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POLICY BRIEF

SHIFTING BURDENS: MALARIA RISKS IN A HOTTER AFRICA

Climate variability and change present both immediate and future risks to human health. Changes in temperature, precipitation, and the frequency and intensity of extreme weather events will alter the nature of vector-borne diseases, such as malaria, across sub-Saharan Africa, placing more people at risk of exposure. This brief highlights findings from an analytic report illustrating the potential shift in malaria transmission suitability in sub-Saharan Africa due to increased temperatures caused by climate change. This information improves understanding of how malaria seasonality will change across the continent, putting lives at risks, with important implications for malaria management and programming.

KEY FINDINGS

- As temperatures rise, **new challenges to prevent and treat malaria** across the continent will emerge.
- By 2030, increased temperatures will likely put **more people across Africa at risk from exposure to malaria**, while at the same time reducing, though in many cases not eliminating, the risk to others.
- Improved understanding of the influence of temperature on malaria can lead to **improved public health planning and response** and safeguard current investments in malaria control and prevention.

DEFINING SUITABILITY

We modified the Mapping Malaria Risk in Africa (MARA) definitions of malaria suitability to better illustrate the impact of changing climate and to provide information that decision-makers can use to carry out control and/or intervention activities. Our definitions specify the duration in months per year of malaria transmission suitability:

Endemic: 10–12 months | *Seasonal:* 7–9 months

Moderate: 4–6 months | *Marginal:* 1–3 months

The suitability measure is derived from temperature response curves for the mosquito species *Anopheles* gambiae and the malaria pathogen (Plasmodium falciparum). The report assesses the ways in which suitability will shift as temperatures rise under two climate scenarios: Representative Concentration Pathways (RCPs)—moderate temperature increase (RCP 4.5) and higher-temperature increase (RCP 8.5)—at three time periods (2030s, 2050s, and 2080s).

Feburary 2020
This brief was prepared under the Adaptation Though Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013 under the Restoring the Environment through Prosperity, Livelihoods and Conserving Ecosystems (REPLACE) IDIQ. The contents of this brief do not necessarily reflect the views of USAID.

RISING TEMPERATURES INFLUENCE RISK

1. **Temperature drives suitability.** Hotter temperatures are projected under all future climate scenarios (see Table 1). In some regions malaria transmission may be limited where temperatures become too high for the malaria-carrying *Anopheles* mosquito, but other regions may become more suitable for *Anopheles* in areas that were previously too cool

2. **Suitability drives the number of people at risk.** As temperatures rise, more people will be at risk of malaria transmission in various geographic areas throughout sub-Saharan Africa, putting greater emphasis on the need to modify surveillance and the portfolio of responses that can address these risks.

THE BIG PICTURE

The geographic and temporal shifts of future suitability of areas for malaria-transmitting *Anopheles* mosquitoes is closely tied to expected temperature changes under both the moderate temperature increase or "best-case" (Representative Concentration Pathway [RCP] 4.5) and higher temperature increases or "'worst-case" climate scenarios (RCP 8.5) as seen in Figures 1, 2, and 3. While areas in white in these figures do not necessarily represent a complete elimination in months of suitability of malaria under endemic or seasonal conditions, they could represent areas that continue to be either moderately or marginally suitable. These scenarios indicate that as temperatures rise, important changes are expected in *Anopheles* transmission suitability:

» **By the 2050s**, large areas of coastal West Africa and the Horn of Africa are expected to exceed mosquitoes' thermal tolerance, with suitability substantially reduced to a few months.

» **At the same time (2030s–2050s)**, rising temperatures will likely increase the southern range of seasonal suitability for *Anopheles* mosquitoes into Southern and Central Africa.

» **By the 2050s**, as temperatures continue to rise, both endemic and seasonal zones will likely continue to exhibit an eastward shift. Under the worst-case scenario (RCP 8.5), thermal threshold is exceeded, and suitability will likely be eliminated across Central Africa.

» **By the end of the century (2080s)**, concentrated areas of endemism will likely emerge in previously unsuitable or marginally suitable areas, namely the highlands of East Africa and Southern Africa.

Table 1. Average annual temperature increases (°C) from baseline (1960–1990) by region, RCP, and time period

REGION	2030s		2050s		2080s	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
West Africa	1.32	1.57	2.29	2.32	2.84	4.5
East Africa	1.32	1.63	1.90	2.32	2.96	4.38
Central Africa	1.10	1.42	1.63	2.07	2.69	4.04
Southern Africa	0.94	1.28	1.33	2.01	2.51	4.08

SHIFTING BURDEN HIGHLIGHTS

Three categories of changes in malaria suitability due to temperature increase were examined in the technical report:

» New areas of suitability,

» Increases in the number of months of suitability, and

» Decreases in the number of months of suitability.

Identifying both ***where*** these changes will emerge and how many ***people*** will be affected has important programming implications.

CATEGORY 1: NEW AREAS OF MALARIA SUITABILITY

What's at risk?

Malaria outbreaks where people have little or no immunity to the disease can often lead to epidemic "flares," especially among vulnerable groups such as pregnant women and children.

Where and when are new areas of endemic suitability (10–12 months) going to emerge where malaria was previously unsuitable?

Regions of endemic (10–12 months) suitability will likely emerge in the center of the continent, the East African highlands, the Lake Victoria region, and northern Zambia, by the 2030s, becoming more pronounced in the latter part of the 21st century (2050s and 2080s).

How many people will be affected from this change?

Approximately 16 to 18 million people currently living in areas with no suitability will be -at risk from endemic exposure to transmission in East Africa under both the best-case (RCP 4.5) and worst-case scenarios (RCP 8.5) by the 2030s.

Figure 1. Areas that are not suitable under current climate for malaria but will become endemically suitable under a changing climate by the 2030s, 2050s, and 2080s (RCP 4.5 and RCP 8.5)

RCP 4.5 **RCP 8.5**

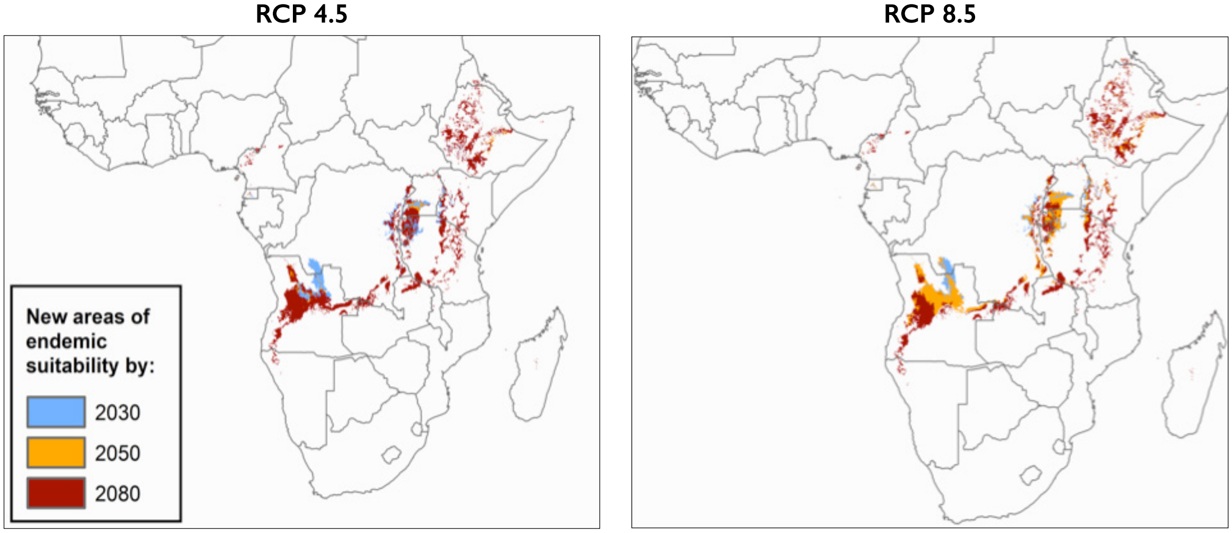
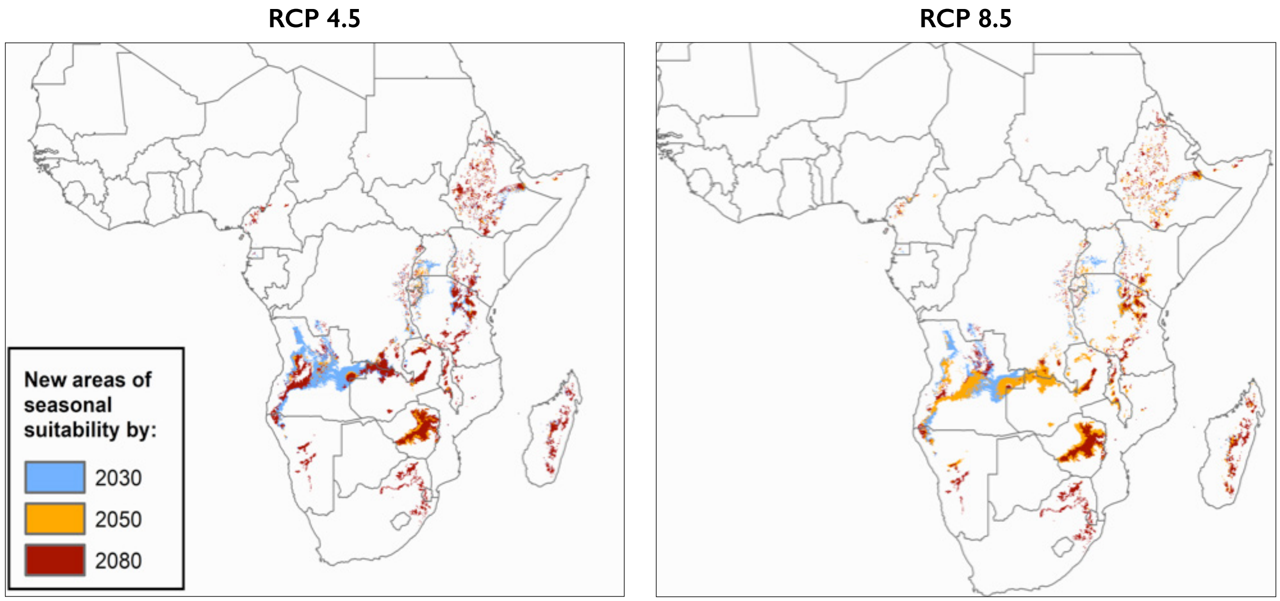


Figure 2. Areas that are not suitable under current climate for malaria but will become seasonally suitable under a changing climate by the 2030s, 2050s, and 2080s (RCP 4.5 and RCP 8.5)



Where are new areas of seasonal suitability (7–9 months) going to emerge where malaria was previously unsuitable, and by when?

Concentrated regions of seasonal suitability (7–9 months) will likely emerge in central Angola, northwestern Zambia, northern Tanzania, and the southern coast and northern region of Mozambique by the 2030s. These seasonal suitability regions will either remain as they are currently or will move both northward and southward into the highlands of Ethiopia and Southern Africa toward the latter part of the 21st century (2050s and 2080s).

How many people will be affected by this change?

These new areas of suitability will put approximately 12 to18 million and 14 to 34 million people at risk of exposure to seasonal conditions by the 2030s and 2050s, respectively. The most marked increases will be in East Africa, where approximately 10 to 15 million additional people will enter conditions of seasonal risk by the 2030s.

CATEGORY 2: EXTENSION OF THE MALARIA SEASON

What's at risk?

In areas where people have acquired immunity due to prolonged malaria exposure, outbreaks of malaria trigger interventions such as vector control and case management to prevent or reduce transmission. The goal is to pinpoint areas where elimination and elimination targets need to be revisited to consider the effect of climate on malaria risk profiles.

Where will these changes take place and how many people will be at risk?

CHANGE IN SUITABILITY	Where will this happen?	How many people are at risk?
Moderate or marginal to Endemic	Northern Angola, southern DRC, western Tanzania, and central Uganda by the 2030s. By the 2050s impacted areas may extend into western Angola, the upper Zambezi River Basin, and northeastern Zambia, as well as becoming more concentrated along the East African highlands.	Approximately 33 to 37 million people in East Africa alone as early as the 2030s;in terms of the current burden of endemic disease, could add 6 to 11 million people in Tanzania alone to the approximately 2 million currently living under endemic conditions across all future time periods and scenarios.
Moderate or marginal to Seasonal	Large portions of Tanzania, Uganda, and Northern Mozambique	Approximately 27 to 29 million people at increased risk from transmission under the best-case scenario (RCP 4.5) by the 2030s, adding an additional approximately 9 to 12 million people in Zambia alone to those currently living in seasonal conditions of risk across all time periods and scenarios.

CATEGORY 3: DECREASE IN THE NUMBER OF MONTHS WHEN MALARIA IS SUITABLE

What's at risk?

The strong seasonal cycle of malaria across Africa is related to climate and weather conditions. During some periods of the year, climate conditions are not conducive to spread of the disease. Other factors, such as changing agricultural activities which alter food availability, can also affect malaria's seasonal cycle. Thus, a key opportunity lies in the possibility of climate change reducing the period during which the *Anopheles* mosquito thrives and transmits malaria. This may ultimately present an opportunity to alter control efforts and/or shift resources to other more critical areas.

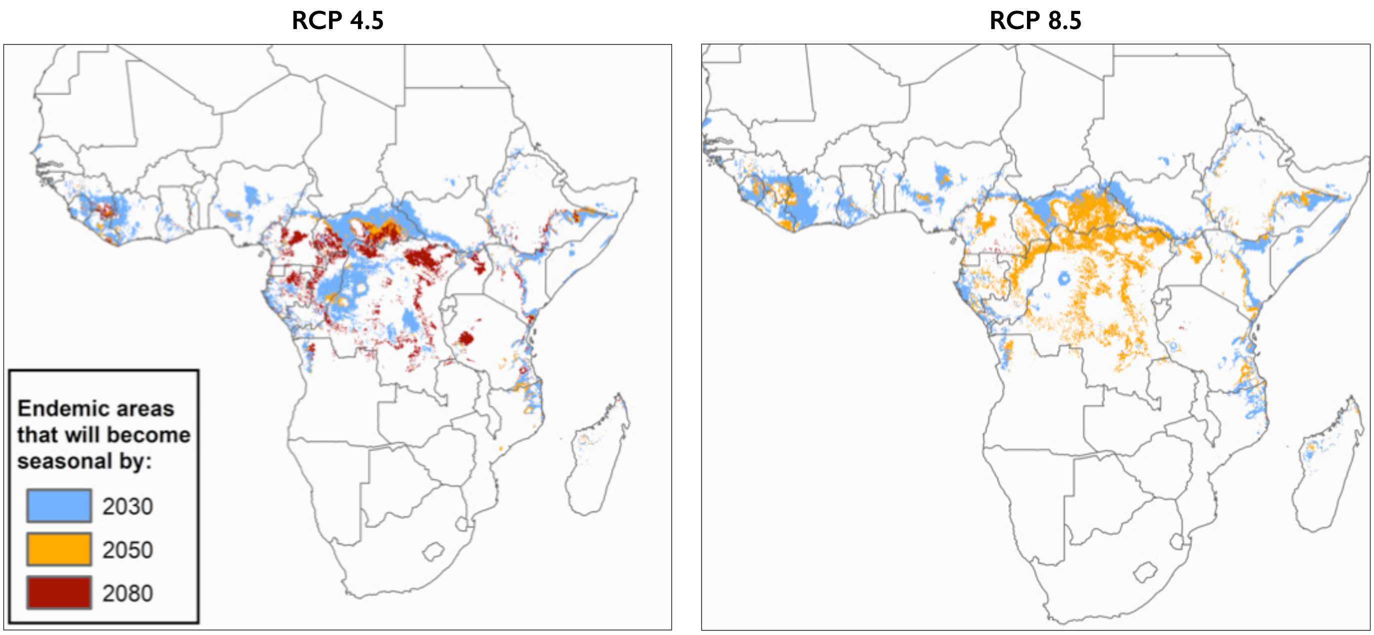
How many people will be affected by this change?

The net change in numbers of people at any risk of malaria transmission (those moving to marginal/ moderate malaria exposure) will increase by approximately 65 million people in West Africa alone by the 2030s under the best-case scenario (RCP 4.5). In Nigeria alone, for example, approximately 24 million people will shift out of endemic conditions of exposure to seasonal conditions by the 2030s.

Where and when will endemic areas become seasonal?

Significant changes will be seen in West Africa, where the region will see reduced endemic risk due to temperatures exceeding the thermal thresholds of mosquito-parasite survival. But these areas will still experience marginal to moderate risk.

Figure 3. Areas that are currently considered endemically suitable but will change to seasonally suitable for malaria under a changing climate by the 2030s, 2050s, and 2080s (RCP 4.5 and RCP 8.5)



CONCLUSIONS AND INSIGHTS FOR ACTION

This analysis offers a new, initial view of potential changes in malaria seasonality due to projected rising temperatures. Some of the implications of this research for action and strategic decision-making are discussed below. Nevertheless, it is important to note that this study alone is not meant to guide programmatic decisions. Additional field studies are needed for these findings to be used as predictive insights, and it is important to consider the role of temperature as a driver of malaria burden when combined with many other likely drivers.

Adapt to Changing Epidemiology and Incorporate New Tools

There are many examples across sub-Saharan Africa where investments have shown marked progress in malaria control strategies. These gains, however, could be compromised if future investments do not consider the role of rising temperatures in changes to epidemiology. The analysis presented here offers several insights of relevance to these risks:

» ***Targeted and informed on-the-ground surveillance:*** Knowing where and when changes in burden are likely to take place offers the opportunity to geographically target interventions and monitoring programs to achieve the highest impact with limited resources. For example, where malaria suitability is likely to shift from unsuitable to newly suitable, whether seasonal or endemic, the risks are critical. When local populations will have little or no immunity to the disease, suitability changes can often lead to epidemic conditions, especially among vulnerable groups such as pregnant women, children, and the elderly. Issues such as delayed diagnoses or the potential emergence of novel strains that rapidly become drug resistant could complicate the response. Targeted and informed geographic surveillance and early warning systems in these regions can help to prepare timely responses before the outbreak of epidemics and guide decisions about the distribution of malaria services and their use by impacted communities.

» ***Adjusting current management and control interventions:*** Current interventions may need to be updated and adapted to account for likely changes in incidence. This information offers an opportunity to increase the investment time frame (seasonal to year-round, or vice versa), optimize vector control, and improve case management, with the evidence base to support these actions. Pinpointing regions where transmission could be reduced lowers the cost of interventions and provides an opportunity to reach pre-elimination or elimination.

» ***Early and targeted strategic planning:*** In many instances, projected temperature increases are criticized because they cannot address immediate disease planning. However, much like preventive medicine, which aims to promote long-term well-being, planning forward 10 to 12 years, and even further into the future, can save lives and money over the long term and promote sustainable malaria elimination efforts. For example, if we know that temperature rise is likely to increase malaria burden in a certain country or region where there is currently little investment, an investment in surveillance and prevention now could reduce costs in the future.

» ***Address malaria elimination:*** Understanding the effect of temperature on the seasonality of malaria in sub-Saharan Africa—particularly for new areas at risk of malaria transmission or areas where the length of the season may shorten or extend— can inform malaria programs and policy and help reach the goal of elimination. In areas where the months of malaria suitability decrease, opportunities will arise to direct resources to making surveillance and response systems more sensitive and focused to identify, track, and respond to malaria cases and any remaining transmission foci (e.g., infected mosquitoes or affected patients). Elimination efforts informed by these analyses could reduce the potential burden of additional cases through timely treatment and preventive measures to avoid disease spread in exposed populations, such as the distribution of bed nets or indoor residual spraying.

Improve Capacity for Collecting and Using Information at the National Level

Understanding how rising temperatures could impact vector ranges, and thus have the potential to alter disease dynamics, is an important first step toward building the knowledge base to evaluate the impact of climate on malaria incidence and to inform investments. Importantly, temperature-driven changes in vector dynamics are themselves mediated by direct and indirect environmental and societal factors, such as changes to ecosystems, land use, and other factors that may reduce or increase the vulnerability of certain groups to malaria risks.

While significant progress has been made to improve data and information available for malaria programming, management, and evaluation via investments, new methods of data collection and integration will require cross-ministry investment, information-sharing, and analysis but will also be critical to understanding the complex links between these factors.

Public health observatories, many already operational around the world, could provide a model for scaling up analysis of health data in the context of other climate and environmental factors. In general terms, health observatories are virtual platforms that can link health systems to other information of relevance, such as weather data, to support health policies and planning. According to the World Health Organization (WHO), "their purposes vary but the major objectives are: monitoring health situations and trends, including assessing progress toward agreed-upon health-related targets; producing and sharing evidence; and supporting the use of such evidence for policy and decision making." Such observatories could also help with the timely use of remotely derived weather and climate information to inform investments and strategies in malaria control.

Establishing a health observatory in countries where malaria patterns are changing rapidly could:

» ***Leverage information technology*** such as geographic information systems (GIS) and other tools to support efforts to scale as well as to fine-tune analyses focused on improving the timeliness and completeness of surveillance during critical periods. Information technology will also help to integrate information from various sectors and sources in order to rapidly evaluate the potential risks from specific weather events to a country, region, or health post.

» ***Build a community of practice*** on malaria beyond the traditional program partners that could explore the links between environmental factors of interest (including weather and climate) and strategic and programmatic decisions that need to be made in a malaria program.

» ***Advance research on critical outstanding gaps*** with respect to the use of climate information to inform malaria planning. These gaps include, but are not limited to, understanding more fully the links between increased temperature, changing rainfall patterns, extreme weather events, and malaria; determining specific climatic thresholds of concern for surveillance; and improving analytic tools to visualize cross-sectoral information.

» ***Encourage and formalize interdepartmental and interministerial links and data-sharing.*** Research and monitoring to understand climate and weather impacts on epidemiology requires the historical climate and trend information, together with the health data related to past events. Furthermore, most countries and agencies lack the mandate to coordinate interactions between the many stakeholders in the health sector. Improved communication across the sector will aid the more widespread use and understanding of all the information that could be used in planning.

Build Capacity in Health Systems

In spite of the significant advances made in many parts of sub-Saharan Africa in reducing malaria incidence and outbreaks, weak health systems slow progress toward malaria control goals and targets. For example, health posts are understaffed, skilled human capacity is lacking, and supply chain management is unreliable across the spectrum of services and programs. The following investments need to be made in building the skills and capacity of health workers to understand and address the health risks posed by climate:

» ***Training health workers on the links between health and climate change:*** Many public health workers and leaders are ill-equipped to face the challenges of climate risks and lack an understanding of how health service delivery will need to change. The uptake and use of early warning systems, educational and advisory systems for disseminating clinical guidelines, and even the guidance offered by community health workers will all require building awareness of the risks and responses available to address climate phenomena.

» ***Streamlining supply chain management:*** Especially in countries where malaria control interventions have been successful, supply chain management will need to be streamlined to guarantee the delivery of commodities and services to remote and mobile populations.

» ***Promoting research on applied, regionally responsive health services research for a future of climate change:*** The lack of service-oriented research to drive regional health service development for climate change has potentially serious implications for future control efforts.