaria as a case study

Malaria, a vector born disease continue to jeopardize the life of many people in Africa due to the adverse impacts of climate change. Despite Africa's low greenhouse gas emissions, the continent has been disproportionately affected by climate change [2]. African countries account for 94% of the global malaria cases, with a staggering 233 million cases recorded in 2022 [7]. The role of weather and climate in malaria transmission in Africa has been widely acknowledged [3, 17].

However, the association between malaria transmission and climate change is complex, and there is limited empirical evidence to support reliable predictions. Numerous studies have identified climatic factors such as rainfall, relative humidity, and temperature as the primary drivers of malaria in Africa [3, 14]. Variations in temperature and rainfall patterns in Africa create favorable conditions for the development and proliferation of malaria [9, 13]. Temperature, precipitation, and relative humidity significantly influence larval development, mosquito survival, parasite development within mosquitoes, and vector competence in many African countries [14]. Temperature fluctuations can disrupt mosquito larval development, reducing malaria spread. An air temperature range of 25–35 °C is conducive to malaria transmission in Africa. Influence varies among Anopheles mosquito species. Rainfall creates favorable conditions for mosquito breeding and egg laying. Humidity, closely linked to precipitation, positively affects mosquito spread in many African countries. Relative humidity within 60-86% is suitable for mosquito development. The potential indirect effects of climate change on malaria include the loss of livelihoods, increased economic and food insecurity, displacements and disruptions in services, challenges and increased costs of malaria programs, and variations in access to and quality of healthcare systems [26]. The failure of antimalarial treatment, rising costs of malaria treatment, variations in climate patterns, and the creation of new vector habitats due to rainfall patterns pose significant challenges for African countries in their efforts to eliminate malaria transmission.

The annual costs of malaria treatment

The impact of climate change on malaria exacerbates the challenges faced by health systems in Africa. Many

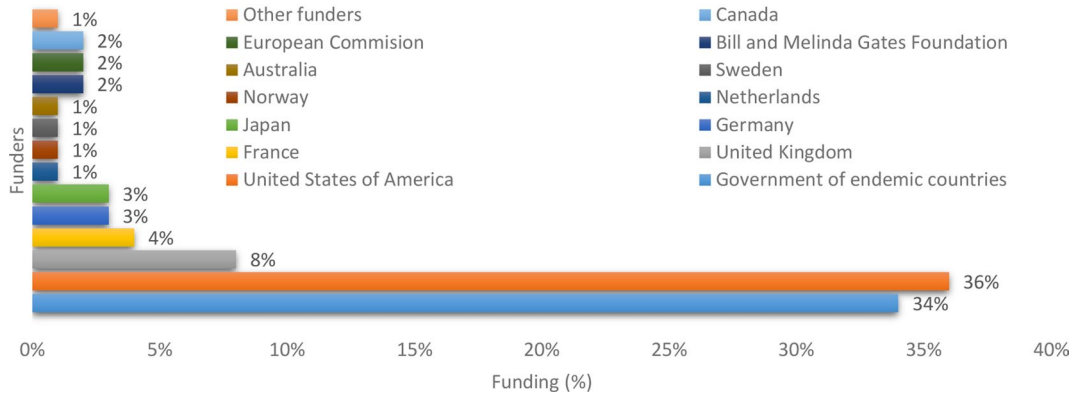

Fig. 2 International funding made available for malaria prevention and control, 2010–2022. (Source: WHO, [26])

African countries struggle with under-resourced health systems that are ill-prepared to cope with the existing malaria burden. African regions requires heightened attention and targeted investments to effectively control and treat malaria infections.

The estimated annual cost for malaria control and eradication in 2022 is US$4.1 billion, with domestic contributions accounting for 38% of the total funding. Notably, there has been an increase in malaria treatment costs compared to the previous two years, with US$ 3.5 billion invested in 2021 and US$ 3.3 billion in 2020 [26]. Figure 2 illustrates the funding allocated to malaria treatment from 2010 to 2022, highlighting the United States of America, the United Kingdom, and France as the leading international contributors. Given that Africa bears the highest malaria burden and possesses limited resources, it is evident that developing countries should intensify their efforts to finance and support African nations, particularly those in Sub-Saharan Africa, in their malaria treatment and elimination endeavors.

Despite a substantial increase in overall funding from 2021 to 2022, the total amount in 2022 only accounted for 52% of the required funding set by the Global Technical Strategy targets (GTS). Significant efforts are still needed to support malaria control and elimination programs in Sub-Saharan African countries. Considerable investments are required to aid malaria-endemic countries in Africa in assessing the temporal effects of climate change on malaria response and developing more effective tools. Additionally, researching effective ways to communicate existing and future malaria risks to policymakers, funders, and the public can facilitate preparedness actions to mitigate the threats of malaria. This can help achieve the GTS's objective of lowering malaria incidence and death by 90% by 2030, with 2015 as the baseline.

The growing impact of climate change on malaria transmission indirectly leads to increased malaria treatment costs, heightened poverty, food insecurity, and the undermining of healthcare systems. The health sector's response to malaria in the context of climate change is not just about mitigating the impacts but also about seizing the opportunity to strengthen systemic health resilience.

By embedding climate adaptation into health planning, African countries can enhance their overall health system responsiveness, not only improving malaria outcomes but also setting a precedent for addressing other climate-sensitive health challenges.

Handling the challenges

As this Commentary has shown, African health systems face significant challenges due to climate change, necessitating a comprehensive approach to enhance resilience. There are some measures which may be deployed, in order to address current trends.

Firstly, it is important that additional investments in climate change adaptation are made, may be as part of international development aid. Health infrastructure needs to be climate-resilient, ensuring that hospitals and clinics can withstand extreme weather events like floods, droughts, and heatwaves. Building and retrofitting health facilities with sustainable materials and designs that promote natural ventilation and temperature regulation can reduce the impact of climate extremes. Furthermore, investment in renewable energy sources, such as solar panels, can ensure a reliable power supply during climate-induced disruptions, maintaining essential health services.

Secondly, there a need to strengthen health surveillance systems.Enhanced surveillance can facilitate early detection and response to climate-sensitive diseases such as malaria, dengue fever, and cholera, among many others. This involves integrating climate and health data to predict outbreaks and implementing real-time monitoring systems. Mobile technology and digital health tools can be employed to collect and analyse health data, providing timely information for decision-making. Training

healthcare workers to recognise and respond to climate-related health issues is also an important requirement.

Additionally, community-based adaptation measures should be promoted. Engaging local communities in climate adaptation planning can ensure that interventions are context-specific and culturally appropriate. Public health campaigns to raise awareness about the health impacts of climate change and promote adaptive behaviors, such as the use of mosquito nets and proper sanitation practices, can also be effective and should be more widely implemented.

Investing in research to understand the specific health impacts of climate change in different regions of Africa is another measure which may help to address current trends. This knowledge can guide targeted interventions and policy development. The fragile economies of most African countries suggests that more international cooperation and funding support are needed to bolster these efforts, ensuring that African countries have the resources to implement these measures effectively. By adopting these strategies, African health systems can become more resilient to the impacts of climate change, safeguarding the health of their populations now and in the future.

Since the impacts of climate change in Africa are becoming increasingly severe, enhanced international cooperation to address these challenges effectively is needed. As African nations grapple with the ramifications of rising temperatures, erratic rainfall, and extreme weather events, it is crucial to recognize the interconnections between climate change and public health. Institutions such as the World Health Organization (WHO) play a vital role in forging frameworks that facilitate this cooperation.

As stated earlier in this paper, Africa is particularly vulnerable to climate change due to its reliance on rain-fed agriculture, limited financial resources, and existing health challenges. The effects of climate change exacerbate issues such as food insecurity, water scarcity, and the spread of diseases, leading to a cyclical pattern of poverty and health deterioration. For instance, changing weather patterns can heighten the incidence of vector-borne diseases like malaria, directly impacting public health systems in African countries.

International cooperation can foster the sharing of knowledge, resources, and innovative solutions to enhance resilience in vulnerable communities. Frameworks linking climate change initiatives with health organizations such as the WHO can help develop integrated strategies aimed at mitigating health risks associated with climate variability. This could involve improving surveillance systems for disease outbreaks linked to climatic changes, promoting sustainable agricultural practices, and reinforcing health infrastructure to cope with climate-related emergencies. Moreover, such cooperation would encourage investments in climate adaptation and mitigation efforts. By pooling resources and expertise, countries can effectively tackle the multi-faceted challenges posed by climate change. Building partnerships between African governments, international organizations, and local communities can lead to a more coordinated approach in combating the adverse impacts of climate change while safeguarding public health. Ultimately, strengthening these links will not only address immediate challenges but also promote sustainable development in the face of ongoing climate variability.

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Author contributions
Walter Leal designed the study, contributed and reviewed the manuscript. Gouvidé Jean Gbaguidi and Wassa Diarrassouba collected the data, analysed, and contribute the manuscript writing. Pim Martens contributed to the manuscript drafting. All authors had full access to all the data in the study, had the final responsibility for the decision to submit for publication, and approved the final version of this article to be published.

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Data availability
Data are available at the Haw Hamburg University of Applied Sciences, Faculty of Life. You may contact the corresponding author for the data request.

Declarations

Ethical approval
The authors confirm the paper adheres to all procedures used at HAW Hamburg, Germany. The nature of the paper does not require ethical approval since it entails no sensible data or personal information.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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