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# Gendered exposure, vulnerability, and response: Malaria risk in a changing climate in Western Kenya

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Climate change has been linked to increasing rates of malaria infection in Western Kenya. Projections show an increased risk of malaria infection under climate change scenarios, impacting vulnerable populations and placing millions of people at risk. Developing suitable risk management strategies requires understanding the hazard, exposure, vulnerability and response to climate change and malaria risk in the context of other local environmental, socio-economic and socio-cultural factors (including gender) that influence exposure, vulnerability and capacity to cope. This paper draws upon two analytical frameworks, using data gathered from focus group discussions with small-scale farmers in Western Kenya: The Intergovernmental Panel on Climate Change (IPCC) Risk Assessment Framework; and Feminist Political Ecology (FPE) to analyze social constructions underpinning farming responsibilities and decision-making power and how these influence the gendered dimensions of exposure, vulnerability and response to climate change and malaria risk in the community. This paper finds that gender influences the risk of malaria through feminization of agricultural activities in the region, socially constructed gendered responsibilities for care and farm work, which increases exposure and vulnerability to mosquito bites and malaria infection, and socially constructed rights of women to make farming decisions and manage farm income, which influences their capacity to manage risk and cope in the long term. Drawing on these findings, this paper proposes that an intersectional gender lens needs to be incorporated into climate and malaria adaptation policy and programming. It concludes with recommendations for implementing the UNFCCC Enhanced Lima Work Program on Gender at the country levels and the development of gender-responsive climate change and malaria risk management.

KEYWORDS

**climate change, malaria risk, agriculture, gendered exposure and vulnerability, gendered responses**

# Introduction

The impact of climate change on malaria transmission in the East African highlands is well documented in the literature (Mordecai et al., 2013; Ryan et al., 2015; Beck-Johnson et al., 2017). Changes in temperature associated with climate change increase the lifespan of *Anopheles* and the rate of development of the parasite responsible for causing Malaria within the mosquito, while changes in precipitation and/or humidity influence mosquito development by creating suitable breeding conditions leading to an increase in mosquito density and abundance.

Malaria remains a major public health problem in Kenya and accounts for an estimated 13–15% of outpatient consultations (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021a). Environmental factors influencing malaria transmission and infection risk in Kenya are altitude level, rainfall patterns, and temperature leading to considerable variation in malaria prevalence by season and across geographic zones. Social factors influencing malaria infection include access to nets, livelihood activities and responsibilities for food and water collection. Approximately 70% of the population is at risk for malaria (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021a).

The Western Kenyan highlands is classified as mixed endemic and epidemic-prone malaria transmission area malaria (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021a). Several studies have investigated the associations between climate change and changes in malaria transmission in this region, with biophysical data showing an increased risk of malaria transmission under climate change (Githeko and Ndegwa, 2001; Zhou et al., 2004; Minakawa et al., 2005; Yanda et al., 2006; Cohen et al., 2008; Pascual et al., 2008; Ernst et al., 2009; Hashizume et al., 2009; Munga et al., 2009; Wandiga et al., 2009; Chaves et al., 2012; McCann et al., 2014; Sewe et al., 2015, 2017; Akpan et al., 2019; Matsushita et al., 2019). However, there is a lack of studies assessing climate change and malaria risk in the context of other biological, ecological, demographic, cultural and socio-economic factors which can mediate exposure, vulnerability and response to projected risks at a local level (Bates et al., 2004; Protopopoff et al., 2009; Onyango et al., 2016). In addition, there remain gaps in understanding and identifying how socio-economic drivers, including gender, interact with biophysical drivers of malaria risk and how these drivers interact with climate hazards to influence exposure, vulnerability and response of communities.

In particular, understanding the gendered dimensions of vulnerability and/or exposure and how these can contribute to differential climate change impacts on men and women has not been fully addressed in climate change and malaria literature. The *Anopheles* mosquito does not discriminate on the basis of gender; given equal exposure, men and women are equally vulnerable to mosquito bites and risk of diseases. Gendered vulnerability to malaria arises as a result of the roles, responsibilities and power relations between men and women in a community that will influence how they are exposed and their capacity to cope with climate change risks and impacts (Rao et al., 2019). Gendered vulnerability to climate change and malaria risk can arise from biological factors or other social, cultural and economic structures and constructs within the community. Pregnant women are more biologically vulnerable to malaria due to their reduced immunity arising from pregnancy-associated physiological and behavioral changes (Schantz-Dunn and Nour, 2009; World Health Organization, 2021). Gendered social vulnerability to malaria arises from social norms, which see women responsible for food and water collection and preparation and rural economy changes which are seeing women carry out an increasing amount of farm work, thus increasing their exposure to malaria. Gender relations and norms at the household level also impact how women can manage and respond to this risk, including their capacity to access prevention and treatment options (WHO, 2007; Aguilar et al., 2015; Ministry of Health Kenya, 2015).

Building on previous research (Onyango et al., 2016, 2017; Onyango, 2017), this paper explores the connections between climate change, malaria transmission and gender in a rural agricultural community in Western Kenya. We conceptualize risk using the IPCC Risk Assessment Framework (IPCC, 2022) to analyze the gendered dimensions of exposure, vulnerability and response to malaria. We integrate this with Feminist Political Ecology (FPE) Theory (Rocheleau et al., 1996) to understand how gender norms and social constructions around gender contribute to climate change and malaria risk. We draw upon our findings to determine recommendations for integrating gendered responses into climate change and health response policy and programming and identify areas of strengthening the UNFCCC Enhanced Lima Work Program on Gender at the country levels, in particular priority Area D: Gender-responsive implementation and means of implementation.

# Methods

## Study context

The findings in this article are based upon insights drawn from three focus group discussions (FGDs') conducted in low socio-economic rural communities in Ikolomani in Kakamega County in the Western Kenya highlands. Kenya is stratified into five malaria zones determined by factors including malaria prevalence, climate factors (i.e., temperature, rainfall, altitude), and topography. Kakamega County falls within the highland epidemic-prone (areas > 1,500 m above sea level) and lake endemic zones (areas up to 1,300 m above sea level) (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021b).

Elevation in the study site Ikolomani ranges from 1,401 to 1,600 m. Thus, it is located in the highland epidemic-prone zone for malaria. Temperatures in the area are relatively cool, with an annual mean daily temperature of 20.5°C (range: 10.3–30.8°C) and annual rainfall of 1,250–1,750 mm. Malaria transmission in the area is seasonal, with considerable yearly variations. Epidemics occur when climatic conditions favor sustained minimum temperatures above 18°C. During the rainy season, favorable temperatures and rainfall conditions promote vector breeding and parasite development, resulting in increased intensity of malaria transmission and/or epidemics. The entire population is vulnerable, with case fatality rates up to 10 times higher than in stable transmission areas (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021a). Malaria interventions include vector control through the use of long-lasting insecticidal nets (LLINs), clinical case management, surveillance, health education, behavior change communication and epidemic preparedness and response (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021a).

Ikolomani is predominantly rural (15% urbanized) and has a low socio-economic status. This is reflected in the type of housing construction, which is either made from mud with iron sheet roofing or semi-permanent, i.e., mud walls and floor plastered with cement, with iron sheet roofing. Houses made of brick with tiled roofs (permanent) are in the minority (Onyango, 2017). Like other rural communities in Kenya, the area is experiencing rapid change due to the shifting aspirations of young people seeking education and white-collar jobs in preference to pastoral or agricultural lifestyles. This is influenced by the vision of the Kenyan government to transform the agriculture sector through intensification, irrigation and infrastructure development (Few et al., 2015). This vision of agricultural modernization is far from reality in Kenya, where there is minimal irrigation, with most farming being rain-fed, small-scale production. Gender relations are still patriarchal, and girls and boys usually are raised within specific gender roles and constructs; within the household, wives are expected to be subservient to their husbands; the man is considered the head of the household, while women are expected to take care of the home and children (Cultural Atlas, 2022). Men will commonly leave their rural communities to seek employment opportunities in urban areas—while this may provide some income relief to the family, it also increases women's workload in the home.

Over the years, changes in rainfall patterns along with soil degradation have seen crop yields fall in recent years. The gendered implications of a changing climate and changing rural communities are yet to be fully understood in Kenya. Still, there is evidence of shifts in the forms of marriage expectations and male and female contributions to household welfare and resource and responsibility sharing (Rao et al., 2019). Climatic variability will influence gendered relations in rural economies but will intersect with other factors such as wealth, age, race, ethnicity, religion, education level, and marital status in determining climate vulnerability (Mungai et al., 2017).

## Study sample and design

The FGDs' were conducted with small-scale farmers in the region: one comprised of 13 women from the community; one comprised of 14 men from the community; and one mixed group of 18 men and women who had either higher education levels (post-primary) or had status in the community, for example, a village elder or retired professional. The selection of participants was undertaken to ensure gender representation across the study site. While this study was designed to enable the participation of both men and women within the focus group discussions, the study was not originally designed to identify gendered implications of malaria risk in a changing climate. The initial FGD design was intended to identify if there were any differences in the educational status knowledge of climate change impacts, risks, and adaptation. Separate female and male FGDs were planned for community groups due to social constructions within Western Kenya, which mean that women are more comfortable sharing views in single-gender forums. Analysis of the FGD data later revealed that there were gendered implications of malaria risk for women in a changing climate, which is the focus of this paper.

All FGD participants were briefed on the study objectives, assured of their confidentially and the voluntary nature of the research and signed consent forms. In addition, background information on occupation, age, household head status and housing type was obtained from each participant before commencing discussions. The discussions were conducted in both English and Swahili, as needed for participant understanding, and were moderated by a facilitator while the researcher observed and took notes. The FGDs lasted an average of 2 h and were recorded and transcribed as soon as possible after the interview with the help of the discussion notes. Any translation of Swahili into English was done during the transcription process. Final interview transcripts were uploaded into the QSR Software Nvivo® 10 for analysis.

Following an inductive approach, thematic analysis of the transcripts from the FGDs was undertaken to identify themes from participant responses following an iterative five-step process (Figure 1).

Refer to the Supplementary material for a detailed description of the data analysis and coding process for each step.

### Gendered emergent themes and sub-themes

Sub-themes of gendered exposure, vulnerability and barriers to adaptation emerged during content analysis, i.e., step 5 of the process (Figure 1). These themes are summarized in Table 1.

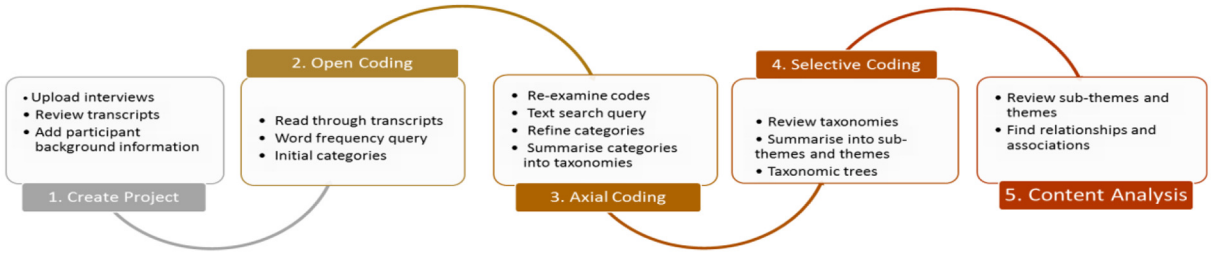


FIGURE 1
Steps in the thematic analysis process for the focus group discussions and interviews.

TABLE 1 Gendered dimensions of exposure, vulnerability, and response among identified themes and sub-themes.

| Theme | Sub-themes | Gender dimensions |
|---|---|---|
| Land use and land use change | Water edge farming | • Higher exposure of women to mosquito bites |
| | Maize farming | • Higher exposure of women to mosquito bites |
| Malaria transmission | Malaria incidence and prevalence | • Higher vulnerability of pregnant women |
| | Early biting | • Higher exposure of women to mosquito bites |
| | Malaria prevention | • Coverage and use of insecticide-treated bed nets |
| Vulnerable groups | Women | • Higher vulnerability for pregnant women |
| Quality of life | Food insecurity | • Women will eat less when there is limited food in the household |
| | High cost of living | |
| | Poor health | • Women take responsibility for household health even when they are sick |
| Gender Bias in the household | Farming responsibilities | • Weeding and planting early in the morning or late evening |
| | | • Maize harvesting |
| | Household responsibilities | • Water collection from rivers at dawn or dusk |
| | | • Cooking and cleaning |
| | | • Women are responsible for most farm labor and all household labor |
| | Women as caregivers | • Primary care for sick children |
| | | • Women will go without mosquito nets when there are not enough in the household |
| | Decision-making | • Men make household decisions, including planning the farming calendar |
| | Access to assets | • Household assets controlled by men |
| | | • Women cannot sell assets to access treatment |
| Prevention and treatment | Malaria treatment | • Women must ask permission to access assets for the treatment of sick/hospitalized children |
| | Inequitable net distribution | • Women give up their nets for their children at night, increasing their exposure to mosquito bites |

## Framework analysis

### The IPCC risk assessment framework and complex risks theory

The 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) conceptualized risk to climate change impacts as arising from the interaction of climate-related hazards, the exposure and vulnerability of human and ecological systems and in the context of other socio-economic, environmental and/or institutional factors influencing risk (IPCC, 2014b).

According to the IPCC Risk Framework, a hazard is "The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources"; exposure is the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected", and; vulnerability is "the propensity or predisposition to be adversely affected, encompassing a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2014b). Biological, social, economic, geographic, cultural, demographic, institutional, governance, and environmental factors increase women's vulnerability to malaria transmission. In addition, climate change is a multiplier of existing health vulnerabilities,

including insufficient access to clean water and safe sanitation, food insecurity, and limited access to health care and education, all of which can increase vulnerability to malaria transmission (IPCC, 2014a).

In the sixth assessment report, the IPCC expanded the risk framework, acknowledging that in the context of climate change, risks can arise from the potential impacts of climate change and human responses to climate change (Reisinger et al., 2020). Including responses to risk in the framework allows the identification of risks that may arise from actions taken to manage climate risks, which is useful for decision-making processes. Including climate change responses as potential drivers of risk is particularly useful for identifying potential trade-offs and co-benefits from addressing interacting responses and linked goals, which is important for developing actionable and transparent responses and multisectoral responses (Simpson et al., 2021). Furthermore, the IPCC acknowledges that the capacity to respond to climate change risks is gendered and is influenced by factors on multiple scales, from household traditions and regional customs to national policies and international rights protections, and is shaped by power, knowledge, and agency (IPCC, 2014b). In our analysis, we apply the IPCC Risk Framing to determine the gendered dimensions of hazard, exposure, vulnerability and response to climate change and malaria risk (Figure 2).

Climate change impacts malaria transmission through multiple pathways, including changes in climate hazards, the vector life cycle, the parasite life cycles and human and ecological systems in a complex system of interactions of the determinants of risk, i.e., hazard, exposure, vulnerability and response. Within each of these components and interactions are the various aspects that are influenced by differences in gender and gendered dimensions, which adds another layer of complexity to the interactions of the risk determinants. Therefore, an accurate assessment of how gender intersects with climate change and malaria risk determinants means explicitly identifying the interactions within and among determinants of risk. These interactions are defined within the Complex Risks Theory by Simpson et al. (2021). This approach is useful for detailed and more accurate assessments of risks where there are multiple interacting determinants. In addition, it facilitates a more complex and accurate risk assessment to better support multisectoral approaches to reduce negative risk outcomes (Simpson et al., 2021).

## Feminist political ecology

This paper draws upon the feminist political ecology ("FPE") theory to understand the gendered impacts of climate change and malaria risk. Rocheleau et al. (1996) created FPE to understand and interpret lived experiences in the context of global environmental and economic change. FPE emerged as a sub-field of political ecology to recognize "gendered power relations as a critical variable in shaping resource access and control interacting with class, caste, race, culture, and ethnicity to shape processes of ecological change" (Rocheleau et al., 1996). FPE was created to draw together three critical lines of enquiry: (1) gendered knowledge encompassing the creation, maintenance and protection of healthy environments at home and work in regional ecosystems; (2) gendered environmental rights and responsibilities, including property, resources, legal and customary rights that are gendered; and (3) gendered environmental politics to explore the surge of women's involvement in collective struggles over natural resource and environmental issues.

FPE scholarship on climate and gender identifies two discourses framing women in climate policy and projects. The first more prominent discourse frames women as "victims" of climate change. This literature emphasizes the greater vulnerability of women to the environmental damage associated with climate change and naturalizes women's vulnerability (Leach, 2007; Terry, 2009). The second discourse paints women as powerful agents of change in adapting to climate change due to a close connection with nature. Women are viewed as having a more virtuous relationship with the environment than men (Leach, 2007). Both of these framings are problematic as portraying women as vulnerable, weak, poor and socially isolated rather than seeing them as negotiating and dealing regulatory with different kinds of changes in their lives means that adaptation policies and projects fail to include locally derived gendered adaptive knowledge (Okali and Naess, 2013). Secondly, essentialist framings of women being depicted as closer to nature are not only inaccurate but also serve to reinforce norms making women responsible for improving sustainability practices (Boserup et al., 2007). It is critical for climate policy and projects to embrace more complex frameworks for considering gender and value different forms of knowledge of traditional, local and gendered knowledge for effective climate mitigation and adaptation.

As a result of rural-urban migration in Africa and Asia, FPE literature is starting to examine how the feminization of agriculture is changing gender dynamics (Kawarazuka et al., 2022). The feminization of agriculture refers to the increase of women participating in the agricultural labor force, whether as independent producers or unremunerated family workers (Lastarria-Cornhiel, 2006). FPE literature examines whether this shift in farm responsibilities and activities results in greater gender equality or empowerment (Kawarazuka et al., 2022). The Women's Empowerment in Agriculture Index (WEAI) provides a framework for considering female empowerment through an assessment of agricultural production, resources, income, leadership and time (Haug et al., 2021) carried out a study of 6 African countries: Malawi, Rwanda, South Africa, Kenya, Tanzania and Ethiopia using the 5 WEAI criteria of empowerment to assess how gender dynamics are changing at the farm level as a result of the feminization of agriculture

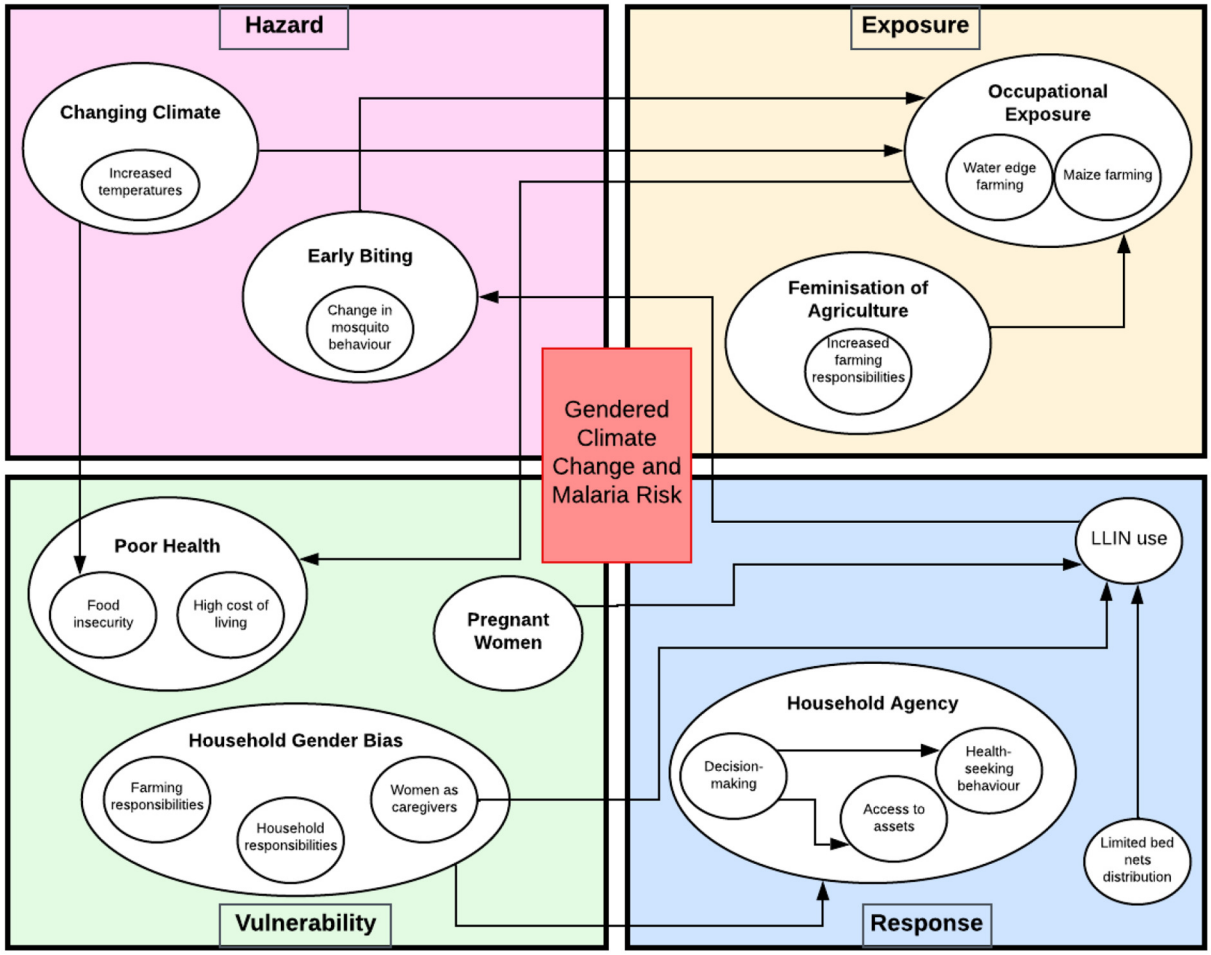


FIGURE 2
Conceptual framework outlining gendered aspects of exposure and vulnerability to climate change hazards and malaria transmission, and responses to the changes in exposure and vulnerability. This framework is derived from the IPCC risk framework, complex risks theory and feminist political ecology to illustrate the complexity of the interactions between and within the gendered determinants of climate change and malaria risk.

(Haug et al., 2021). It was found that while women are starting to participate more in agricultural decision-making, women could not be classed as more empowered in any of the country sites as women have more responsibilities and heavier workloads absent of improvements in wellbeing.

FPE studies in rural African agriculture settings increasingly emphasize the need for an intersectional analysis (Vercillo, 2021). Intersectionality acknowledges that factors such as race and skin color, caste, age, ethnicity, language, ancestry, sexual orientation, religion, socio-economic class, ability, culture, geographic location, and marital status combine to determine one's social status (Mungai et al., 2017). Factors that intersect with gender to increase climate risk in agricultural settings in Africa include age, marital status, education level and geographical location (Tavenner and Crane, 2019; Wood et al., 2019; Lawson et al., 2020). FPE scholarship also considers power and resource access and control relationships at the community, household and intra-household levels (Vercillo, 2021). Studies exploring gender and agriculture across Sub-Sahara Africa show that despite women's contribution to and dependence upon agriculture, women continue to face barriers in exercising control over resources and opportunities related to their agriculture-based livelihoods (Kilic et al., 2015). Compared to men, women are less likely to own land or livestock, adopt new technologies, and use credit or other financial services (Johnson et al., 2018). At the household level, as a result of social relations, women have less agency to make household decisions and have limited power to determine how household income should be used (Head et al., 2014).

In the context of climate change impacts on malaria transmission, risks can arise from the dynamic interactions between climate-related changes in malaria transmission and the exposure and vulnerability of affected communities to these changes. Responses to climate change and malaria risk

management can also contribute to risks, particularly when there are multiple factors that influence the capacity to respond based on gender. For example, the primary policy intervention to protect from mosquito bites is through distributing long-lasting insecticide-treated bed nets, one net for every two people in the household. However, in households with insufficient nets, it is often women who will give up their nets to their children at night, leaving them exposed and at risk of mosquito bites at night.

This paper explores how gender and intersectional factors shapes/influence exposure, vulnerability and response to climate change and malaria risk. Our analytical framework combining IPCC Risk Framework, Complex Risks Theory and insights from FPE is represented in Figure 2 to show the complexity of and interactions between and within the gendered determinants of (i) exposure to climate change hazards and malaria transmission, (ii) vulnerability to climate change hazards and malaria transmission, and (iii) responses to the changes in exposure and vulnerability. We use this framing in our analysis of the findings and subsequent recommendations for policy and practice.

## Findings and discussion

### Gendered exposure to climate change and malaria risk

Analysis of the FGD data revealed that gendered roles and responsibilities increased the risk of malaria in a changing climate. Analysis of data from this study showed that the increased biting period of the mosquitos makes women more exposed to mosquito bites due to gendered constructs informing house and farm divisions of responsibility and due to the feminization of the farming responsibilities.

Historically, *Anopheles* was typically a dusk-to-dawn biter, and mosquitos are usually active when humans are sleeping, from ∼10 p.m. until dawn, but some respondents reported higher frequencies of mosquito bites from 6 p.m. until 9 p.m.:

> *"We have always been told that the mosquitoes that transmit malaria start biting from 10 p.m., but our experience is that from around 6 pm, even while we are cooking till about 9 pm when we go to sleep, there are lots of mosquitoes [biting]."*

This correlates with findings from other studies that confirm that *Anopheles* has extended its biting period, meaning that people are now exposed for at least 2 h before the average bedtime (Cooke et al., 2015; Wamae et al., 2015). In addition, the highest biting rates have been recorded as occurring indoors between 6 p.m. and 9 p.m., during the peak rainy season (May–June) (Wamae et al., 2015).

The extended biting period also produced gendered exposure implications. Women stated that they were responsible for carrying out farming activities early in the morning and in the late afternoon to early evening to avoid working in the peak heat during the day and being responsible for water collection from rivers or lakes at dawn to prepare for the morning meal, and at dusk to prepare for the evening meal. The extended biting pattern of mosquitoes increased their gendered exposure to malaria while farming at dusk and dawn. Mosquitos tend to bite at dawn and dusk and tend to live in areas close to water; meaning that water-fetching activities significantly increase exposure to malaria (Sorenson et al., 2011; Aguilar et al., 2015; Ministry of Health Kenya, 2015).

Variations in mosquito biting behavior and early biting have been linked to long-term use of LLINs at night while sleeping (Geissbühler et al., 2007; Moiroux et al., 2012, 2014; Yohannes and Boelee, 2012). The Kenyan government has a program which aims to distribute one LLIN for every two people in a household, but there are often inadequate supplies of nets within households. Women reported that they prioritized giving nets to their children, thus increasing their exposure to being bitten by mosquitoes at night:

> *"Sometimes, when they distribute nets, these children are not counted, and when it comes time to use, the nets are not enough. Sometimes it means that I [mother] give the net to my child."*

Participants reported that women were primarily responsible for all farm labor besides plowing, which men carried out. However, in some households, women reported being responsible for all farm activities, from plowing to harvesting, especially in instances where men were employed in urban areas or traveled for business:

> *"The main role for men is to decide on when to start farming, and once they plough, they leave all the other work to the women"… "Matters such as planting, weeding, harvesting is left to women. Very few men help in this area."*

Participants in this study explained that, while women were responsible for carrying the physical labor associated with agriculture, men retained control over economic gains from the harvest:

> *"It's mostly women who work on farms. Men will plough, but most of the work that is done is normally done by the women. When it comes to selling, then it's back to the man."*

This finding is consistent with existing research, which demonstrates the trend of feminization of the agriculture sector in Kenya (Onyalo, 2019), and that while women have the power to make decisions for subsistence crops, men retain the power to make decisions over economic or profit-making crops (Haug et al., 2021). This remains true even when the woman performs all the manual work and even when the man has migrated

to an urban area (Bikketi et al., 2016). The impact of the feminization of agriculture meant that the women interviewed were more likely to be responsible for carrying out the physical labor associated with farm work, leading to higher exposure to the risk of mosquito bites and malaria infection, particularly during peak malaria transmission periods from May to July, which is also when harvesting of the dominant maize crop takes place. During this time, numerous bushy plants on the farms provide suitable resting grounds for the Anopheles mosquito, contributing to mosquito abundance. As a result, respondents reported high malaria infection rates coinciding with the period when the maize plant was flowering. Previous studies have also demonstrated a link between maize crop harvesting and malaria transmission (Kebede et al., 2005). Maize pollen is also a food source for mosquito larvae. Studies have shown that this pollen aggravates mosquito abundance, as it produces chemicals that encourage egg-carrying Anopheles mosquitoes to lay their eggs in maize fields (Wondwosen et al., 2017).

> *"We get a lot of malaria when the maize is flowering" . . . "when the maize [cob] is starting to harden"*

Participants reported that they had observed increases in temperature and changing rainfall patterns over time alongside population increases, competition for land and regional deforestation. Combined, these pressures have led to shrinking land sizes and competition for local arable land resulting in land being cleared at the edge of rivers and streams for horticulture. The irrigation from these farming activities creates stagnant pools of water that become suitable breeding grounds for mosquitoes, putting the women who are working in the farms at dawn and dusk at risk of mosquito bites:

> *"If we go down to the river at the water collecting areas, we find that we have farmed right up to the water's edge."*

Thus, due to socially construed gender norms surrounding farm labor and care responsibilities, this research has identified higher gendered exposure of women to contracting malaria linked to caring responsibilities, household responsibilities and farming responsibilities due to the feminization of agriculture.

## Gendered vulnerability to climate change and malaria risk

Data from this study showed two types of gendered vulnerability to climate change and malaria risk; biological and social. Respondents reported that pregnant women and children under five were the groups most vulnerable to malaria. Gendered social vulnerability results from social norms, which make women primarily responsible for caring for those with malaria either in the house or accompanying sick family members to hospital while still maintaining other household responsibilities.

Women who are pregnant or who have contracted HIV are biologically more vulnerable to malaria infection (Division of National Malaria Programme (DNMP) [Kenya] ICF, 2021a). A separate study on the prevalence of malaria in adult populations of Western Kenya demonstrated that women were 40% more likely to contract malaria than men (Jenkins et al., 2015). The findings from this study were attributed to the two biological factors listed above that reduce immunity: (i) that HIV prevalence in the study area is higher in women, and (ii) pregnant women are more susceptible to malaria (Jenkins et al., 2015).

Due to household roles and responsibilities, women are responsible for caring for those who have contracted malaria. Even when these women themselves are sick with malaria, social norms mean that they must continue to care for other family members who are sick. This includes taking sick children to the hospital and remaining present with them throughout hospital admissions while simultaneously maintaining the household and farm:

> *"Burden of illness seems to be on women. Very few men will bring children to hospital, even if their wives are away."*

> *"women are mostly responsible for care, they are the first to realise when a child is sick and will take them to hospital."*

The additional caring responsibilities placed on women when other household members are sick means that women are more generally focused on providing care for their children or husbands and will place a lower priority on their self-care, leaving them more vulnerable to extended/complicated malaria infection. In rare cases, fathers may take children to the hospital and care for them when the mother is not present, but this goes against societal beliefs and practices regarding care responsibilities for the sick.

> *"it's the women who understand care of the sick"*

> *"When the mother is not around, fathers may take responsibility [with sick children], but the Community Health Workers (CHWs) must really assist them a lot."*

> *"My job [as a man] is to give money and to find transport to the hospital. And if the child gets really sick and has to be admitted, I've gone there, and they've told me to go home and asked my wife to stay."*

FPE literature shows that any social vulnerability assessment must be based upon an intersectionality assessment examining how various factors combine to produce power, inequality, privilege and oppression. Power differences emerge in the everyday practice of farming, managing natural resources,

migrating and participating in community or project activities (Rao et al., 2019). While biological and social factors may combine to enhance the vulnerability of women to malaria, socially construed gender norms also mean that women are more likely to seek medical assistance once unwell. As one participant explained:

> *"More women will appear to have more malaria, but this is because they tend to seek health services faster and more readily than men."*

Research on gender and health suggests that gendered health-seeking practices are influenced by hegemonic "masculine" ideals that correlate masculinity with a capacity to show strength in the face of sickness (Heise et al., 2019). Socially constructed gender norms result in seeking health care being seen as a feminine act, and masculine gender norms stipulate that "real men" prioritize paid work over seeking health care (Chikovore et al., 2017). This means that vulnerability once malaria has been transmitted is gendered with social norms preventing men from seeking medical assistance, which enhances their vulnerability to recover from malaria. While women are more likely to seek medical assistance, their ability to pay for expenses is hindered by gendered relations, as explained in the following section on gendered responses.

## Gendered responses and adaptive capacity to climate change and malaria risk

In this study, getting treatment in response to malaria infection was impacted by gender relations at the household level. Generally, women had limited power to sell farm assets, except for chickens, unless they had prior permission from the leading male of the farm. Lack of financial self-sufficiency reduced women's response capacity as they have fewer resources for medical costs, which could be used without permission. When medical costs are high, and there is a need to sell land or livestock, permission must be sought from male heads of the house before a sale can be made. If the man is away on business and there is an emergency involving a sick child, treatment will likely be delayed while permission is sought from the man:

> *"Men can own and sell livestock without consulting their wives."*

> *"When it comes to an emergency, if a child is sick or hospitalised, women can sell poultry, but for a cow, they have to seek consent [to sell] from the man. Also, trees are for men."*

Previous studies have demonstrated that gender influences the capacity to respond in small-scale farming enterprises (Nabikolo et al., 2012). One of the key issues impacting the ability to manage and cope with malaria arose with respect to power disparities in the sale of farm assets to raise funds for medical treatment. Some of the respondents explained that even if a woman had bought a cow with money she had generated, women were still expected to consult with men before selling the cow. One respondent explained that her very limited independent income was expected to fund medical treatment for herself, her children and even her husband.

> *"My little money will not only take care of the children's needs, but I will also have to take care of him when he is sick. Even for him as a grown man, I still buy him medicine etc[...], but I have no idea what he uses his money for, and I can't ask".*

Thus, this research suggests that gendered responses to malaria are constrained by gendered social norms regarding the power to make decisions are farm assets. Women reported a lack of power over resources, which hampers their ability to independently seek and pay for medical treatment.

# Implications for gender-sensitive climate change and malaria risk policies

This research highlights how gendered differences in occupational exposure, care arrangements and decision-making influence malaria risk at the household level. Future malaria interventions should take into consideration the gendered aspects of prevention, treatment decisions, and access to care. Findings from this paper produce policy implications for both health and climate policies at local and international levels.

## Gender in Kenya's malaria strategic plan

Findings from this analysis support the recommendations from a Kenyan government report which found that gendered patterns of behavior can influence exposure to mosquitoes, such as access to treatment and decision-making and provides recommendations on integrating gender into malaria response policies (Ministry of Health Kenya, 2015). The report draws attention to limited consideration of gender in existing malaria transmission studies and a lack of sex-disaggregated data and research on gender dynamics and malaria risk. A key recommendation of the report stressed the need to include gender in the implementation, monitoring and evaluation of the national strategies and plans for malaria risk management and specifically to mainstream gender into the six objectives of the Kenya National Malaria Strategic Plan. However, the revised

Plan (Ministry of Health Kenya, 2019) still lacks attention to gender-sensitive indicators for malaria risk in any of the six objectives and does not mention gender-sensitive data needs or analysis. Also, while the report acknowledges that climate change influences malaria transmission, there is no mention of integrating climate risk indicators into the interventions, monitoring and evaluation strategies under the six objectives.

## Gender in the UNFCCC

In 2017, a Gender Action Plan ("GAP") was adopted within the United Nations Framework Convention on Climate Change ("UNFCCC"). The GAP calls upon state parties (of which Kenya is a party) to mainstream gender into their national climate policies (UNFCCC, 2017a,b). There are two key gender concepts within the UNFCCC: gender balance, which considers issues of representation, and gender-responsive climate policy, which considers issues around the design and implementation of climate policy. The International Union has defined the concept of Gender Responsive Climate policy for the Conservation of Nature as: "identifying, understanding, and implementing interventions to address gender gaps and overcome historical gender biases in policies and interventions. Gender-responsiveness in application contributes, pro-actively and intentionally, to the advancement of gender equality. More than 'doing no harm', a gender-responsive policy, program, plan or project aims to do better" (Oliva and Owren, 2015). The Paris Agreement also requires Parties to embed gender into climate policies through article 7 (5), which requires Parties to "acknowledge" that adaptation action should follow a "country-driven gender responsive approach" (UNFCCC, 2015). Furthermore, Article 11 (2) requires capacity-building initiatives to be gender-responsive (UNFCCC, 2015). Article 7 (5) and 11 (2) of the Paris Agreement provides a basis for ensuring that national adaption climate policy is gender responsive and recognizes that a lack of gender-responsiveness in climate change adaptation policies may be inextricably linked to an increase in overall gender inequality (Dankelman, 2010).

## Recommendations

Based on these national and international initiatives, this article recommends that the gendered dimensions of climate change and malaria risk be factored into Kenya's health national adaptation plan and in Kenya's national plans and strategies for malaria risk management. Within the broader context of climate change adaptation policy, Kenya has sought to mainstream gender *via*:

a) Initiating a process to mainstream gender into the national climate change response strategy;
b) Developing national guidelines for mainstreaming gender into adaptation programs; and
c) Designing interventions that empower women to adapt to climate change implications (LDC Expert Group, 2015).

Kenya's National Adaptation Plan ("NAP") 2015–2030 (GOK, 2016) recognizes the need for a coordinated approach to address climate variability and change. The NAP proposes macro-level adaptation actions and sub-actions in 20 planning sectors and sets adaptation indicators for monitoring and evaluation at national, sub-national and sectoral levels. The action areas particularly relevant to this research include health action, gendered vulnerable group action, and agriculture action. The health action seeks to strengthen the integration of climate change adaption into health sectors and specifically recognizes malaria infection risk associated with climate change. While the Gender Vulnerable Group Action recognizes that certain groups often have the least access to and control over resources such as capital, credit, and land and often live-in areas more geographically exposed to climate risks (such as arid lands and urban poor areas). In combination, these two action areas support the development of policy and programming to foster local and international initiatives to target the gendered malaria risks of climate change.

Based on the findings of this study, the following interventions for the development of gender-responsive climate change and malaria risk management are recommended:

### Exposure

i. Action beyond the distribution of LLINs needs to be explored to protect women who face increased exposure when performing farming and caring roles at dawn and dusk when the use of nets is impracticable. This may include the distribution of and education on repellent for protection; and
ii. The collection and analysis of sex-disaggregated data to identify pathways of gendered exposure and vulnerability to climate change and malaria risk, particularly in highland vulnerable communities. These findings should be utilized to inform climate change and vector-borne disease policies and programs. Based on the findings of this study, the following sex-disaggregated data at the household level is recommended:

    a. Education level
    b. Roles, responsibilities, and division of labor
    c. Income earning potential/sources of income
    d. Power structures and decision-making
    e. Health-seeking behavior

At the community level, the collection of the following sex-disaggregated data is recommended:

a. Number of pregnant women
b. Hospital admissions
c. Clinical and confirmed cases of malaria
d. Total number of household occupants
e. Policies and programs for risk management

### Vulnerability

i. Encourage science-driven programs to embed a social analysis based on an intersectional analysis of climate vulnerability to identify how various factors combine to increase vulnerability to malaria.
ii. Further studies to identify malaria interventions that work for women to reduce their vulnerability at the household level.
iii. Education targeting men on the importance of seeking medical treatment for malaria.
iv. Increased education targeting pregnant women around the biological risks of malaria and identifying interventions suitable for pregnant women and women with HIV.

### Response/adaptive capacity

i. Continue to support programs regarding gender transformations at the household level that integrates and educate men, women and those working in the agricultural sector.
ii. Involve local women as co-researchers and co-designers of solutions in technical and scientific research to better understand how gender influences malaria risk and design strategies contextualized to local conditions.
iii. Strengthen the capacity of key stakeholders, managers, and data analysts in climate change, malaria and other related sectors to understand the gendered aspects of climate change and malaria risk and how to use this information to develop gender responsive climate change and malaria risk strategies at all levels.
iv. Engage other sectors and stakeholders, such as agriculturally vulnerable communities, in developing multi-sectoral programs and policies to respond to climate change and malaria risk.
v. Mainstream gender and climate indicators of hazard, exposure, vulnerability and response into national policies and programs, such as the Health National Adaptation Plan, Kenya Malaria Strategy, Malaria M&E Plan and the Kenya Malaria Indicator Survey.

## Conclusion

Vector-borne diseases account for more than 700,000 deaths globally, and malaria is one of the deadliest of these diseases and is a major public health burden globally. Risks of malaria are projected to rise into the future under climate change scenarios and will adversely impact those most vulnerable, including women. The connections between climate change, malaria and gender are complex and can impact health and wellbeing through multiple pathways, influencing all four dimensions of risk, i.e., hazard, exposure, vulnerability, and response. Drawing on FPE and the IPCC Risk Framework through the lens of Complex Risks Theory, this paper demonstrates that socially construed gender norms and responsibilities combined with a changing climate influence gendered exposure and vulnerability to malaria risk of agricultural communities in Western Kenya. This research recommends the design and delivery of research, initiatives and policies, which include approaches for mainstreaming gender into climate change and malaria risk policy and practice. Understanding and addressing gender-differentiated exposure, vulnerability and response to climate change and malaria risk has the capacity to contribute to contextualized adaptation programs and policies that promote gender equality. As this research shows, there is a pressing need to further explore and understand the gendered dimensions of climate change, and in particular significant attention needs to be paid to the gender-related health implications of climate change. Future research can expand beyond vector control methods and health-seeking behavior to understand how other drivers of climate change and malaria can contribute to gendered exposure, vulnerability and response.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by the Griffith University Human Research Ethics Committee, under Protocol No. ENV/21/14/HREC and by the Kenya Medical Research Institute (KEMRI), under Protocol No. KEMRI/RES/7/3/1. The participants provided their written informed consent to participate in this study.

## Author contributions

EO contributed to the study design, results, and discussions in the context of the IPCC risk framework, while RM contributed to the study findings and

discussions from the context of feminist political theory. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2022.929667/full#supplementary-material

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