CGIAR FOCUS Climate Security

Assessing the relationship between climate, food security and conflict in Ethiopia and in the Central American Dry Corridor (CADC)

Quantitative analysis on the impact of climate variability on conflict in Ethiopia and in the CADC countries

Final report

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Contents

Acronyms

ACLED Armed Conflict Location and Event Data

CADC	Central America Dry Corridor
CGIAR	Consultative Group on International Agricultural Research
EME	Emergency Operations Division in WFP
ENSO	El Niño–Southern Oscillation
FFA	Food For Assets initiative in WFP
GBV	Gender Based Violence
GFDRR	Global Facility For Disaster Reduction And Recovery
HCC	High Conflict Cluster
LCC	Limited Conflict Cluster
MCC	Medium Conflict Cluster
MSD	Mid-Summer Drought
SIPRI	Stockholm International Peace Research Institute
UN	United Nations
WFP	World Food Programme

Main definitions

Climate variability

Climate Variability is defined as variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events. The term "Climate Variability" is often used to denote deviations of climatic statistics over a given period of time (e.g. a month, season or year) when compared to long-term statistics for the same calendar period. Climate variability is measured by these deviations, which are usually termed anomalies. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external factors (external variability). (Extracted from https://www.wmo.int/pages/prog/wcp/ccl/faqs.php)

Conflicts

Conflicts are defined as any type of violence, conflict, tensions, and related socio-political co-variate insecurities affecting a group of individuals in certain geographical area. Empirically, we measure conflicts using the Armed Conflict Location & Event Data. ACLED defined conflicts as political violence, which is "the use of force by a group with a political purpose or motivation", including battles, protests, explosions/remote violence, violence against civilians, riots and non-violent conflicts, called "strategic developments", including looting/property destruction, disrupted weapon use, arrests, etc. (ACLED n.d.)

Food and nutrition security

Following the UN Committee on World Food Security, we define food security a situation in which "all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life." Food security has four dimensions: availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports; access by households and individuals to adequate resources to acquire appropriate foods for a nutritious diet; utilization of food through adequate diet, water, sanitation, and health care; stability is about being food secure at all times (Extracted from Timmer, 2012).

Climate security nexus (CS-nexus)

Climate does not directly affect conflict and peace. Instead, it exacerbates existing risks and insecurities that can increase grievances and tensions and ultimately affect peace and insecurity in a given area, country, region, or continent. The climate security nexus describes these relationships and dynamics across three main systems: the ecological systems (including climate variability and natural resource access and quality), the economic system (including agricultural productivity, food and nutrition security, poverty, inequality, migration, etc.) and the socio-political systems (including social structures, identities, institutions, governance, stability, peace, etc.).

Executive summary

We live in a world of increasingly unpredictable, more frequent, and more extreme climate impacts, where the most vulnerable are also the most exposed to climate shocks and stressors and are less able to improve their resilience capacity against those. In conflict settings, the impact of climate on food security, poverty, inequality and other existing threats and vulnerabilities may push the poorest and the most vulnerable into a spiral of further risks, insecurities, and social exclusion. Similarly, in fragile contexts, additional deprivations generated by the inability of the poorest households to cope with the climate impacts, can significantly increase competition over essential resources and exacerbate grievances, tensions, and conflicts. Thus, acknowledging the role of climate on peace and security has become a priority for many national and international policy makers.

The objective of this report is to present the results of the WFP – CGIAR project "Action on Climate Change and food security to improve the prospect for peace" started in October 2020. The project is part of thematic deep dive on climate change of the broader, multi-year SIPRI-WFP knowledge partnership on understanding WFP's contributions to improving the prospects for peace. In this study, we investigate the climate-food security-conflict nexus in Ethiopia and the Central American Dry Corridor (CADC). Both Ethiopia and the CADC are hotspots of high climate variabilities, high political insecurity, and conflicts and widespread food and nutrition insecurities across their populations. Therefore, the main research questions that this study aims to answer for the CADC countries (Guatemala, El Salvador, Nicaragua, Honduras) and Ethiopia are:

- Is climate exacerbating existing threats that could increase the risk of conflict in the CADC countries and in Ethiopia?
- Do areas of high climate variability co-occur with high socio-political insecurity in the CADC countries and in Ethiopia?
- How can WFP programming become more climate security sensitive?

The results of this study are intended to inform WFP's understanding of the climate and conflict nexus and support the organization in addressing these through future WFP's Country Strategic Plans in the CADC and Ethiopia. In addition, this research fits into the wider WFP-SIPRI-CGIAR joint research framework whose objective is to qualify and quantify the climate security nexus and to assess if, and how, WFP's programming is mitigating conflict risk, including both the challenge of conflict-sensitive programming and WFP's role in longer-term peacebuilding efforts against the backdrop of negative climate trends[1].

[1] The document "CGIAR Responses to WFP main comments" submitted to WFP on the 30th of April 2021 clearly describes the linkages between this study and the WFP-CGIAR-SIPRI research framework. A summary of this document related to the research questions can be found in the Appendix.

The following paragraphs summarise the results of this study.

Ethiopia

- Is climate exacerbating existing threats that could increase the risk of conflict in Ethiopia?

Climate exacerbates food insecurity and poverty that can lead to more frequent conflicts. With a high proportion of the Ethiopian population relying on rain fed agriculture and pastoralism, climate variability exacerbates existing household level insecurities that are correlated with a higher likelihood and intensity of conflict. Climate is a threat multiplier. Drought and high temperature extremes are the main drivers hindering crop and livestock productivity, increasing household level food and nutrition insecurity, poverty and inequality and decreasing agricultural employment, which in turn are correlated with a higher likelihood and intensity of conflicts. For example, we find that an increase of ten days in the year with high temperature (>37 degree Celsius) increases the number of food insecure households, on average, by 3% and that the increase of one food insecure household is correlated with a 3% increase of the likelihood of future conflicts at woreda level. Similarly, high temperatures are positively correlated with the number of poor people in the woreda and that an additional household falling into poverty is positively correlated with the likelihood of conflict (on average +2%) and insurgence of more battles (on average an increase by fifty of the number of poor households is correlated with an additional local battle) in the woreda.

The impact of climate on food insecurity can cascade in multiple, wider security risks. Our analyses also show that the impact of the climate on food security and poverty will result in the increase of multiple additional socio-economic risks that are connected to food insecurity and poverty. Using network analysis we are able to show that that there exists a clear interconnection between several key socio-economic dimensions, climate and conflicts. Our findings show that the strongest nodes are between aridity (ecological system), food and nutrition insecurity, high population pressure, lack of education, agricultural productivity, number of people in a crisis and intensity (events and fatalities) and diversity (richness) of conflicts. This suggests that an increase exposure to climate impacts of a part of this system, such as food security and poverty, can generate in increasing risks and insecurities across multiple dimensions of the network, such as inequality, agricultural productivity, and crisis exposure.

- Do areas of high climate variability co-occur with high socio-political insecurity in Ethiopia?

Afar, Somali and Tigray regions are currently the most exposed to climate security risks. Climate security risks are not the same everywhere in Ethiopia. Using spatial analysis, we can identify hot spots of climate insecurities. In Ethiopia, areas where persistent dry-hot climate conditions, chronic food insecurity and different socio-economic vulnerabilities converge present a moderate to severe conflict incidence. These areas encompassed the woredas of Elidar, Dubti, Mile, and Afambo in the north-eastern part of the Afar region. In Somali, affected areas included the northern woredas of Ayisha and Shinile, eastern woredas of Danot, Warder, Shilabo, Kebridehar, Denan, Shekosh, Gunagado, Aware, and Gashamo, and southern woredas of Dolo Odo, Filtu, and Moyale. Additional climate-security hotspots include border regions with Eritrea in the woredas of Gulomekeda and Erob in the Tigray region. In addition, for the period 1980 – 2020, there exist a number of hotspots where harsh climate conditions and conflicts co-occurred with other insecurities, such as high prevalence of malnourished children, low education levels, and low agricultural productivity. These hotspots cover the regions of Amhara, Benshangul - Gumuz, Gambela and SNNP in areas bordering Sudan and South Sudan and areas in the Oromia region bordering north-east Kenya.

In the harshest climate conditions (dry-hot weather), there exist highly localized hotspots for each of these insecurities. For instance, hotspots of dry-hot climate, moderate conflict intensity and highest rates of

stunting, wasting and underweight are mostly located in the Afar zone 2 and in the Gode and Degehabur woredas in the Somali region. On the other hand, hotspots of climate security risks and inequality are in the coastal areas of Degehabur and Warder woredas in the Somali region, in the Borena and Bale woredas in the Oromia region and in the centra parts of the Afar. Finally, hotspots of climate security risks and low agricultural productivity in the dry-hot climate areas are in the Shinile Dire Dawa, Karahe, Worder, Liben and After woredas in the Somali region.

CADC countries

- Is climate exacerbating existing threats that could increase the risk of conflict in the CADC countries and in Ethiopia?

Climate exacerbates food insecurity, poverty and inequality that can lead to more frequent conflicts. Our analysis shows that, in El Salvador[2], climate exacerbates household level food insecurity, poverty and inequality; it reduced income and increases agricultural production costs, which in turn increase the likelihood and intensity of conflicts. At national level, we find that precipitation anomalies and temperature extremes exacerbate food insecurity, poverty, increase agricultural costs and reduce agricultural income which in turn increase the likelihood and the intensity of conflicts at municipal level. Higher poverty and agricultural costs also increase the intensity of battles. In areas with high conflict intensity and diversity the main climate drivers are lack of precipitation, intensity, and magnitude of the mid-summer drought. These climate extremes increase food insecurity, poverty, and inequality which in turn increase the likelihood of conflict.

The impact of climate on food insecurity can cascade in multiple, wider security risks. Our analyses also show that the impact of the climate on food security and poverty will result in the increase of multiple additional socio-economic risks that are connected to food insecurity and poverty. In El Salvador, for instance, in area of high conflict diversity, food security and poverty are connected, through household income and the wealth status, to extreme climate events (ENSO and mid-summer drought) and conflicts. Household income is also strongly linked with the type of employment of household members and with youth unemployment. While wealth in general is strongly connected with agricultural income and employment as well as to access to safe water for drinking. This suggests that increased exposure to climate impacts of a part of this system, such as food security and poverty, can generate in increasing risks and insecurities across multiple dimensions of the network, such as employment, agricultural productivity, and access to essential services.

- Do areas of high climate variability co-occur with high socio-political insecurity in the CADC countries and in Ethiopia?

There exist "climate insecurity hotspots" at sub-national levels where high levels of climate variability, conflict intensity and diversity co-occur with other existing socio-economic insecurities. Using spatial analysis, we can identify hot spots of climate insecurities. In Guatemala, particular attention should be given to the rural and peri-urban areas around Guatemala City, which show high conflict occurrence while at the same time being socially vulnerable. We also highlight the subsistence farming areas in Huehuetenango, Quiché, and Baja Verapaz, where social vulnerability is high and climate conditions can exacerbate this vulnerability. While these areas are classified as having only limited conflict. In Honduras, the southern areas (Choluteca department) show significant social and biophysical vulnerability, while also

[2] Note that for both Guatemala, Honduras, and Nicaragua we could not run household level analyses due to lack of suitable data.

showing moderate to high conflict. In these areas, we find occurrence of poorly productive staple crop systems, combined with high accessibility to mining concessions and some presence of cash crops (cotton, coffee). We also highlight the areas of western Honduras (Copán, Intibucá, Lempira) where nutritional insecurity is high, but conflict has low intensity and diversity. In El Salvador, vulnerability hotspots tend to cover border areas (with both Honduras and Guatemala), and though these areas do not show high conflict, they show high prevalence of stunting. High conflict areas of El Salvador tend to be associated with access to opportunities for deforestation, whereas the moderate conflict cluster shows low agricultural productivity for staple crops, high density of cash crops, and to a lesser degree access to deforestation spots.

- How can WFP programming become more climate security sensitive?

Combining the results of our analysis with a series of key informant interviews carried out with representatives of different WFP divisions and teams we have identified a set of priority areas to increase WFP programming sensitiveness to climate security concerns, that can be summarized as follows:

i. **A monitoring and decision support tool will be key to guide and inform WFP targeting and programming** at national and sub-national level in a real time fashion. A "Climate Security Observatory", using the methods used in this study, could be designed to link to on-going decision-making processes, e.g. for the Country Strategic Planning, and should help future initiatives and projects in accounting for climate security risks. A proposal for such an Observatory can be found in the Appendix.

ii. **Strengthening the adoption of shock responsiveness of national and international interventions and policies**, that aim to increase the flexibility of social protection policies to cope with crisis in a timely fashion and use early warning systems and protocols to prevent crisis and not only to prepare for upcoming ones. An example of this can be found in the Caribbean, and especially in Jamaica, Dominica, British Virgin Islands, and the Bahamas, where national cash transfer and/or voucher programmes were effectively leveraged to provide relief support during shocks (Barca et al. 2019). Linking these programmes with school feeding interventions will ensure that schools are kept open where possible and that children, households and local producers can increase their hazard resilience in the short to medium term.

iii. **Addressing the root causes of conflict while maintaining neutrality and improving climate resilience**, via separating humanitarian and development needs from the causes of conflicts, keeping the advocacy focus with the national and local governments on human rights and provision of technical assistance to governments and local decision makers and enhancing active participation of communities in the design of interventions. Addressing root causes of conflicts can be done using for example the complaint mechanisms. These effective tools are critical for EME to understand where local grievances are building and can be used to start the discussions on those with local governments. Active presence in the field is also important. In Tigray for example WFP EME has deployed two staff to improve WFP programming sensitivity to conflict via directly engaging with local communities in the region to understand their needs during periods of crisis. Finally, in Tanzania, using the findings of an impact analysis in refugee camps, EME has been able to advocate for the withdrawal of restrictions imposed by the government on the refugee population, which had a significant impact on the role of women in the communities. Strengthening the field presence and the real time monitoring of risks, grievances and tensions will be critical for changing and saving lives of people in climate insecure areas.

iv. **Adopting truly integrated programming within WFP interventions**, which accounts for the complexity and interconnectedness of the climate security nexus and that accurately defines and assess risks and insecurities in fragile and non-fragile settings across multiple dimensions. For example, in areas where

there exist high nutrition insecurities, and following the three-pronged approach, FFA should collaborate with the humanitarian and emergency teams to improve immediate food security needs of the targeted population. This will ensure that FFA beneficiaries are healthy and able to contribute to FFA related activities and at the same time continue improving their food security. Other important complementary activities are those that improve energy access and access to alternative fuels.

v. **Making women the agents of change**, by tailoring interventions to reduce inequalities, counteracting existing social norms, and fostering women's leadership roles to decrease tensions at community level. For example, in Libya, WFP has implemented activities to rebuild livelihoods along the Tunisia and Libya border, working specifically with women, who are now recognised as acting leaders in their communities, have increased livelihood opportunities and improved their education. Also in Nicaragua, WFP has provided a "degranadora" machine, that has reduced drastically the time that women used for maize processing, allowing them to produce outputs of higher quality and freed time for women to attend community meetings.

Challenges and limitations of the analyses[3]

Using a data driven approach presents some limitations. One is the availability of data. Some of the analyses were not carried out due to the lack of secondary socio-economic data. This is an important limitation that constrained mostly the estimation of the household level drivers of the climate security nexus in Guatemala and Honduras. In the case of Guatemala, the household level analysis was not feasible as a critical identification variable was missing from the available datasets: the "Encuesta National de Condiciones de Vida". Honduras has a wealth of socio-economic datasets, collected each year since 2012, via the "Encuesta Permanente de Hogares de Propósitos Múltiples". Unfortunately, these data are not publicly available.

Furthermore, data driven approaches require validation from qualitative analysis (stakeholders' interviews and focus group discussions). Field work in the main hotspots of climate insecurities could help testing which of the mechanisms identified in the quantitative analyses explain the climate security nexus better. Finally, directly engaging with local communities will help identify those, if any, traditional and non-traditional mitigating factors, and systems that could alter the climate security nexus identified in this analysis[4].

[3] As highlighted by SIPRI, ACLED data provide a limited coverage of homicide events as they mostly focus on violence, conflict, tensions, and related socio-political co-variate insecurities affecting a group of individuals in certain geographical areas. This limitation might be important in the context of the CADC countries where homicide rates are higher. Nonetheless, when we compare the "security proxy" constructed using official police department social media data on any criminal events we find an extremely high correlation between what ACLED data capture and our security proxy, which gives us confidence on the ability of the former to capture the overall level of insecurity in the counties under analysis.

[4] Another major limitation of the analyses presented in this report regards the access to and systematization of WFP data. Linking WFP operations data with our analyses was particularly important for the assessment of the sensitivity of WFP targeting and programming to the climate security nexus. During this project, we were only able to access SCOPE data for Ethiopia. SCOPE data has allowed us to map WFP interventions across the country and to have a general understanding of the type of activities implemented and for whom. However, these data are not comprehensive and are very limited in scope, width and length which has severely affected our ability to evaluate the climate security sensitivity of WFP interventions. This part of the analyses was indeed removed from this report and added to the Appendix. We acknowledge that there exists a wealth of WFP data that is underutilized across the organization and much more could be done for this and related analyses if some adjustments in terms of data cleaning and accessibility are put in place.

Introduction and research questions

The changing climate has shown to have a negative impact on livelihoods in developing countries. The main reason is that most economic and labour opportunities depend on the agricultural sector, which is increasingly influenced by strong climate variability around equatorial areas of the world (Beg et al. 2002; Campbell et al. 2016; Vermeulen, Campbell, and Ingram 2012). Some regions are more prone to extreme climate events, amongst them the Central American Dry Corridor (CADC) and the Horn of Africa. Specifically Guatemala, El Salvador, Honduras and Nicaragua are projected to be affected more frequently by strong precipitation variability and intense droughts (Stocker et al. 2013). Similarly, in the Horn of Africa, Ethiopia is one of the world's most drought-prone countries (USAID 2016). Since the 1970s, drought occurrence has increased in magnitude, frequency, and impact, leaving millions of people in need of food assistance each year (GFDRR 2016)[5]. The more frequently occurring droughts and floods in these regions are increasingly posing a threat to internal food security (Imbach et al. 2017). In the words of the UN Secretary General, "The fallout of the assault on our planet" - (*cfr increasing climate impacts*) - "is impeding our efforts to eliminate our poverty and imperilling food security"[6]. Without peace, there is no end to hunger. Without food security, peace cannot last. And without climate sensitive actions for peace and security, none of these efforts will succeed.

Multiple pathways of the climate security nexus can be identified. Scheffran et al. (2012), for instance, argue that climate indirectly affects the likelihood of conflict outbreaks through multiple channels such as water shortage, crop failures, human migration, and institutional effectiveness. Specifically, in agricultural households, climate variability and extreme weather events are likely to affect incomes through reduced agricultural outputs. Opportunity costs theory implies the existence of a strong inverse relationship between rebellion and incomes from agricultural activity (Dal Bó and Dal Bó 2011). Hence, the loss of agricultural income due to the negative impact of climatic impacts could trigger conflict events. Additionally, climate-induced migration can burden competition over resources such as land, employment, education, health care and social service and possibly cause ethnic tensions (Brzoska and Fröhlich 2016; Reuveny 2007).

The current literature does not display an exact consensus on the interface of climate and peace. Many authors have attempted to estimate the causal effect of climate on conflict[7]. These studies mostly look at the longer-term effects of climate change. The increasing impacts of irregular weather and seasonal patterns, the increasing intensity and frequency of climate hazards such as drought, floods, landslides significantly impact the livelihoods of millions across the world, but in a relatively shorter-term scale. Therefore, a significant part of the climate security literature has increasingly shifted the focus from larger and longer-term changes in climatic conditions to almost current and near current climate hazards – otherwise related as climate variability (Buhaug, 2010, Theisen et al., 2012, Wischnath & Buhaug, 2014,

[5] According to the Global Facility For Disaster Reduction And Recovery (GFDRR), the 2011 Horn of Africa drought, for instance, left more than 4.5 million people in need of food assistance.

[6] 02 December 2020 UN Secretary General speech on the state of the planet. https://www.un.org/en/climatechange/un-secretary-general-speaks-state-planet

[7] For example, Burke et al. (2009) find a robust link between temperature increases and civil war in African countries. Similarly, Hendrix & Glaser (2007) conclude that positive changes in rainfall lead to a decrease in likelihood of conflict in sub-Saharan Africa. By conducting a meta-analysis of 60 studies, Hsiang et al. (2013) also find an overall significant relationship between climate and conflict. Another larger scale study using a sample of 57 western and non-western countries shows that increasing temperatures can lead to increase in homicide rates, finding strong effects in African countries (Mares and Moffett 2016).

Gartzke, 2012, Chen et al., 2016). These authors argue that climate does not have a direct effect of peace and security but, rather, it acts as a "threat multiplier", exacerbating existing socio-economic risks and insecurities such as agricultural losses, food insecurity or forced migration, which can increase the risk, duration and intensity of political insecurity and conflicts and therefore impact peace and security (Causevic, 2017; Gilmore, 2017; Hsiang et al., 2013; Scheffran et al., 2014; Koubi, 2019). This is what is called the "climate security nexus". Food insecurity can lead to violent conflict on a national and international scale when exacerbated by climate impacts and associated with further insecurities, such as poverty, inequality and overall socio-political fragility (Martin-Shields and Stojetz 2018; Koren and Bagozzi 2016). Conflicts such as gang violence, homicides, robberies and increasing participation in recruitment of armed groups are endangering food and human security (Fogelbach 2011; Tellman et al. 2014). The main underlying forces can be attributable to economic instability and loss of job opportunities, loss of agricultural land and money for education. The last especially is affecting local youth, leading them to be drawn into illegal groups and violent activities, often as the last resort (Olate, Salas-Wright, and Vaughn 2012; Williams and Castellanos 2020).

Several scholars confirm that with droughts, strong rainfall variability and the past presence of civil wars, communities are more susceptible to acts of violence (O'Loughlin et al. 2012; Raleigh, Jin, and Kniveton 2015). These conditions, i.e. high climate variabilities, high political insecurity, and conflicts and widespread food and nutrition insecurities across their populations, have been strongly present in the CADC and Ethiopia. However, evidence from current research focusing specifically on the climate-food security-conflict nexus in these geographical area are scarce (Adams et al. 2018). Since several years many studies have focused on food security as one of the main drivers of conflict (Fjelde and von Uexkull 2012; Hendrix and Brinkman 2013; Martin-Shields and Stojetz 2019; Nordkvelle, Rustad, and Salmivalli 2017; Raleigh, Jin, and Kniveton 2015), leaving the question on the linkage between climate induced food insecurity and conflict unanswered. The opportunity is great to take the numerous insights from climate change literature and food security studies and place it in relation to the wider climate security nexus.

In this study we use a combination of qualitative and quantitative methods and data to enrich our knowledge of the complex, context specific and dynamic pathways through which climate affects the risk of conflict. We specifically assess the links between climate-induced food insecurity and conflict. The main research questions are:

- Is climate exacerbating existing threats that could increase the risk of conflict in the CADC countries and in Ethiopia?
- Do areas of high climate variability co-occur with high socio-political insecurity in the CADC countries and in Ethiopia?
- How can WFP programming become more climate security sensitive?

The results of this study are intended to inform WFP's understanding of the climate and conflict nexus and support the organization in addressing these through future WFP's Country Strategic Plans in the CADC and Ethiopia. In addition, this research fits into the wider WFP-SIPRI-CGIAR joint research framework whose objective is to qualify and quantify the climate security nexus and to assess if, and how, WFP's programming is mitigating conflict risk, including both the challenge of conflict-sensitive programming and WFP's role in longer-term peacebuilding efforts against the backdrop of negative climate trends[8].

[8] The document "CGIAR Responses to WFP main comments" submitted to WFP on the 30th of April 2021 clearly describes the linkages between this study and the WFP-CGIAR-SIPRI research framework. A summary of this document related to the research questions can be found in the Appendix.

Methodological approach

Figure 1 summarizes the analysis steps with corresponding methods, study scales, purposes, and analysis-specific questions, in relation to the overall research questions of the study[9]. The impact pathway analyses "qualify the climate security nexus" by giving national context on the CS-nexus from both, scientific and policy perspective. The impact pathway analyses develop clear and coherent narratives that describe any known links between peace, security, conflict, climate, and other existing insecurities.

These impact pathways (IPs) are base for selecting variables (or proxies) to be used in the quantitative analysis, and for defining a set of empirical hypotheses to be tested in the subsequent econometric and network analysis. The purpose of the econometric and network analysis is to quantify the indirect impact of climate variability on existing risks and insecurities based on household and larger scale level data, respectively. These analyses are run at national level and by conflict clusters, i.e. geographic areas where reported conflict events share certain characteristics[10]. The purpose of the spatial analysis is to map the climate security nexus across different conflict drivers, i.e. to show where climate, conflict and other insecurities co-occur.

Key Informant Interviews (KII) were also conducted to identify priority areas to increase climate security sensitiveness of WFP programming.

[9] A detailed description of each analytical step can be found in the Appendix.

[10] Cognizant of the heterogeneity of the security risks across different regions and woredas in Ethiopia, we divide the country in a set of conflict clusters. We define 'conflict clusters' as geographic areas where reported conflict events share certain characteristics. These clusters are developed through statistical analysis of conflict data aggregated at the municipality (CADC) and woreda (Ethiopia) level, respectively. The variables included aim at characterizing conflict in three dimensions, namely, intensity, geographic coverage, and diversity. For each country, we estimated three main clusters representing level of high, moderate, or limited conflict intensity and richness. Clustering was performed following (Chavent et al. 2018) incorporating geospatial constraints into the conflict data. More details on the method can be found in the Appendix.

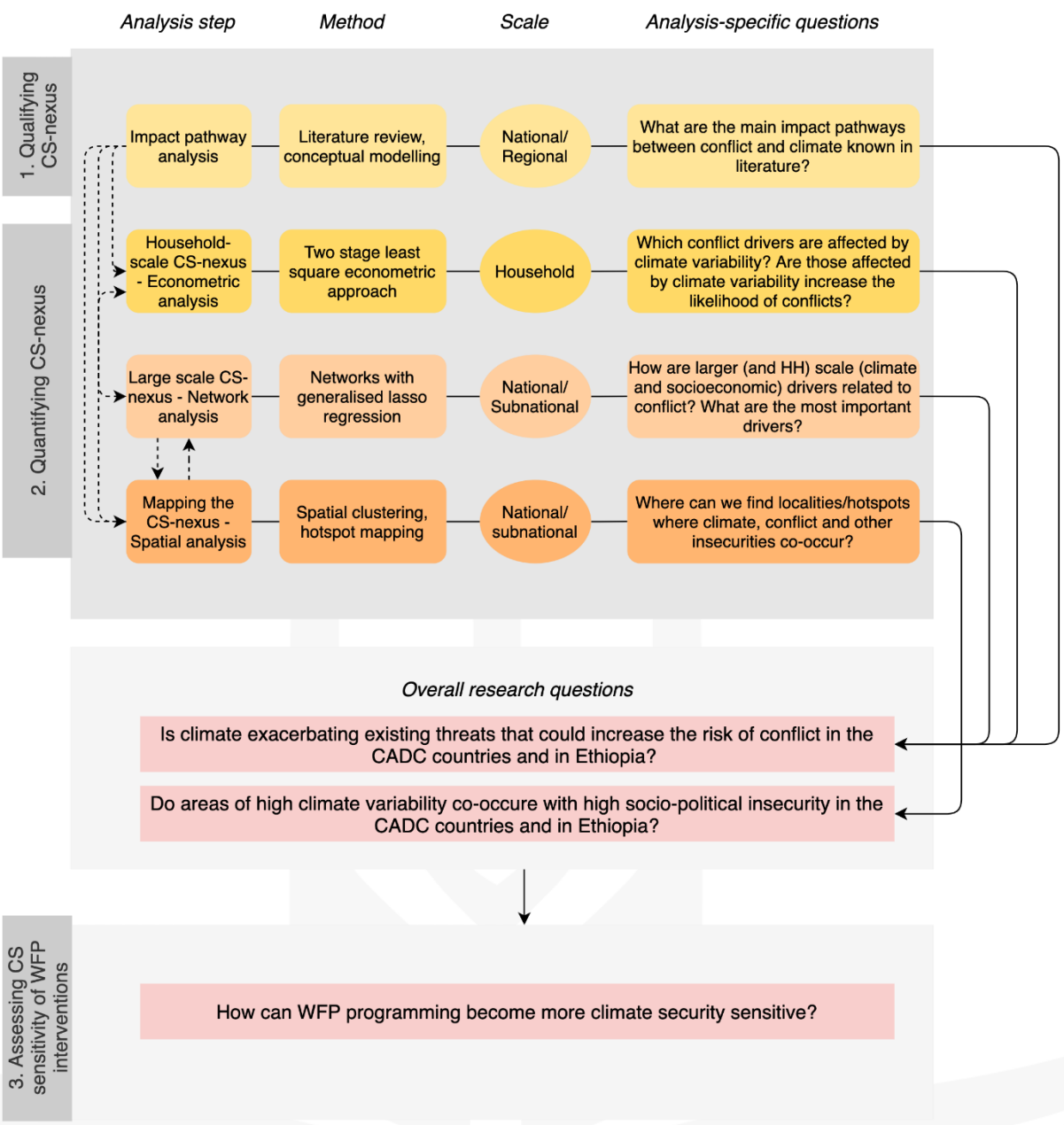


Figure 1. Analytical framework used for the study, linking approaches to overarching research questions

Results

The climate security nexus in Ethiopia

Summary of findings

1) Two main impact pathways explain the potential linkages between climate and conflict in Ethiopia: the natural resources pathway and the weak governance and maladaptation pathway.
2) Climate exacerbates existing household level risks and insecurities that can increase the likelihood and intensity of conflict. In other words, we find evidence that climate is a threat multiplier. We find that climate exacerbates *household level* food and nutrition insecurity and reduces agricultural employment, which in turn increase the likelihood and intensity of conflicts.
3) In addition to climate induced insecurities, there exist other important household level predictors of conflict, such as age, education, and gender of the head of the household, ethnicity, access to electricity and location.
4) The climate security nexus – the way climate, socio-economic and political risks and insecurities are linked to each other – differs across the country and conflict clusters. The climate security nexus is characterized by the combination of aridity (ecological system), nutrition insecurity, high population pressure, lack of education and higher number of people in a crisis (socio-economic system) and intensity and diversity of conflicts (political system) at national level and across conflict clusters.
5) There exist "climate insecurity hotspots" at sub-national level where high level of climate variability, conflict intensity and diversity co-occur with other existing socio-economic insecurities. We find the following areas where harsh climate conditions, conflict, food insecurity co-occur with a number of other socio-economic drivers in a time period of 1980-2020:
    1. The north-eastern part of the Afar region, encompassing the woredas of Elidar, Dubti, Mile, and Afambo.
    2. The north (Ayisha and Shinile woredas), eastern (Danot, Warder, Shilabo, Kebridehar, Denan, Shekosh, Gunagado, Aware, Gashamo), and southern (Dolo Odo, Filtu, Moyale) parts of the Somali region.
    3. The Gulomekeda and Erob woredas in Tigray –both bordering with Eritrea

In these areas, we find:

- high (>25%) prevalence of stunting, wasting and underweight children,
- low levels (< 3 years of schooling) of education for men and large gaps (>1.5 years of schooling) between men and women,
- low levels of agricultural productivity Net Primary Product (NPP < 2,500 kg-C/ha/year), high NPP variability (coefficient of variation > 15%), and high (up to 75% or more) shares of pasture area

Qualifying the climate security nexus in the CADC countries – an impact pathway analysis

Impact pathway analysis

Ethiopia is extremely vulnerable to changing climatic conditions (Germanwatch). Extensive periods of droughts have become more frequent in the past decade and caused significant economic losses, primarily through their impact on agricultural productivity. Studies on Ethiopia and on East Africa more broadly principally agree that there are observable relationships between climate variability, agriculture, resource availability and management, and conflict events (Detges, 2017; Fjelde & von Uexkull, 2012; Hendrix & Salehyan, 2012; Landis, 2014; Megerssa & Bekere, 2019; Nordkvelle et al., 2017; O'Loughlin et al., 2012; Theisen et al., 2012). Based on an exhaustive literature review[11], Figure 2 visualises the climate security nexus for Ethiopia that will inform the analysis in this report. We highlight two important paths:

1. ***Natural resources pathway:*** *climate-induced scarcity can heighten inter-household and inter-group competition over access to and usage of scarce resources, potentially leading to tensions and violence, particularly when migration is not an option. Climate-induced migration may also, however, both directly and indirectly contribute to conflict by producing inter-group tensions or putting increasing pressure on resources in destination areas.*
2. ***Weak governance and maladaptation pathway:*** *weak governance and a lack of institutional support for adaptation can cause households and communities to pursue maladaptive practices or fail to adapt altogether, leading to an inequitable distribution of climate vulnerability based on hierarchy and potentially negative downstream effects for other households or communities. This can serve as a pathway towards intra- and inter-group grievances and tensions.*

Climate variability, characterised by irregular seasons and weather patterns, floods, droughts and heatwaves, and an increased prevalence of pests and disease can cause resource scarcity if households are unable to adapt. This scarcity can be exacerbated by contextual social and institutional factors which impact household and community choice and access to scarce resources, intra-community inequality, knowledge of and ability to apply adaptive and absorptive practices, limited formal and informal support services, insufficient agricultural extension services, and a lack of economic opportunities. Whilst scarcity may cause some populations to become 'trapped' in scarce contexts, others may turn to migration strategies. There exists a great deal of variation in terms of both the exact nature and impact of climate migration. Generally speaking, however, climate migration can (given the presence of appropriate auxiliary conditions) lead to conflict both directly due to socio-economic or cultural tensions between new and host populations (or at an international scale between distrustful governments) or indirectly by increasing pressure on scarce natural resources, labour markets, and support services, thereby potentially threatening existing livelihoods in host communities and causing a loss of prosperity. A loss of prosperity, increased poverty, food and nutrition insecurity, and inequality, can instigate adaptation strategies that may increase insecurity and tension, especially when households are highly reliant on agriculture. Rural-urban migration, for instance, has put pressure on social services and labour markets, pushing many into informal, low-wage, insecure, and sometimes dangerous employment. These risks are often exacerbated for women. Poor job quality and security, coupled with high vertical or horizontal inequality, can lower the opportunity cost for engaging in criminal activity or give rise to group-based grievances and inter-group tensions.

[11] The full literature review is described in detail in the Appendix.

More generally, the climate security nexus creates specific and unique challenges for men and women. Whilst drought-induced economic hardships have forced men to migrate into urban areas to find new job opportunities or join armed groups to earn money, and adolescent boys face the prospect of being taken out of school to help with household labour and water collection (Le Masson et al. 2016), women and girls have become disproportionately more vulnerable and exposed to violations of their rights. Water stress and scarcity have placed women and girls at higher risk of exploitation, harassment, and violence (Swarup et al. 2011), visible for instance in the increasing number of families selling girls for early marriage in exchange for livestock.

Furthermore, the nature and type of adaptation is largely influenced by the financial capacity a household possesses, as well as the degree to which adaptive practices are culturally and communally accepted. For instance, climate change has disproportionately affected women and girls as a result of gender norms and practices that have constrained their adaptive capacities (Wossen 2016). Women have experienced domestic violence as a spill-over effect of frustrated masculinities and anxieties over household insecurity, as well as rape and sexual abuse when walking long distances to collect water (Sommer et al. 2015). In Lalibela, adolescent girls have been documented to miss school during periods of drought because of poor sanitation and time dedicated to fetching water (Swarup et al. 2011). Combined climate shocks, gender-based violence and discriminatory practices have compromised the productivity and adaptive capacity of women who rely on rain-fed agriculture and natural resources for their livelihoods. In several areas of rural Ethiopia, women have limited access to farmland, water and agricultural credits compared to men, and this structural condition has been further aggravated by climate-induced scarcity that has caused women to lose their traditional control over resources (Wossen 2016). Low access to agricultural market and restricted access to alternative livelihood options have led women to experience widespread poverty and severe food insecurity, making them particularly susceptible to trafficking, sexual abuse and forcing them to migrate into local towns or enter prostitution to earn money (Swarup et al. 2011).

There equally exists a relationship between the nature of adaptation and the institutional and governance frameworks and capacities within which communities live, such as the degree of success and scope of social support efforts or extension services. A lack of or weak governance can, for example, lead to maladaptive strategies being deployed by communities that have negative downstream effects on their households and other communities. The loss in productivity can lead to income loss and the selling of productive assets such as livestock to secure short-term survival, thereby eroding purchasing power and contributing to further food insecurity and malnutrition. Conversely, productivity gain and therefore food abundance has been linked with more intra-community disruptions due to intra-community inequalities, including gender inequality and rent-seeking behaviour. Such intra-communal inequality, and the kind of behaviours it enables, can also be conceptualised as facilitating the adoption of maladaptive strategies centred around an unequal distribution of resources, evidencing the indirect causal pathways through which climate factors interact with local social, political, and institutional factors.

A lack of access to the market (formal sources of credit and investment) and support in the form of extension service and adequate weather and climate information further prevents adaptation, further contributes to food insecurity, and increases the risk of conflict. The significance of this must be seen in the context of Ethiopia-Somalia border disputes and the presence of armed groups in the region, for which joining can have a comparatively low opportunity cost in some of these circumstances.

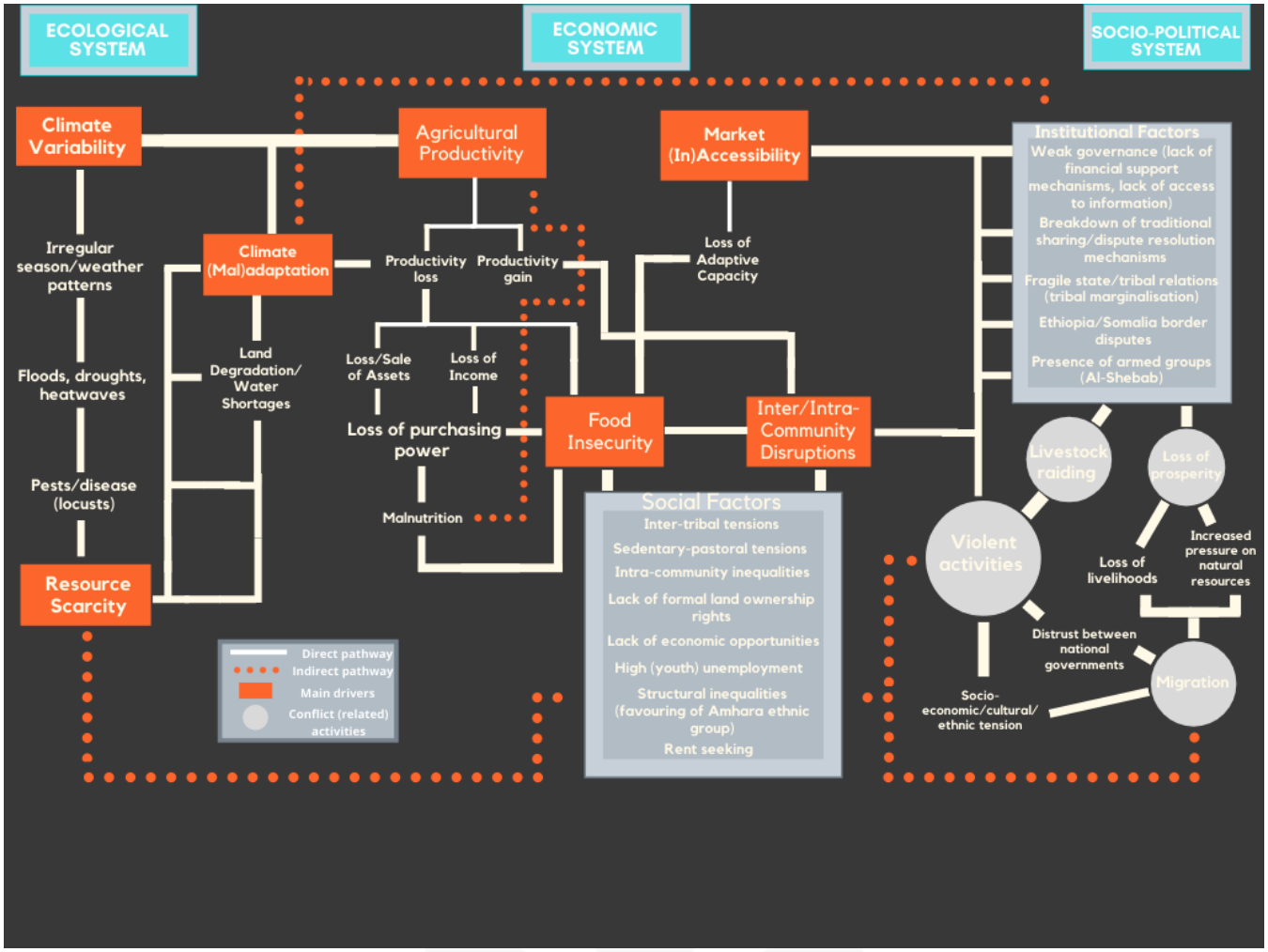


Figure 2. The climate security nexus in Ethiopia, an impact pathway analysis. Note (1): There is a complex web of interactions linking the impacts of climate variability on conflict in Ethiopia. The aim of these impact pathways is primarily to investigate how to bridge between the two elements with an additional focus on food insecurity as an intermediate driver. In the graph we are highlighting two important paths, of which each originates on the left-hand side, where we can see how climate variability impacts are effective (irregular season and weather pattern; floods, droughts and heatwaves; pests and diseases). These pathways are highly qualitative and contextual. They display relationships and potential avenues, rather than unavoidable outcomes, and are dependent on the social and institutional factors in the diagram.

Quantifying the climate security nexus in Ethiopia

ACLED reports conflict events of six different types, namely, battles, violence against civilians, explosions / remote violence, riots, protests, and strategic developments. For the period 1997–present, ACLED data included 5,666 individual events in total and 46,733 fatalities, distributed as shown in Figure 3 below.

Across the whole country, as well as on a cluster-specific basis (see Figure 4), battles and protests are the dominant type of conflict observed, followed by protests. A large number of battles also leads to a large number of deaths, whereas the converse is true for the protests. Consistent with this, armed clashes are the most frequent type of battle, whereas the most common type of protest is 'peaceful protest'. Armed clashes can take many forms, but the most common is a clash between the Military Forces of Ethiopia (involved as one of the actors in 1,381 out of the 1,870-armed clashes reported) and different types of non-state armed (guerrilla) groups. Two common non-state groups which often clash with the Ethiopian Military are the Oromo Liberation Front (OLF, 291 battles reported) and the Ogaden National Liberation Front (ONLF, 512 battles reported).

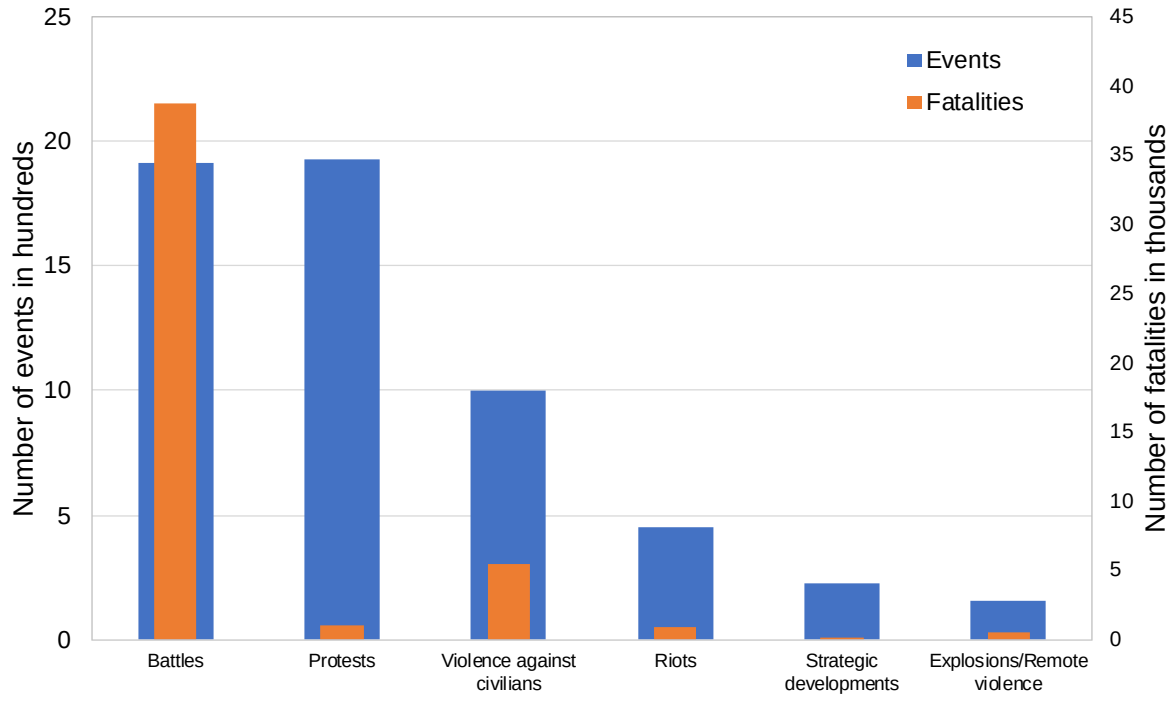


Figure 3. Overview of reported conflict events and fatalities in Ethiopia per event type, period 1997–2020. Data from the ACLED database

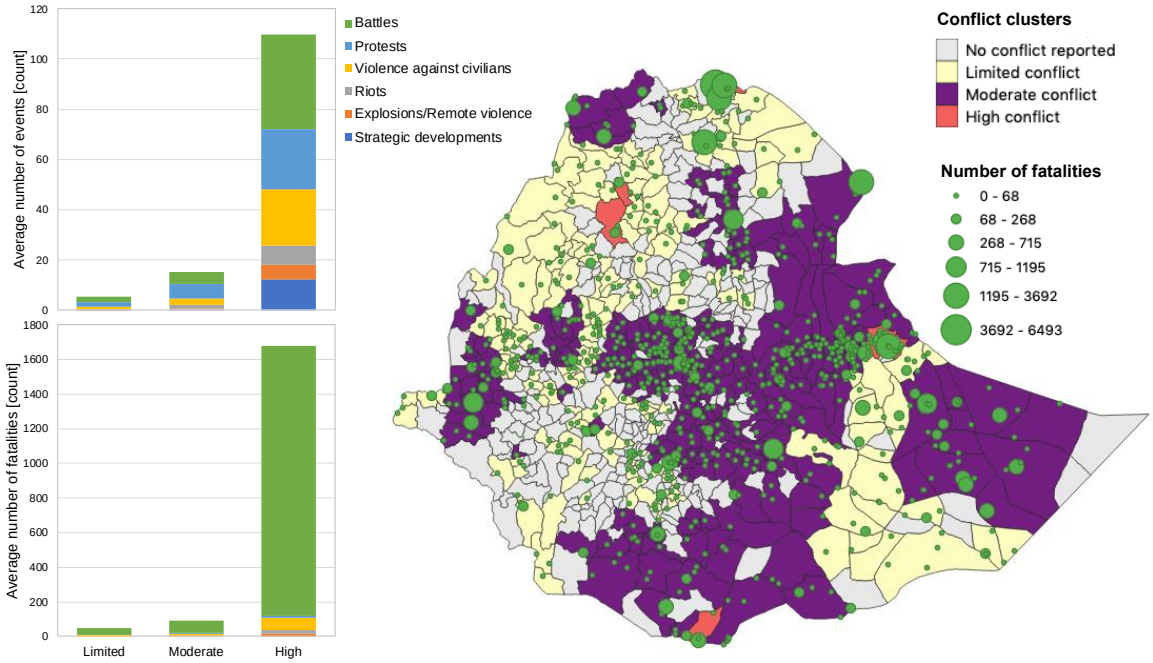


Figure 4. Geographic distribution of conflict clusters in Ethiopia. The bar charts to the left show the average relative distribution of different event types for each cluster, and the total conflict intensity (# events –top, # fatalities –bottom) per cluster. The green circles in the map show the total number of fatalities (all event types).

Figure 4 shows the geographic distribution of the three resulting conflict clusters and their general characteristics in terms of conflict occurrence and fatalities. A substantial part of Ethiopia shows no reports of conflict in the ACLED database (grey areas). In the rest of the country, our analysis identifies classifies conflict in three groups:

- **Limited conflict cluster (LCC):** This group occurs primarily across rural areas in which cash crops are an important source of income. LCC shows the lowest average diversity of conflict types and subtypes, actors, as well as the lowest number of events and fatalities.
- **Moderate conflict cluster (MCC):** This group also occurs throughout rural areas, but is typically associated with pastoral and agropastoral areas across the Afar and the Somali regions. Average conflict intensity, diversity and geographic coverage are moderate in this cluster.
- **High conflict cluster (HCC):** This group occurs in localized spots within Ethiopia, showing a substantially larger average intensity, diversity and geographic coverage of conflict. HCC includes the western part of Addis Ababa, and two woredas on the border with Eritrea (Erob, Gulomekeda –Tigray area) which have a large number of fatalities owing to specific events related to the Ethiopian–Eritrean war (1998–2000). In fact, in 1999 alone, the Ethiopian–Eritrean war reportedly led to 10,153 fatalities (3,692 in Erob and 6,461 in Gulomekeda). HCC also includes Jijiga (Somali region); Gonder Zuria and Bahir Dar Zuria (Amhara); and Moyale, Chinaksen, and Gursum (Oromia). These woredas have been subject of constant struggle between the Ethiopian Military and both the Oromo Liberation Front (seeking the independence of the Oromo peoples) as well as the Ogaden National Liberation Front (seeking the independence of the Somali region). Political marginalization, ethnic claims to territory, and land and other resources have been key drivers behind these conflicts. Both the OLF and ONLF either ceased fire or signed peace agreements in the last two years.

The climate security nexus at household level

Drawing on the impact pathway analysis, we test whether climate *induced* food and nutrition insecurity, poverty and inequality have an impact on conflict at household level. Poverty, inequality, food, and nutrition security, especially when linked to agricultural losses due to the climate impacts have all been identified as major drivers that when exacerbated by climate risks could lead to increased socio-political insecurities, both within the "natural resource" and "weak governance" pathways. In line with these pathways, we also test whether reliance on agriculture (farm employment and livestock farming) increases the likelihood and intensity of conflicts when impacted by adverse climatic conditions.

The results of the analyses are summarised and presented in Figure 5. They confirm our hypothesis that climate exacerbates existing insecurities and increases the risks of conflicts in Ethiopia. The estimates show that climate *induced*[12] food and nutrition insecurities, poverty and inequality increase the likelihood of the occurrence of conflicts at woreda level. These results differ significantly depending on the type and intensity of conflicts. The role of climate *induced* food security as a driver of conflict is particularly evident at national level and in the HCC and MCC, while it is not significant in the LCC. Even though the relationship among violent conflict and food insecurity has attracted large attention in the past years, there is a general lack of quantitative studies that try to assess the causality between food insecurity and the occurrence of conflicts. Until the past decade, most of the analysis that consider the correlation among these two aspects are principally focused on estimating the impact of conflict on food insecurity rather that the other way around (Martin-Shields and Stojetz 2019). More recently, scholars have also increased their interest in quantifying the impact of food insecurities on conflicts and social unrest and find that, indeed, food insecurity can increase the likelihood and intensity of conflicts (Bellemare 2015; Koren and Bagozzi 2016; Maystadt and Ecker 2014). Similarly, Humphreys & Weinstein, 2008 find evidence that food insecurity can increase the likelihood of joining armed groups. Finally, Berazneva & Lee (2013) show that higher food prices and riots are correlated with an increasing political repression. Our results are in line with this literature in showing that higher climate *induced* food insecurity can lead to an increased risk of conflict.

Our analyses also show that poverty, when impacted by climate, increases the likelihood of conflicts and the number of battles at woreda level. There is a vast literature that posit a relationship between poverty and conflict (Collier et al. 2003; Collier, Bank, and Hoeffler 2002; Fearon and Laitin 2003; Hess and Orphanides 1995; Sambanis 2004). A growing literature also explicitly investigates the role of poverty in increasing the risk of conflicts (Collier et al. 2003; Collier, Bank, and Hoeffler 2002; Djankov and Reynal-Querol 2010; Fearon and Laitin 2003; T. Gurr 1970; Jakobsen, de Soysa, and Jakobsen 2013; Muller and Seligson 1987). Conflicts are often seen as a consequence the "failure of economic development" (Collier et al. 2003) or a "problem of the poor" (Sambanis 2002)[13]. These studies find that recruitment in rebel groups constitutes a common coping strategy for the poorest, especially in presence of weak states and institutions (Fearon and Laitin 2003). In the case of Ethiopia, we observe this effect at national level only. The impact of climate *induced* poverty on conflict becomes insignificant in the cluster level results.

[12] Here we use the term *induced* in a very loose way, as we acknowledge that there are many other factors that drive food insecurity. Our assumption, which is validated by our statistical tests is, however, that climate variability is effective in capturing the degree and extent of food insecurity patterns and trends in the woredas in Ethiopia.

[13] But as in the case of food security, these studies do not provide any details regarding those mechanisms, such as climate, that could exacerbate poverty and render it a significant driver of insecurity (Collier, Bank, and Hoeffler 2002; Fearon and Laitin 2003; Jakobsen, de Soysa, and Jakobsen 2013; Miguel, Satyanath, and Sergenti 2004).

Interestingly, inequality, measured as the ratio of poorest to the richest at woreda level, significantly increases the likelihood and intensity of conflicts (battles) in those woredas in the low intensity conflict clusters. Economic inequality has often been found as an important predictor of conflict and overall political instability (Alesina and Perotti 1996; J. A. Booth 1991; Boyce 1996; Cramer 2003; T. R. Gurr 2015; Nafziger and Auvinen 1997a; Wickam-Crowley 1992). More recently, some authors have challenged these views claiming that high inequality does not necessarily translates into political instability. Instead, it is important to unveil those mechanisms that "enable a relatively peaceable durable inequality to turn into a violent conflict" (Cramer 2003). There is quite strong evidence that climate impacts could be exacerbate these mechanisms, as it is found to significantly exacerbate economic inequality (Pacillo et al. 2020). In line with these studies, our findings suggest that adverse climatic conditions can exacerbate economic inequality which in turn can increase the likelihood of conflicts and instability in those areas in Ethiopia historically less affected by conflict events.

Finally, our results show that reliance on agricultural activities has a limited and non-consistent role in explaining conflicts in Ethiopia. As proxy for the reliance on agriculture, we use agricultural employment and number of cattle in the woreda. Past literature suggests that that lower demand of agricultural labour, due to a decrease of agricultural productivity, is associated with higher conflict density (Barnett and Adger 2007; Guardado and Pennings 2020; Kelley et al. 2015; Raleigh, Jin, and Kniveton 2015). Similarly, natural resource scarcity as aggravated by adverse climatic conditions is expected to increase pastoral conflicts and therefore, we would expect that the higher density of livestock the higher the number of conflicts (Hagmann and Mulugeta 2008). Our results do not confirm these hypotheses. Farm employment is not significant in any of the specifications, while livestock density is only significant at national level and not consistent throughout the conflict clusters. Thus, we find that higher livestock density increases the likelihood of conflicts and the number of battles, but it reduces the number of overall conflicts and riots. The lack of significance of agriculture and livestock production in the estimation of the climate security nexus can be explained by the fact that these two variables do not necessarily represent insecurities per se.

Among other drivers of conflicts, ethnicity consistently increases the risk and intensity of conflicts at national level and in the HCC and MCC. Ethiopia is historically involved in ethnic base conflicts. Consistently with Yusuf (2019), who depicted the history of ethnic base conflict, we found that all the selected ethnic groups (Amhara, Oromo, Tigrinya, Somalie) are positively and significantly correlated with the likelihood of conflict and its intensity (number of conflict events, number of battles). Similarly, access to electricity is highly significant and consistently positively associated with the higher likelihood of conflicts, especially in the high intensity conflict cluster. This could be explained by the urban nature of protests and riots and similar conflict events. Yusuf (2019) for instance argues that ethnic marginalisation and weak governance in support of the most marginalised have caused the insurgences of grievances and tensions that often results in riots and protests in towns and cities across Ethiopia. Growing urbanisations and the use of social media are some of the key factors that facilitated the organisations of such events in urban areas.

Finally, lack of education is also an important driver of conflicts. Previous studies have found evidence that inequality of educational opportunities can increase grievances and lead to conflict (Kett and Rowson 2007; McLean Hilker 2011). Our results show that lack of education, of women in particular, significantly increases the risk of any conflict, the number of conflict and the number of battles.

A: Full sample

		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Children not fed min meal frequency	+++	ns	ns	ns
	Children not fed min diet diversity	+++	ns	ns	ns
Nutrition security	Low Rorher index	+++	ns	ns	ns
	Wasting (women)	+++	ns	ns	ns
	Stunting (children)	ns	ns	ns	ns
Poverty	Poverty count	+++		+++	
Inequality	Inequality ratio	---	---	ns	ns
Agriculture	Agricultural employment	ns	ns	ns	ns
	Livestock - cattle	++	--	++	--
Unemployment	Unemployment	ns	++	---	+
Demography and other control variables	Population pressure*	ns	+++	ns	+++
	Male HH head*	ns	ns	ns	--
	Age HH Head*	ns	--	--	ns
	Ethnicity - Amhara*	++	+++	ns	ns
	Ethnicity - Oromo*	++	+	+++	ns
	Ethnicity - Tigrie*	++	+++	ns	ns
	Ethnicity - Somalie*	+++	+++	++	--
	Urban area*	ns	ns	ns	ns
	Access to electricity*	+++	ns	+++	ns
	Irrigation*	ns	ns	ns	ns

*used as controls

B: High conflict intensity cluster

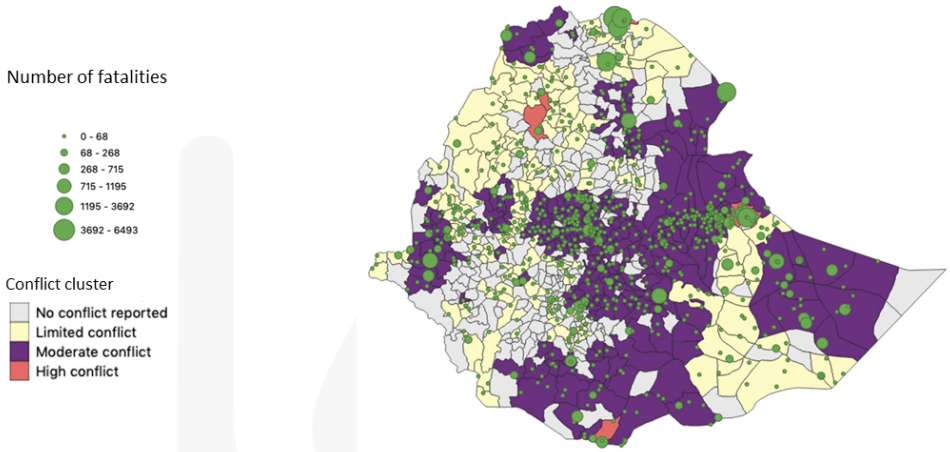
		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Children not fed min meal frequency	+++	ns	ns	ns
	Children not fed min diet diversity	+	+	ns	ns
Nutrition security	Low Rorher index	ns	ns	ns	ns
	Wasting (women)	ns	ns	ns	ns
	Stunting (children)	ns	ns	ns	ns
Poverty	Poverty count	ns	ns	ns	ns
Inequality	Inequality ratio	ns	ns	ns	ns
Agriculture	Agricultural employment	ns	ns	ns	ns
	Livestock - cattle	ns	ns	ns	ns
Unemployment	Unemployment	ns	ns	ns	ns
Demography and other control variables	Population pressure*	ns	ns	ns	ns
	Male HH head*	ns	--	ns	ns
	Age HH Head*	ns	ns	---	+++
	Ethnicity - Amhara*	++	++	+++	--
	Ethnicity - Oromo*	+++	++	+++	
	Ethnicity - Tigrie*	++	ns	ns	---
	Ethnicity - Somalie*	+++	+++	+++	ns
	Urban area*	ns	ns	ns	-
	Access to electricity*	+++	++	++	++
	Irrigation*	-	-	ns	--

*used as controls

C: Moderate conflict intensity cluster

		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Children not fed min meal frequency	+++	ns	ns	ns
	Children not fed min diet diversity	+	ns	ns	ns
Nutrition security	Wasting (women)	+	ns	ns	ns
	Low Rorher index	ns	ns	ns	ns
	Stunting (children)	ns	ns	ns	ns
Poverty	Poverty count	ns	ns	ns	ns
Inequality	Inequality ratio	ns	ns	ns	ns
Agriculture	Agricultural employment	ns	ns	ns	ns
	Livestock - cattle	ns	ns	ns	ns
Unemployment	Unemployment	ns	ns	ns	ns
Demography and other control variables	Population pressure*	ns	ns	ns	ns
	Male HH head*	ns	ns	ns	ns
	Age HH Head*	ns	ns	--	ns
	Ethnicity - Amhara*	++	++	ns	ns
	Ethnicity - Oromo*	+		+	ns
	Ethnicity - Tigrie*	+	++	ns	ns
	Ethnicity - Somalie*	+++	+	ns	--
	Urban area*	--	ns	ns	ns
	Access to electricity*	ns	ns	+	ns
	Irrigation*	ns	ns	ns	ns

*used as controls



D: Limited conflict intensity cluster

		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Children not fed min meal frequency	ns	ns	ns	ns
	Children not fed min diet diversity	ns	ns	ns	ns
Nutrition security	Low Rorher index	ns	ns	ns	ns
	Wasting (women)	ns	ns	ns	ns
	Stunting (children)	ns	ns	ns	ns
Poverty	Poverty count	ns	ns	ns	ns
Inequality	Inequality ratio	+++	+++	ns	ns
Agriculture	Agricultural employment	+	ns	++	ns
	Livestock - cattle	---	ns	ns	ns
Unemployment	Unemployment	--	ns	ns	ns
Demography and other control variables	Population pressure*	ns	ns	ns	ns
	Male HH head*	---	---	---	ns
	Age HH Head*	ns	ns	ns	ns
	Ethnicity - Amhara*	ns	ns	ns	ns
	Ethnicity - Oromo*	+++	+++	ns	ns
	Ethnicity - Tigrie*	ns	ns	ns	ns
	Ethnicity - Somalie*	+++	+++	+++	ns
	Urban area*	ns	ns	ns	ns
	Access to electricity*	ns	ns	ns	ns
	Irrigation*	ns	ns	ns	ns

*used as controls

Figure 5. Heat maps of results of the econometric analysis quantifying the climate impacts on conflicts via the exacerbation of existing insecurities in Ethiopia, at country level (panel A), in the high conflict intensity cluster (panel B), in the moderate conflict intensity cluster (panel C) and in the limited conflict intensity cluster (panel D).

The large-scale climate security nexus: cascading risks in the climate security nexus

The analyses presented thus far show how the climate security nexus occur across low scale drivers that are estimated at household level. However, there exist some important drivers that can only be observed at larger scale, at municipality or district level.

We run network analyses at country level and across the conflict clusters. For network analysis to be robust we need sufficient data points. For this reason, the HCC, which is the smallest cluster of the Ethiopia dataset, was removed from the analysis. Figures 6 show the networks at country level, where the purple nodes represent climate variables, whilst the green nodes represent socio-economic variables. Conflict is represented in yellow. Table 1 summarises the results of the analyses at country and conflict cluster level, listing the main large drivers and their relationship with climate and security in Ethiopia.

The findings show that there exist clear relationships between several key socio-economic variables (nodes), climate and conflicts. For instance, the strongest links (thickest edges) between ecological and social/economic systems can be observed between climate and *prevalence of insufficient food (FCS)* and *aridity*. Conflicts, on the other hand (represented by four key variables – *fatalities, events, richness*, and *subtype richness),* have the strongest relationship with *education, stunting* (childhood stunting) and *population per district.* Moreover, there exists a strong relationship between three *education nodes, upper net primary productivity (upper npp)* and *percentage of people in crisis (rCSI).* We also see that the variables resulting in conflict do not act in isolation. *Population per district* which has the thickest line to conflict is itself connected to *percentage of people in a crisis (rCSI)* and *aridity.* By following pathways of connectivity, we can gain a greater understanding of the complex nature of conflict, and how management interventions must consider multiple factors at play.

At conflict cluster level (Table 1 and Figure S3 in the Appendix) *education* variables still maintain the strongest links in the network in both MCC and LCC as well as the overall network. Education has the greatest influence and power in the system largely due to educations link to a suite of other socioeconomic variables. In the MCC, all *conflict* variables are also linked to *population per district.* The population per district in turn has a strong relationship with a*ridity index*. This cluster is situated largely in pastoral area and so conflict outbreaks are likely to be more strongly associated with climate drivers most closely linked to atmospheric demand (aridity). When we look at the LCC, we can see how although conflict is still largely driven by *population per district* as in MCC the nodes to *population per district* have now shifted to *rCSI* (*percentage of people in a crisis)* and *education* i.e., from more climate to socioeconomic driven conflict.

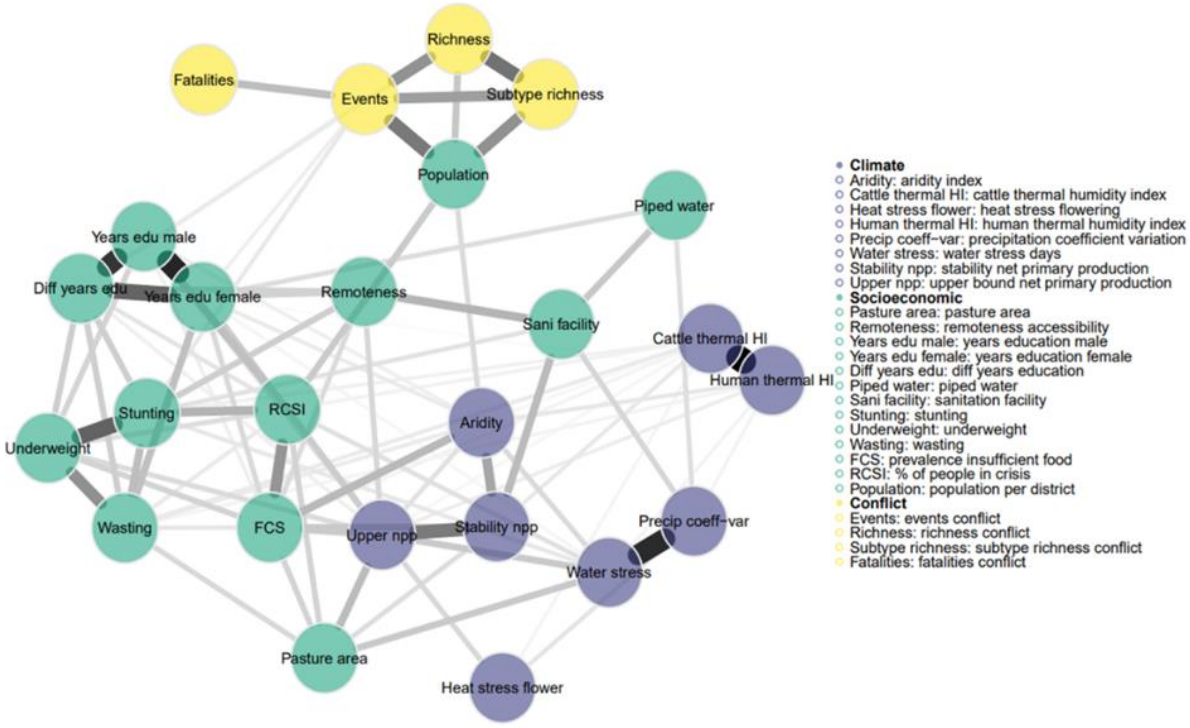


Figure 6. Network analysis of Ethiopia's socio-economic, climate and conflict variables at a country (all) level.

	Key intermediary socio-economic drivers *This describes those drivers which have the strongest link with conflict in the network*	**Climate factors that affect these outcomes** *Describes climate drivers that are in the near vicinity of the key socio-econ drivers or that are directly linked to conflict*	**Other (less relevant) socio-economic factors** *Describes any other factors that might be at play, but of less importance in driving conflict (on the periphery of the network)*	**Relationships with food security and nutrition** *Answers "where in the network is food security?"*
Country (All)	-Education -Stunting -Population per district	- Aridity	- rCSI (percentage of people in a crisis)	Food security is most strongly linked to rCSI (percentage of people in a crisis) and aridity
Moderate Conflict Cluster	-Population per district	-Aridity	-Education	Food security is most strongly linked to RCSI (percentage of people in a crisis)
Limited Conflict Cluster	-Population per district	-Aridity -Heat stress flowering -Upper net primary productivity	-Education -rCSI (percentage of people in a crisis)	Food security is most strongly linked to rCSI (percentage of people in a crisis) and aridity

Table 1. Table showing main large-scale drivers and their relationship with climate and conflict identified in the network analyses at country level and across the moderate and limited conflict cluster in Ethiopia

Mapping the climate security nexus

Climate, conflict, and food security hotspots

In Ethiopia, our analysis identified four distinct groups of climate conditions (Figure 7a). To ease interpretation, these groups are named 'dry-hot', 'dry-warm', 'dry-cool', and 'humid' (see the Appendix for more details on the methods). An overlay of these climate groups with the conflict clusters shows the climate groups occur in different frequencies and locations within the three conflict clusters (Figure 7b).

We also determined food insecurity groups (three groups, as shown in Figure 7c), and then intersected these with the climate and conflict areas of Figure 7b. In grouping the spatial variation of food insecurity, we also include migration. This is because the spatial scale of the migration data available at the time of this analysis did not allow for a more detailed analysis. The findings of the analysis can be summarised as follows (see Figure 7d):

- Conflict-climate spatial associations are diverse and complex. Climate conditions vary widely across conflict clusters, and likewise conflict levels vary widely across climate conditions. The moderate and limited conflict clusters experience the entire range of climate conditions, whereas the HCC does not occur in the 'dry-hot' climate.
- Extreme and severe food insecurity (as defined by the groups established here) are experienced throughout virtually the entire conflict – climate space. This means that, in each existing combination of conflict cluster and climate, it is always possible to identify the areas with greatest food insecurity (darkest areas per colour type in Figure 7d).
- The dry-hot and food insecure areas are often in border regions with other countries (e.g., Somalia, Eritrea, Kenya, Djibouti). We highlight areas of severe food insecurity in the dry-hot environments of the Somali region within the moderate conflict cluster. These areas warrant attention for addressing food insecurity and climate resilience.

At this point, we refrain from sub-selecting or classifying woredas as hotspots of conflict–climate–food insecurity, since our data analysis shows that even those areas classified as having 'moderate' food insecurity can have relatively high rCSI (percentage of people using crisis or above crisis food-based coping), FCS (prevalence of insufficient food –the sum of 'poor' and 'borderline' consumption in the FCS), as well as prevalence of stunting, underweight, and wasting. We thus concentrate on assessing the spatial dimension of some of the other key drivers, as identified in the network analysis: nutrition security, inequality – measured by unequal access to education, and agricultural productivity. These are described in the subsections below.

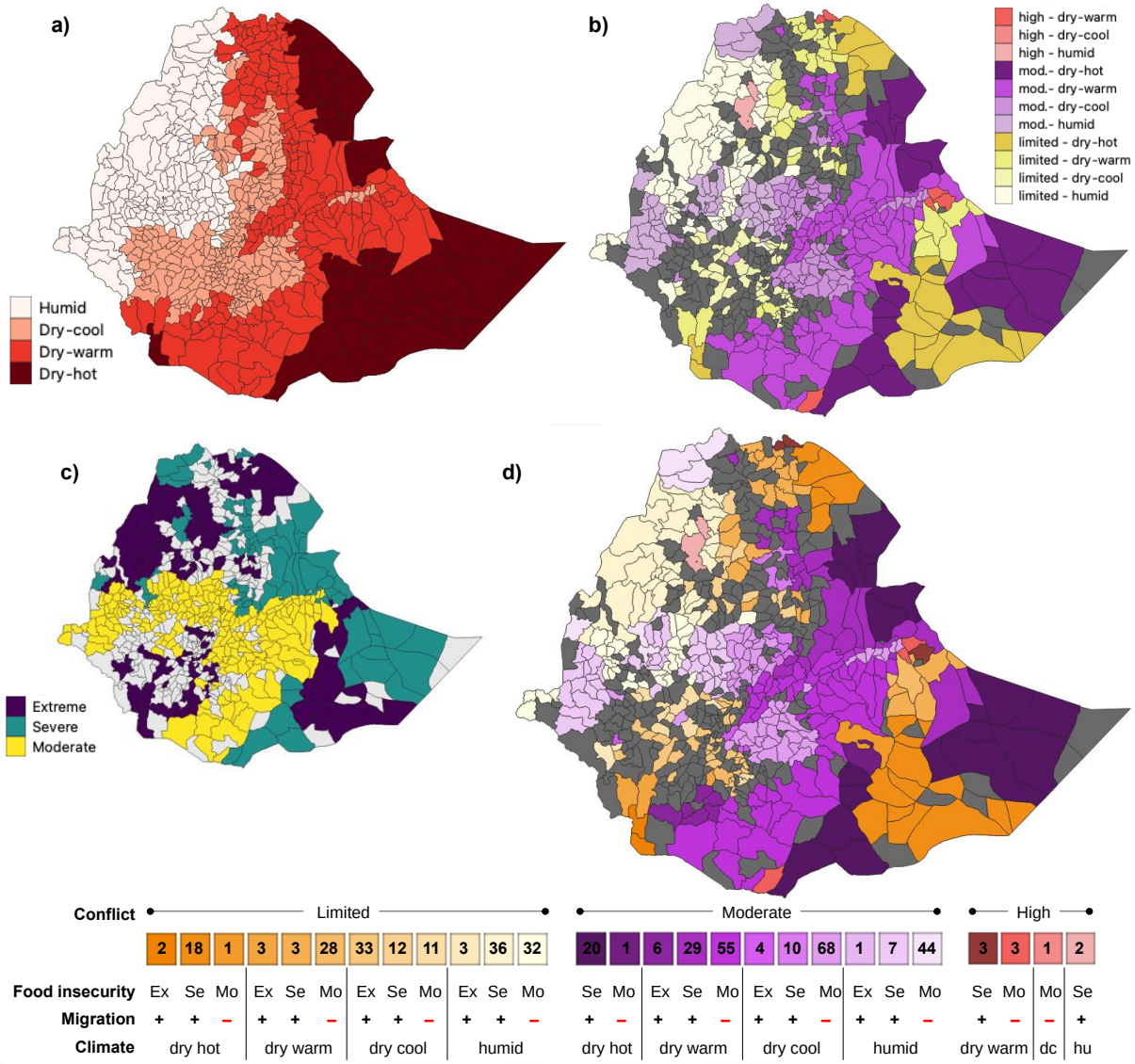


Figure 7. Climate groups (a), their intersection with conflict clusters (b), food insecurity groups (c), and their intersection with climate and conflict for Ethiopia (d). The bottom legend corresponds to panel (d). The numbers within the colour legend of panel (d) indicate the number of woredas in each combination of conflict – climate – food insecurity. Food security levels (Ex: extreme, Se: severe, and Mo: moderate). Migration levels (+: immigration and -: outmigration). Climate levels (dry-hot, dry-warm, dry-cool, and humid). Dark grey areas have no conflict reported according to ACLED.

Nutritional outcomes within climate, conflict, and food security hotspots

We characterise nutrition using the prevalence of stunting, underweight and wasting as derived from the Local Burden of Disease. Figure 8 shows the hotspots (dark brown areas in the map on the right) of high prevalence (75% percentile across Ethiopia or greater) of nutritional problems across the climate–conflict–food insecurity nexus (map on the left in Figure 8).

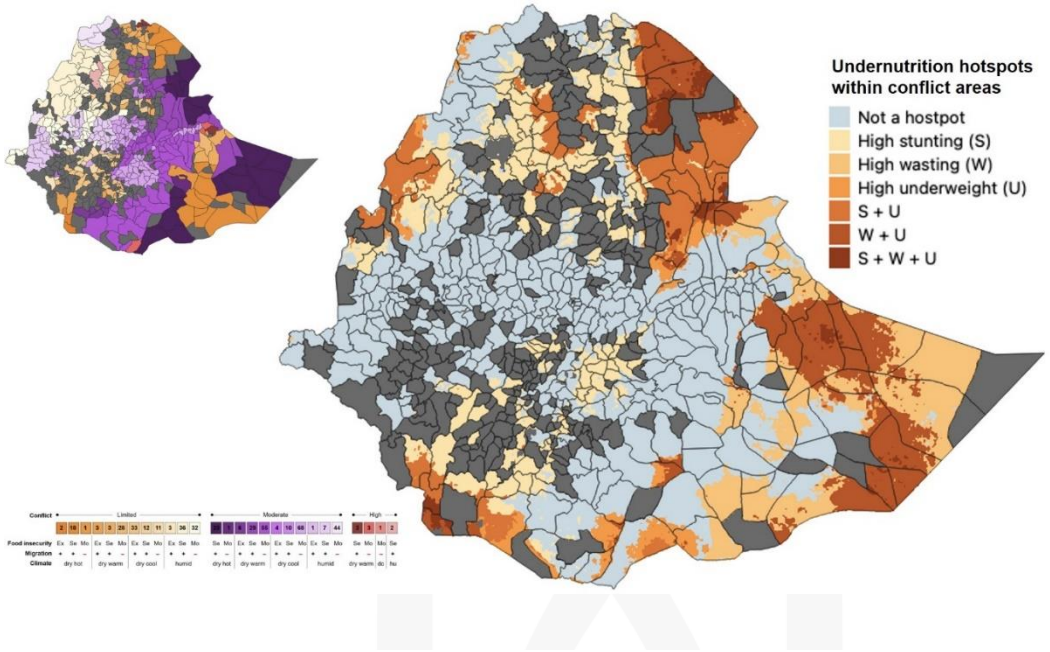


Figure 8. Undernutrition hotspots (map on the right) and the conflict–food insecurity–climate nexus (map on the left). The colour code of the small map on the left follows Figure 7. Dark grey areas have no conflict reported according to ACLED.

While the maps show the entirety of Ethiopia, it is also possible to visualize these results for specific conflict–climate–food insecurity combinations. Therefore, combining the results of the hotspot analysis of the climate-conflict-food security nexus (small map on the left) with the analysis of nutrition insecurity hotspots (map on the right), we can identify three areas which possess severe nutritional problems, while also showing significant levels of conflict, being located in harsh climate conditions, and also experiencing high levels of food insecurity:

- The north-eastern part of the Afar department, encompassing the woredas of Elidar, Dubti, Mile, and Afambo.
- The north (Ayisha and Shinile woredas), eastern (Danot, Warder, Shilabo, Kebridehar, Denan, Shekosh, Gunagado, Aware, Gashamo), and southern (Dolo Odo, Filtu, Moyale) parts of the Somali region.
- The Gulomekeda and Erob woredas in Tigray –both bordering with Eritrea

We also identify several instances in which poor nutritional outcomes co-occur with low conflict and favourable climate conditions, such as the west of Ethiopia (Benshangul-Gumaz region).

Inequality within climate, conflict, and food security hotspots

We characterise inequality using two variables: (i) the average number of education years for men, and (ii) the gap in education years between men and women. Lack of education is one of the key drivers of conflict identified by the network analysis and household level analysis. The average education years for

men allows analysing the equality in access to education as a potential way out of poverty. The gap in education between men and women highlights gender inequalities

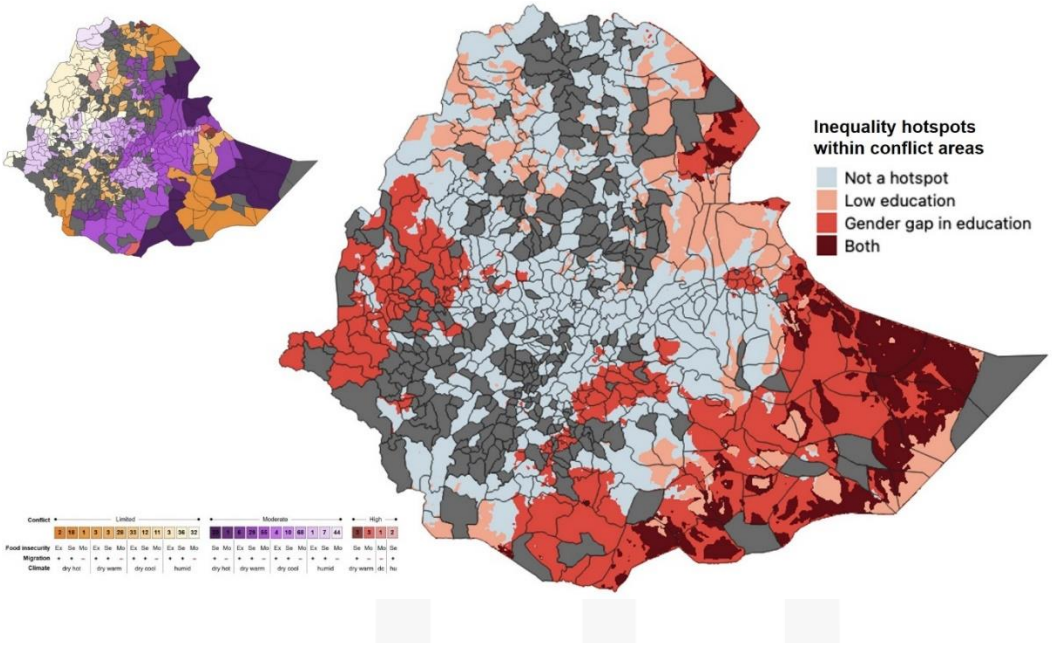


Figure 9. Inequality hotspots and the conflict–food insecurity–climate nexus. The colour code of the small map on the left follows Figure. 7. Dark grey areas have no conflict reported according to ACLED.

The results suggest that the hotspots of low education and gender differences do generally coincide with the areas of poor food security outcomes (e.g., north-eastern Afar, and many parts of the Somali region). Notably, we find that education is generally higher for men in areas where conflict is limited within the Somali region (Figure 9). In some of these areas, however, the gender gap is substantial, with women having on average at least 1.5 years of education less than men. These areas, coloured in dark red, indicate specific spots where investment toward improving education with an explicit gender lens could help mitigating the impact of the climate security nexus.

Hotspots of multiple climate security risks

The dry-hot and food insecure areas within conflict areas tend to occur in border regions with other countries (e.g., Somalia, Eritrea, Kenya, Djibouti). We highlight the following areas where harsh climate conditions, conflict, food insecurity co-occur, with a number of socio-economic drivers (see Figure 11)

- The north-eastern part of the Afar regions, encompassing the woredas of Elidar, Dubti, Mile, and Afambo.
- The north (Ayisha and Shinile woredas), eastern (Danot, Warder, Shilabo, Kebridehar, Denan, Shekosh, Gunagado, Aware, Gashamo), and southern (Dolo Odo, Filtu, Moyale) parts of the Somali region.
- The Gulomekeda and Erob woredas in Tigray –both bordering with Eritrea

In these areas, we find

(i) high (>25%) prevalence of stunting, wasting and underweight children,
(ii) low levels (< 3 years) of education for men and large gaps (>1.5 years) between men and women,
(iii) low levels of agricultural productivity (NPP < 2,500 kg-C/ha/year), high NPP variability (coefficient of variation > 15%), and high (up to 75% or more) shares of pasture area.

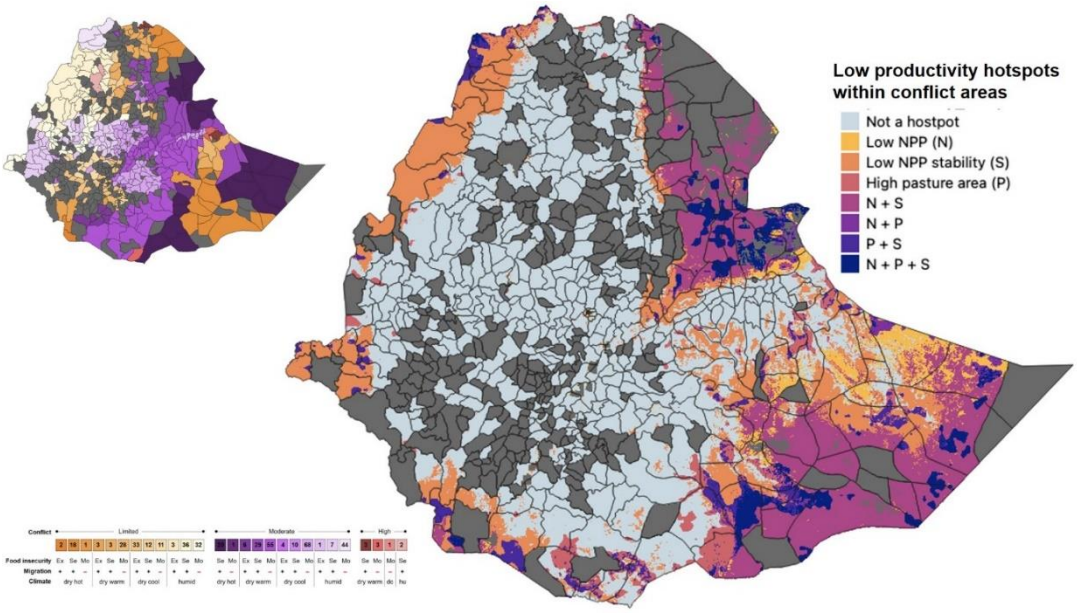


Figure 10. Low productivity hotspots (top map) and the conflict–food insecurity–climate nexus (bottom map). The colour code of the small map on the left follows Figure 7. Dark grey areas have no conflict reported according to ACLED.

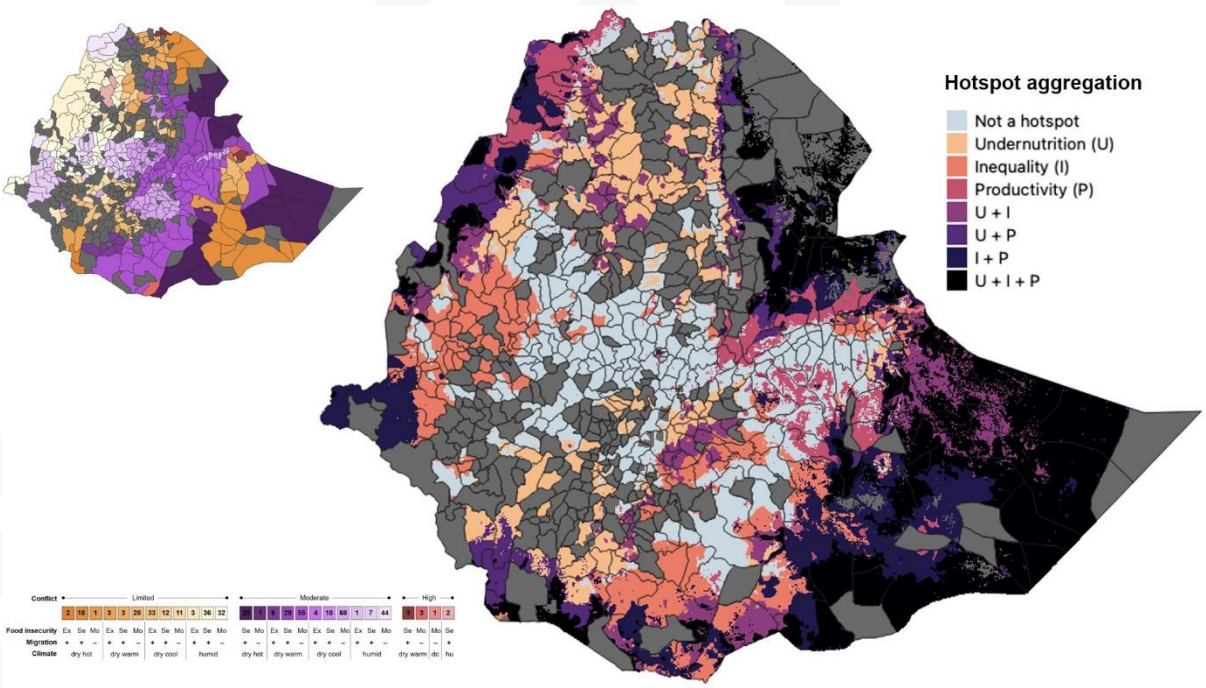


Figure 11. Hotspots of undernutrition, inequality and low productivity (map on the right) and the conflict–food insecurity–climate nexus (map on the left). The colour code of the small map on the left follows Figure 7. Dark grey areas have no conflict reported according to ACLED.

The climate security nexus in the CADC countries

Summary of findings for CADC countries

(1) Two main impact pathways link climate to conflict, the agriculture losses pathway captures the and the natural resources pathways.

(2) Climate exacerbates existing household level risks and insecurities that can increase the likelihood and intensity of conflict. In other words, we find evidence that climate is a threat multiplier[14]. In El Salvador, the analysis shows that climate exacerbates household level food insecurity, poverty and inequality; it reduced income and increases agricultural production costs, which in turn increase the likelihood and intensity of conflicts.

(3) In addition to climate induced insecurities, there exist other important household level predictors of conflict, such as age, education, and gender of the head of the household, ethnicity, access to electricity and location.

(4) The climate security nexus – the way climate, socio-economic and political risks and insecurities are linked to each other – differs across countries and conflict clusters. In El Salvador, the climate security nexus is characterized by the combination of ENSO effects and mid-summer drought intensity (ecological system), higher household dependency ratio, youth unemployment, agricultural income, accessibility, inability to meet basic needs, wealth (socio-economic system) and diversity of conflicts (political system) at national level. In Guatemala[15], the climate security nexus is characterized by the ENSO effect and MSD duration (ecological system), food security, ability to meet basic needs, lack of education and limited access to alternative sources of income (socio-economic system) and number of conflicts (political system). In Honduras, the climate security nexus is characterized by MSD magnitude duration and ENSO effect (ecological system), cropping area and access to alternative sources of income (socio-economic system) and number of conflicts and diversity of conflict actors (political system).

(5) There exist "climate insecurity hotspots" at sub-national level where high level of climate variability, conflict intensity and diversity co-occur with other existing socio-economic insecurities. In El Salvador, vulnerability hotspots tend to cover border areas (with both Honduras and Guatemala), and though these areas do not show high conflict, they show high prevalence of stunting. In Guatemala, particular attention should be given to the rural and peri-urban areas around Guatemala City, which show high conflict occurrence while at the same time being socially vulnerable. We also highlight the subsistence farming areas in Huehuetenango, Quiché, and Baja Verapaz, where social vulnerability is high and climate conditions can exacerbate this vulnerability. In Honduras, the southern areas (Choluteca department) show significant social and biophysical vulnerability, while also showing moderate to high conflict. In these areas, we find occurrence of poorly productive staple crop systems, combined with high accessibility to mining concessions and some presence of cash crops (cotton, coffee). We also highlight the areas of western Honduras (Copán, Intibucá, Lempira) where nutritional insecurity is high, but conflict has low intensity and diversity.

[14] Note that for both Guatemala and Honduras we could not run household level analyses due to lack of suitable data.

[15] This analysis is carried out at national level only for Guatemala and Honduras due to limited data availability.

Qualifying the climate security nexus in the CADC countries – an impact pathway analysis

Impact pathway analysis

To reveal the linkages between climate, food security and conflict in the CADC, we identify potential impact pathways through which climate can exacerbate security risks. Socio-political instability is driven by a complex web of interactions linking many different actors and aspects of society which can be looked at from different hierarchical levels, such as the community, regional, national, and international levels. Figure 12 below suggests few possible pathways and interactions, drawn from the existing evidence of the climate-security nexus in the CADC countries[16]. The following paragraphs will describe two main pathways:

1 ***Agriculture losses pathway:*** *Climate induced food insecurity and poverty, due to declining agricultural yields, income and employment opportunities, reduces the opportunity costs of joining armed groups, of especially young and unskilled men and women, and leads to forced migration, which due to population pressure, structural inequalities and lack of adequate social protection systems in the destination areas, creates favourable conditions for the recruitment of vulnerable people into criminal groups and increases the risk of violence and conflicts.*

2 ***Natural resources pathway:*** *Natural resource scarcity due to irregular seasons and weather patterns, coupled with precarious economic status, extreme poverty, inequality, and food insecurity increases the competition over natural resources, especially land, increase deforestation and favours the insurgence of tensions and potentially conflicts over the acquisition of titles and rights regarding the use and access to natural resources.*

Previous literature has found that climate variability (irregular seasons and precipitation events) have increasingly occurred in the CADC countries. Similarly, extreme events, such as floods and droughts, have significantly increased and are expected to further increase in the near future. Climate can remarkably affect agricultural productivity, increase incidence of pests and diseases (such as coffee rust) and exacerbate insecurities when major staple and cash crops, such as maize and coffee, respectively are affected. These impacts could translate in reduced income, increased food insecurity and poverty (FAO 2017; Magrin et al. 2014).

Climate variability also negatively influences job availability in the agricultural sector, as the demand for on-farm labour decreases, and negatively impacts the profits of off-farm workers (e.g., street sellers, retailers). The combination of decreased agricultural productivity with a lack of access to markets can lead to unfair pricing of the affected production output. The negative impacts of climate variability include reduced agricultural livelihood conditions and food insecurity, which may push people to migrate and become more susceptible to the recruitment into organized crime groups. This dynamic has been found in CADC countries, where extended climate variability and extreme events

[16] The full literature review is described in detail in the Appendix.

coupled with the lack of economic opportunities has been found to facilitate the recruitment of young people to criminal organizations (Delgado 2020).

The gender dimensions of these climate-related security risks have been poorly explored (Abdenur 2020). CADC societies are permeated by remarkable patterns of gender discrimination and inequality, with women and girls having unequal access to basic public services, formal labour markets and decision-making processes at all levels. Moreover, violence against women and girls is a widespread phenomenon in both urban and rural areas, and Guatemala and El Salvador account for the highest rates of gender-based violence (GBV) in the CA region (Musalo and Bookey 2013). Structural conditions, such as inequalities and social norms, have made women and girls, especially those living in rural and indigenous communities, particularly susceptible to climate shocks and associated security risks (UNEP et al. 2020). CADC rural men and women are highly dependent on rain-fed agriculture and natural resources and, therefore, climate variability and land degradation have directly affected their ability to achieve and maintain food and water security (Abdenur 2020; Fraga 2020). The women's capacity to absorb and recover from climate shocks have been further hindered by gender norms and discriminatory practices that have led rural and indigenous women to have unequal access to agricultural land and technical assistance (OXFAM-International 2020). This economic vulnerability combined with the high levels of GBV and domestic violence women experience during and following extreme weather events (UNFPA 2010), have created a negative vicious climate security cycle, undermining their adaptive capacities and constraining their livelihood options, which in turn have reinforced sexual violence and discrimination (UNEP et al. 2020).

Finally, natural resource scarcity is a widely recognized source of conflict, although under debate in its impact on political security when taken in isolation from important socio-economic and political factors (Hauge and Ellingsen 1998; Homer-Dixon 1994; Theisen 2008). However, the link between climate, natural resource scarcity and conflict in CADC countries is not fully investigated in the environmental security literature (Delgado 2020; O'Toole 2017). Existing evidence shows that climate impacts can exacerbate soil degradation, water scarcity and induce deforestation in CADC, and that increasing competition over resources, exacerbated by the increasing acquisition of land affecting the indigenous population in Central America are important factors in the prediction of conflicts in the CADC (Myers et al., 1987; Yagenova & Garcia, 2009, Castro-Nunez et al., 2017).

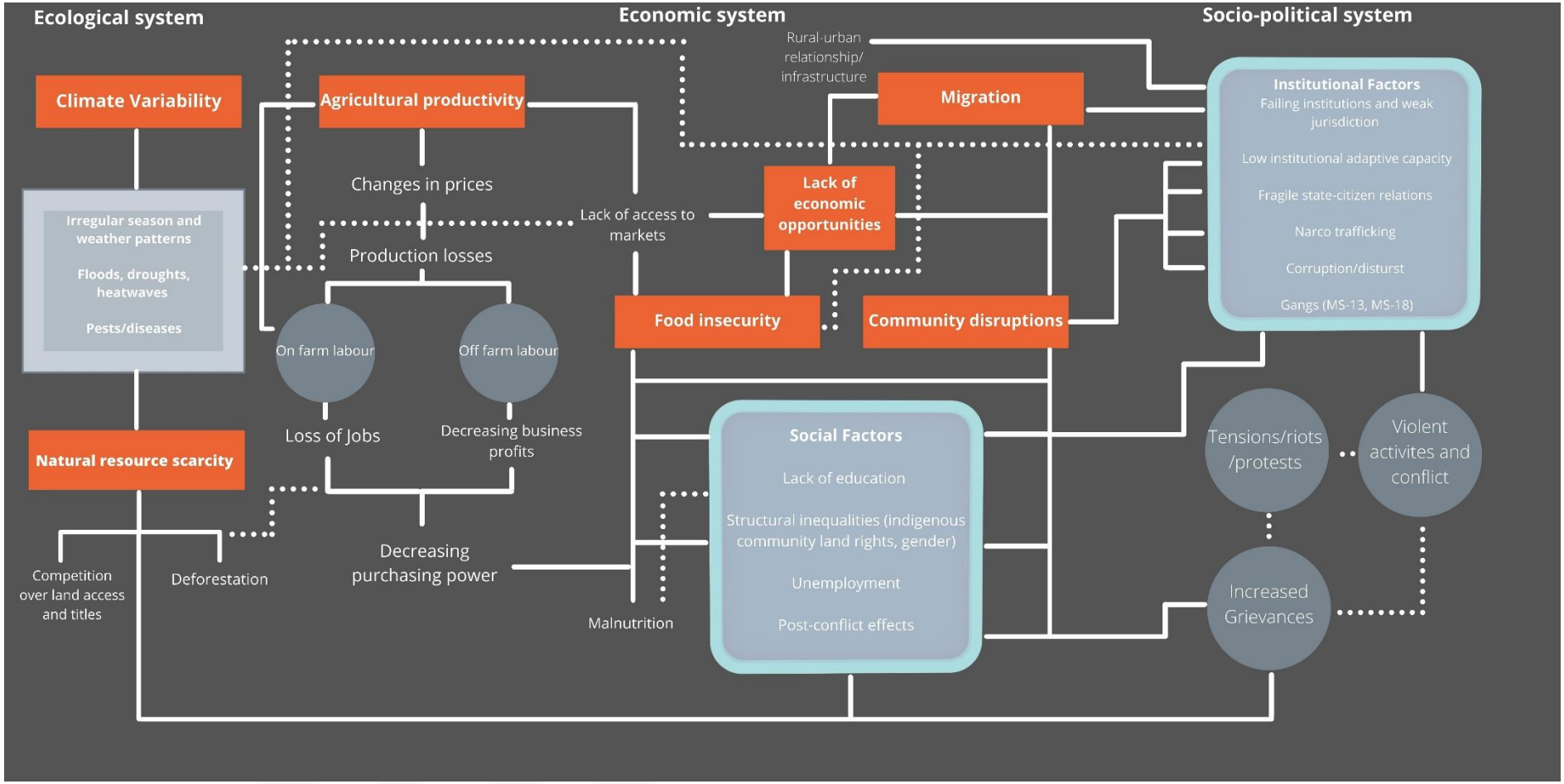


Figure 12. The climate, food-security, conflict nexus in the Central American Dry Corridor

Quantifying the climate security nexus in the CADC countries

Three countries were analysed in the CADC, namely, Guatemala, Honduras, and El Salvador. Over the period for which data were available (2018–2020) in the ACLED database, we find that conflict intensity (measured by the total number of events) is generally greater in Honduras, followed by Guatemala and finally by El Salvador (Figure 13).

In the three countries gangs and non-state armed groups are by far the leading violent actors, as they are responsible for virtually all the battles (consisting solely of armed clashes) and violence against civilians (mostly attacks). In the vast majority of cases, armed clashes occur between two different gangs or armed groups, whereas only seldom the military or police are involved. Both armed clashes and attacks against civilians take place in different areas of the countries, though they tend to have a greater concentration around the major cities (especially for Honduras and Guatemala). The average number of fatalities per events for these two conflict types (battles, and violence against civilians) ranges between 1 (Guatemala) and 1.3 (Honduras).

Protests are also very frequently reported in the ACLED database for the CADC. Protests are primarily peaceful, and hardly lead to deaths. Overall, protests are more common in Honduras, followed by Guatemala, and finally by El Salvador.

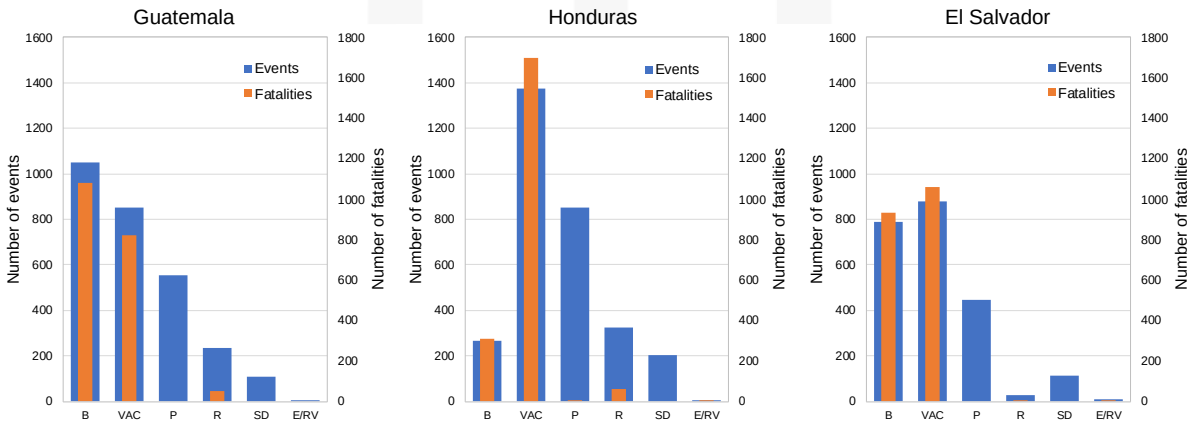


Figure 13. Overview of reported conflict events and fatalities in the CADC per event type, period 2018–2020. Data from the ACLED database. Letters in the x-axis refer to the event type as follows, B: battle, VAC: violence against civilians, P: protests, R: riots, SD: strategic development, and E/RV: explosion / remote violence.

We identify 4 clusters for Guatemala, 3 for Honduras, and 3 for El Salvador (Figure 14). In Guatemala, the four clusters are formed primarily by intensity (Extreme, High, Moderate and Limited), whereas in El Salvador the clusters are formed by diversity of event types and actors (high, moderate and low diversity). For Honduras, the three identified clusters structure the country in terms of both intensity and diversity (low diversity – low intensity; moderate diversity – low intensity; and high diversity – high intensity). Country-specific results can be summarised as follows:

- In Guatemala, the "extreme" violence cluster is composed by a single municipality (San José, in the Peten department). While the total number of events and fatalities in San José is not the highest of Guatemala, the intensity of conflict per total population is by far greater than the rest of the country. Apart from San José, the entire Peten department experiences significant violence. Peten is mostly classified in the "Moderate" violence cluster. The characteristics of the Peten department make it very prone to violence, as (i) it largely lacks government presence; (ii) has large natural areas which armed groups and gangs can use as shelter from police and other gangs; (iii) has a border with Mexico which make it attractive for narcotraffic routes; and (iv) it has substantial ethnic diversity and has historically suffered from colonization and violence towards ethnic groups (Hurtado Paz Y Paz, 2010).The high violence cluster of Guatemala encompasses the areas immediately surrounding Guatemala City, whereas the limited violence cluster extends through most of the productive highlands.
- In Honduras, the high diversity and high intensity cluster encompasses the main cities (Tegucigalpa and San Pedro Sula, and their surroundings) in addition to the western part of the Gracias a Dios department (Brus Laguna municipality). This area in general experiences a similar situation to San José in Guatemala, whereby lack of government presence and low accessibility and infrastructure allow for gangs and narcotraffic groups to establish operations. Consistent with this, strategic developments by either the Honduras police and military against gangs (or vice versa) are the main sources of both conflict events and deaths. The low intensity but moderate diversity covers important areas of the dry corridor of Honduras (e.g., Choluteca department), whereas the low diversity - low intensity cluster covers is large and covers most of the rural areas of the country.
- In El Salvador, violence is distributed relatively uniformly in terms of intensity, but varies substantially in terms of the diversity of conflict types and actors involved. Since gangs and illegal armed groups are the main actors, this means that the low diversity cluster is dominated by specific gangs, which fight between themselves and against government forces (police and military). These areas are widespread across El Salvador, and cover many rural areas where poverty is high. By contrast, high diversity areas are located around San Salvador, but also occupy the Ahuachapan and Sonsonate departments. In these areas, many gangs and armed groups are present, fighting for survival and territory between themselves, but also with significant push back from the Salvadorian military and police. Moderate diversity areas are generally in between high and low diversity areas, and likely represent transitional areas where conflict diversity is likely to intensify towards the future.

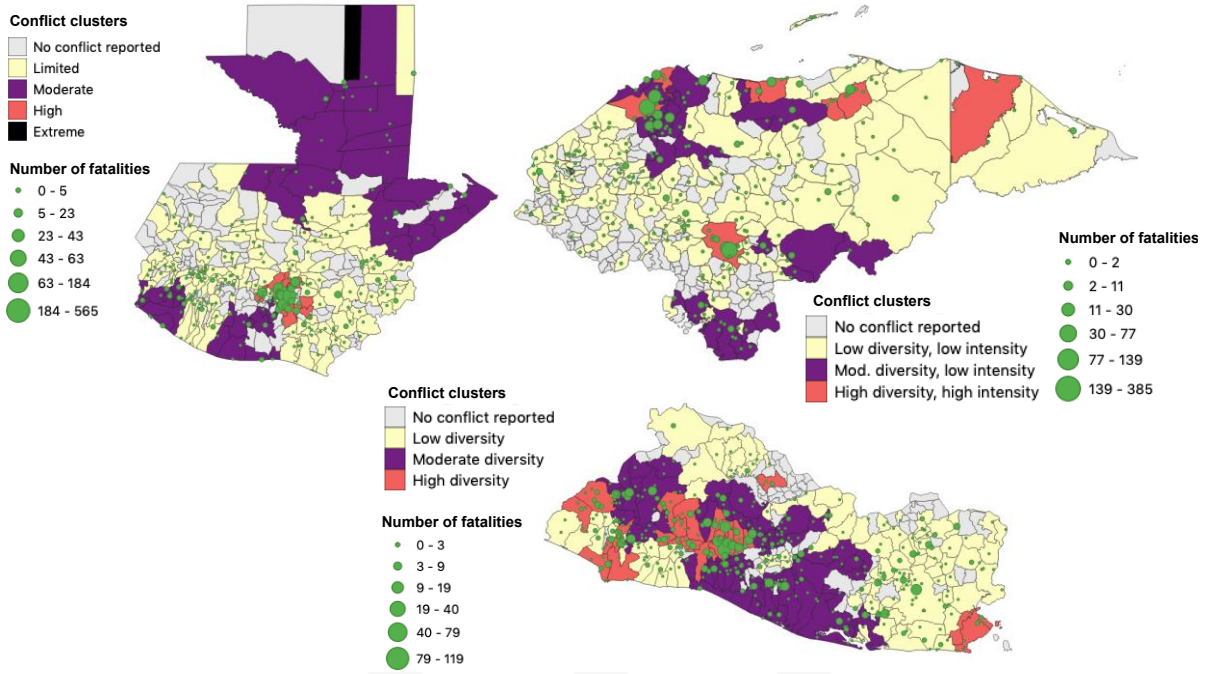


Figure 14. Geographic distribution of conflict clusters in CADC countries. Light grey areas have no conflict reported according to ACLED.

The climate security nexus at household level

The results of the analyses are summarised and presented in Figure 15. They confirm our hypothesis that climate does exacerbate existing insecurities and increases the risks of conflicts in El Salvador. Conflicts are defined as any type of violence, conflict, tensions, and related socio-political co-variate insecurities affecting a group of individuals in certain geographical area. More specifically, our estimates show that climate *induced*[17] food insecurities, inequality, poverty, and increased agricultural costs increase the likelihood of the occurrence of conflicts at municipality level. But these results differ significantly depending on the type and diversity of conflicts (Figure 15).

First, we find that climate induced food insecurity exacerbates the occurrence and intensity of conflicts at national level and across conflict clusters. Following Moltedo et al., (2014), an increase in the proportion of income allocated to food is a signal of decreased food security. We find that an increase of food insecurity, as affected by climate, has a positive effect on our conflict dependent variables. This result in line with previous literature (Berazneva and Lee 2013; Humphreys and Weinstein 2008; Koren and Bagozzi 2016) who find robust evidence that food insecurity is associated with the presence of violent conflicts, the likelihood of joining armed groups and increased political repression. In our analysis we find strong evidence that the climate-food insecurity-conflict nexus exists, and that the strongest and more consistent effect of climate induced food insecurity is observed in the moderate conflict cluster (purple areas in the map in Figure 14). This cluster includes municipalities where conflict diversity is likely to intensify towards the

[17] Here we use the term *induced* in a very loose way, as we acknowledge that there are many other factors that drive food insecurity. Our assumption, which is validated by our statistical tests is, however, that climate variability is effective in capturing the degree and extent of food insecurity patterns and trends in the woredas in Ethiopia.

future. Here we find that food insecurity increases the likelihood of the occurrence of any conflict event and the intensity of battles, riots, and overall conflict events at municipality level.

Our results also show that inequality is a strong predictor of climate induced conflicts. Inequality has historically been a major risk in El Salvador. Despite a recent improvement, El Salvador remains the second most unequal country in Latin America and the Caribbean(The World Bank 2021) . Economic inequality has often been found as an important predictor of conflict and overall political instability (Alesina & Perotti, 1996; Boyce, 1996; T. Gurr, 1970 on El Salvador; and also on Latin America, K. Booth, 1991; Nafziger & Auvinen, 1997b; Wickham-Crowley, 2018)). More recently, some authors have challenged these views claiming that high inequality does not necessarily translates into political instability. Instead, it is important to unveil those mechanisms that "enable a relatively peaceable durable inequality to turn into a violent conflict" (Cramer 2003). There is quite strong evidence that climate impacts could exacerbated these mechanisms, as it is found to significantly exacerbate economic inequality (Pacillo et al. 2020). In El Salvador, we also find robust evidence that inequality is exacerbated by climate and that this influences the risk and intensity of conflict events at municipality level in high, moderate and limited conflict clusters. The high conflict cluster is mainly located around San Salvador, but also occupy the Ahuachapan and Sonsonate departments. In these areas, many gangs and armed groups are present, fighting for the control over territories between themselves, with significant push back from the Salvadorian military and police. On the other hand, the low diversity cluster is dominated by specific gangs, which fight between themselves and against government forces (police and military). These areas are widespread across El Salvador, and cover many rural areas where poverty is high. The moderate conflict cluster is somehow in between and are areas where most likely conflicts could intensify in the future. Across all the conflict clusters, we find that climate induced inequality strongly increases the likelihood of any conflicts, number of overall conflicts events, numbers of battles and riots.

Another important climate security risk for El Salvador is agriculture, more specifically the costs associated with the agricultural activities. We find that the increase of agricultural costs, as affected by climate, is positively and strongly associated with the likelihood and intensity of conflicts. Past suggests that climate has had a strong negative impact on agriculture in El Salvador. For instance, due to a long drought period in 2014 and in 2018, El Salvador lost 90% and 55% of its bean harvest, respectively, largely increasing prices of the staple crop driving many households into severe food and nutrition insecurity (Calvo-Solano et al. 2018). Other studies also suggest that a decrease of agricultural productivity, and a consequent, lower demand of agricultural labour, is associated with higher conflict density (Barnett and Adger 2007; Guardado and Pennings 2020; Kelley et al. 2015; Raleigh and Kniveton 2012).

Finally, our impact pathway analysis suggests that a reduced agricultural productivity can push people out of rural areas in search for better economic opportunities and lowers their opportunity costs to join criminal groups. Our results overall confirm this hypothesis in the national level analysis. At cluster level, we observe non-consistent results, as agricultural costs and income are not significant or negatively correlated with the risk and intensity of conflicts. A negative correlation can be explained by the fact that this variable might be capturing the value of the land. A land that required high expenses on inputs (fertilizers, soil conservation practices, etc.) might not be regarded as valuable compared to land which requires less inputs (i.e. not so degraded or eroded) and therefore not competed for among gangs. On the other hand, higher costs and incomes are also associate to larger agricultural lands, therefore potentially capturing the economic status of the household. If so, the higher the cost the higher the land size and, consequently, the higher the wealth of the farmer. If this is the case, past literature and our impact pathway analysis suggest that the increase in costs and incomes could lead to a reduction of the likelihood and intensity of conflicts.

There is a wealth of literature that show the link between poverty and conflicts (Collier et al. 2003; Collier, Bank, and Hoeffler 2002; Djankov and Reynal-Querol 2010; Fearon and Laitin 2003; T. Gurr 1970; Jakobsen, de Soysa, and Jakobsen 2013; Muller and Seligson 1987; Sambanis 2004). Conflicts are often seen as a consequence the "failure of economic development" (Collier et al. 2003) or a "problem of the poor" (Sambanis 2002)[18]. These studies find that recruitment in rebel groups constitutes a common coping strategy for the poorest, especially in presence of weak states and institutions (Fearon and Laitin 2003)[19]. Our results show that an increase in poverty, as affected by climate, increases the likelihood and intensity of conflicts, including battles and riots, at national and conflict cluster level. Some authors suggests that governance can effectively mitigate, offset and potential reverse the link between poverty and insecurity (Ross, Ross, and L. 2004; Thies 2010). We find that poverty has a deterrent effect in the moderate cluster level. Also, comparing this cluster to the multi-dimensional poverty distribution map (Figure 16) shows that most of the municipalities have a much higher level of poverty that the rest of the country, suggesting a higher level of structural deprivation in this cluster. Some authors suggest (e.g. Goodhand, 2001) that "it is more likely to be the transiently poor, rather than the chronically poor who rebel". People who experience high level of multidimensional deprivation might not be able to organize protests, or look for better opportunities in criminal activities, as they tend to be the most passive group in the society.

Finally, among other drivers of conflicts our results show that land tenure, age, sex and education of the household head, household size and rurality have a significant correlation with the type and intensity of conflicts. These results suggest that the risk and intensity of conflicts increases in those municipalities where household are headed by younger, female[20] and less educated heads; where households size is above average, and they located in the urban areas. Land tenure is also found to be a strong deterrent of conflict. Our results show that land ownership significantly and strongly reduces the risk and intensity of conflicts. These results are almost exclusively observed in the national level analysis, but they are not consistent across the conflict clusters, apart from land ownership, which is strongly significant also in moderate conflict clusters. Interestingly, none of these drivers are significant in the limited conflict clusters, suggesting that the interaction of effect of these household demographics is less relevant in relatively peaceful municipalities.

[18] But as in the case of food security, these studies do not provide any details regarding those mechanisms, such as climate, that could exacerbate poverty and render it a significant driver of insecurity (Collier, Bank, and Hoeffler 2002; Fearon and Laitin 2003; Jakobsen, de Soysa, and Jakobsen 2013; Miguel, Satyanath, and Sergenti 2004).

[19] In addition to poverty, there are a lot of other factors that are associated with recruitment beyond poverty, including identity, ideology, and mistreatment by government.

[20] In interpreting these results, one should consider that oftentimes women are often left behind and not able to flee insecure areas as much as older and more educated men are. Also, in areas of high conflict intensity, it might be more likely that women have lost their husbands due to violence or temporarily separated due to migration to access better economic opportunities and support the families from remote.

A: Full sample

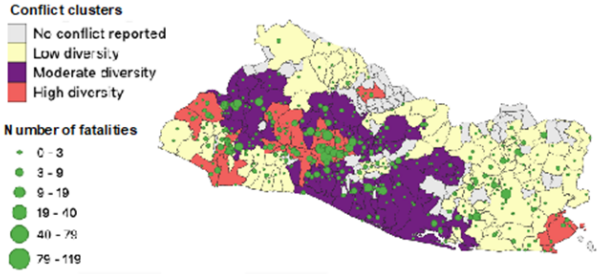
		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Total food expenditure/total income	+	ns	ns	ns
Migration	Total remittances (log)	ns	ns	ns	ns
	Family members abroad	ns	ns	ns	ns
Poverty	Poverty	++	+	++	
Inequality	Gini coefficient	ns	ns	ns	ns
Agriculture	Total agricultural costs	+++	++	++	ns
	Share of income from agriculture (log)	+	ns	ns	ns
Youth unemployment	Num. unemployed youth in HH	ns	ns	ns	ns
Demography	Land ownership*	---	--	--	
	Age of HH head*	--	--	--	
	Female HH head *	++	++	++	+
	Years of education HH head*	--	--	--	ns
	HH size*	++	nc	nc	nc
	Rural area*	---	--	--	ns
*used as controls					

B: High conflict cluster

		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Total food expenditure/total income	+++	ns	ns	ns
Migration	Total remittances (log)	ns	ns	ns	ns
	Family members abroad	ns	ns	ns	ns
Poverty	Poverty	+++	+++	+++	+++
Inequality	Gini coefficient	++	+++	+++	+++
Agriculture	Total agricultural costs	ns	ns	ns	ns
	Share of income from agriculture (log)	ns	ns	ns	ns
Youth unemployment	Num. unemployed youth in HH	ns	ns	ns	ns
Demography	Land ownership*	ns	ns	+	ns
	Age of HH head*	nc	nc	nc	nc
	Female HH head *	-	++	++	++
	Years of education HH head*	nc	nc	nc	nc
	HH size*	nc	nc	nc	nc
	Rural area*	---	---	---	---
*used as controls					

C: Moderate conflict cluster

		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Total food expenditure/total income	+++	+++	+++	+++
Migration	Total remittances (log)	ns	ns	ns	ns
	Family members abroad	ns	ns	ns	ns
Poverty	Poverty	---	---	---	---
Inequality	Gini coefficient	+++	+++	+++	+++
Agriculture	Total agricultural costs	---	---	---	---
	Share of income from agriculture (log)	---	---	---	---
Youth unemployment	Num. unemployed youth in HH	ns	ns	ns	ns
Demography and other control variables	Land ownership	---	---	---	--
	Age of HH head*	nc	nc	nc	nc
	Female HH head *	+++	+++	+++	+++
	Years of education HH head*	nc	nc	nc	nc
	HH size*	nc	nc	nc	nc
	Rural area*	ns	ns	ns	ns
*used as controls					



D: Limited conflict cluster

		Any conflict	Number of conflicts	Number of battles	Number of riots
Food security	Total food expenditure/total income	++	--	--	--
Migration	Total remittances (log)	ns	ns	ns	ns
	Family members abroad	ns	ns	ns	ns
Poverty	Poverty	+++	+++	+++	++
Inequality	Gini coefficient	+++	+++	+++	+++
Agriculture	Total agricultural costs	---	---	---	---
	Net income from agriculture (log)	---	---	---	---
Youth unemployment	Num. unemployed youth in HH	ns	ns	ns	ns
Demography and other control variables	Land ownership*	nc	nc	nc	nc
	Age of HH head*	nc	nc	nc	nc
	Female HH head *	nc	nc	nc	nc
	Years of education HH head*	nc	nc	nc	nc
	HH size*	nc	nc	nc	nc
	Rural area*	nc	nc	nc	nc
*used as controls					

Figure 15. Heat maps of results of the econometric analysis quantifying the climate impacts on conflicts via the exacerbation of existing insecurities in El Salvador, at country level (panel A), in the high conflict cluster (panel B), in the moderate conflict cluster (panel C) and limited conflict cluster (panel D). Note (2); the sign (+/-) indicate the direction of the effect of the specific driver or control factor and the colour (a scale of red) indicates whether the direction of the causality is in line with expectations and reflects the strength of the statistical significance of such effect. The stronger and more consistent results are those with +++ or --- and in a dark red coloured cell. Conflict data used for this analysis were extracted from the official Twitter account of the El Salvador police department. Based on these data, we estimated a conflict proxy using a machine learning and text mining approach. More detailed on the methodology can be found in the Appendix.

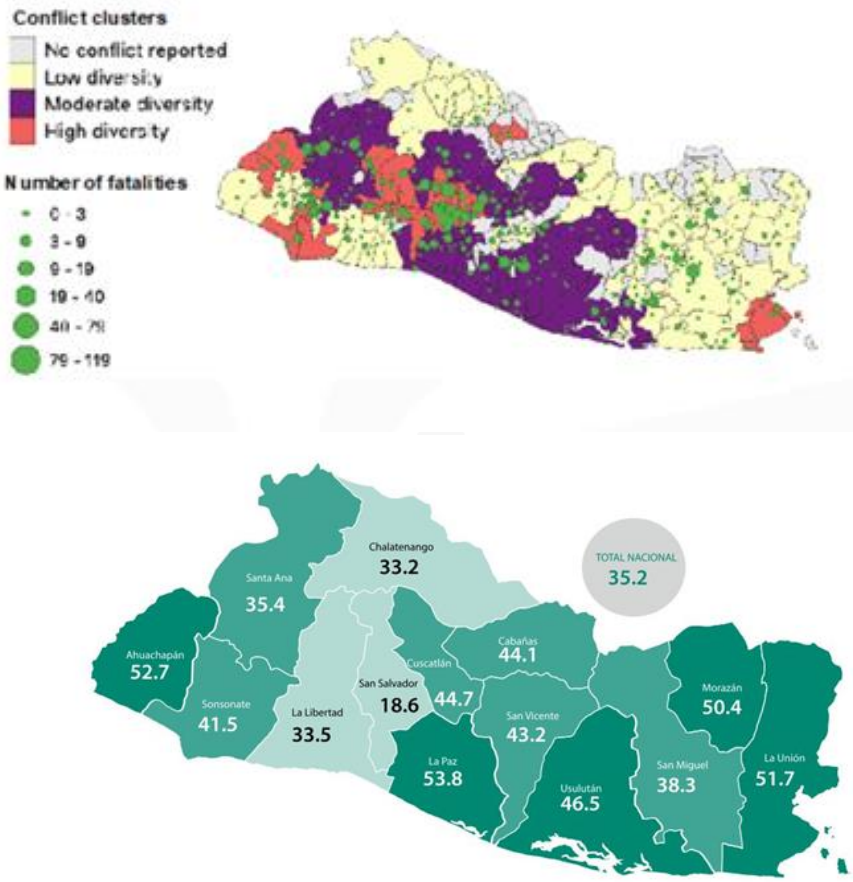


Figure 16 Distribution of multi-dimensional poverty (left) and conflict clusters (right) in El Salvador. Source: Secretaria tecnica.gob.sv (2015).

The large-scale climate security nexus: cascading risks in the climate security nexus

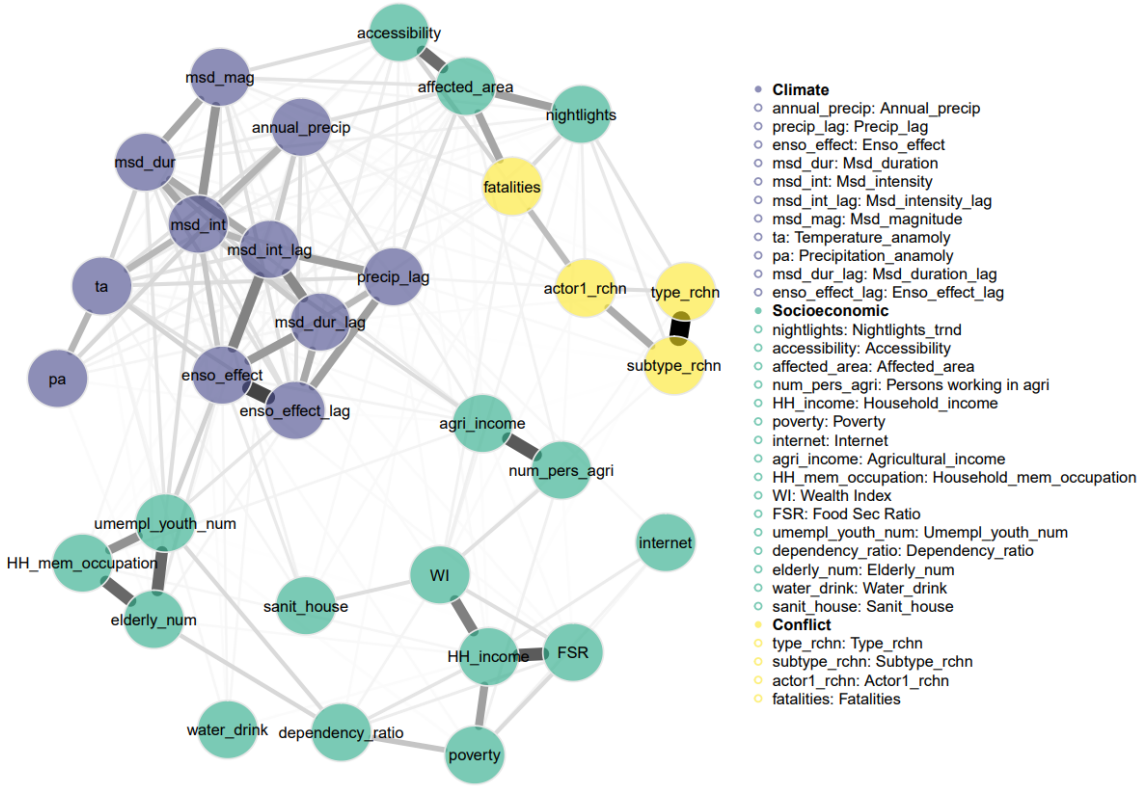
The analyses presented thus far show how the climate security nexus occur across low scale drivers that are estimated at household level. However, there exist some important drivers that can only be observed at larger scale, at municipality or district level.

We run network analyses for El Salvador, at country and conflict cluster level, and for Guatemala and Honduras at country level only[21]. The results for El Salvador are presented in Figure 17 where the purple nodes represent climate variables, whilst the green nodes represent socio-economic variables. Conflict is represented in yellow[22]. Table 2 summarises the results of the analyses for all the countries, listing the main large drivers and their relationship with climate and security.

In **El Salvador,** the results for the country level analysis show that the strong prevalence of high youth unemployment and lack of economic opportunities is central to the socio-economic status (poverty, wealth index, food security ratio) in El Salvador (Figure 17). Mid-summer drought intensity and ENSO events are key factors which determine the food security status (high prevalence of food insecurity) and wealth index, through employment in the agricultural sectors (agricultural income and household members' occupation). Accessibility (time required to travel to healthcare facilities) is strongly linked with affected area which in turn are closely associated with conflict (specifically fatalities). This analysis therefore suggests that agricultural related indicators (income from agriculture) as well as the number of unemployed youth, form the interface between climate (El Niño Southern Oscillation- ENSO and mid-summer drought) and conflict events, represented by four key variables – fatalities, type richness, subtype richness and actor1 richness. In the high conflict diversity cluster (Table 2 and Figure S4 in the Appendix), forming one of the most densely clustered networks, conflict is linked to socio-economic vulnerability or status (*wealth index, household income, food security ratio*) and directly to sources of income from agriculture. These in turn are both tightly connected to extreme climate events *(ENSO* and *mid-summer drought*). *Accessibility (time required to travel to healthcare facilities)* is strongly linked with *affected area* as well as *nightlights* which in turn are strongly associated with *conflict* (specifically *fatalities*). In the moderate conflict diversity cluster, *FSR* (*high prevalence of food insecurity)* is linked strongly to household income *(hh_income).* Household income is central to wealth and poverty indicators (*WI- wealth index, poverty, unemployed youth*). Accessibility *(time required to travel to healthcare facilities)* is strongly linked with conflict (specifically *fatalities*). Finally, in the low conflict diversity cluster, *FSR* (*high prevalence of food insecurity)* is linked strongly to household income *(hh_income).* Accessibility *(time required to travel to healthcare facilities)* is strongly linked with affected area which is strongly associated with *conflict* (specifically *fatalities and actor1_richness*). Household income is central to wealth and poverty indicators (*WI- wealth index, poverty*). These are driven by an array of other socioeconomic variables which are linked to conflict.

[21] We could not run the analysis at cluster level for Guatemala and Honduras due to the limited sample size of the observations available for these two countries.

[22] The network graphs of the cluster level analysis for El Salvador and the country level graphs for Guatemala and Honduras can be found in the Appendix.



In

Figure 17. Network analysis of El Salvador's socio-economic, climate and conflict variables at a country (all) level.

The results of the network analysis at country level for **Guatemala** show that conflicts are a product of a vulnerable socio-economic situation (*FCS – high prevalence of food insecurity)*, exacerbated by extreme climate cases (*ENSO* and *mid-summer drought*) on staple crops (rice, maize). The socioeconomic vulnerability in this pathway is further emphasized with strong links to alternate illegal or seasonal work (*deforestation* which may indicate illegal logging in Guatemala and/or agricultural expansion and *mining concessions*). Conflicts in this analysis are represented by six key variables – *fatalities, events, type richness, subtype richness, actor1 richness* and *actor2 richness*. In this network, conflict is heavily influenced by the prevalence of unmet basic social needs (prevalence of insufficient food consumption- *FCS*, safe drinking water- *SDWater*, availability of healthcare per capita- *Phealth*). Participatory involvement of people in the decision-making process of policies that will affect basic needs is a priority as to address conflict we need to address the lack of basic necessities that are driving these outbreaks. These indicators have the greatest strength or centrality in the network and are therefore very strongly linked to climate pressures (*ENSO, Mid-summer drought duration*), valuable natural resources (crop yields) and conflict. The network flow indicates that large scale climate events, i.e., the duration of mid-summer drought and strong anomalies in temperature and precipitation from ENSO events are directly impactful on valuable natural resources (rice and maize production). These natural resources are then linked to prevalence of insufficient food and the distance to mining and deforestation concessions. This may indicate that once food security has been compromised by extreme climate events, vulnerable groups may turn to other sources of income and be more exposed or inclined to conflict events.

Finally, in **Honduras** the analysis shows that *FCS* – high prevalence of food insecurity is linked directly to *net flow* (migration) and *msd_mag* (midsummer drought magnitude). Conflict is revolved around areas with

large population density (*population*) which in turn has a confirmatory connection to the prevalence of *nightlights* and *housing.* Conflict is represented by six key variables – *fatalities, events, type richness, subtype richness, actor1 richness,* and *actor2 richness*. S*ubtype richness* shows a direct link to *Enso effect. Enso effect* largely influences an array of other socioeconomic variables. The remaining conflict variables are linked to *population size*. The population resulting in conflict outbreaks are in more densely populated areas indicated by a large number of *nightlights* as well as *housing* (rural dwellings built with long-lasting material) and access to safe drinking water (*SDwater*).

	Key intermediary socio-economic drivers *This describes those drivers which have the strongest link with conflict in the network*	**Climate factors that affect these outcomes** *Describes climate drivers that are in the near vicinity of the key socio-econ drivers or that are directly linked to conflict*	**Other (less relevant) socio-economic factors** *Describes any other factors that might be at play, but of less importance in driving conflict (on the periphery of the network)*	**Relationships with food security and nutrition** *Answers "where in the network is food security?"*
El Salvador				
Country (All)	- Dependency ratio/unemployed youth - Income from agriculture - Accessibility	- ENSO - Mid-summer drought Intensity	- Unmet basic needs - Wealth indicators	- Food security is linked strongly to household income
Cluster 1 – high conflict	- Wealth Index - Income from agriculture - Accessibility	- Total amount of precipitation - ENSO	- Unsatisfied basic needs - Poverty	- Food security is linked strongly to household income
Cluster 2 – moderate conflict	- Wealth Index - Income from agriculture - Accessibility	- ENSO - Mid-summer drought related indicators	- Food security - Income from agriculture	- Food security is linked strongly to household income
Cluster 3 – limited conflict	- Number of unemployed youth - Accessibility	- Mid-summer drought intensity	- Unmet basic needs - Wealth indicators	- Food security is linked strongly to household income
Guatemala				
Country (All)	- SD Water (Safe Drinking water) - Population size	- ENSO effect - Mid-summer drought duration	- Food security - Unmet basic needs - Education - Access to alternative sources of income (mining concessions, deforestation)	FCS (food insecurity) is largely connected to extreme climate (ENSO effect) as well as illegal or seasonal work (access to deforestation). FCS is also connected to staple food production (yield rice)
Honduras				
Country (All)	- Permanent fixed assets (rural dwelling built with long-lasting materials) - Unmet basic social needs	- ENSO effect (direct link) - Mid-summer drought duration	- Cropping areas - Access to alternative sources of income	FCS (food insecurity) is largely connected to illegal or seasonal work (net flow) as well as to extreme climate (MSD intensity).

Table 2. Main large-scale drivers and their relationship with climate and conflict identified in the network analyses at country level and across the moderate and limited conflict cluster in the El Salvador, Guatemala and Honduras

Mapping the climate security nexus

Climate, conflict, and food security hotspots

The Central American Mid-Summer Drought (MSD) is likely the most important driver of agricultural productivity and food insecurity in the CADC. The MSD is a dry period with a duration of approximately two weeks which typically occurs in the '*postrera*' season (August–November). In extremely dry seasons (e.g., when ENSO is in a positive phase) the MSD can last for longer than two weeks, severely hindering crop and livestock productivity, and often leading to food insecurity. The MSD is characterised using three different metrics: (i) intensity or the average daily rainfall during the period, (ii) duration, and (iii) magnitude or the minimum 30-day running mean precipitation. We use the long-term (1981–2019) means of these three indicators and the influence of ENSO in the local precipitation to develop climate groups within the three CADC countries of interest (Guatemala, Honduras, El Salvador).

Our analysis identified six distinct climate groups in the CADC, which arise as a combination of the duration, intensity, and magnitude of the MSD (Figure 18). Four groups show short duration of the MSD with different levels of drought (ranging from not significant to extreme), and two other groups show a longer MSD with either moderate or extreme drought. These groups occur in different frequencies in the region, with the 'long MSD with extreme drought' occurring only in Honduras, and the rest occurring both in Honduras and Guatemala. In El Salvador, we find only two groups, namely, 'short MSD with mild drought' and 'long MSD with moderate drought'.

When intersecting these climate groups with the conflict clusters, the following findings become apparent:

- In Guatemala, climates with short MSD dominate, but they vary widely in intensity across the country and within conflict clusters. The extreme and high conflict clusters are both dominated (100 and 82% of municipalities, respectively) by climates with short MSD but extreme drought. In the moderate conflict cluster, conversely, these short MSD and extreme drought conditions occur only in 5% of the municipalities, but short MSD with mild or insignificant drought are more dominant (32.5% in each case). The limited conflict cluster, on the other hand, shows 39% of municipalities in the short MSD with extreme drought, followed by short MSD with mild drought (27%).
- In Honduras, long and extremely dry MSD conditions dominate in all conflict clusters, but especially so in the high diversity – high intensity cluster (75% municipalities). As conflict intensity and diversity reduce, so does the dominance of this type of climate, with 43.3% municipalities having long and extremely dry MSD in the moderate diversity – low intensity conflict cluster, and 27.7% municipalities in the low diversity – low intensity conflict cluster.
- El Salvador shows the most favourable climate conditions. Across the conflict clusters, short MSD with mild drought occur in 95% of the municipalities with moderate conflict diversity, in 86% of the municipalities with high conflict diversity, and in 62% of the municipalities with low conflict diversity.

Food insecurity groups (Figure 19) were developed by spatial clustering of five variables, namely, the food consumption score (FCS), prevalence of stunting, prevalence of underweight, and prevalence of wasting. Due to the spatial scale of the migration data, we also include migration in the food insecurity groupings. These groups are developed to provide a general overview of the food insecurity situation in these countries. Contrary to Ethiopia, in the case of the CADC, we refrain from overlaying these groups with the conflict and climate groups due to the size of the countries and the spatial scale of the food insecurity data.

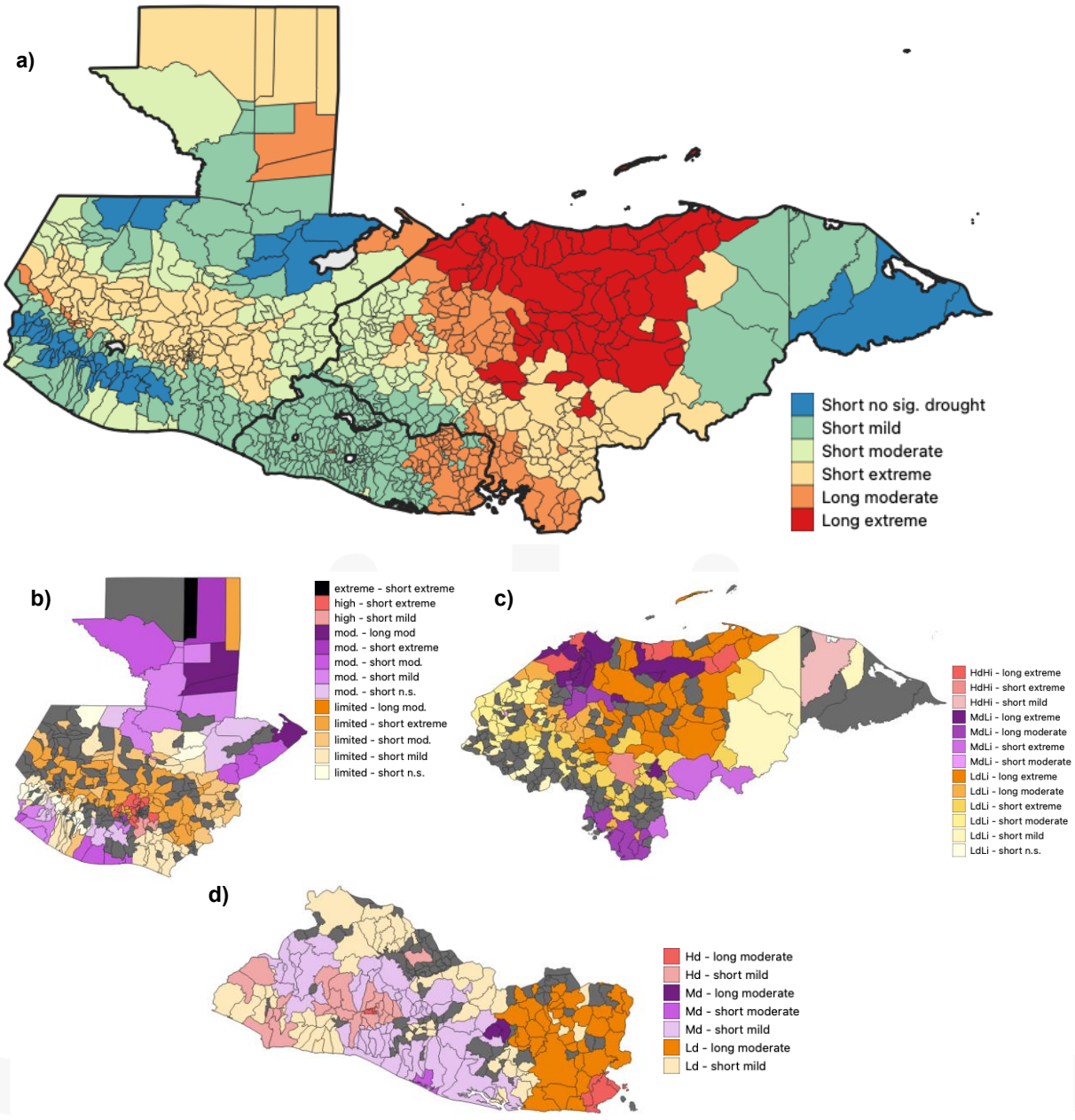


Figure 18. Climate groups in the CADC (a), their intersection with conflict clusters for Guatemala (b), Honduras (c), and El Salvador (d). For panel (c), HdHi: high diversity, high intensity; MdLi: moderate diversity, low intensity; LdLi: low diversity, low intensity. For panel (d), Hd: high diversity, Md: moderate diversity, and Ld: low diversity. Dark grey areas have no conflict reported according to ACLED.

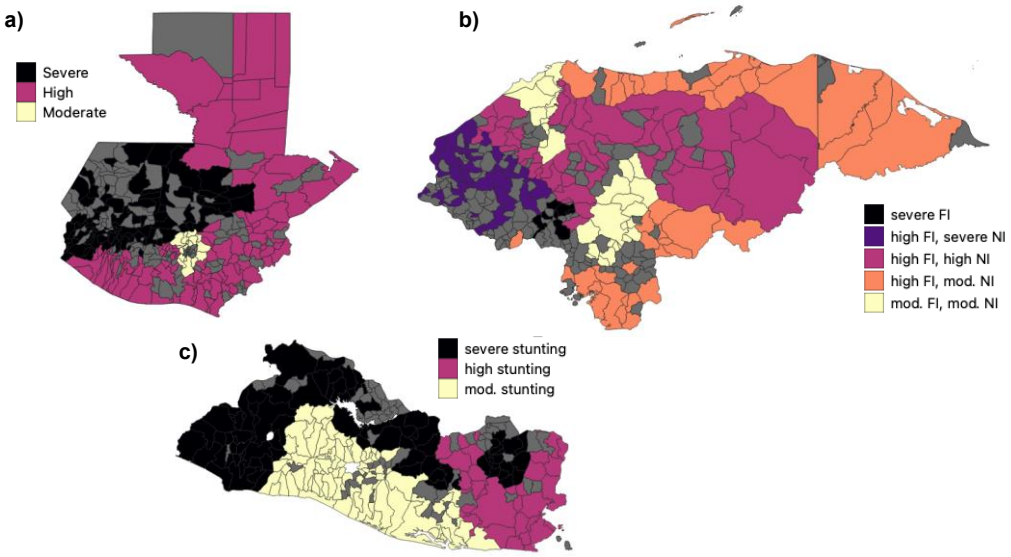


Figure 19. Spatial variation in food insecurity in the CADC for Guatemala (a), Honduras (b), and El Salvador (c). For panel (b), FI: food insecurity, and NI: nutritional insecurity. The names of the groups are given per country based on the values of the variable for each cluster. Dark grey areas have no conflict reported according to ACLED.

In Guatemala and Honduras, the food insecurity groups are formed as a result of the spatial variation in the FCS as well as in the nutritional indicators, whereas in El Salvador all indicators except the prevalence of stunting present only limited spatial variation. Generally speaking, the areas of highest conflict in Guatemala (surroundings of Guatemala City) have the lowest food insecurity. By contrast, many of the areas of the biophysical dry corridor, where conflict is limited but the MSD is short and intense, show high food insecurity conditions. Virtually all areas of moderate conflict show high food insecurity. For Honduras, high food insecurity occurs in areas of high and moderate conflict diversity and intensity, and to a lesser degree in areas of low conflict diversity and intensity. It is noteworthy that in Honduras the most extreme food insecurity conditions occur in areas of low conflict and relatively favorable climate conditions (short MSD with mild or moderate drought). Finally, for El Salvador, we note that the highest rates of stunting occur primarily in the low conflict diversity cluster, and within these in areas of more favorable climates.

Undernutrition and inequality within climate, conflict and food security hotspots

To analyse nutritional outcomes within conflict areas we determine hotspot areas for wasting, stunting and underweight prevalence through spatial analysis. Figure 20 shows the results of this process for undernutrition and Figure 21 for inequality. The results identified the following hotspots (dark brown municipalities in Figure 20 and blue, orange and purple in Figure 21):

- In Guatemala, the departments of Baja Verapaz, Huehuetenango and Quiché show the greatest nutritional insecurity problems.
- In Honduras, high nutritional insecurity is found in the west towards the departments of departments of Copán, Intibucá, Lempira and Ocotepeque. Undernutrition is also a significant problem in specific pockets within the department of Madre de Dios (eastern Honduras).
- In El Salvador, nutritional insecurity problems are concentrated toward the borders with both Honduras and Guatemala, suggesting a likely relationship between these and migration.

- In many of the areas in which undernutrition hotspots are identified, we also see inequality being a problem (Figure 21). Particular attention should be given to western Guatemala, western Honduras, and south-western El Salvador due to significant occurrence of gender gaps in access to education.

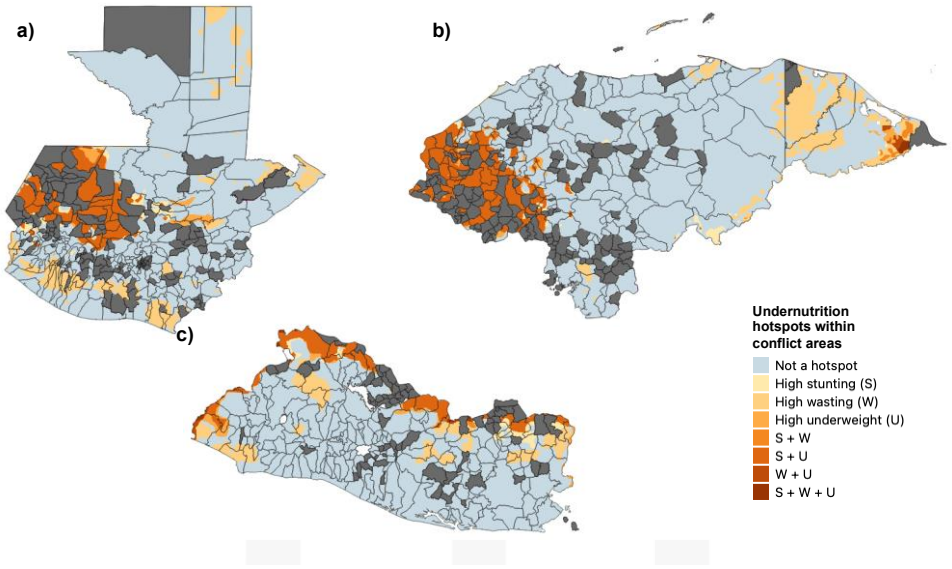


Figure 20. Undernutrition hotspots in the CADC for Guatemala (a), Honduras (b), and El Salvador (c). Dark grey areas are those where no conflict has been reported. For reference, Figure 30 shows the spatial distribution of the conflict–climate nexus. Dark grey areas have no conflict reported according to ACLED.

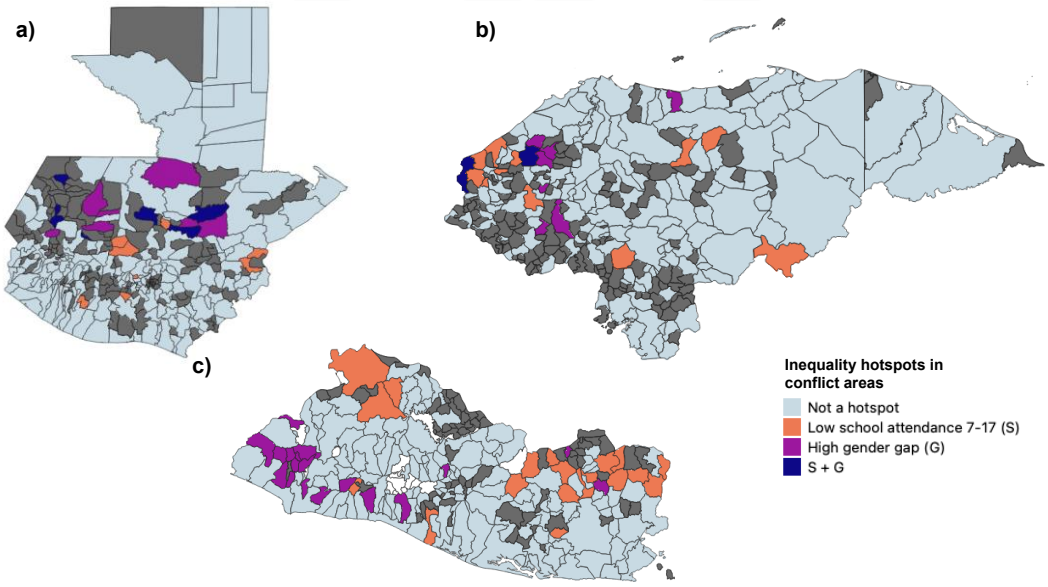


Figure 21. Inequality hotspots in the CADC for Guatemala (a), Honduras (b), and El Salvador (c). Dark grey areas are those where no conflict has been reported. For reference, Fig. 30 shows the spatial distribution of the conflict–climate nexus. Dark grey areas have no conflict reported according to ACLED.

Agricultural and natural ecosystem productivity within climate, conflict and food security hotspots

Hotspots where low agricultural or ecosystem productivity exist are determined based on the hypothesis that where these agricultural or ecosystem resources are limited, it is more likely that competition for resources will lead to migration and conflict.

Agricultural and natural ecosystem productivity is assessed using six different variables: (i) the upper bound of net primary productivity (NPP); (ii) the stability of NPP (coefficient of variation); (iii) the total harvested area for staple crops (bean, maize, and rice); and (iv) the yield gaps of these staple crops (bean, maize, rice). Areas of low NPP, low NPP stability, high cultivation density of staple crops and high yield gaps of these crops are flagged as hotspots. Individual variable hotpots were aggregated to produce a map of combined (count) of productivity issues (Figure 22). We use the count given the relatively number of hotspot combinations between the variables that arise across the geography of the CADC.

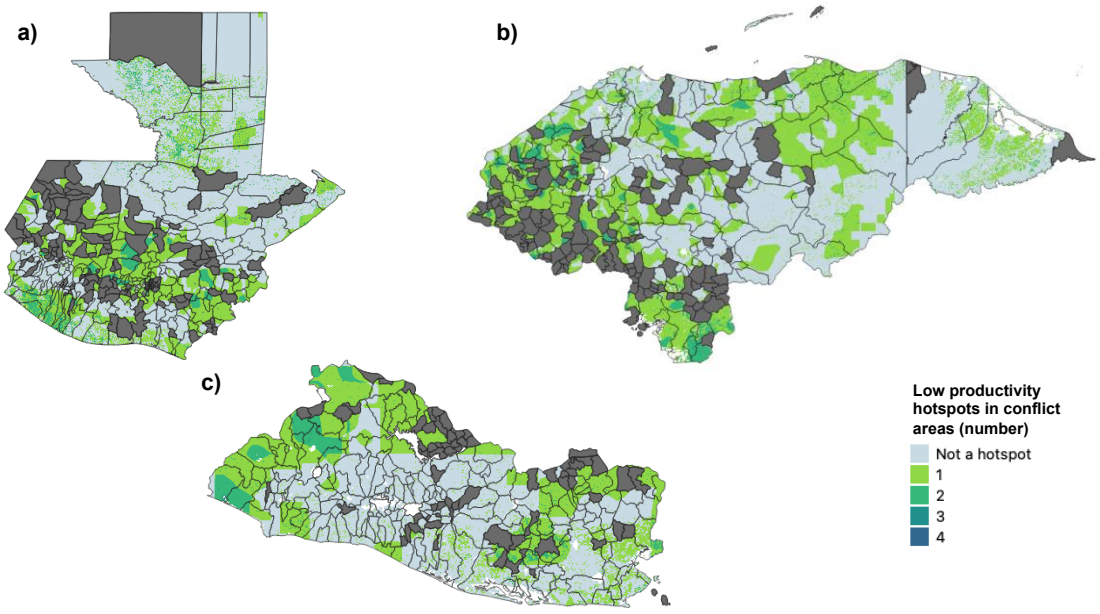


Figure 22. Low productivity hotspots in the CADC for Guatemala (a), Honduras (b), and El Salvador (c). Dark grey areas are those where no conflict has been reported. For reference, Figure 30 shows the spatial distribution of the conflict–climate nexus. Dark grey areas have no conflict reported according to ACLED.

The analysis shows that:

- In Guatemala, low productivity hotspots are mainly concentrated across the subsistence farming area (south of Quiche, Huehuetenango, and departments of Chimaltenango, Totonicapan, Solola and Quetzaltenango), and to a lesser extent in the south.
- In Honduras, we find hotspots toward the south (Fonseca Gulf) but also in the west, where undernutrition and inequality are also problematic.
- Finally, in El Salvador, low productivity is concentrated towards the west of the country, in the border with Guatemala.

Access to other valuable resources within climate, conflict, and food security hotspots

Valuable resources can also represent a source of conflict if groups with different interests fight for such resources (Figure 23). Here we analysed three key resources known to have significant impact on conflict in the CADC. These were (i) the accessibility (travel time) to mining concessions; (ii) the accessibility to deforestation; and (iii) the density of cash crops (coffee and cotton). We hypothesise that areas with greater access to mining and forest resources, as well as high density of cash crop cultivation are more likely leading to conflict since these areas are desired by many competing groups.

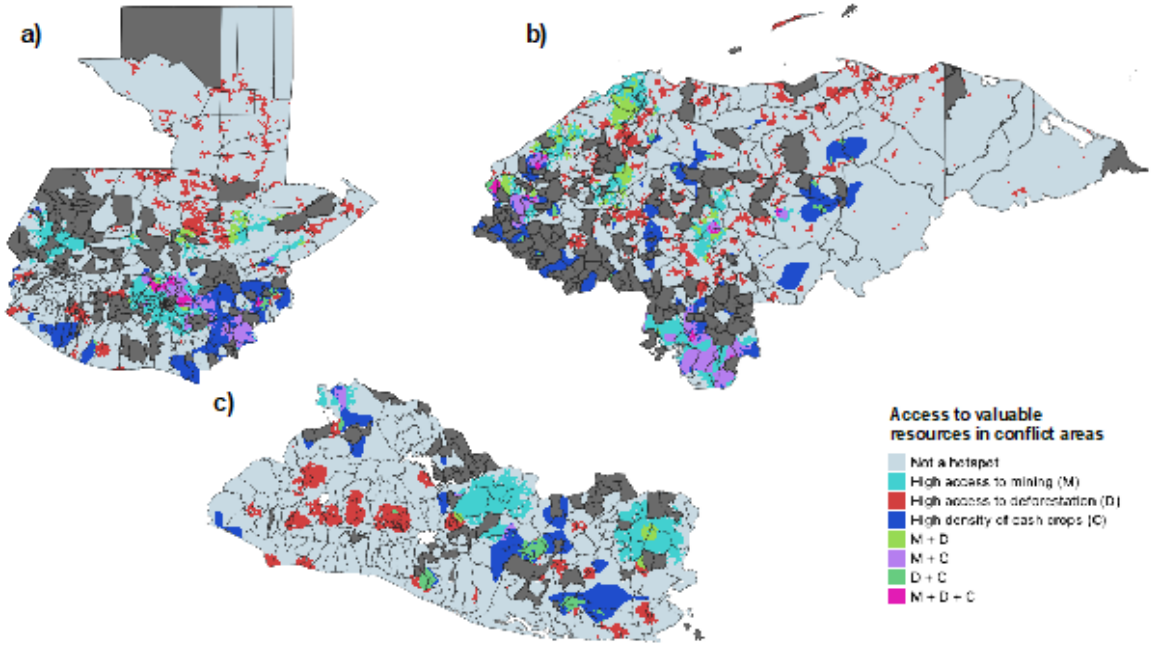


Figure 23. Hotspots of access to valuable resources in the CADC for Guatemala (a), Honduras (b), and El Salvador (c). Dark grey areas are those where no conflict has been reported. Dark grey areas have no conflict reported according to ACLED.

Our results indicate that:

- In Guatemala, high conflict areas are associated with high accessibility to mining concessions, and to a lesser extent the combination of mining and cash crops, and the combination of those with deforestation areas. In moderate conflict areas, we note more prevalence of deforestation access spots (Peten department) and cash crop presence (south).
- A similar pattern is identified for Honduras, where high conflict and moderate conflict co-occur with mining and/or mining – cash crop density areas.
- In El Salvador, high diversity conflict tends to co-occur near deforestation areas, whereas moderate conflict is more likely in areas of high cash crop cultivation.

Hotspots of multiple insecurities combined

We analysed the climate security nexus and its co-occurrence with food insecurity, undernutrition, inequality, agricultural productivity, and valuable resource access. Combining all these dimensions reveals overall hotspot areas (Figure 24) in different locations of the conflict–climate nexus. Here we use the count of dimensions given that the number of hotspot combinations arising from the four dimensions is relatively large (16 in total). We specifically highlight the following,

- In Guatemala, particular attention should be given to the rural and peri-urban areas around Guatemala City, which show high conflict occurrence while at the same time being socially vulnerable. We also highlight the subsistence farming areas in Huehuetenango, Quiché, and Baja Verapaz, where social vulnerability is high and climate conditions can exacerbate this vulnerability. While these areas are classified as having only limited conflict, conflict is still prevalent.
- In Honduras, the southern areas (Choluteca department) show significant social and biophysical vulnerability, while also showing moderate to high conflict. In these areas, we find occurrence of poorly productive staple crop systems, combined with high accessibility to mining concessions and some presence of cash crops (cotton, coffee). We also highlight the areas of western Honduras (Copán, Intibucá, Lempira) where nutritional insecurity is high, but conflict has low intensity and diversity.
- In El Salvador, vulnerability hotspots tend to cover border areas (with both Honduras and Guatemala), and though these areas do not show high conflict, they show high prevalence of stunting. High conflict areas of El Salvador tend to be associated with access to deforestation, defined as the opportunity for groups to carry out deforestation activities outside the control of the authorities, whereas the moderate conflict cluster shows low agricultural productivity for staple crops, high density of cash crops, and to a lesser degree access to deforestation spots

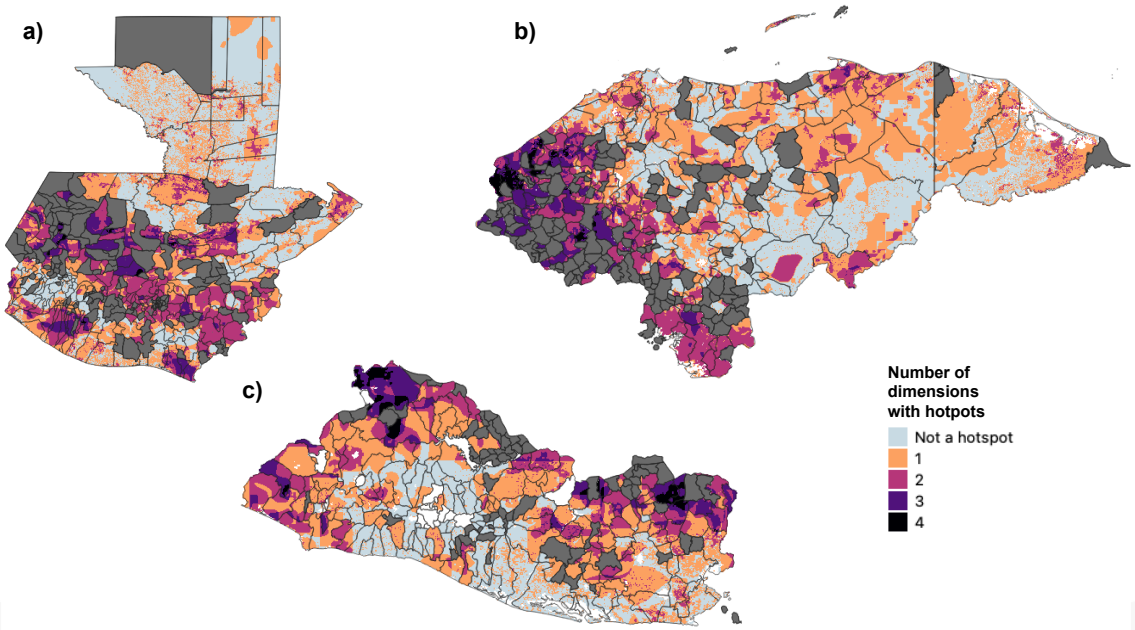


Figure 24. Multi-dimensional hotspots overlaid on the conflict–food insecurity–climate nexus in CADC for Guatemala (a), Honduras (b), and El Salvador (c). Dark grey areas are those where no conflict has been reported. The values show the count of dimensions highlighted as hotspots from a total of four dimensions, namely, high undernutrition, inequality, low productivity, and high potential for access to valuable (mining, forest, cash crop cultivation) resources.

How can WFP programming become more climate security sensitive?

We have carried out a series of key informant interviews with representatives of different WFP divisions and teams to identify a set of priority areas needed to increase WFP programming sensitiveness to climate security concerns. The following sub-sections discuss the priority areas for the following WFP teams: Social protection, Nutrition, SAMS, School Feeding, Emergency operations, FFA and gender. Social Protection programming

Social protection interventions are crucial in the mitigation of those existing risks and insecurities that climate and conflict can exacerbate. WFP work on social protection is strictly linked to national governments' work. Its main role is in supporting national governments in creating or improving existing systems and schemes, such as safety nets, working on the government's behalf only when directly invited on schemes that the government will take up in the near future. Therefore, WFP social protection programming in climate insecure setting should focus on three main priorities:

1. Ensure equality and equity of access to food assistance and social protection schemes to the entire population. In area with high intensity of conflict, this can be done by: 1) separating humanitarian and development needs from the causes of conflicts; 2) keeping the advocacy focus on human rights and provision of technical assistance.

In highly insecure area, WFP social protection interventions are difficult to implement. This is because WFP cannot take sides or decide to work in areas that are mostly populated by the opposition parties or by rebel organisations. Nonetheless, food assistance, humanitarian aid and equal access can be granted to the whole population if the discussion with the national government keeps a human rights angle, and it clearly focuses on the provision of specialised technical assistance. In highly unstable and conflict affected area, it is therefore important to separate between the humanitarian and development needs from the root cause of conflict. This approach proved highly successful in Sri Lanka, where despite a major conflict between the central government and the rebel groups, WFP has been able to provide food assistance effectively across the entire population. Furthermore, despite its limited role on root causes of conflict during emergencies, WFP plays an active role in post-conflict settings. Social protection advocacy efforts by WFP have been successful in addressing the main divide created by conflicts. For instance, in Myanmar, WFP has provided significant relief and built bridges across the different parties through humanitarian interventions.

2. Ensure that social protection schemes are flexible enough to take into account the impact of the climate crisis by supporting the government in the adoption of a "Shock Responsive Social Protection" policy that includes the development of an effective early warning system and SOPs.

WFP can work with government in making social protection schemes flexible and adaptable to the changing needs of the population. An example of the so called "Shock-Responsive Social Protection" can be found in Burkina Faso, where WFP has advocated for the inclusion of food security in the national policy as well as for the development of a scheme that is responsive to climate change impacts. Within this scheme, households are provided with a monthly cash transfer that becomes higher during those months that are known to be regularly hit by severe droughts, ensuring that their level of food security is kept constant throughout the year, despite the impact of climate on local productive assets. Furthermore, in areas where climate impacts are high, it is crucial to also advocate and strengthen early warning systems that trigger social protection schemes effectively throughout the year. Successful examples of this are the Dominican Republic, Madagascar and Uganda. In these countries, WFP has been working with the national governments for the adoption of the Standard Operation Protocols for a Shock Responsive Social Protection

policy. The Dominican Republic and Madagascar have already been able to institutionalise them and also active them during the COVID19 pandemic.

3. Support national governments in unpacking the multi-dimensionalities and complexity of poverty and its linkages with the impacts of the climate crisis.

WFP supports governments in mainstreaming climate issues in the national social protection policies. However, these advocacy efforts are often quite challenging as policies often focus on poverty, and usually without accounting for its multi-dimensionality or for its linkages with the climate crisis.

Nutrition programming

Our analysis also shows that nutrition insecurity can be exacerbated by climate and, in turn, increases the likelihood and intensity of conflicts. Acknowledging and mitigating the link between climate security and nutrition is critical to ensure that people living in harsher climatic and insecure areas can have regular and systematic access to nutritious food and diets. In WFP, nutrition interventions are cross-cutting, intersecting with multiple programmes, including gender. In climate insecure areas, WFP nutrition programming should focus on the following priorities:

1. To effectively address nutritional needs of people living in climate insecure areas, integrated climate and nutrition analysis should be carried out during the design stage of both climate and nutrition interventions.

An example of the type of nutrition analysis that could be used is the "Fill the nutrition gap" analysis, which uses qualitative and quantitative methods to understand the nutritional context, estimate food affordability in local settings and identify suitable interventions. Linking this with climate activities will be critical for building resilience of the most vulnerable. Although a fully-fledged integrated approach is not yet developed within WFP, in Tanzania Social Behaviour Change Communication (SBCC) approaches are used to ensure that the communities are aware of good nutrition principles but also that climate smart approaches are adopted. Similarly, WFP should ensure that nutrition is effective integrated into the peace and security programming. This tripartite dialogue between nutrition, climate and conflict should be initiated and institutionalised.

2. In areas highly political insecure areas and/or with active conflicts, food assistance should be prioritised, while in presence of localised and low intensity conflict nutrition activities should be coupled with FFA interventions that strengthen dialogue across groups and help defusing tensions.

In highly fragile and conflict setting, nutrition activities focus on addressing immediate needs of the population via food assistance activities. Nonetheless, in presence of localised and low intensity conflicts, such as farmers – herders' conflicts, WFP also helps increasing the dialogue across groups in the community, via the community-based planning and FFA interventions aiming to build social cohesion. These activities ensure that both farmers and herders have access to productive assets and can reach their essential needs in terms of food and nutrition security. An example of this approach can be found in Chad, where WFP supported the creation of fencing to protect crops from animals and producing a diverse set of crops, increasing climate resilience, among other activities. In the targeted communities, nutrition has improved significantly especially for young people.

3. In areas most exposed and vulnerable to extreme climate conditions, nutrition activities should be coupled with those FFA activities that aim to strengthen resilience capacities (e.g. landscape restoration, adoption of climate smart practices).

In harshest climatic condition, as in the case of some parts of the Sahel, WFP implements integrated programmes which combines asset creation to food assistance and school meals. FFA activities, such as landscape restoration, adoption of climate smart practices, nutrition sensitive agricultural production and technical assistance are carried out to ensure that agricultural activities become resilient to climate impacts and that at the same time households can meet their nutrition needs. On the other hand, home-grown school feeding activities are more suitable in area less vulnerable to climate impacts.

4. In areas with protracted conflict and high exposure to extreme climatic conditions, a diverse set of integrated WFP nutrition interventions should be carried out to improve the entire set of resilience capacities.

Where protracted conflicts are present in addition to adverse climatic conditions, WFP also works to enhance peace and development and create an enabling environment to increase resilience to climate shocks and stressors of the targeted communities, including climate and political shocks. This includes activities:

- To improve the capacity to absorb shocks and stressors, such as food assistance.
- To adapt to the climate crisis, including linking nutrition activities to the FFA approach, making sure that households can grow their own crops, have access to right type of resources and information to understand climate impacts.
- To transform behaviours and systems in light of the increasing climate impacts, including capacity building activities, working with government in strengthening preparedness, establishing early warning systems that are sensitive to nutritional needs.

Small Agriculture Market Support (SAMS) programming

Keeping value chains efficient and operational during times of high insecurities is critical to ensure long term stability and security in communities. The Technical briefing Note "Peace, Conflict and Food Systems, Value Chains, and Smallholder Farmer Access to Markets", identifies four main pathways whereby SAMS operations can contribute to keeping peace and security, via enabling and keeping trust, strengthening relationships and contribute to a shared and equitable economic growth. To address climate security issues, SAMS programming must build on these pathways and enforce its commitment to a more integrated programming, which links with climate resilience, nutrition, agricultural productivity, and gender inequality. For this purpose, the following priorities have been identified to link SAMS interventions to climate security concerns:

1. Ensure that SAMS interventions address climate security concerns across the entire value chain, via strengthening resilience capacities and mitigating the climate security nexus.

There exists five main entry points to make SAMS value chains more sensitive to climate security issues. At buyers' level, SAMS should support the purchase of drought resilient crops to mitigate the impact of climate on the production side. At aggregator level, activities should aim to improve storage practices and energy savings practices. At farmers' level, support should be provided to enhance the diversification of crops, adoption of climate resilient crops, providing inputs and insurances services. At consumers level, focus should be on local value chains, implement Social Behaviour Change Communication and awareness raising activities. And, finally, at market and system level, WFP SAMS should strengthen infrastructure and establish trading platform and increase sensitiveness of policy and regulations to the climate security nexus.

2. Tailor specific interventions to local risks that are exacerbated by climate insecurity. In areas of high political instability and in presence of active conflicts, SAMS operations should focus on shorter value

chains, linking local small holder farmers and close buyers, retailers, and schools and building on traditional systems of collective work.

When possible, value chain relationships should be kept within the same region. Specific activities include cash-based transfers, increasing capacity in governance, post-harvest management, training. The focus on these activities should be to keep and strengthen social cohesion, trusts and relationships across value chain actors, different groups in the same community, refugees, and host communities. In fact, value chain activities, if fair transactions and contractual arrangements are set up, might even create incentives across groups to cooperate for the common economic growth despite social and cultural differences, and therefore reduce the likelihood of future tensions and conflicts. For SAMS to be successful in unstable and fragile contexts, it is critical to build on those traditional systems that relay on collective work. In Liberia, for example, linking the traditional value of kuus, communal actions to prepare fields, to the establishment of future purchase commitments allowed the rehabilitation of community relationships in the aftermath of the civil war that destroyed infrastructure and caused overgrown land.

3. In areas with high climate variability and extremes it is crucial to provide training and capacity building activities to increase knowledge and adoption of climate resilience crops, facilitate access to markets and reduce the risk of grievances.

An integrated programming, linking PRO-C activities, such as insurance, risk reduction and savings schemes, and SAMS activities would require the alignment of objectives that move beyond the production stage, possible via the support of climate smart agricultural practices and adoption of energy efficient practices that would ensure stable production and returns also during period of crisis.

4. In areas of high gender inequality, SAMS activities should prioritise value chains where women play a significant role and support women's leadership roles across these.

Climate security concerns related to high gender inequality and nutrition insecurity can be addressed via a better integrated programming at different levels. To address gender inequality at farmers level, SAMS focuses on value chains where women play a significant role, provides training and equipment directly to women and increase their access to resources and decision making across the entire value chain. At aggregator level, SAMS should work to increase women's representations in decision making process and at market level it supports the government and advocates for development of gender sensitive policies.

5. In areas with high nutrition insecurities, SAMS should focus on shorter value chains while strengthening longer supply chains to increase local offer of highly nutritious food.

To address issues related to nutrition security, SAMS should work with shorter value chains, linking producers to local schools and retailers. It should also strengthen longer supply chains for the process of fortification and other nutrition enhancing activities to increase availability of bio-fortified crops. Additionally, it carries our nutrition awareness activities, grants access to markets and supports the development and enforcement of fair contractual arrangements.

School feeding programming

School feeding (SF) interventions include a combination of school, health and nutrition approaches. A new corporate strategy was developed in 2020 building on the evidence that the most effective way to improve and sustain children's health and wellbeing is to directly invest on the health and nutrition of the learner. School feeding activities can play a strong role in mitigating the climate security nexus. It has been long recognised that keeping children in school and well-nourished can contribute to peace building, via

preventing enrolment in armed group and providing food security to whole households. School feeding interventions can also constitute an incentive to keep school open during crises as they might be the only source of food for vulnerable households. For the WFP SF agenda to become truly climate security sensitive, the following priorities have been identified:

1. Strengthen the role of SF activities in community ownership and engagement to build trust across groups and, consequently reduce local tensions and grievances.

A strong collaboration between WFP SF and the emergency transition team is needed to make SF activities more conflict sensitive. Detailed conflict and power dynamics analysis are needed to not only understand active conflicts, tensions and root causes of those but also to provide a clear picture of how schools can contribute to peace and security in the community. The role of WFP and the choice of school feeding interventions depends on a set of indicators that identify the level of economic and human capital of the country, the level of instability, intensity and type of conflicts presents in the country. In active conflict settings, for instance Chad, Niger, Mali or Nigeria, WFP has an active operational, emergency, humanitarian role, helping the governments in delivering emergency interventions. The type of school feeding interventions in these settings will depend on the type of conflict and emergency. A good example of innovative school feeding activities in emergencies is the creation of "mobile schools" by the government of Niger, that are specifically designed to help keeping children in school during periods of emergency induced displacements. Others include making arrangement for sending children to schools located in neighbouring areas where tensions and conflicts are not that high. More insights on how to best carry out school feeding interventions in emergencies will be provided by the upcoming evaluation of WFP school feeding programming in DRC, Syria, Niger and Lebanon.

2. To increase resilience to climate insecurity, SF should work with SAMS and FFA teams and ensure that school source from local producers, that land and water insecurities are addressed and that households have access to nutritious food, also and especially during period of crisis.

In areas most exposed to climate extremes and variability, SF should strengthen its linkages with those interventions that aim to increase resilience to climatic shocks in the medium term. This would mean linking school food provision from local producers and suppliers as well as investing in reducing land degradation, improve watershed management and support production of good quality and nutritious food crops. Therefore, building resilience to climate extremes and vulnerability would require the combination of SAMS, SF and FFA interventions.

3. Advocate and support the adoption of Shock Responsive Social Protection policies that allocated and enforce school feeding interventions during period of crisis.

A key entry point for SF interventions to effectively respond to climate security concerns is the adoption by national government of the "Shock Responsive Social Protection" policies. The COVID19 pandemic has demonstrated that countries are able to flexibly expand and allocate safety net schemes due to emergencies. School Feeding should become an active part of these policies. An example of this can be found in the Caribbean, and especially in Jamaica, Dominica, British Virgin Islands, and the Bahamas, where national cash transfer and/or voucher programmes were effectively leveraged to provide relief support during shocks (Barca et al. 2019). Linking these programmes with school feeding interventions will ensure that schools are kept open where possible and that children, households and local producers can increase their hazard resilience in the short to medium term.

4. Ensure that inequalities are appropriately addressed and tailored.

School feeding interventions can also help mitigating inequalities. Examples of these interventions are the take-home rations, which support food security and access to education for girls, and lean season interventions which support the most vulnerable and food insecure households during periods of crisis. For SF interventions to be truly sensitive to these concerns, ad hoc nutrition situation analysis should be complemented by detailed gender and conflict analysis.

Emergency operation division programming

EME programmatic response is often seasonal and mostly related to provide relief in the aftermath of climate disasters. The main role of EME is to ensure access to food assistance to the groups affected by disasters. Timing of these interventions is critical for these interventions and often reaching people in need is highly challenging. This is the case of countries where active conflicts are present. In some of these contexts, as for instance, in Syria, WFP EME is forced to adopt expensive practices, such as air drops to deliver food assistance. In areas of protracted crisis, for example those lasting for one month or more, EME supports WFP country offices in the distribution food, cash, and nutrition activities to prevent and treat acute malnutrition. In case of widespread displacement, EME also supports the provision of packages of these interventions via mobile phones, as in Burkina Faso. Although the focus of EME interventions is on saving lives, these activities can also play a significant role in mitigating climate security concerns during and before the insurgence of crisis. For this purpose, the following priorities have been identified to link EME interventions to climate security concerns:

1. Enhance participatory design of climate sensitive interventions to respond to community needs of regular access to nutritious food and crops and production support in collaboration with FAO and UNDP.

EME supports the collaboration with other UN and local agencies to ensure alignment and coherence of emergency interventions with long term programmes that aim to increase resilience capacity of local communities while ensure food and nutrition security. Working with communities, EME identifies the type of food and assistance (e.g. local procurement systems, storage capacity, improvement of yields) that communities need to be able to respond and adapt to the climate crisis.

2. Strengthen the use EME assistance to enhance communication and interaction across groups in the communities and interventions and to provide incentive for the government for an equal access to benefits of all competing parties in the short and long run.

For instance, in Tigray, where markets are not functioning, WFP EME interventions are critical to ensure access to nutritious food to for the entire population, defusing potential tensions related to food security issues. Moreover, in addressing Rohingya refugee crisis, EME was able to neutrality and impartiality and ensure to intervene in these areas, provide assistance to people in the short run and advocate for a more equal social protection schemes despite the local disputes. EME interventions should be more and more used to foster dialogue, build trust and defuse tensions across competing groups.

3. Strengthen the use of early warning systems and analyses to mitigate the climate security nexus and prevent the need for humanitarian interventions.

Oftentimes crises do not occur in a vacuum. Signs of tensions and conflicts are evident for months before they escalate in active conflicts and might be directly linked to climate events. This is the case for instance of Madagascar, where La Nina related events coupled with repeated seasonal production fails significantly contributed to generate grievances and exacerbated insecurities that then erupted in conflicts. Therefore, it is important for WFP to capture these signals well in advance. EME has developed a set of Early Warning

analyses (ADAM; Watch List) and a conflict forecasting tool (CAS) to help WFP HQ and country offices to inform humanitarian and emergency interventions in a timely fashion. CAS analyses are directly available to COs and Early Warning monthly analysis are shared with COs regularly. These analyses are then used by the COs to estimate the amount of people that would need assistance during the expected emergencies. Despite critical in the planning of humanitarian interventions, these analyses do not effectively mitigate the climate security nexus ahead of the insurgence of the crisis. Integrating these systems with evidence on how climate and other crisis can lead to emergencies via the exacerbation of existing risks and insecurities could contribute to reducing the need for relief and humanitarian interventions in the future.

4. Ensure stable and strong presence in climate insecure countries of WFP operations to support national institutions and local communities in mitigating climate security concerns.

Not all conflicts are of large scale and active. In many countries where WFP operates, there exists low intensity tensions and conflicts that could still significantly affect food and nutrition security. In these cases, the role of WFP EME is in enforcing the implementation of humanitarian principles, building on years of interactions and relationships between WFP overall and the local government. EME work throughout the year focus on building and increasing awareness and knowledge across local stakeholders and beneficiaries. This has, for instance, ensured access to Tigray with the support of both Ethiopian and Eritrean forces.

5. Regularly monitor the insurgence on grievances and insecurities at community level to address root causes of insecurities.

The complaint mechanisms are effective tools for EME to understand where local grievances are building and can be used to start the discussions on those with local governments. Active presence in the field is also important. In Tigray for example WFP EME has deployed two staff to improve WFP programming sensitivity to conflict via directly engaging with local communities in the region to understand their needs during periods of crisis. Finally, in Tanzania, using the findings of an impact analysis in refugee camps, EME has been able to advocate for the withdrawal of restrictions imposed by the government on the refugee population, which had a significant impact on the role of women in the communities. Strengthening the field presence and the real time monitoring of risks, grievances and tensions will be critical for changing and saving lives of people in climate insecure areas.

Food For Assets programming

Although FFA interventions are not suitable in areas with highly climate insecure areas, there exists some critical entry points that would ensure stability and sustainability needed for asset creation:

1. Create a FFA enabling environment even in more insecure areas.

In countries affected by active conflicts, such as Yemen, it is crucial to identify those more stable settings within which FFA can be implemented. In these areas as well as those countries affected by localised and moderate or limited intensity conflicts, such as the ones between farmers and herders, FFA interventions should aim to increase access to natural resources, such as water, including building and/or strengthening institutional arrangements that take into account transhumance movement and proper use and access to important assets for both farming and pastoralists neighbouring communities.

2. Ensure an equal access to assets, such as land, and strengthen trust across to different groups in the community.

In presence of refugees-hosts communities' tensions, FFA could be working on strengthening and broadening of land rights and other related policies to ensure that refugees and host communities are

equally able to benefit from WFP interventions. An example is the case of Zimbabwe, where as a consequence of a land reform, entire communities where displaced across the country, increasing tensions and instabilities. WFP, in collaboration with a local NGO, worked to improve the relationship, trust and communication across displaced and resident communities, which in turn created the enabling environment for effective and sustainable FFA asset creation, with shared benefits and improved livelihood across all the communities, displaced and resident.

3. Address access to essential resources in the aftermath of climate events, first, and then improve climate resilience capacities.

In area highly exposed to climate variability and extremes, FFA interventions can contribute to easing immediate impacts of such climatic conditions and events. In this scenario, FFA activities would aim to, first, address water scarcity, via the construction, for example, of water storages, reduce desertification trends, by landscape restoration and other soil interventions to improve ground water recharge, decrease erosion, and overall increase water availability. Once these immediate needs are addressed, FFA could also work to improve local capacity in adopting and using climate smart agricultural practices. Among these practices, FFA focuses mostly on water availability and soil rehabilitation and not so much on climate resilient crops and crops' related technologies. This is somehow beyond WFP's scope.

4. Strengthen collaboration between FFA and emergency response teams to ensure food and nutrition security in emergencies.

To address the multitude of climate security concerns, an integrated programming, linking FFA with other WFP units will be needed. For example, in areas where there exist high nutrition insecurities, and following the three-pronged approach, FFA should collaborates with the humanitarian and emergency teams to improve immediate food security needs of the targeted population. This will ensure that FFA beneficiaries are healthy and able to contribute to FFA related activities and at the same time continue improving their food security. Other important complementary activities are those that improve energy access and access to alternative fuels.

5. Explicitly address gender inequalities.

Among other climate security concerns, such as gender inequality, FFA interventions should be implemented to achieve an equal distribution of benefits across women, men and other vulnerable groups. For instance, interventions aiming to reduce the time used particularly by women in accessing water should be prioritised in areas with higher gender inequality. It will also be important to work on social norms that constrain women's diversity of livelihoods. For instance, in Zimbabwe, WFP interventions influenced the role of women and men in washing clothes, a chore traditionally carried out by women and now undertaken by both men and women in the community. Changing social norms related to traditional roles in the community is critical to increase climate security resilience among women and other most vulnerable groups.

6. Strengthen climate smart practices and technologies in FFA interventions.

WFP's Food for Assets interventions include a waste variety of practices and technologies that help adapt to and mitigate progressive climate change, while increasing agricultural productivity and income – or otherwise called Climate Smart Agriculture (CSA). However, FFA interventions often don't systematically highlight and measures such benefits contributing to climate resilience. Increased awareness and systematic use of CSA could help thrive adaptation and mitigation actions in WFP's saving and changing live programming.

Gender programming

Our analysis shows that one important driver of the climate security nexus in Ethiopia is gender inequality, especially related to education. The role of women as agents of peace and rebuilders after conflicts has been widely recognized and the importance of including women in peace talks and reconstructions strongly recommended also by the UN Resolution 3025 (S/RES/1325) on Women, Peace and Security (The UN Security Council 2010). This resolution clearly argues that women are better in keeping peace in the communities, in building trust. WFP recognises that improving inequality and power relations in the community will increase the ability of women to improve their resilience capacities and to contribute to keeping peace and stability in the communities. Therefore, reducing inequality could contribute to addressing both climate and security vulnerability.

As of now, gender is not effectively mainstreamed in the WFP climate and conflict programming, despite some donor interest in the topic. To make WFP gender programming more climate security sensitive the following priorities should be pursued:

1. Ensure that girls are kept in school also during emergencies to avoid child marriages and multiplier effects on food and nutrition securities, which are key drivers of further tensions and conflict.

There exists evidence that climate can increase inequality and that this in turn can increase food and nutrition insecurities, and lead to further tensions and conflicts, especially in emergency settings. Women are particularly vulnerable during emergencies. Child/forced marriage increases significantly during conflicts and wars. Early marriage has a substantial multiplier effect on the nutrition of the children, reducing with every year of missed education by the mother. Therefore, WFP should ensure that girls continue going to school and are well nourished, for instance via combining Social Behaviour Communication Change interventions and school feeding. Moreover, in fragile and climate vulnerable areas, providing incentives to families and not only to women might help in reduce inequality. For instance, the take-home rations as part of the School Feeding WFP programme in Mozambique and Zambia have been found to increase women's participation to education, even in times of difficulties.

2. Tailor interventions to reduce inequalities and counteract existing social norms and foster women's leadership roles to decrease tensions at community level.

In certain occasions WFP activities, for example climate solutions, might not be able to reach women effectively as women do not have access to the right assets. For instance, insurance interventions might end up excluding women as they often do not own mobiles used for insurance transactions. Similarly, for climate information services it is essential that assets, such as radio, are accessible by women, men and most vulnerable groups equally. WFP should tailor its interventions to the needs of the women and define selection criteria for its activities accordingly. The Adaptation Fund project "Building adaptive capacity through food and nutrition security and peacebuilding actions in vulnerable Afro and indigenous communities in the Colombia-Ecuador border area (Colombia, Ecuador)" is one of the few examples where WFP has been able to address issues of climate, security, and gender effectively. In this project, for instance, after realising that women were not effectively involved in the community decision making process, despite being the most knowledgeable on how to respond to climatic crisis, WFP changed their operations drastically to increase women participation and voice.

Another example of interventions that link climate security issues with gender is in Mauritania, where FFA activities have been carried out specifically targeting women with the main objective of both improving climate change resilience and creating a culture of peace in two communities. In Libya, WFP has implemented activities to rebuild livelihoods along the Tunisia and Libya border, working specifically with

women, who are now recognised as acting leaders in their communities, have increased livelihood opportunities and improved their education. Also in Nicaragua, WFP has provided a “degranadora” machine, that has reduced drastically the time that women used for maize processing, allowing them to produce outputs of higher quality and freed time for women to attend community meetings.

Moreover, to effectively address inequality, WFP ought to become gender transformative, changing the power relations in communities and directly intervening on those social norms that for instance force women to eat last, do not allow them to own land and other important agricultural assets or to access training. WFP must promote interventions that improve the position of women and most vulnerable in the places of power in the community. WFP has worked on this on few occasions, supporting gathering of men, women and other people in the communities and giving women a leading role in certain activities.

3. Always making sure that women are safe, healthy, and well nourished, first.

It remains that essential needs of girls and women must be addressed first. Increasing their food, health and nutrition security and safety are a pre-requisite for women to become agents of positive change, re-builders and peacekeeping actors in the community. Aside from food assistance, WFP also provides shelter to the victims of violence. Improving safety and overall wellbeing is critical for women to contribute to increasing climate resilience and the prospect of peace in the community.

4. Ensure that a gender sensitive and transformative approach does not generate further tensions and conflicts in the community via a thorough integrated monitoring system.

In certain contexts, targeting women might also generate tensions, conflicts withing communities and cause domestic violence. Therefore, a thorough monitoring of interventions that disproportionately target women must be implemented to ensure that peace and stability is kept within the households and communities.

Conclusions

In this study, we investigate the climate-food security-conflict nexus in Ethiopia and the CADC (Guatemala, El Salvador, Nicaragua, Honduras). Both Ethiopia and the CADC are hotspots of high climate variabilities, high political insecurity, and conflicts and widespread food and nutrition insecurities across their populations. Therefore, the main research questions that this study aims to answer for the CADC countries:

- Is climate exacerbating existing threats that could increase the risk of conflict in the CADC countries and in Ethiopia?
- Are areas of high climate variability correlated to high socio-political insecurity in the CADC countries and in Ethiopia?
- How can WFP programming become more climate security sensitive?

Our main findings can be summarized as follows:

(1) Climate exacerbates existing household level risks and insecurities that can increase the likelihood and intensity of conflict. In other words, we find evidence that climate is a threat multiplier in Ethiopia and El Salvador[23].

(2) In addition to climate induced insecurities, there exist other important household level predictors of conflict, such as age, education, and gender of the head of the household, ethnicity, access to electricity and location in Ethiopia and El Salvador.

(3) The climate security nexus – the way climate, socio-economic and political risks and insecurities are linked to each other – differs across countries (Guatemala, Honduras, Nicaragua, El Salvador and Ethiopia) and conflict clusters.

(4) There exist "climate insecurity hotspots" at sub-national level where high level of climate variability, conflict intensity and diversity co-occur with other existing socio-economic insecurities.

Our main recommendations can be summarized as follows:

1. **To increase WFP programming sensitiveness to climate security concerns, a specific set of priority actions should be implemented across the entire spectrum of WFP operations for changing and saving lives.** More specifically,

    a. Strengthening the adoption of shock responsiveness of national and international interventions and policies, that aim to softened social protection policies to cope with crisis in a timely fashion and use early warning systems and protocols to prevent crisis and not only to prepare for upcoming ones.
    b. Addressing the root causes of conflict while maintain neutrality, via separating humanitarian and development needs from the causes of conflicts, keeping the advocacy focus on human rights and provision of technical assistance and enhancing active participation of communities in the design of interventions.
    c. Adopting a truly integrated programming, which accounts for the complexity and interconnectedness of the climate security nexus and that accurately defines and assess risks and insecurities in fragile and non-fragile settings across multiple dimensions.

[23] Note that for both Guatemala and Honduras we could not run household level analyses due to lack of suitable data.

d. Making women the agents of change, by tailoring interventions to reduce inequalities, counteracting existing social norms and fostering women's leadership roles to decrease tensions at community level.

2. **Qualitative analysis (stakeholders' interviews and focus group discussions) will be essential to validate the results of these analyses.** More specifically,

   a. SIPRI field work could target the climate insecure hotspots that have been identified and explore how socio-economic risks and insecurities have recently been exacerbated by climate and how these then affected the insurgence of grievances and conflict at local level.
   b. It will be essential to engage with local communities to identify those, if any, traditional and non-traditional mitigating factors, and systems that could alter the climate security nexus identified in this analysis.
   c. And related to this, a map of on-going national and international interventions that are contributing to the climate security nexus at community level could be useful.

3. **Any further quantitative analysis in assessing WFP sensitivity to climate security would require a substantial improvement in WFP data on operations.** More specifically,
   a. The accessibility and interoperability of WFP intervention data is very limited, partly because it is being collected using different standards and stored in different formats without the use of ontologies or metadata. SCOPE data are not representative of WFP's operations at country level. Nonetheless, it is the only source of information that we were able to access with detailed information on the specific location of WFP interventions. We thus suggest that project / WFP intervention data be made FAIR (Findable Accessible Interoperable and Reusable) and be stored with appropriate metadata.

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