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Measuring the climate security nexus: The Integrated Climate Security Framework

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Abstract

International, regional, and national organizations, alongside policymakers, are increasingly acknowledging the crucial connection between climate, peace, and security. However, there remains a notable gap in research methodologies capable of fully grasping the intricate dynamics of this relationship. This paper introduces the Integrated Climate Security Framework (ICSF), a comprehensive mixed-methods approach designed to unravel the complexities of climate-human security-conflict connections across various scales. By integrating traditional and innovative research methods, the ICSF aims to provide cutting-edge, policy-relevant insights to address five main measurement challenges of the climate security nexus: multiple pathways; context specificity; non-linearity; multiple actors and scales, and multiple geographic and time scales. By drawing on diverse epistemological perspectives and engaging directly with local communities, the framework offers a comprehensive evaluation of the complex social-ecological dynamics at play. Using Kenya as a case study—a country where climate and security risks frequently intersect and amplify each other—we demonstrate the comprehensive insights the framework offers to address the complex challenges at the nexus of climate, human security, and conflict.

Introduction

Analyzing the correlation between climate conditions, peace and security, commonly referred to as the "climate security nexus," has emerged as a key concern for numerous national,

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regional, and international policymakers [1–3]. This is primarily due to the escalating unpredictability, frequency, and severity of climate-related impacts, which are heightening the risks of human insecurity, particularly among the most vulnerable populations [4–7]. The ramifications of climate change are exacerbating underlying causes of conflict, while conflict and instability, in turn, render populations more susceptible to climate hazards. This creates a "vicious circle" wherein the most vulnerable individuals become ensnared in heightened marginalization, poverty, inequality, and fragility stemming from conflict-related issues [8,9].

Generating policy-relevant evidence regarding this nexus is challenging. The climate security nexus is an intricately complex and multifaceted phenomenon, encompassing dynamic interactions between environmental, social, cultural, economic, and political factors [10]. This complexity makes it difficult to understand the emergence, nature, and extent of climate-security links, complicating efforts to effectively inform policy decisions.

Previous efforts to explore the climate security nexus have struggled to establish a consensus on the intersection of climate and security. With a few notable exceptions (e.g. [10,11]), the complexity of this nexus has often been overlooked or minimally addressed. For instance, many researchers have sought to characterize the climate security nexus through statistical models aiming to identify a direct, causal, and long-term impact of climate on conflict or peace [12–17]. They assume the absence of intermediary mechanisms between climate and conflict, overlook the temporal variability of impacts by focusing solely on long-term climate change events, and calculate global, regional, and national averages of effects, thereby disregarding the contextual specificity of the nexus. Moreover, they fail to incorporate indigenous knowledge provided by local stakeholders and affected communities.

To address some of these limitations, other authors have focused on short-term hazards resulting from climate change (climate variability) rather than larger and longer changes in climatic conditions (climate change). They have used methods to account for intermediary effects and have embarked on more qualitative approaches to elicit indigenous knowledge [18–21]. These studies acknowledge that climate does not have a direct, linear effect on peace and security but, rather, that it acts as a "multiplier", exacerbating existing socio-economic risks and insecurities such as agricultural losses, food insecurity, forced migration, and inequality, which can increase the risk, duration, and intensity of tensions and conflicts and therefore impact peace and security [7,14,22–24]. Some of these authors also explicitly recognize part of the complexity of the nexus by studying how both climate and conflict risks are influenced by and interconnected through a multiplicity of these intermediary factors that make up climate-insecurity feedback loops through a "vicious circle", where climate can indirectly affect conflict dynamics and conflict can increase vulnerabilities to future climate hazards [8,10].

Another strand of the literature has challenged methods aiming to find causation or quantitative links between climate and conflict [25,26]. By focusing entirely on qualitative, ethnographic, and anthropological approaches, these authors intend to define the relation between climate and conflict by understanding how populations experience these risks in an overlapping and compounding manner, and by situating insecurity and vulnerability in a historical and cultural context [27].

Despite some significant improvements in the methodological approaches to studying the nexus, a recent systematic review of climate security literature showed that out of 142 studies on the climate security nexus, only 6 used a mixed-method approach [25,28]. In line with Beaumont & Coning (2022) [29] and Reyes-Garcia et al (2023) [30] and building on Zografos et al (2014) [31], in this paper we argue that comprehensive assessments of the complex social-ecological dynamics that comprise this nexus require not only adopting mixed-methods that rely on a combination of diverse qualitative and quantitative, locally-relevant, and multifaceted

data sources, but also systems approaches that engage with a diversity of actors involved in the co-production of knowledge. The Integrated Climate Security Framework (ICSF) presented in this paper uses a comprehensive set of approaches and data to qualify and quantify the climate security nexus, addressing five main complexity challenges (multiple pathways, context specificity, non-linear dynamics, multiple sectors and actors, and multiple geographical and temporal dimensions). Although some of these methods are not new, they have been tailored and designed to specifically address climate security challenges. To showcase the range of information and knowledge we can gather through the ICSF, this paper presents a case study of Kenya, a hotspot for climate and security risks.

The framework aims to elicit robust, policy-relevant evidence and to provide tools to inform targeting, programming, and the design of effective climate security-sensitive policy and investments that are tailored to specific contexts. Adopting such a systems approach is crucial not only to help policymakers target and prioritize areas and groups of the population that are most affected by compound risks and insecurities but also to align climate resilience to peacebuilding objectives thereby reshaping food, land, and water systems to sustain peace in a changing climate.

The rest of the paper is structured as follows: Section 1 presents the theoretical framework that describes how we define the linkages between climate, human security, and conflict; Section 2 discusses the complexities of measuring this nexus; Section 3 describes the ICSF framework and its components; Section 4 presents findings of the ICSF in Kenya, and Section 5 concludes.

Section 1. The climate security nexus theoretical framework

Our conceptual framework builds and connects the work by Buhaug and Von Uexkull (2021) [8] and Zografos et al (2014) [31]. We argue that a "vicious circle" between climate hazards, conflict, and overall human security exists through their reinforcing impacts on vulnerability and exposure and as mediated by political ecology interactions and adaptation processes and outcomes that are highly contextual (Fig 1).

Human security is defined as freedom from fear [32], freedom from need [33], freedom from hazards [34], and freedom to live in dignity [35]. These freedoms translate into individual safety and the protection of basic human rights, access to material well-being, and equality [36–38]. Human security encompasses a series of material and non-material security of individuals and communities within the specific socioeconomic, cultural, and political economy context they occupy [31].

Our conceptual framework postulates that the impact of climate hazards on human security is a result of the interaction of exposure and vulnerability to climate hazards (for definitions please see S1 Table). We specifically focus on climate extremes and variability that manifest in fast and slow-onset climatic shocks and stressors [39]. Climate can have direct and indirect impacts on the exposure and vulnerabilities of individuals and communities. Direct impacts often occur in the presence of severe and extreme climate events, such as floods, which cause losses of infrastructure and assets, and forced displacement, among others. Indirect impacts materialize through the effects on the quality and quantity of natural resources, such as land and water, agricultural productivity, rural livelihood options, and food prices, that can significantly affect the functioning and effectiveness of food systems, causing food and nutrition insecurities and exacerbating existing inequalities.

Climate hazard impacts on exposure and vulnerability do not directly result in changes in human security outcomes. Rather, these impacts are mediated and shaped by structural, institutional, and relational drivers (Table 1) that reflect the historical, socio-political, cultural,

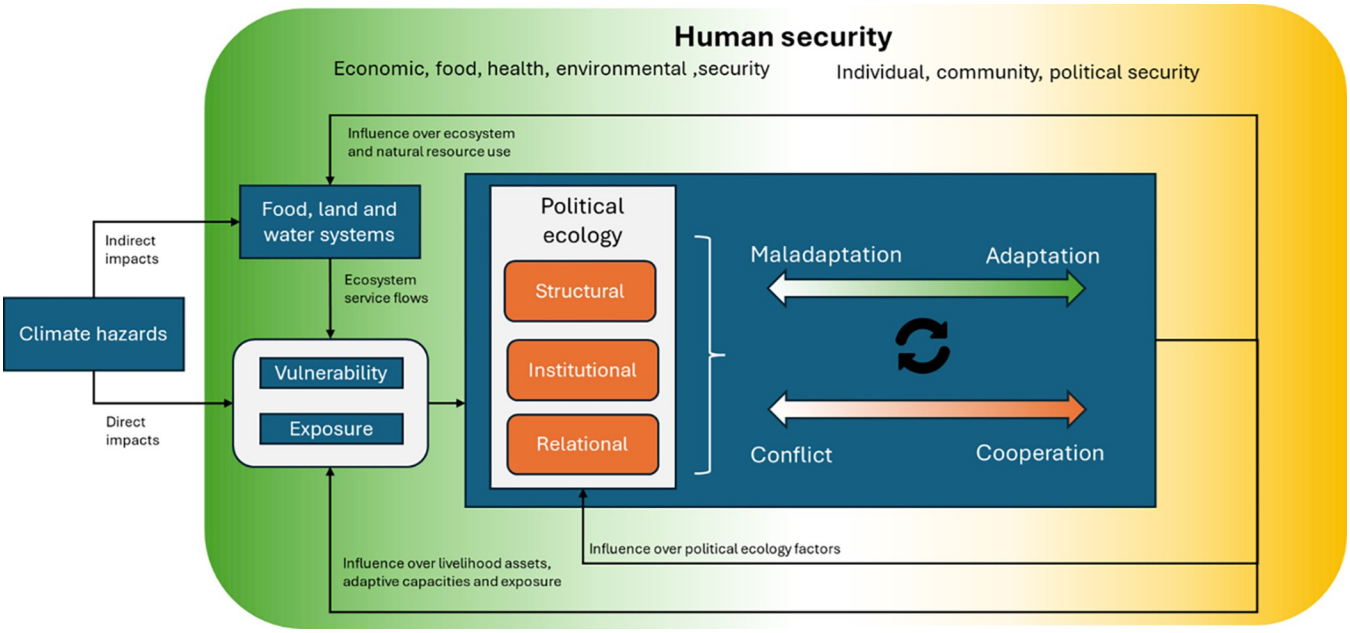

Fig 1. The climate security nexus theoretical framework. The graph shows a "vicious circle" between climate hazards, conflict, and overall human security through their reinforcing impacts on vulnerability and exposure and as mediated by political ecology interactions, conflict and cooperation dynamics, and adaptation processes and outcomes that are highly contextual.

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economic, and environmental specificity of the context where individuals and communities are located. These political ecology drivers mold behaviors within decision-making processes and influence resource entitlements, adaptive capacities, and societal relations, such as conflict and cooperation.

Pre-existing patterns of cooperation and conflict, and adaptation processes and outcomes can also impact exposure and vulnerability. Armed conflict, conflict, and tensions, through development failure, forced migration, and hunger crises, for example, can increase vulnerability by lowering economic development, increasing inequalities and marginalization, also affecting climate adaptive capacities [41]. It is important to note that, in our framework, we refrain from large-scale, internal, or international conflict or civil wars but we focus on small-

Table 1. Definition of structural, institutional, and relational political ecology factors that can mediate the impact of climate on vulnerabilities, human security, and conflict. Adapted from Lederach (2003) [40].

Category	Description
Structural	Historical, political, socioeconomic, and cultural drivers that extend beyond the purview of climate adaptation but influence institutional arrangements and relational patterns between social groups. Includes issues such as legacies of colonialism, corrupted political structures, cultural backgrounds, state-society relations and political legitimacy, and historical effects of armed conflict.
Institutional	Focuses on underlying drivers related to how social structures, organizations, and institutions are built, sustained, and changed by conflict and collaboration, especially in the context of responses to climate threats. Examples include drivers related to the statutory and customary structures that dictate resource tenures and access rights, control of adaptation resources, and decision-making processes within the purview of efforts for climate adaptation.
Relational	Issues of emotions, power, and interdependence, and the communicative and interactive aspects of conflict are central. Specifically, these drivers relate to patterns of communication, perceptions, and interaction in relationships, and how they affect conflict and collaboration. Includes drivers such as the perceived relative socio-economic traits of social groups, the state of relations between them, previous experiences of engagement, and perceptions of the Self in relation to the Other.

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scale internal tensions, violence, and conflicts, including protests, riots, and conflict events with or without fatalities whose dynamics might be related to the impact of climate on food, land, and water systems, which are reliant on and contribute to ecosystem services crucial for sustaining rural livelihoods.

Finally, the overall impact of climate hazards on human security also depends on the ability of the government to adapt infrastructure and society to current and future climate impacts and to foresee the impact that climate has on multiple root causes of human security. Early warning systems, drought and flood-resistant agricultural policies and practices, and resilient infrastructure that equally benefit different groups of the population and disproportionately help the most vulnerable and exposed can reduce the impact of climate hazards on overall societal human security. Failure to do so can be the source of "divergent" or maladaptation episodes [42], or else situations where climate adaptation interventions produce adverse vulnerability outcomes and could increase competition over resources or generate grievances that can increase the risk of conflict [31,43].

The results of these interactions can increase or decrease human security outcomes, alter political economy factors, and directly or indirectly affect vulnerability via impacts on livelihood assets, adaptive capacities and exposure, and its effect on natural resources and ecosystems. It can also generate grievances and reduce the opportunity cost of tensions and violence, in contexts with higher dependence on a climate-sensitive agricultural sector, lower human development (poverty, illiteracy, low health), lower adaptive capacity, higher inequality, socioeconomic and political discrimination and marginalization, weaker traditional institutions (such as chiefs and customary rules in natural resources access and management) [10,28,31].

This conceptual framework draws inspiration from a range of theories developed in the fields of human security, common-pool resource management, climate security, political ecology, and conflict transformation. The framework was developed under the understanding that, although the abundance or scarcity of natural resources may incentivize conflict and collaboration [19,44–47], it is rather historical, socioeconomic, political, and cultural factors that have the greatest impact on the onset and development of conflicts and collaborative processes that are related to the environment. As such, focusing on indirect and complex pathways, our reading of the climate security nexus does not embrace the securitization or commodification of climate and natural resources [48]. Rather, drawing inspiration from the field of common-pool resource management, particularly the Institutional Analysis and Development (IAD) framework, developed by Ostrom (2005) [49] our framework acknowledges that institutional practices shape responsive behaviors among diverse stakeholders in the face of climate threats and actions, both within formal and informal decision-making contexts.

Post-structural political ecologists have emphasized the socially constructed nature of resource entitlements and scarcities [50], along with the need to account for the historical material drivers of contemporary conflict [51]. This perspective challenges eco-determinist approaches to the study of environmental security and its frequent reliance on simplistic causation between climate change effects and conflict. In line with this argument, the framework guides a more nuanced understanding of the intricate interplay between environmental changes and their effects as ultimately shaped by sociocultural, political, economic, and historical contexts unfolding in a globalized society [31,52]. It intends to recognize the environment as a site of power contestation that transforms natural resources into entitlements and shapes the degree of individual and collective agency in the face of climate threats [53,54].

Moreover, following Barnett (2019) [27], we recognize that research on climate and conflict tends to focus overwhelmingly on violence and its drivers, neglecting the fact that social relations are often shaped more by collaboration than conflict [55]. From a positive ontological perspective, climate change has the potential to foster a "climate-resilient peace" by promoting

interdependencies and collaborative patterns through climate adaptation efforts [27]. Hence, even in settings where empirical evidence suggests an interconnection between climate effects and conflict dynamics, conflictive situations can mobilize societies towards constructive outcomes, such as challenging structural sources of climate-related vulnerabilities and the powers perpetuating them [56,57]. This assertion does not preclude, though, the possibility that, in certain contexts, the effects of climate change might interact with and exacerbate pre-existing factors contributing to antagonistic relations [58] or undermine peacebuilding efforts in post-conflict settings [59].

Section 2. The challenges in measuring the complex climate security nexus

One of the primary challenges in understanding and measuring the climate security nexus lies in the existence of *multiple pathways* or mechanisms through which climate factors can worsen existing risks and vulnerabilities, leading to heightened conflicts, and on the other side conflicts can weaken resilience capacities. Various plausible pathways include competition for scarce and abundant resources like water, land, and forests, food insecurity, population displacement, shifts in livelihood opportunities and economic performance, heightened exposure to extreme events, and increased grievances against governmental authorities, among others [44,45,51,60,61].

The interplay between these pathways and their interactions with socio-political dynamics can vary significantly depending on the context (*context specificity*) [25]. Different regions, countries, and communities experience distinct environmental, socioeconomic, cultural, and political conditions, which shape their susceptibility to climate impacts which could co-occur and interact with common drivers of human security and conflict. Political awareness and planning, governance structures, institutional capabilities, social cohesion, historical contexts, and cultural norms are significant determinants of how climate-related pressures translate into conflict risks and vice versa [50,62,63].

Another challenge in measuring the nexus between climate, human security, and conflict is that climate, human security and conflict often exhibit *nonlinear* dynamics. This means their relationship is neither consistently linear nor proportional [64]. Even minor alterations in climate or environmental conditions can yield disproportionately significant effects on social systems and conflict patterns. Feedback loops and tipping points are common occurrences, wherein climate-induced changes exacerbate pre-existing vulnerabilities, social tensions, and conflict dynamics. This amplification effect can lead to unpredictable and potentially severe consequences for social cohesion, peace, and security [65].

Furthermore, the climate-human security-conflict nexus encompasses a diverse array of stakeholders operating across various scales, ranging from local communities to national governments, international organizations, and transnational networks (*multiple actors and scales*). These actors possess distinct interests, priorities, and capabilities in addressing both climate-related challenges and conflict prevention. Understanding the diverse perspectives and capacities of these stakeholders is essential for developing comprehensive and inclusive strategies to address the interconnected issues of climate and conflict [66].

Lastly, it is essential to consider the spatial and temporal scales of the impacts of different hazards on drivers of vulnerability and human security are highly context-specific and heterogeneous *(multiple geographical and temporal dimensions* [17,18]). This heterogeneity derives from the sequential and circular nature of the impact of climate and conflict on human security. Namely, the occurrence of hazards that affect human security at a specific point in time and location might not result in a change in conflict or cooperation patterns in the same

location and time. Spatial and temporal lags exist between the occurrence of the hazard and its resulting insecurity. This variability underscores the importance of carefully assessing and interpreting findings within their specific spatial and temporal contexts to draw accurate conclusions about climate security dynamics [60,67,68].

Section 3. The integrated climate security framework

The Integrated Climate Security Framework attempts to address the five challenges of the climate security nexus—multiple pathways, context specificity, non-linear dynamics, varied sectors and actors, and diverse geographical and temporal dimensions—by employing nine distinct qualitative and quantitative empirical methods. It embraces a systems-thinking, multi-dimensional, mixed-method approach, utilizing both qualitative and quantitative, primary and secondary data. It significantly capitalizes on local wisdom from indigenous and local communities [30], alongside expertise from global to sub-national levels. The framework aims to provide policymakers with the most possible comprehensive overview of how, where and for whom climate is exacerbating root causes of human insecurity and conflict to guide the design of climate adaptation policies, programs, and investments that do not only avoid harm but actively contribute to sustaining peace. The ICSF is embedded in the CGIAR Climate Security Observatory (CSO), a global decision support tool that collates the evidence generated by the framework globally across different climate security hotspots.

Table 2 briefly describes each method and data proposed while Table 3 describes each method's strengths and weaknesses in addressing the climate security nexus complexity challenges. Links are also provided to method papers that describe in detail how to replicate the approaches. A more detailed description of the methods is provided in the Supplementary materials (S1 Text). Also, cleaned data can be downloaded from the CSO and scripts can be provided upon request.

Section 4. The climate, human security, and conflict nexus in Kenya

Kenya is one of the fastest-growing economies in Sub-Saharan Africa. With a devolved governance system, it can be characterized as a relatively peaceful context when compared to most of its neighboring countries. However, due to a combination of political, agroecological, and socioeconomic factors, Kenya has been recognized as one of the most vulnerable African countries to the impacts of climate change [69]. Extreme weather events and shifting climatic patterns, primarily in the form of heat waves, rainfall variability, and droughts, are increasingly affecting the country's crop and livestock systems, with severe implications for the income, employment, and food production of the entire Kenyan population [70]. Recurrent floods and droughts have major repercussions on water, energy, and land availability, thus leading the country to lose large cropland areas, limit production, and experience more water scarcity, as well as being a driver of food and nutrition insecurity [69–71].

Vulnerability to climate variability and extremes poses significant challenges not only to the country's economy but also to overall social stability, especially when climatic events disproportionately affect already vulnerable groups (Ibid.). Rural poor households, for instance, are particularly vulnerable to economic collapse and unable to cope with these shocks if repeatedly exposed to weather-related stressors and ecological deterioration [72].

Conflict in Kenya is a multifaceted issue rooted in historical, political, and socio-economic factors. Ethnic tensions [73], often exacerbated by political manipulation and competition for resources, have frequently led to violence, especially around election periods. Land disputes are another significant source of conflict, with historical injustices and unequal distribution

Table 2. Summary table describing the 10 empirical methods of the Integrated Climate Security Framework (ICSF), including research questions, objectives, data, and sources.

Complexity challenges	ICSF approach	Research question(s)	Objective	Method(s)	Data/Source(s)
Multiple Pathways	Climate Security Pathway Analysis (CSPA)	What is the latest evidence on the pathways that link climate-induced vulnerabilities to human insecurity and conflict?	To summarise dynamics whereby climate-induced vulnerabilities can translate into human insecurity and conflict as represented in the literature.	A combination of text mining, machine-driven and systematic literature review	Reports and other grey literature; journal articles. Source: Web of Science (WoS) and Google and Google Scholar repository
	Participatory Research: Towards the common vision workshops	How is the climate security nexus perceived and characterized by local stakeholders?	To develop a shared vision of the multiple pathways of the climate security nexus; identify contextual structural institutional and relational factors that interact with climate-induced vulnerabilities; map maladaptation and conflict risks; define adaption capacities and cooperation dynamics.	National-level stakeholders' consultations and expert elicitations involving regional, national, and local policymakers, researchers, and practitioners.	Primary data; Source: regional, national, and local policymakers, researchers, and practitioners
	Social Learning: Community voices on climate, peace, and security	How do affected communities experience the linkages between climate, human security, and conflict?	To understand how vulnerability, exposure, and political-ecological factors interact with hazards such as climate and conflict at the community level and identify potential solutions to mitigate the nexus.	Community-level fieldwork in hotspots of climate and security risks using 6 main methods: Transect walks; historical timeline; seasonal calendar; problem and response trees; collective action planning and method evaluations	Primary data; Source: affected communities located in climate security hotspots
	Mediation analysis	Is the food system a mediator of the impact of climate on human insecurity and common drivers of conflict?	To quantify how climate variability and conflict risks are indirectly linked through highly localized food and nutrition insecurity dynamics	Structural equation modeling	Conflict data–ACLED; climate data–TerraClimate; socio-economic data: Demographic Health Surveys (DHSs)
Context specificity *(in addition to Participatory workshops and Social Learning fieldwork)*	Spatial analysis	Where do different conditions of conflict, climate, and socio-economic vulnerabilities co-occur?	To identify subnational clusters where specific vulnerabilities to climate, human security, and conflict co-exist.	Geospatial clustering and hotspot analysis	Conflict data–ACLED; climate data–CHIRPS, TerraClimate, and AgERA5; and socio-economic variables–the Institute for Health Metrics and Evaluation (IHME), Facebook's wealth maps, Malaria Atlas Project, MODIS, NASA SEDAC at the Center for International Earth Science Information Network, Earth Observation Group, Payne Institute for Public Policy, Colorado School of Mines, EnvirometriX Ltd, amongst others.
	Vulnerability profiles	Who are the vulnerable groups to climate-induced insecurities and risks?	To profile the demographics of groups of the population that are located in climate security hotspots.	Descriptive statistical analysis	Socio-economic data used for the Spatial analysis above
	Mapping the policy landscape around climate, peace and security: Policy Coherence and Awareness Analysis	How salient is climate security in the policy agenda?	To understand whether national and local policies acknowledge and intend to address the role of climate in exacerbating vulnerabilities, in human security.	Text mining and content analysis	Policy documents originating from sectors deemed relevant for the themes under study, such as climate, agriculture, food systems, and security.
	Mapping the policy landscape around climate, peace and security: Social Media Analysis	How are climate, conflict, and human insecurities represented in the public narratives of policymakers?	To examine how climate, conflict, and socio-economic risks and uncertainties are represented in the current public discourses of a different array of policy actors at the national level.	Online issue mapping	Publicly available Tweets from the official accounts of central government bodies, ministries of agriculture, environment, and natural resources, as well as national security bodies

(*Continued*)

Table 2. (Continued)

Complexity challenges	ICSF approach	Research question(s)	Objective	Method(s)	Data/Source(s)
Non-linearity	Network analysis	How are climate, human insecurity, and conflict drivers and systems connected?	To quantify the underlying structure of the climate, socioeconomic, and conflict system and reveal intricate, non-linear patterns of interactions and dependencies among environmental, socioeconomic, and political factors	Regularized partial correlation networks analysis.	Same as the spatial analysis above
Multiple actors and scales	Towards the Common Vision Workshop; Community voices fieldwork and Social Media Analysis	Who are the relevant actors operating in the climate security nexus and how do they interact?	To identify, characterize, and assess the relationships among policy actors operating in the climate security space	See above, in addition for the social media analysis: social network analysis was used to map actors' interactions.	Primary data and tweets from selected policymakers
Multiple geographical and temporal dimensions	Mediation analysis	What are the geographical and temporal lags for climate-induced food and nutrition insecurity drivers of vulnerability?	To identify the most accurate geographical and temporal lags whereby climate-induced vulnerability could translate into insecurity	See above. In addition: 50km conflict buffers–and 3,6,9 months lags of the conflict response variable are used to test for geo-temporal heterogeneity	See above

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fueling tensions between communities [74]. Additionally, terrorism and radicalization, particularly by groups such as Al-Shabaab, pose security challenges, leading to periodic attacks and instability [75]. Despite efforts by the government and international organizations to promote peace and development, addressing the underlying causes of conflict, as affected by the accelerating climate crisis in Kenya remains a complex and ongoing challenge [76].

The following sections present the findings of our research trying to unpack this complexity across the five main challenges that the ICSF attempts to address. For all the field studies reported in this section a rigorous ethics assessment was conducted by the Leibniz Centre for Agricultural Landscape Research (ZALF), which approved the research. The fieldwork was carried out from the 8th to the 29th of September 2022. In the field, participants also provided verbal consent, recorded in an audio file, for their engagement in the research prior to the execution of the activities. No minors were involved in the research.

Multiple pathways

Multiple mechanisms and dynamics that link climate, human security, and conflict have been found. The literature review carried out through the Climate Security Pathway Analysis mainly identified two mechanisms that link climate, human security, and conflict: 1) Resource availability and access, whereby climate-related impacts limit or increase the availability of valuable resources such as water, pasture, livestock, and fish, through altering terrestrial and maritime ecosystems and affecting the water-cycle and the degradation of arable land. This is increasing inter- and intragroup competition around the access to resources of land, water or fish, which depending on the state capacity, governance, and local resource and conflict management, further affects insecurity dynamics. 2) Livelihood and food security, whereby rising temperatures, erratic rainfall, and flooding threaten climate-sensitive livelihoods and food security by reducing agricultural productivity [77].

Participatory methods, such as stakeholders' consultation and community participatory exercises provided much deeper nuances of the multiple pathways characterizing the nexus. Following a workshop with more than 40 actors working at the intersection of the nexus, participants identified three more pathways specifically for the Arid and Semi-Arid Lands

Table 3. Strengths and weaknesses of the ICSF methods.

ICSF approach	Strengths	Weaknesses
Climate Security Pathway analysis (CSPA)	It produces a comprehensive snapshot of the current evidence on the ways that climate-induced vulnerabilities are linked to human insecurities and conflict, which can give an enhanced understanding of how interlinkages present themselves in a given context	Existing literature, especially peer-reviewed articles might not be able to produce a comprehensive picture of the pathways as research timelines are often slow and selective; often too deterministic, and lack context specificity and nuances
Participatory Research: Towards the common vision workshops	It provides highly contextual insights into the climate security nexus at the country level. Moreover, the deployment of participatory instruments for collective deliberation supports the emergence of networks that learn to act in more synergistic manners thereby contributing to creating an agenda on climate security in the country.	It provides the perspective of policymakers, researchers, and practitioners and therefore is unable to capture the nuances that only affected communities can address.
Social Learning: Community voices on climate, peace, and security	It provides highly contextual insights into the climate security nexus at the community level. The pedagogical methods applied also contribute towards raising community and indigenous peoples´ voices in integrating local-level perceptions in climate security programming for resilience building.	Only communities in selected hotspots are included, which makes these findings not representative of the population affected by diverse climate insecurity risks
Mediation analysis	SEM is more flexible than approaches (e.g. instrumental variable) by relaxing the assumption that there exists only one channel that links climate to human insecurity and conflict	The food and nutrition insecurity channel is not the only mediator through which climate could affect conflict. Thus, the estimated direct effect captures many other potential mediators that are not included in the model. In addition, the food and nutrition insecurity mediator can have problems of endogeneity, and thus is difficult to establish causality
Spatial analysis and Vulnerability profiles	Spatial analysis enables rapid detection and descriptive analysis of places and communities at risk from climate, security, and socioeconomic vulnerabilities and impacts.	Due to the data-driven nature of this approach, specific nuances of vulnerabilities and how they interact with political-ecological factors cannot be captured. Moreover, demographic information and data are not updated regularly which can affect the accuracy of the degree and extent of vulnerability drivers presented.
Mapping the policy landscape around climate, peace and security: Policy Coherence and Awareness Analysis	It provides a clear mapping of the extent to which and how complex, multi-variate phenomena across several thematic areas are discussed and understood within relevant policy and strategy documents, based on which targeted and practical recommendations can be produced for policymakers.	Due to the desk-based nature and its reliance upon document review, it is unable to evaluate both the institutional structures and processes that inform policy design, formulation, and evaluation, nor has it been designed to evaluate the extent to which provisions made in policy and strategy documents are successfully or accurately implemented.
Mapping the policy landscape around climate, peace and security: Social Media Analysis	It provides a current perspective on the policy discourses that have not yet been translated into formal documents. Discourse crucially constructs and justifies emerging rationalities of governance and serves to define responsibility and control about a certain issue between various governing stakeholders	Social media narratives may not fully capture the complexity of policy cycles, as policy actors may interact across multiple scales, with their presence and voice not adequately represented in digital spaces.
Network analysis	It is a powerful tool that contributes to a deeper understanding of the structure and organization of complex systems by focusing on the relationships between the components of the system (biophysical, socio-economic, atmospheric)	Due to the data-driven nature of this approach, specific nuances of vulnerabilities and how they interact with political-ecological factors cannot be captured. Moreover, available data are not often aligned in terms of geographical and temporal scales.

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(ASALs), deemed as the main climate security hotspots. These additional pathways are displacement and mobility, warrior culture, and increased mistrust in the government [78].

Our fieldwork in a selection of climate security hotspots, namely Baringo, Laikipia, and Busia counties, provided further evidence of highly localized dynamics that link the evolution of the climate crisis and conflict risks that can be summarized in six main pathways: 1) increasingly scarce natural resources have led to a higher frequency and intensity of inter- and intra-community conflict; 2) conflicts over political boundaries are exacerbated due to the effects of climate change on livelihoods and income strategies; 3) the interloping impacts of climate

change and conflict undermine livelihoods, erode social cohesion within the community, and increase vulnerabilities to future climate threats; 4) maladaptive income strategies adopted by some community members to cope with climate threats are perceived as negatively affecting others; 5) limited institutional capacities to address climate threats, rent-seeking practices, indigenous peoples' rights and the political instigation of violence impair efforts for conflict resolution and resilience building, exacerbate conflicts, and reduce trust in formal institutions; 6) the increasing frequency and intensity of rapid-onset floods lead to community-wide temporary displacement [79]. These pathways are inherently different across the case studies. Specifically, in-depth discussions with various groups in the affected communities show that in the Yaaku community in Laikipia County, conflicts between the Yaaku and the Samburu communities around access and use of food and other resources from the Mukogodo forest are intensifying because of recent droughts. Members of the Yaaku villages within the forest report to be the victims of cattle rustling, mostly by Samburu pastoralists to the north, around once per week. In Busia County, the increase in flooding has made it increasingly difficult for the Banyala community to find alternative sources of food and livelihood, and they are now forced to go deeper into the lake and across the Ugandan border to fish. This is putting them at risk of arrest, torture, destruction of property, and death by Ugandan authorities and pirates. The effects of climate are forcing populations to maintain a livelihood strategy that puts them at risk of lawbreaking and insecurity. Finally, the Endoróis community in Baringo County has been subjected to violent attacks from the neighboring Pokot communities since 2005. Members of the Endoróis understand that high levels of vulnerability, food insecurity, poverty, and marginalization among Pokot populations make them more susceptible to recruitment by bandits. This is enhanced by the effect of climate change, mainly through the loss of agricultural productivity and livelihoods during extreme droughts. These impacts are now higher due to the widespread presence of internally displaced people across their territory and affect the loss of life and livelihoods due to the impact of violence [79].

These analyses reveal that climate impacts on vulnerabilities are primarily mediated by changes in food, land, and water systems, underscoring their significance in the intricate relationship between climate, human security, and conflict. We tested this assumption with a quantitative method called Structural Equation Modelling. In this analysis, we focus primarily on the impact of climate on nutrition insecurity, following the extensive literature on the impact of food and nutrition insecurity on conflict (see for example [80]. Our analysis confirms the centrality of nutrition insecurity in mediating climate impacts on conflict. Specifically, it shows that decreased rainfall is indirectly linked to more frequent violent conflicts through an increase in malnourishment–stunting–with each unit increase in below-average rainfall anomalies being associated with an 8% increase in foreseen violent conflicts as mediated by malnutrition [81].

Context specificity

The interaction and co-occurrence of climate and conflict hazards and human insecurities differs significantly across geographies in Kenya. Our study shows that not all the areas that that are vulnerable to climate or conflict risks are climate security hotspots, defined as the co-occurrence of high level of conflict intensity and diversity, high level of climate exposure and high level of vulnerability due to high socio-economic insecurities, such as food and nutrition insecurity, low agricultural productivity, inequality, unemployment and migration.

Our findings illustrate a complex landscape of varying levels of climate exposure, vulnerabilities, and conflict across Kenya from 1997 to 2021 (Figs 2 and 3). Conflict events are widely dispersed throughout the country, with statistical analyses revealing three distinct clusters.

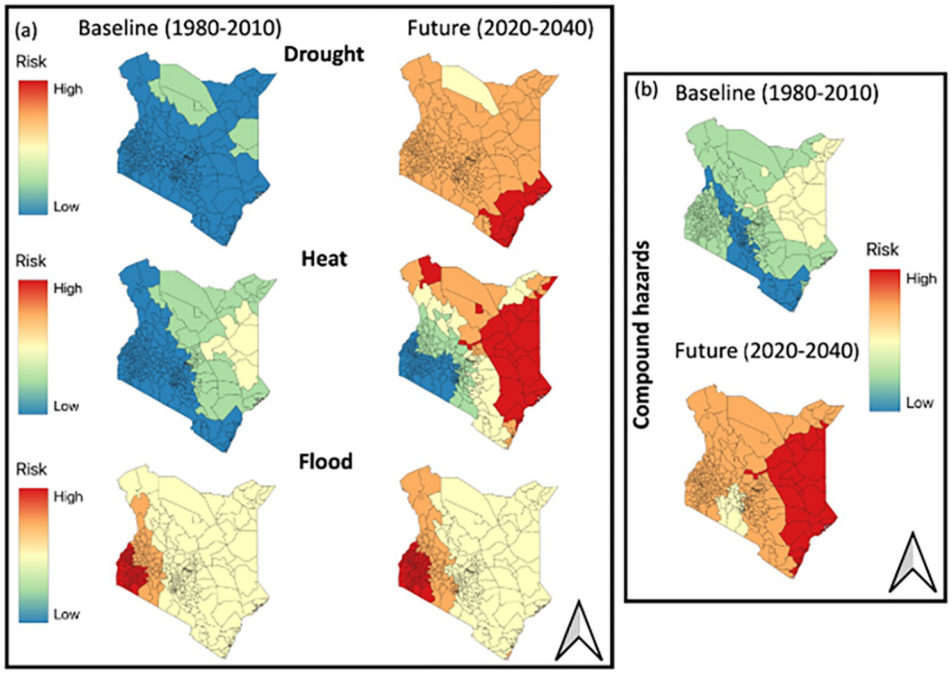

Fig 2. Level of exposure to climate hazards, specifically, drought, floods, and heat. Note: The base layer of the maps can be found here: https://gadm.org/maps/KEN.html and the terms of use/license can be found here: https://gadm.org/license.html. These maps are not an authority on boundaries.

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High-conflict areas are notably concentrated in the Nairobi county and nearby counties like Kiambu, Muranga, Machakos and Nakuru as well as counties to the west like Kisumu, Siaya, Bungoma, Trans-Nzoia, and West Pokot. Additionally, significant conflict hotspots are found in the southeastern regions, including the counties of Kwale, Mombasa, Kilifi, and Lamu. The moderate-conflict cluster spans much of the remaining areas of the country. The primary types of conflict identified include riots, protests, battles, and violence against civilians.

The regions experiencing both high or moderate conflict, coupled with severe climate conditions, are predominantly located in the northern and eastern parts of Kenya. These include areas such as eastern Turkana, Marsabit, Mandera, Wajir, central Isiolo, northern Garissa, and Lamu counties. These regions are not only characterized by challenging climate conditions but also coincide with significant socio-economic stressors, including inequality, low agricultural productivity, undernutrition, and migration pressures. As a result, these areas have been identified as critical climate security hotspots, where the interplay between environmental and socio-economic factors exacerbates the risks of conflict and insecurity (Fig 4) [82–85].

However, following our conceptual framework, we argue that also in the case of Kenya exposure to hazards and vulnerabilities doesn't automatically lead to heightened risks of human insecurity and conflict. Instead, these risks are mediated by political and ecological factors, which can both influence and be influenced by policymakers' decisions on managing food, water, and land systems. These decisions can, in turn affect, vulnerabilities and exposure between social groups; and collaborative/conflictive and adaptive/maladaptive behaviors in the context of climate threats. Analyzing policy discourses and documents can help understand to what extent national decision-makers and local institutional processes are apt to address and mitigate the complex contextual pathways of the nexus.

The results of both online issue mapping and policy coherence analysis show significant gaps in the acknowledgment of the role of climate on human security and conflict both at

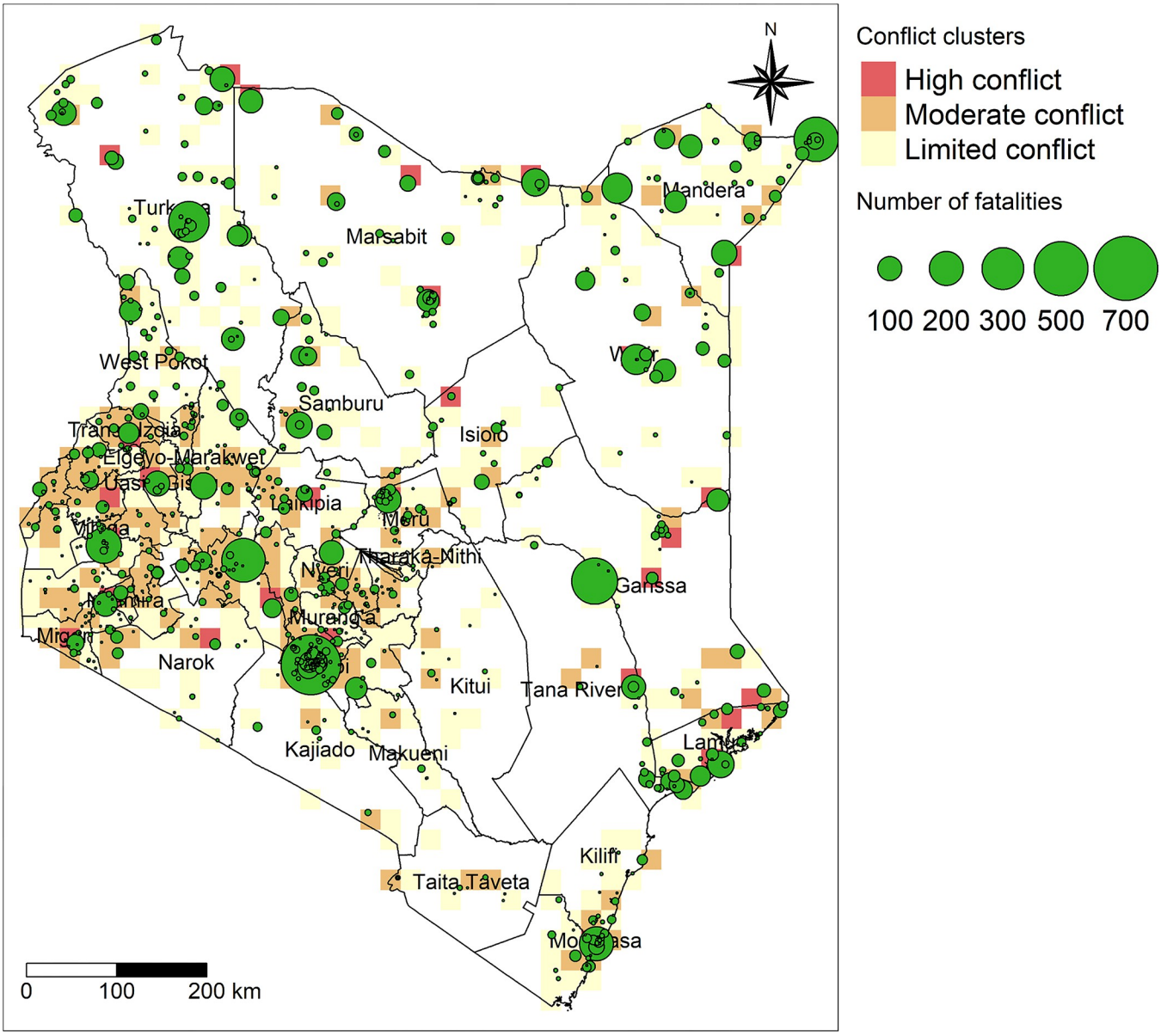

Fig 3. Level of occurrence of conflict events. Note: The base layer of the maps can be found here: https://gadm.org/maps/KEN.html and the terms of use/ license can be found here: https://gadm.org/license.html. These maps are not an authority on boundaries.

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institutional and policy levels. These gaps suggest that climate, human security, and conflict pathways are not adequately addressed and mechanisms, including historical political ecological factors, whereby climate can exacerbate root causes of human security and conflict, are not mitigated.

Specifically, the assessment of the salience of climate, peace, and security concepts in the social media communications of Kenyan policy actors found that the pathways that link climate stressors, socioeconomic risks, and conflict are largely disassociated in the narratives of government bodies [86].

The examination of policy and strategy documents confirms this finding [87]. Firstly, the nexus is only acknowledged in disaster risk reduction (DRR), and rather absent in peace and

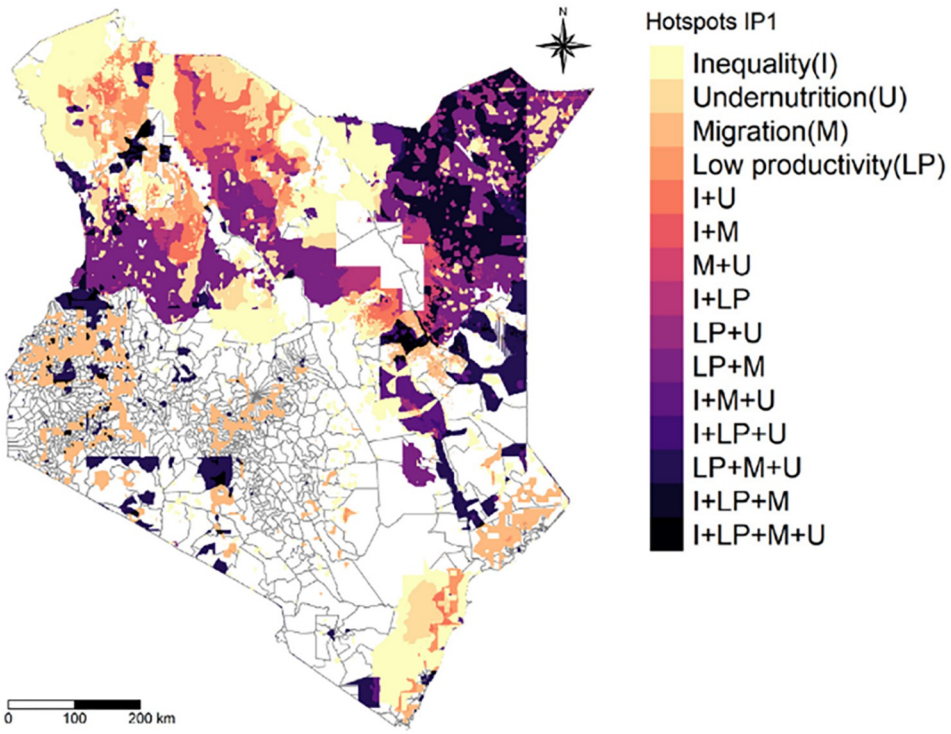

Fig 4. Incidence of a selection of human insecurity dimensions, namely inequality, net migration, low productivity and a combination of those. Note: The base layer of the maps can be found here: https://gadm.org/maps/KEN.html and the terms of use/license can be found here: https://gadm.org/license.html. These maps are not an authority on boundaries.

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security, gender, or adaptation and mitigation policy documents. Secondly, our results suggest that despite discursive constructions around the nexus having taken place in Kenya, translating policy discourses into concrete programmatic initiatives and outcomes remains a persistent challenge. There exists a fundamental knowledge and policy gap about how to design adaptation and mitigation interventions that can form entry points for conflict prevention, conflict transformation, and peacebuilding. Thirdly, there are limited institutional spaces for interaction and coordination between those working on climate and those working on peace and security and there is not an institutional body within the Kenyan governance architecture with a boundary spanning or bridging mandate across climate, human security, and conflict actors.

Therefore, despite the existing evidence that climate, human insecurities and conflict co-occur and interact at different degrees across the whole country, policy instruments to mitigate and mold political ecological factors that mitigate the nexus are merely absent.

Non-linearity

In Kenya, the climate, human security, including various socio-economic dimensions, and conflict nexus is highly non-linear. In Fig 5 we show the results of the network analysis which shows the statistical correlation of multiple drivers of the climate, human security, and conflict dimensions. Stronger relationships are visualized with thicker lines. Arrows show higher-level connections and feedback loops. The results of our analysis show that there exist strong non-linear connections across different systems and dimensions [88].

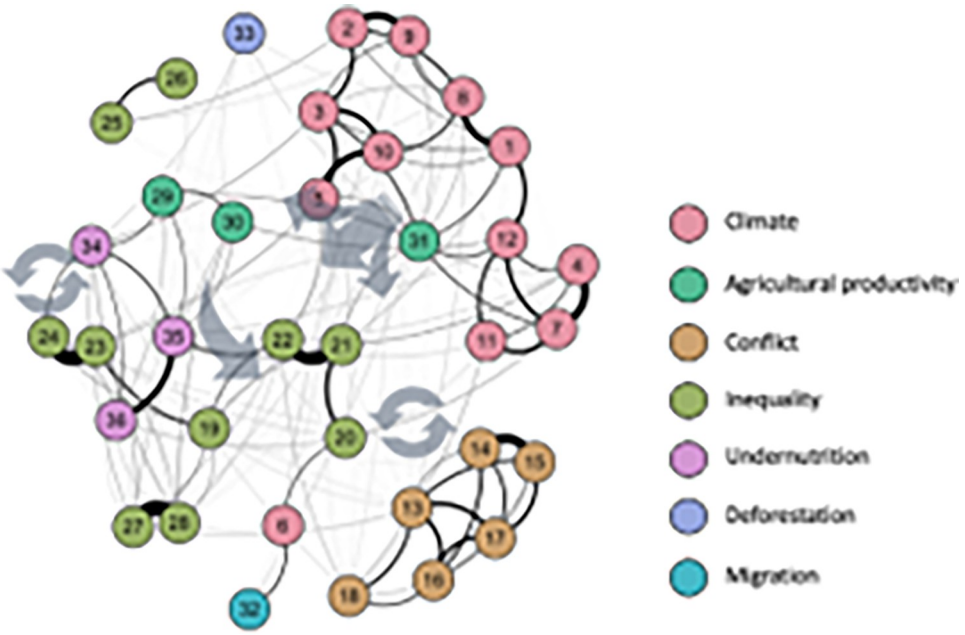

Fig 5. The climate security network in Kenya. Fig 5 shows how climate, agriculture, conflict, inequality, undernutrition, deforestation, and migration variables and data are connected in Kenya. Stronger relationships are visualized with thicker lines. Arrows show higher-level connections and feedback loops. Key variables referenced in text are Climate water deficit (multi-annual average) #1; Number of days with ratio of actual to potential evapotranspiration ratio below 0.5 (multi-annual average) #3; Number of days with waterlogging (multi-annual 90th percentile) #5; Frequency of 5-day dry spell within rainy seasons (multi-annual average) #6; Heat stress on cattle (THI) (multi-annual average) #7; Maximum temperature (multi-annual 90th percentile) #12; Total number of conflict events #13; Total number of unique conflict sub-type events #15; Total number of conflict fatalities #18; Accessibility to healthcare services at 2019 #19; Difference of years of education (male—female) (multi-annual median) #20; Years of education male (multi-annual median) #22; Population density (multi-annual average) #23; Population density (multi-annual trend: Sen's slope) #24; Absolute wealth index #27; Relative wealth index #28; Net primary production (multi-annual upper bound) #31; Estimated Net Migration (multi-annual 90th percentile) #32; Deforestation #33. All other variables can be found in [89].

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Central nodes within the Kenyan climate-socio-economic-conflict network are the number of conflict events, net primary agricultural production, wealth indicators (relative #28 and absolute wealth indexes #27), and a rainfall pattern indicator (number of days with waterlogging #5).

Agricultural productivity plays a key role in the network of interactions. Specifically, the agricultural production node (net primary production #31) is situated at the heart of the climate cluster and is negatively correlated to many climate extremes, such as drought (number of days with a ratio of actual to potential evapotranspiration below 0.5 #3) and heat stress (climate water deficit #1, heat stress on cattle #7, maximum temperature #12). This highlights the strong connection between climate extremes and the agricultural sector. The same node is then connected with many socio-economic indicators such as food and nutrition insecurity, migration, and inequality which is linked to conflict.

Amongst all subcategories of socio-economic variables, inequality variables have the most connections (in terms of number and width of edges) with conflict variables. The total number of conflict events is linked to several inequality factors (years of education for males #22, wealth index #28, population density #24, healthcare #19). This indicates that inequality is one of the primary pathways to instability or conflict in Kenya. Moreover, the total number of conflict events is also associated with resource scarcity and maladaptive behaviors, which are proxied with a measure of deforestation (#33).

Moreover, several conflict variables—such as the number of fatalities (#18) and the diversity of conflict sub-events (#15)—are strongly associated with undernutrition indicators. These, in turn, are connected to climate variables through agriculture, highlighting the critical mediating role that food and nutrition insecurity, as well as agricultural practices, play in the climate-security nexus.

Migration is strongly correlated with climate factors and their intersections with inequality and conflict. For instance, an extreme climate indicator—such as the frequency of 5-day dry spells within rainy seasons (#6)—is closely linked to migration (#32) and education inequalities (the difference in years of education between males and females #20). Education inequalities (node #22) are also connected with the incidence of conflict with fatalities node (#18), suggesting a reinforcing loop between climate impacts, inequalities, forced migration, and conflict dynamics.

Multiple actors and scales

Our social learning and media analyses reveal a diverse array of stakeholders at regional, national, and subnational levels who are actively involved in addressing the climate, human security, and conflict nexus (Fig 6).

Additionally, during the 'Towards a Common Vision of Climate Security in Kenya' workshop, a participatory exercise helped identify existing multi-stakeholder platforms that could advance the climate security agenda in Kenya. We identified three regional, three national, and two sub-national platforms, detailed as follows. At regional level:

1. The Greater Horn of Africa Climate Outlook Forum (GHACOF) is an annual conference that brings together key climate stakeholders from the region, working to develop climate services for sustainable development. It provides the opportunity to showcase innovations for climate change adaptation. Three of its working groups (Agriculture and food security, Conflict early warning, and Climate change) are deemed relevant to share innovative practices towards integrating climate security in climate adaptation and peacebuilding programming.
2. The IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI) brings together different stakeholders such as IGAD Member States, development organizations, and implementing partners, including UN agencies, Civil Society Organizations (CSOs), and research institutes. The platform serves as an exchange space that extends from regional to sub-national levels and means to address the phenomenon of recurrent droughts and worsening environmental concerns in a sustainable manner.
3. The UWIANO platform within the Peace Actors Forum is managed by the National Cohesion and Integration Commission (NCIC), the National Steering Committee on Peace Building and Conflict Management (NSC), PeaceNet Kenya, and the United Nations Development Program (UNDP). The platform serves as a conflict preventive strategy that provides space for a wide range of partners, actors, and stakeholders to build synergies and leverage their efforts for conflict prevention and peacebuilding in Kenya. This space was considered a suitable starting point to systematically explore the integration of climate action within peacebuilding strategies across the country.

At national level:

1. The Climate Smart Agriculture Multi-Stakeholder Platform (CSAMSP) is a network of organizations whose work is inclined toward Climate Smart Agriculture (CSA) practices. The platform's goal is to coordinate stakeholders in the CSA arena and their work.

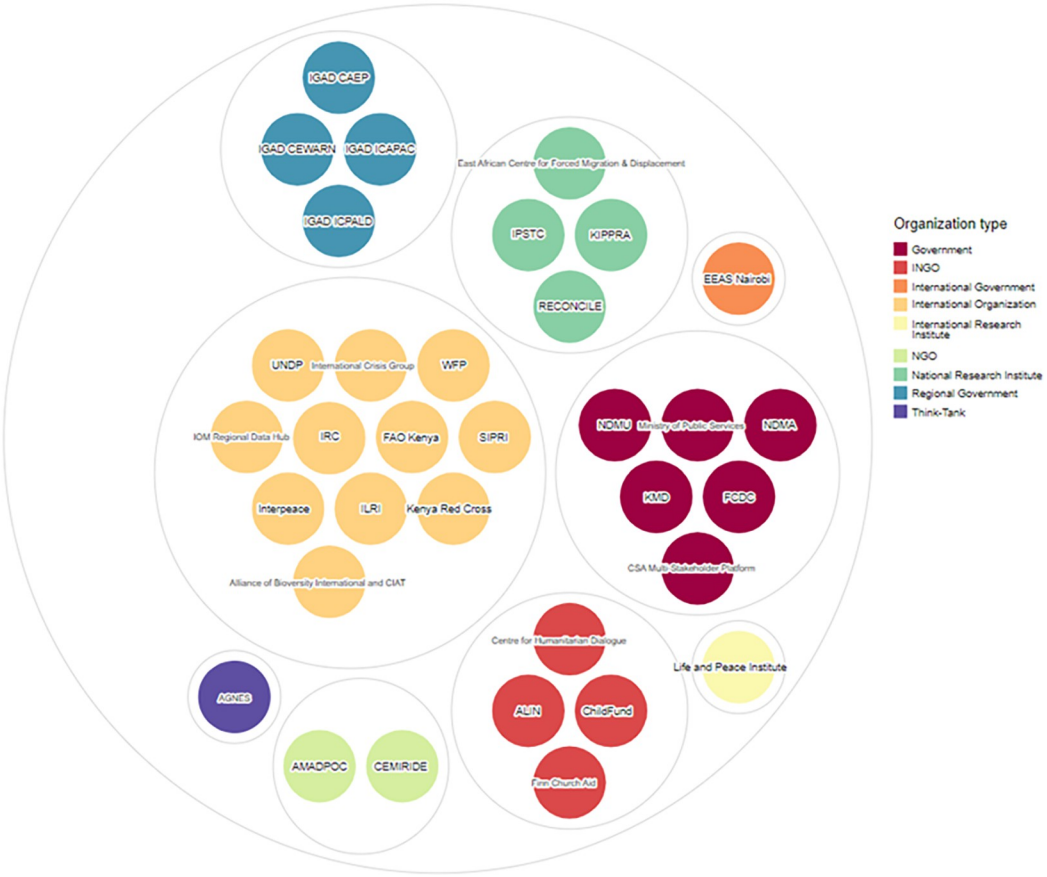

Fig 6. Stakeholders working on the climate, human security, and conflict nexus in Kenya, cluster by type: Government, international NGO, International Government, International Organisation, International Research Institute, NGO, National Research Institute, Regional Government, and think tank. This list was compiled through the ICSF participatory exercises at national and sub-national levels. Note: AMADPOC stands for "African Migration and Development Policy Centre"; AGNES "Africa Group of Negotiators Expert Support; ALIN "Arid Lands Information Network"; CEMIRIDE "Center for Minority Rights Development"; CSA Multi-Stakeholder Platform "Climate Smart-Agriculture Multi-Stakeholder Platform—Ministry of Agriculture, and Livestock Development" of the Ministry of Agriculture, and Livestock Development; EEAS "European External Action Service"; FAO KE "Food and Agriculture Organisation" Country Office for Kenya; FCDC "Frontier Counties Development Council"; IGAD CAEP "Centre of Excellence for Climate Adaptation and Environmental Protection"; IGAD CEWARN "Conflict Early Warning and Response Mechanism"; IGAD ICPAC "Climate Prediction & Applications Centre"; IGAD ICPALD "Centre for Pastoral Areas and Livestock Development"; ILRI "International Livestock Research Institute"; IPSTC "International Peace Support Training Centre"; IRC "International Rescue Committee"; NDMA "National Drought Management Authority"; NDMU "National Disaster Management Unit"; RECONCILE "Resource Conflict Institute"; SIPRI "Stockholm International Peace Research Institute"; UNDP "UN Development Programme"; WFP "World Food Programme".

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Currently, county-level chapters of the CSAMSP are being planned and implemented in several counties. Differently from other existing platforms, the CSAMSP steering committee has already expressed a strong willingness to lead the climate security research agenda. For this reason, workshop participants proposed that the platform could integrate a working group to develop a climate security agenda in Kenya, including issues on policy and governance, evidence, programming, and finance.

2. The Kenya Food Security Meeting is a multi-stakeholder exchange forum open to all organizations with an interest in food security. The Kenya Food Security Steering Group is a subset of the KFSM for which membership is restricted to organizations with a clear

commitment to a collaborative approach and which possess technical, policy, or administrative capability in food security and drought management. The forum was considered suitable to discuss multiple aspects of a climate security agenda in Kenya, accounting for policy, programmatic practices, and finance.

3. Peace Committees are community representative institutions that facilitate peace forums at the various governance levels and bring together traditional and modern mechanisms for conflict resolution. They are supported by the National Steering Committee on Peacebuilding and Conflict Management (NSCPCM), mostly through the Peace Forums, which act at the provincial level as coordinating mechanisms, hence linking national and sub-national efforts. Peace Committees are responsible for a wide set of peacebuilding-related activities, therefore representing suitable spaces to assess climate security strategies at sub-national and ward levels.

And finally, at sub-national level:

1. The County Climate Change Fund (CCCF) finance climate projects which have been prioritized by local communities. The County Climate Change Planning Committees (CCCPCs) and the Adaptation Planning Committees (APC) are responsible for the identification and prioritization of investment opportunities for climate adaptation at ward and county levels. Ward APCs conduct participatory assessments to develop priority projects, while County APCs review the proposals and coordinate the sharing of experiences. The bottom-up approach to climate finance was deemed a suitable setting to integrate climate security risks as experienced by populations.

2. The County Agricultural Sector Steering Committees (CASSCOM) are meant to enhance agricultural productivity and well-being in the agricultural sector. CASSCOMs have the mandate to establish multidisciplinary structures for coordination, develop instruments for operation and accountability, foster collaborations and linkages with public, private, and civil society organizations, and support the implementation of agriculture-related development projects. Given that climate security risks are mostly manifested through agriculture-related livelihoods, this platform was considered suitable to explore the management of climate security risks.

Multiple geographical and temporal dimensions

The last challenge of the climate, human security, and conflict nexus lies in the realization that the occurrence of climate hazards in a specific place or time does not always lead to grievances and conflict immediately and in the exact same location. Although this challenge is easily addressed when using participatory and qualitative approaches, it is less so in the case of quantitative and statistical analysis.

For this reason, in our econometric mediation analysis, we developed a framework that considers different temporal and geographical scales to better understand the intersection of climate and conflict dynamics. In terms of timescale heterogeneity between the occurrence of climate impacts and human insecurity and conflict outcomes, the methodology incorporates past climate anomalies with different time lags (three, six, nine, and twelve months before the assessment of the main mediator) and foreseen conflict variables that capture conflicts happened three-to-nine months after the assessment of the main mediator. Geographically, the analysis uses grid cells of 20 square kilometers instead of administrative units as our geographics benchmark units as well as assesses the frequency of conflicts within 55km buffers around the given GPS locations [90].

The results of our analysis show that the most significant impact of climate variability—measured as below-average rainfall anomalies—on conflict, as mediated by malnutrition, does not occur in the short term (within three months from the present time). Rather climate-induced stunting is positively correlated with an increase in the number of conflicts at the grid level only in the medium (six months) to long-term (twelve months). These findings reflect the long-term nature of the malnutrition indicator studied–namely stunting–which arises from prolonged nutritional deficits often linked to recurrent inadequate dietary patterns [91]. As such, our results suggest that stunting manifests gradually over time in response to the repeated impacts of climate variability over the medium to long term. Once established, this condition is likely to increase the risks to peace by affecting the incidence of violent conflicts. While studies on chronic malnutrition and conflict remain limited, this trend aligns with emerging evidence suggesting that livelihood losses, including nutritional insecurity, can contribute to conflictual dynamics [80]. Overall, these results are consistent with existing literature on the climate-malnutrition [92,93] and malnutrition-conflict nexus [94,95]. They expand upon this research by offering new insights into the timing and varied geographical scales at which nutrition insecurity mediates these complex relationships.

Conclusions

Discourses on how to qualify and quantify the "climate security nexus" have increased significantly in the past decade. This is because the accelerating climate crisis is visibly exacerbating a combination of human security risks and often causing tensions and conflicts. Our reading of the climate security nexus does not embrace the securitization of climate, which has been largely criticized by scholars and policymakers as it would imply attributing to climate causes of conflicts that are inherently cultural, social, and political. Nevertheless, research points out that a nexus between climate and root causes of vulnerabilities that could lead to or intensify pre-existing drivers of conflict exists. The main challenge of this discourse and research, though, is to identify the right analytical framework that does not simplistically qualify these intricate and complex relationships and dynamics, that identifies multiple pathways, that does not draw linear causal associations, that accounts for context specificity, and that gives voices to affected communities and represent the views of multiple actors at multiple scales.

In this paper, we present the Integrated Climate Security Framework (ICSF), which deliberately attempts to address the multiple complexity challenges of the climate security nexus. The framework uses a combination of qualitative and quantitative methods and data specifically designed to provide state-of-the-art policy-relevant evidence on how, where, and for whom climate is exacerbating root causes of vulnerabilities that can lead to human insecurity and conflict. The wide breadth of methodologies proposed by the framework allows for a comprehensive collation and collection of relevant information that reflects the complex social-ecological dynamics of the climate security nexus. It does so by adopting systems approaches that rely on a combination of epistemological stances, thereby relying on a diverse set of new and specifically tailored qualitative and quantitative, locally relevant, and multifaceted data sources; and on a diversity of actors involved in the co-production of knowledge. We use Kenya as a case study.

The framework outlined in this paper exhibits several limitations. Systems approaches inherently pose complexity and integration challenges. There is a need to refine the sequencing of methods, ensuring that quantitative analyses better inform or align with qualitative findings. However, findings derived from diverse methods often operate at disparate geographical and temporal scales, complicating direct comparisons. Moreover, units of analysis vary depending on the method and data availability. Nonetheless, the diversity of findings is not entirely a

limitation when it comes to complex systems such as the one under analysis. For this reason, our framework abstains as much as it can from averaging this diversity and instead values the richness of information gathered through different approaches and methods to provide a more comprehensive picture of the nexus.

Data scarcity presents another obstacle, particularly concerning values and cultural aspects, which are not consistently documented across different regions and scales. Additionally, discussions on security matters are sensitive, with communities, especially marginalized groups, as well as policymakers and stakeholders, often hesitant to engage in dialogue regarding tensions and conflicts. This reluctance is notably pronounced in relatively peaceful countries.

Even when policymakers are receptive to discussions on climate security, translating scientific knowledge into actionable policy decisions remains challenging. Addressing these limitations requires ongoing efforts to refine methodologies, enhance data availability, and foster inclusive dialogue among stakeholders.

These limitations underscore the need for further research to improve and refine our analytical methods, enabling us to offer decision-makers a multi-dimensional perspective on the complex dynamics of the climate, human security, and conflict nexus as it unfolds in reality. Providing policy-relevant evidence that brings together existing literature, data, policies, and social media, and gives voice to affected communities and stakeholders at multiple scales will help to identify and prioritize areas and groups of the population that are most affected by compound risks and insecurities, as well as to design more effective and sustainable climate adaptation interventions that "do not harm" and become true "instruments for peace".

Supporting information

S1 Table. "Table of definitions".
(XLSX)

S1 Text. "The Integrated Climate Security Framework".
(DOCX)

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