Is climate exacerbating the root causes of conflict in Mali? A climate security analysis through a structural equation modeling approach

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Climate continues to pose significant challenges to human existence. Notably, in the past decade, the focus on the role of climate on conflict and social unrest has gained traction in academic, development, and policy communities. This article examines the link between climate variability and conflict in Mali. It advances the argument that climate is a threat multiplier, in other words, climate indirectly affects conflict occurrence through numerous pathways. We take the view that maize production and household food security status sequentially mediate the relationship between climate variability and the different conflict types. First, we provide a brief review of the climate conflict pathways in Mali. Second, we employ the path analysis within the structural equation modeling technique to test the hypothesized pathways and answer the research questions. We use the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA), a nationally representative data from Mali merged with time and location-specific climate and the Armed Conflict Location and Event Data (ACLED) data. Results show that an increase in positive temperature anomalies when sequentially mediated by maize production and household food security status, increase the occurrence of the different conflict types. The results are robust to the use of negative precipitation anomalies (tendency toward less precipitation compared to the historical norm). Our findings highlight two key messages, first, the crucial role of climate change adaptation and mitigation strategies and interventions on influencing household food security status and thus reducing conflict occurrence. Second, that efforts to build peace and security should account for the role of climate in exacerbating the root causes of conflict.

KEYWORDS

climate security, conflict, impact pathways, food insecurity, Mali, mediation analysis, structural equation modeling, climate variability

Introduction

The recent Intergovernmental Panel on Climate Change (IPCC) report identifies climate change and variability as one of the main challenges threatening human existence (IPCC, 2021). Together with other drivers, climate change and variability threaten human life in many ways including increasing the occurrence of natural disasters, undermining livelihoods security and peace. Concerning human security and peace, an increasing stream of research over the past decades has addressed the climate-conflict nexus (Burke et al., 2009; Fjelde, 2015; Froese and Schilling, 2019; Helman et al., 2020). An ongoing debate within this stream of research revolves around the arguments of causality and the mechanism or the contextual pathways through which climate may affect human security, peace and stability (Busby, 2018; Martin-Shields and Stojetz, 2019).

Existing empirical studies contributing to the climate-conflict debate provided mixed findings. Some support the argument that climate change exacerbates conflict (Burke et al., 2009; Crost et al., 2018; van Weezel, 2020) while others find no effect of climate change on conflict (Bergholt and Lujala, 2012; Slettebak, 2012). Scholars that support the argument that climate change and variability exacerbate conflict can be categorized into two. The first category conceptualize that climate variability has a direct effect on conflict, the second category postulate that the relationship is mediated by economic, social or political factors (Sakaguchi et al., 2017). On the one hand, studies that hold the view of a direct relationship between climate variability and conflict are framed from the General Aggression Model which state that higher temperatures trigger human aggression (DeWall et al., 2011), and Routine Activity Theory which holds that higher temperatures force people to spend more time outdoors increasing chances of that may undermine peace (Groff, 2008). On the other hand, those that take the indirect effect stance argue that climate variability affects conflict trough some intervening factors such as food insecurity (Koren and Bagozzi, 2017; Anderson et al., 2021), crop production (Wischnath and Buhaug, 2014; Caruso et al., 2016; Jun, 2017), and poverty and inequality (Harris and Vermaak, 2015; Helman et al., 2020) and country's economic growth (Bergholt and Lujala, 2012).

Even with the growing consensus that there is an indirect relationship between climate and conflict, there are no generally agreed upon impact pathways, rather, the indirect relations are complex and dynamic with feedback mechanisms. In the studies supporting the hypothesis that climate is indirectly associated with the emergence and persistence of conflict, resource scarcity is the dominant discourse explaining the mechanism at play (Klomp and Bulte, 2013; Salehyan and Hendrix, 2014; Raleigh et al., 2015).

Resource scarcity discourse views climate as a driver that creates resource scarcity which in turn fuels conflict (Evans, 2011; Ide, 2017). Access to arable land and water are some of the resources that are often adversely affected by climate variability and when the access is limited, conflict may arise (Hendrix and Salehyan, 2012; Koubi et al., 2012). For instance, in Africa where a majority of the countries rely on agriculture for economic development, an adverse climate variability may result in reduced agricultural production leading to livelihood and food insecurities and this may in turn trigger emergence of conflict events (Couttenier and Soubeyran, 2014). Moreover, for economies that rely on agricultural sector, reduction in agricultural production due to climate variability may lead to reducing employment opportunities and incomes, and rising food prices which may substantially increase conflicts (Fjelde, 2015). Such indirect relationship between climate and conflict constitute a significant "threat multiplier" to the peace and stability of the communities that rely on agriculture (Hegre et al., 2016). Two shortcomings are evident in the studies that attempt to unravel indirect effects of climate change on conflict, firstly, they do not provide much insight into the context-specific pathway linking climate and conflicts (van Weezel, 2020). Second, the studies on the effect of food production make an implicit assumption that food production is the main cause of food insecurity (Jun, 2017), while the studies on the effect of food security make an implicit assumption that food insecurity is as a result of decline in production due to climate change and variability. In other words, there are limited attempts to model the sequential association between food production and household food security status in influencing conflict.

Another unsettled issue within the climate-conflict research is the question of which climatic events influence conflict. Largely, existing studies consider precipitation and temperature anomalies—the deviation from the historical normal precipitation and temperature. Precipitation and temperature anomalies have been shown to have different effects on conflict depending also on the type of conflict in consideration (Hsiang et al., 2013). On the one hand, an increase in temperature anomalies has been shown to exacerbate conflict (Burke et al., 2009; Collard et al., 2021). On the other hand, rainfall anomalies show inconsistent results, for instance, some studies have found no effect of rainfall anomalies on conflict (Bergholt and Lujala, 2012), others have found rainfall abundance increases conflict (Theisen, 2012; Salehyan and Hendrix, 2014) yet others such as Hendrix and Salehyan (2012) have found a curvilinear relationship between rainfall and conflict.

This paper contributes to filling the knowledge gap and on the debate on the association between climate and conflict in at least four ways. First, we provide a contextualized impact pathways for Mali explaining the mechanisms through which climate variability may trigger to conflict. Second,

we model maize production and household food security status as sequentially mediating the association between climate variability and conflict. Third, estimate path analysis (serial mediation) through the structural equation modeling (SEM) approach. Fourth, we provide a detailed analysis of the association between both temperature and precipitation variability and conflict.

Overall, we advance the argument that the relationship between climate and conflict is complex and dynamic. Specifically, we hypothesize that climate variability negatively affects maize production and this, in turn, adversely affects the household food security status which consequently may trigger different types of conflicts.

The next sections of this article are organized as follows. In Section Climate security impact pathways we briefly provide the contextual climate security pathways in Mali and the theoretical framework of the mechanisms that explain the relationship between climate variability and conflict. Section Data and methods outlines the data and methods. Section Results presents the results and discussion, and in Section Conclusions we draw conclusions placing our findings in the growing debates on climate security, climate adaptation and mitigation in fragile contexts and climate finance.

Climate security impact pathways

Pathway 1: Resource availability and livelihood insecurity

For the past three decades, Mali has experienced an increase in competitive pressures over the access to and use of natural resources by different livelihood groups. These groups are often associated with specific ethnic groups, leading to overlaps between conflict lines. For instance, in northeast Mali, there are considerable tensions between Tuareg and Fulani pastoralist communities over the control of pasture lands and sources of water for their livestock (Nagarajan, 2020) while in central Mali, Fulani herders have also had confrontations with Dogon and Bambara farmers over access to pastures (Benjaminsen and Ba, 2009; Nagarajan, 2020; Hegazi et al., 2021).

Climate change and variability in Mali continues to impact negatively climate-sensitive livelihoods, including agriculture, livestock, and fishing, reducing their production and productivity (Nagarajan, 2020). The combined effect of a rise in temperatures and rainfall variability is likely to result in reduced productivity of some staple crops such as millet, sorghum, maize, and rice as well as cash crops such as cotton (Ministry of Foreign Affairs of the Netherlands, 2018; USAID, 2019). National reports indicate that the climate change reduces animal weight, decrease forage yield, and increase the prevalence of animal diseases, reducing the overall livestock productivity (Ministry of Foreign Affairs of the Netherlands,

2018). The result of the impact of climate will likely translate into increasing food insecurity, malnutrition, poverty, and poor health, which have been considered as the root causes of conflict (USAID, 2018, 2019; Nagarajan, 2020).

In this context, the climate crisis has the potential to exacerbate the competition over the access to and use of available resources through its impact on natural resource availability and environmental conditions. In Mali's conflict-affected context, the increasing competition may continue to reduce levels of social cohesion, further increasing the risks that conflicts will be sustained or (re)emerge between and amongst different socio-professional and ethnic groups (Raineri, 2018; Ursu, 2018; Nagarajan, 2020).

Pathway 2: Farmer-herder conflict

Farmer-herder conflicts have increased in the last decade due to various factors, including the expansion of farming into livestock corridors and the mobility of herders induced by the violent conflict and droughts (Ibrahim and Zapata, 2018; Jourde et al., 2019). The increasing variability in climate and the rise in the number of extreme weather events have negatively affected pastoralist communities in different ways, including the reduction of pasture and water that will further diminish their ability to maintain their primary source of livelihood (Ministry of Foreign Affairs of the Netherlands, 2018; USAID, 2018; Nagarajan, 2020). Pastoralists are forced to change their routes in search of alternative resources while some farmers try to increase agricultural land, frequently at the expense of grazing areas (Ibrahim and Zapata, 2018). This often leads to disputes between farmers and herders, especially as these pressures push herding communities further south where there are fewer demarcated livestock corridors (Nagarajan, 2020).

Harsh climate conditions with more severe dry seasons force pastoralists to move toward the Niger Delta in search of pasture. This becomes a real problem when animals arrive before the crops have been harvested as they damage crops, impacting farmers' livelihoods and increasing the risk of food insecurity and conflict (Ibrahim and Zapata, 2018). If the coping and adaptive capacities are not addressed, the climate crisis will likely exacerbate the root causes of conflicts, increasing both the number and intensity of conflicts (Ibrahim and Zapata, 2018; Hegazi et al., 2021).

Theoretical background and hypotheses

The climate-conflict nexus

The debate around climate-conflict nexus has gained traction since 2007 when climate change was reframed as a

national and international security issue as opposed to being understood as purely an environmental shock (Brzoska, 2012). Key to this debate is the argument that climate is a "threat multiplier" which amplify and compound the cascading effects of economic, social, and political risks that trigger conflict. This debate is active in fragile countries such as those in sub-Saharan Africa where conflict occurrence and climate effects are on the rise (Anderson et al., 2021). In the academic literature, the climate-conflict nexus has been conceptualized and theorized in a variety of ways leading to the application of different analytical methods and often yielding mixed findings. Broadly, two strands of conceptualizations exist: in the first strand, scholars test the hypothesis that climate variability may have a direct association with conflict (Hsiang et al., 2013), the second strand seeks to unravel the relative contribution of climate variability on conflict as mediated by other factors (indirect association) (Koubi et al., 2012). While these two strands of conceptualizations are interesting, the recent systematic review on climate-conflict nexus by Sakaguchi et al. (2017) identify the second strand as that provides the opportunity for policy makers and development community to design interventions that may reduce conflict.

Whereas our research is rooted in the second strand of conceptualization, we nonetheless test the direct association between climate variability and conflict. Studies that have estimated the direct association between climate variability and conflict often stem from the intersection of psychology and economics disciplines. For instance, supporting this line of conceptualization (Anderson et al., 2000) and (Ranson, 2014) argue that high temperature increase the level of aggression and tension, in turn, this may increase the likelihood of violence and the probability that police officers use force (Vrij et al., 1994). There is, however, a caveat to this direct association between temperature and conflict, that is, to date, the physiological mechanism linking temperature to aggression or tension remains unknown (Hsiang et al., 2013). From the foregoing, we test the following hypothesis:

H1: Climate variability is positively associated with conflict.

The mediating role of agricultural production and food insecurity

To advance the second strand of conceptualization that the association between climate variability and conflict is mediated by some factors, we reflect on the impact pathways. In general, the pathway through which climate variability may influence conflict are numerous, complex and context specific. According to Sakaguchi et al. (2017), the mediated association of climate and conflict emerge when climate variability interact with socio-economic factors, resource factors or processes of

migration. Food (in)security has often been conceptualized as a mediator in the climate-conflict linkage (Koren and Bagozzi, 2016; Brück and d'Errico, 2019; Martin-Shields and Stojetz, 2019). Accordingly, Koren and Bagozzi (2016) identifies two pillars that are mostly likely to be contested through violent means, these are food *availability* and *access* pillars. They find that food scarcity is associated with an increased occurrence of armed conflict.

In another study, Martin-Shields and Stojetz (2019) found that at the household and individual levels, nutritional status and economic opportunities trigger participation in any form of anti-social behavior that undermine peace. Notably, there is an implicit assumption in the studies that have attempted to model food (in)security as a mediator between climate variability and conflict. The assumption is that climate variability affects food production which in turn affect household food security status. Indeed, the relationship between climate and food production is often not considered. Instead, another stream of studies has attempted to model agricultural production as a mediator assuming that reduced food production due to climate increases food insecurity and hence the emergence of conflict. In Indonesia, Caruso et al. (2016) studied the effect of climate on conflict as mediated by rice yields. They hypothesize that climate may negatively affect rice production, and eventually food availability and food prices and thus positively the emergence of violence. Their results indicate that increase in the minimum temperature during the core month of the growing season leads an increase in violence driven by the reduction in future rice production per capita.

In sub-Saharan Africa, Jun (2017), studied the effect of temperature on civil conflicts mediated by maize yield. They postulate that high temperatures during maize growing season reduced the maize yield, which in turn increased the incidence of civil conflict. The findings support the hypothesis suggesting that that temperature-induced maize yield positively influences the incidence of civil conflict.

Finally, to our knowledge, limited effort has been directed to unravel the association between climate and conflict through both food production and food (in)security "closing the loop".

In this study we attempt to close this loop by modeling both maize production and food security status as mediators. The choice of maize yield is based on the importance of maize production to household food and livelihood security in Mali. Maize was widely adopted by farmers in the late 1970s following the great droughts during that decade as a crop diversification strategy aimed at addressing national chronic food shortages as well as ensuring food security (Diallo, 2011). The relevance of maize in Mali's total cereal production has been rapidly increasing since the 1990s, representing now around 25% of the total cereal production (Diallo, 2011; FAO, 2014). This boost in production was followed simultaneously by an increase in maize consumption, which went from 250,000 tons in 1996 to 700,000 tons in 2007 (Diallo, 2011). At the household level, annual maize

consumption has increased from 5.9 kg per person in 1980 to 50.9 kg per person in 2011, becoming the fourth most consumed product in Mali after rice, millet and sorghum (FAO, 2014). Human consumption accounts for 90% of the total domestic maize consumption, becoming a crucial cereal in the nutrition of most Malians, providing 10.8% of the total caloric intake in Mali (Diallo, 2011; CIAT et al., 2021). Unlike other cereal crops such as millet and sorghum, maize production is mostly grown for consumption with only 10 to 25% of the production being marketed (FAO, 2014). Recent studies have concluded that maize yield is a determinant factor in the food security of farming households, suggesting that the higher the farming household maize yield, the less the likelihood of food insecurity (Diallo and Toah, 2019).

In this study, we present food production (maize) and food insecurity as the mechanism through which climate influence conflict. To put our impact pathway into perspective, we postulate that climate variability (as measured by both precipitation and temperature anomalies) has a direct effect on maize production, and this in turn has a direct effect on household food security status, consequently influencing conflict. Given the above, we test the following hypotheses:

H2: Climate variability is negatively associated with maize production

H3: Maize production is negatively associated with food insecurity

H4: Food insecurity is positively associated with conflict

H5: Maize production and household food insecurity sequentially mediate the association between climate variability and conflict.

We test these hypotheses through a process called serial/chain mediation analysis in structural equation modeling technique—where the influence of the independent vari-able flows through multiple mediators before impacting the outcome variable (Collier, 2020). The theoretical model guiding this research is illustrated in Figure 1.

Data and methods

Data

The data used to answer the research questions is based on rich nationally representative household data from Mali which is administered by the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) of the World Bank. We use the pooled data of the two waves of Mali LSMS-ISA (2014/15 and 2017/18). We use the pooled data since it is documented that it was not possible to track households between the two waves, thus it is recommended that the data should be considered a cross-sectional
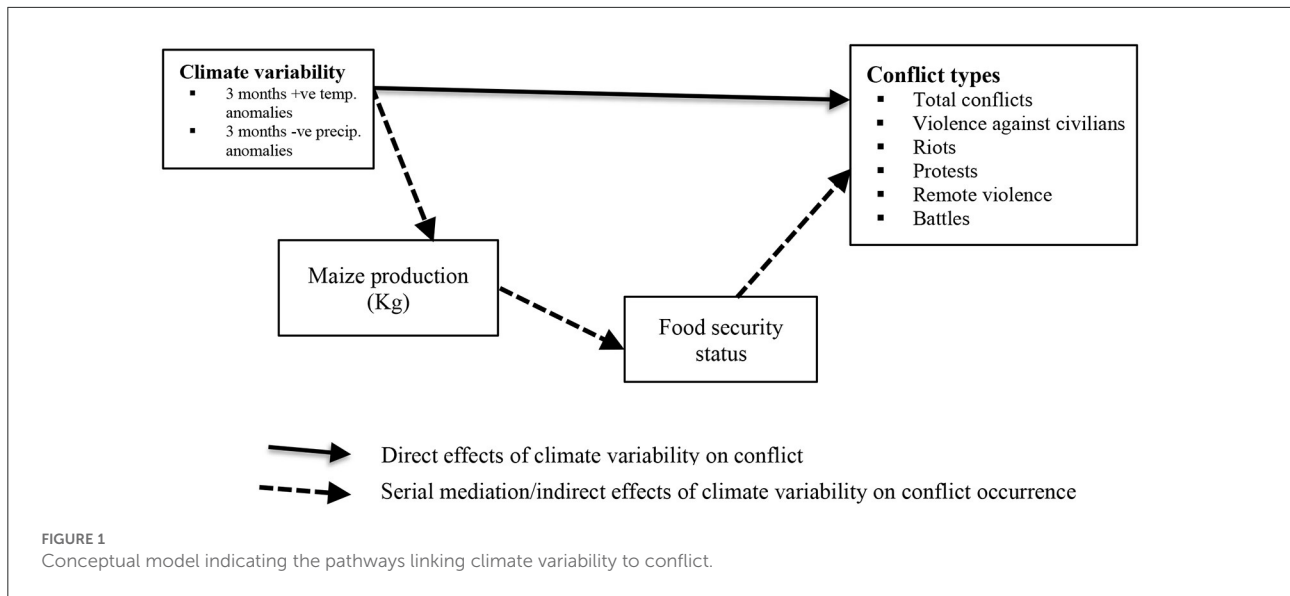
survey[1]. The LSMS-ISA surveys collect detailed data on household characteristics, agricultural production, food security, shocks, and household assets among others.

Maize yield is derived from the agricultural production section calculated by the sum of harvested maize production (kgs) in the two waves of data, this approach has been used previously (Caruso et al., 2016; Jun, 2017). Food security measures are taken from the food security section of the LSMS-ISA data, we use five items that measure the state of household food availability and access, these are: (a) whether or not a household member skipped meals because of lack of resources to buy food; (b) whether or not a household member reduced the quantities of food consumed because of lack of resources to buy food; (c) whether or not you or other household members spent a whole day without eating for lack of money or other resources?; (d) whether or not you or other household members did not eat a variety of food they desired because of lack of money or other resources; and (e) whether or not you or other household members depended on borrowed food, or relied on help from relatives, neighbors or friends.

The conflict variables were derived from the Armed Conflict Location and Event Data Project (ACLED). ACLED is geo-Referenced event dataset collected and coded to tract the conflict and violence occurrence globally. It aims to capture the modes, frequency and intensity of political violence and conflicts as they occurs (Raleigh et al., 2010). In this paper, we consider five forms of conflicts as grouped in ACLED, these are (a) violence against civilians, (b) riots, (c) protests, (d) remote violence, and (e) battles. Violence against civilians are deliberate violent acts perpetrated by an organized political group such as a rebel, militia or government force against unarmed non-combatants. These conflict events harm or kill civilians and are the sole act in which civilians are an actor. Protests are non-violent, public demonstrations against political entities, government institution, policy or group on the other hand riots are violent forms of demonstrations. Remote violence refers to events in which the tool for engaging in conflict does not require the physical presence of the perpetrator. These include bombings, IED attacks, mortar, and missile attacks, etc. Remote violence can be waged on both armed agents and civilians. Battles are violent interactions between two politically organized are groups at a particular time and location. For more details about the ACLED data see ACLED (2019). In addition to these forms of conflict, we also included a variable called total conflicts which is the sum of all the conflict types in a location of interest.

The climate data used were derived from the Climate Hazards Group InfraRed Precipitation with Station? data (CHIRPS) which contains information on maximum and minimum temperature and precipitation (Funk et al., 2015). The

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1 Further documentation of the Mali LSMS-ISA can be found here: https://microdata.worldbank.org/index.php/catalog/3409.

FIGURE 1
Conceptual model indicating the pathways linking climate variability to conflict.

household data, climate data and conflict data we merged using the month and year of survey and at the lowest administrative location referred to as cercle in Mali. We calculated the temperature and precipitation anomalies by considering the lagged values 3 months before the month of the survey. To calculate the climate anomalies, we applied the formula by Maystadt and Ecker (2014).

$$TA_{i,m,y}^n \ = \ \frac{1}{n} \sum_n \frac{T_{i,m,y} - \mu_{i,m}^T}{\sigma_{i,m}^T} \ \text{and}$$

$$PA_{i,m,y}^n \ = \ \frac{1}{n} \sum_n \frac{P_{i,m,y} - \mu_{i,m}^P}{\sigma_{i,m}^P} \qquad (1)$$

where

TA denotes temperature anomalies and PA precipitation anomalies.

$T_{i,m,y}$ and $P_{i,m,y}$ denote the monthly average temperature and monthly total precipitation in location (cercle) unit i during the month-year (m, y) time period. The long-term monthly mean is $\mu_{i,m}$, and the standard deviation is $\sigma_{i,m}$.

For the conflict variables, we consider the number of the different forms of conflicts that were reported 12 months after the survey period. Following our conceptual model logic and mediated hypothesis, if maize production affects household food security, then it is not logical that climate variability in time t will affect food security in time t and hence conflict in time t. Therefore, to test the mediated hypothesis, we believe that climate variability 3 months before the month of survey ($t - 3$) will affect household food security within 12 months after the survey ($t + 12$), and consequently the number of different forms of conflicts within $t + 12$. The choice of calculating both temperature and precipitation anomalies 3 months before the

month of survey takes into consideration the fact that maize has been established to mature between 180 to 210 days in the Sahel (Beah et al., 2021).

Empirical analysis

In this study we investigate the empirical associations between climate variability (as measured by the temperature and precipitation anomalies) maize production, household food insecurity and conflict. Given the complexity of the associations, we employ the structural equation modeling (SEM) approach which has previously used to unravel complex relationships such as the association between climate and conflict through different pathways (Helman et al., 2020; Yue and Lee, 2020). The SEM continues to gain popularity for modeling and estimating path-specific associations within a complex set of relationships. The SEM has the advantage of allowing for the estimation of direct and indirect (mediated) effects of climate change on conflict. Given this characteristic, SEM is preferred over the standard linear regression as it allows for the isolation of specific direct effects from indirect effects. SEM thus is suited for testing the direct and mediated effects based on a *priori* hypotheses. We therefore use SEM to test our conceptual model in Figure 1. We present the standardized effects, the magnitude, and the signs.

Results

Structural model and hypotheses testing

To estimate the structural model and test the mediation effects James and Brett (1984) recommend the use of SEM approach adopting a maximum likelihood estimation. To do

this, we follow MacKinnon et al. (2002) and Collier (2020) procedure of simultaneously estimating the path from the climate variability (temperature and precipitation anomalies) to conflict as measured by the number of the different types of conflicts through two mediators, maize production and household food security status – serial mediation as illustrated in Figure 1. Given the lack of solid theory and the existence of numerous pathways explaining the association between the climate variability and conflict, we constrain the direct effects to 0 when testing mediation effects (James et al., 2006).

The control variables were included in the structural model and regressed on the dependent variables (types of conflict). Descriptive statistics of the variables used in the analyses can be found in Appendix A1. The results of the structural model indicate that a good model fit was achieved as shown by the following fit indices CFI = 0.977; TLI = 0.958; RMSEA = 0.071; and SRMR = 0.054. These measures of model goodness of fit are within the recommended cutoff criteria, that is, CFI >0.95; TLI >0.95; RMSEA <0.08; and SRMR <0.06 (Hu and Bentler, 1999). For the test of mediation hypothesis, we conducted bootstrapping with 5,000 samples and bias-corrected confidence intervals of 95% level to obtain efficient standard errors as recommended in Shrout and Bolger (2002).

Table 1 presents the results of the direct effects both without and with controls. We interpret the panel of results with controls.

For brevity we present the full direct effects results only for the key variables that we hypothesized and provide the full results in Appendix A2. Overall, we find mixed results with some hypotheses supported while others are not supported. Whereas we hypothesized a positive association between climate variability (both temperature and precipitation anomalies) on the number of conflict types (H1), our results indicate that 3 months negative precipitation anomalies are negatively associated with total conflicts, violence against civilians and riots. We find positive association with protests and insignificant association with remote violence and battles. It is important to note here that negative precipitation anomaly denote tendency toward lower rainfall in relation to the long-term mean. Our mixed results are consistent with previous findings indicating that that negative deviations from historical mean are associated with higher risks of violence between communities (Fjelde and von Uexkull, 2012; Hendrix and Salehyan, 2012; Crost et al., 2018). Similarly, our findings are consistent with that of Raleigh and Kniveton (2012) who found that wet periods were associated with higher rates of communal conflicts in Kenya and Ethiopia. As expected, the hypothesis on the effect of 3 months negative precipitation anomalies on maize production is supported suggesting that decrease in precipitation compared to the historical long-term average reduces crop production (H2).

With respect to the direct effects of 3 months positive temperature anomalies on the number of different conflict types, our results are mixed. Some hypotheses are supported

indicating that increase in 3 months positive temperature anomalies increases the number of the different conflict types (H1). Specifically, one standard deviation increase in 3 months positive temperature anomalies increases violence against civilian, riots and protests, however, it reduces number of remote violence and battles. The supported hypotheses are consistent with the findings within the General Aggression Model which state that higher temperatures trigger human aggression (DeWall et al., 2011), and Routine Activity Theory which holds that higher temperatures force people to spend more time outdoors, in resource constraint contexts, this may provide opportunities to engage in activities that may undermine peace (Groff, 2008). As hypothesized, increasing temperatures relative to the long-term average has negative relation with maize production (H2). Two studies closely related to ours, Caruso et al. (2016) in Indonesia and Jun (2017) in sub-Saharan Africa have found results similar to ours.

With respect to the hypothesis that maize production is negatively associated with food insecurity (H3), our results support this hypothesis. This implies that increase in maize production reduces household food insecurity status. This corroborates with the findings that maize yield is crucial for household food security in Mali (Diallo et al., 2020).

Our results also support the hypotheses that household food insecurity increase number of conflict types (H4), indicating that increase in food insecurity by one standard deviation result to an increase in total conflicts by 0.08 standard deviations; increase in violence against civilian by 0.068 standard deviations; increase in riots by 0.067 standard deviations; increase in protests by 0.050 standard deviations; increase in remote violence and battles by 0.058 and 0.047 standard deviations respectively. This is in line with previous studies that have found that household food security status is one of the mechanisms that triggers conflict (Koren and Bagozzi, 2016; Martin-Shields and Stojetz, 2019; Anderson et al., 2021).

In the next step, we performed serial mediation analysis (indirect effects) while accounting for the control variables. This tests the hypothesis that maize production and household food security status sequentially mediate the association between climate variability (both temperature and precipitation anomalies) and the conflict types (H5). We rely on the parameter estimates for the path from temperature and precipitation anomalies to the conflict types via maize production and household food security status sequentially (see Figure 1) while setting the direct path from temperature and precipitation anomalies to the number of conflict types to zero. The mediation hypothesis is supported if the mediation path jointly not equal to zero (MacKinnon et al., 2002).

Table 2 presents the results of the serial mediation analysis both without and with controls.

Specifically, the results indicate that the mediated effect of 3 months positive temperature anomalies on total conflicts is 0.011, on violence against civilians is 0.003, on riots is

TABLE 1 Selection of results of the econometric model showing the direct effects of climate, maize production, food insecurity and conflict, without control variables (col. 2) and with control variables (col. 3). The last column shows whether the results support the hypotheses of our theoretical background presented in section 3.

Hypothesized path	Without controls		With controls		Hypothesis test decision
	Path Coef.	S.E.	Path Coef.	S.E.	
Precip. 3 months negative anomalies → Total conflicts	−0.015	0.448	−0.066***	0.341	Not supported
Precip. 3 months negative anomalies → Violence against civilians	−0.236***	0.153	−0.201***	0.123	Not supported
Precip. 3 months negative anomalies → Riots	−0.015	0.053	−0.155***	0.038	Not supported
Precip. 3 months negative anomalies → Protests	0.202***	0.208	0.041***	0.129	Supported
Precip. 3 months negative anomalies → Remote violence	−0.091***	0.063	−0.017	0.056	
Precip. 3 months negative anomalies → Battles	−0.054***	0.125	0.017	0.104	
Precip. 3 months negative anomalies → Maize production	−0.076***	0.084	−0.073***	0.120	Supported
Temp. 3 months positive anomalies → Total conflicts	0.078***	0.314	0.008	0.239	
Temp. 3 months positive anomalies → Violence against civilians	0.195***	0.107	0.050***	0.086	Supported
Temp. 3 months positive anomalies → Riots	0.369***	0.037	0.171***	0.027	Supported
Temp. 3 months positive anomalies → Protests	0.091***	0.145	0.017**	0.091	Supported
Temp. 3 months positive anomalies → Remote violence	−0.111***	0.044	−0.029***	0.039	Not supported
Temp. 3 months positive anomalies → Battles	−0.124***	0.087	−0.033***	0.073	Not supported
Temp. 3 months positive anomalies → Maize production	−0.073***	0.120	−0.076***	0.084	Supported
Maize production → Food insecurity	−0.076***	0.001	−0.072***	0.001	Supported
Food insecurity → Total conflicts	0.147***	0.699	0.080***	0.530	Supported
Food insecurity → Violence against civilians	0.165***	0.240	0.068***	0.191	Supported
Food insecurity → Riots	0.026**	0.083	0.067***	0.059	Supported
Food insecurity → Protests	−0.014	0.322	0.050***	0.201	Supported
Food insecurity → Remote violence	0.177***	0.098	0.058***	0.087	Supported
Food insecurity → Battles	0.188***	0.195	0.047***	0.162	Supported
Number of observations	**7,110**		**7,110**		

*$p < 0.10$, **$p < 0.05$, ***$p < 0.001$.
S.E, standard errors.

0.001, on protests is 0.003, on remote violence is 0.001, and on battles is 0.002. These, imply that, an increase in 3 months positive temperature anomalies by 1 standard deviation increases the total conflicts by 0.011 standard deviations, increases violence against civilians by 0.003 standard deviations, increases riots by 0.001 standard deviations, increases protests by 0.003 standard deviations, increases remote violence by 0.001 standard deviations, and increases battles by 0.002 standard deviations.

With respect to precipitation, the results indicate that overall, there is a positive association between the 3 months

negative precipitation anomalies and the number of conflict types mediated by maize production and household food security status sequentially. Specifically, the mediated effect of 3 months negative precipitation anomalies on total conflicts is 0.015, on violence against civilians is 0.005, on riots is 0.002, on protests is 0.004, on remote violence is 0.002, and on battles is 0.003. These, imply that, increase 3 months negative precipitation anomalies increase the total conflicts by 0.015 standard deviations, increase violence against civilians by 0.005 standard deviations, increase riots by 0.002 standard deviations, increase protests by 0.004 standard deviations, increase remote

TABLE 2 Results of the serial mediation analysis showing indirect effects of climate on conflict via maize production and food insecurity. The table reports the results of the model without (col. 2) and with (col. 3) control variables. Column 4 reports whether the results support the hypotheses of our theoretical framework presented in section 3. The last column shows whether the mediation is full (i.e. direct effects are not significant) or partial (i.e. direct effects are significant).

Hypothesized path	Without controls		With controls		Hypothesis test decision	Mediation type
	Coef.	S.E.	Coef.	S.E.		
Temp. positive anomalies						
Temp. 3 months positive anomalies → Maize production → Food insecurity → Total conflicts	0.021***	0.006	0.011***	0.003	Supported	Full mediation
Temp. 3 months positive anomalies → Maize production → Food insecurity → Violence against civilians	0.008***	0.002	0.003***	0.001	Supported	Partial mediation
Temp. 3 months positive anomalies → Maize production → Food insecurity → Riots	0.000**	0.000	0.001***	0.000	Supported	Partial mediation
Temp. 3 months positive anomalies → Maize production → Food insecurity → Protests	−0.001	0.001	0.003***	0.001	Supported	Partial mediation
Temp. 3 months positive anomalies → Maize production → Food insecurity → Remote violence	0.004***	0.001	0.001***	0.000	Supported	Partial mediation
Temp. 3 months positive anomalies → Maize production → Food insecurity → Battles	0.008***	0.002	0.002***	0.001	Supported	Partial mediation
Precip. negative anomalies						
Precip. 3 months negative anomalies → Maize production → Food insecurity → Total conflicts	0.030***	0.008	0.015***	0.004	Supported	Partial mediation
Precip. 3 months negative anomalies → Maize production → Food insecurity → Violence against civilians	0.012***	0.003	0.005***	0.001	Supported	Partial mediation
Precip. 3 months negative anomalies → Maize production → Food insecurity → Riots	0.001**	0.000	0.002***	0.000	Supported	Partial mediation
Precip. 3 months negative anomalies → Maize production → Food insecurity → Protests	−0.001	0.001	0.004***	0.001	Supported	Partial mediation
Precip. 3 months negative anomalies → Maize production → Food insecurity → Remote violence	0.005***	0.001	0.002***	0.001	Supported	Full mediation
Precip. 3 months negative anomalies → Maize production → Food insecurity → Battles	0.011***	0.003	0.003***	0.001	Supported	Full mediation

*p < 0.10, **p < 0.05, ***p < 0.001.
S.E, standard errors.
Mediation effects using the bootstrap method with 5,000 samples at 95% CI.

violence by 0.002 standard deviations, and increase battles by 0.003 standard deviations.

In general, all the hypotheses are supported, suggesting that maize production and the household food security status sequentially mediate the association between temperature and precipitation anomalies, and the conflict types. In other words,

maize production and household food security status are some of the mechanisms through which climate variability exacerbate conflict. In terms of the type of mediation, we find partial mediation in all mediated paths except the mediated path from 3 months positive temperature anomalies to total conflicts, the mediated path from 3 months negative precipitation

anomalies to remote violence and to battles which have a full mediation.

Mediated paths showing partial mediation imply that the direct paths are significant. On the one hand, this suggests that the variations in the conflict variables are explained both by the mediated paths and the direct paths. On the other hand, full mediation is where the direct path is insignificant suggesting that the variation in conflict variable is fully explained by the mediated path. While these results have policy implications, we caution that they need to be interpreted with care, this is because the scope of this paper is on one pathway (climate variability to conflict via maize production and household food security status), thus before making policy recommendations or designing interventions to reduce conflicts there is need to take into account the complexity of other pathways at play.

Conclusion

The world is significantly less peaceful now than it was 15 years ago. The 2021 Global Peace Index report shows that the average level of global peacefulness deteriorated for the ninth time in 13 years in 2020. Climate variability and change also accelerate this negative trend by multiplying socioeconomic risks and insecurities, such as food insecurity, forced migration, displacement, and inequality, among others, which are ultimately the root causes of instability, tensions, and conflict. Recent estimates report that approximately 971 million people live in areas with high or very high climate exposure, and of this number, 41 per cent resides in countries marked by low levels of peacefulness.

Despite growing recognition of the potential of climate to amplify existing conflict dynamics or even create new ones, robust, scientific evidence that climate is a "threat multiplier" is lacking. This is reflected in the policy agenda of many fragile countries, where climate security is not acknowledged and therefore risks associated with the nexus are not accounted for in either peacebuilding efforts or climate resilience interventions. More policy relevant research is needed on *how* climate is exacerbating common drivers of conflict; *where* is the climate security nexus occurring; *who* is bearing the burden of these risks and, finally, *what* can be done to break the cycle between climate and conflict.

Our study contributes to fill this gap providing answers to the *how* question above. We do so by testing the hypothesis that climate variability reduces agricultural production, increases food insecurity which in turn increase the intensity of conflict in Mali. We use a rich nationally representative dataset managed by LSMS and merge these with high-resolution climate (CHIRP) and conflict (ACLED) data.

Our findings reveal that climate is a threat multiplier, this is consistent with previous studies that have found that climate

indirectly leads to increased conflict occurrence (Fjelde, 2015; Crost et al., 2018; Mach et al., 2019). We have shown that maize production and food insecurity are important mediators of the impact of climate on conflict. In other words, climate indirectly exacerbates conflict by adversely affecting agricultural production and food security.

Acknowledging the role of climate as threat multiplier has important implications for both peace peacebuilding efforts. Current peace and security interventions do not adequately address the change, variability, and impact of climate on socioeconomic risks that can lead to conflict. There is, therefore, a need to correct this imbalance. And this is particularly important not only for those countries where climate and fragility already intersect but also for many *supposedly* peaceful countries across the developing world, which are regularly exposed to a set of diversified risks that can have a remarkably high destabilizing potential as the climate crisis intensifies.

This is even more important if we think that when it comes to climate action, existing strategies are unlikely to capture the wide range of context-dependent security risks that can arise from climate impacts. While an increasing number of climate interventions, investments, policies, and programmes target fragile and conflict-affected countries, these activities are often blind and less responsive to the context in which they operate. This can lead to the unintended consequences of reinforcing structural and contextual drivers of conflict. Indeed, several examples exist of conflict-insensitive adaptation measures that have increased conflict potential by damaging economic prospects, undermining political stability, and amplifying inequality and grievances.

Therefore, to reduce the potentially harmful effect of climate action and ensure that it positively impacts people and communities, there is a need to design and implement climate investments, policy, and programmes in a climate security sensitive manner. Climate security sensitivity can indeed unveil the potential peace contributing impact of climate measures, thereby addressing the root causes of conflict, and fostering societal levels of peace.

Data availability statement

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

Author contributions

GP: conceptualization, methodology, data analysis, writing, and supervision. DK: conceptualization, methodology, data analysis and curation, and writing. IM-L: conceptualization and writing—review and editing. VV and AB: methodology, data analysis, and curation. PL: review and editing.

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.

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Supplementary material

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