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Climate security in the Central American Dry Corridor

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COVER PHOTO: In eastern Guatemala the daily struggle for water involves walking long distances to fetch water from overused streams. Photo: Manon Koningstein/CIAT

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CGIAR aims to address gaps in knowledge about climate change and food security for peace and security policies and operations through a unique multidisciplinary approach. Our main objective is to align evidence from the realms of climate, land, and food systems science with peacebuilding efforts already underway that address conflict through evidence-based environmental, political, and socio-economic solutions.

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EXECUTIVE SUMMARY

The evidence on conflicts around the world since the turn of the century points to a simple conclusion: conflicts, grievances and insecurities are increasingly being affected by changing climates, environmental degradation, food insecurity, and the struggle to control a finite pool of natural resources.

This paper aims to understand the linkages between climate, conflict, agriculture, and migration in the Central American Dry Corridor and offer a road map for the region while emphasizing the role of research and development. We do this by first clarifying what climate security means and how it links to risk and resilience (introduction). We then present causal impact pathways to describe how climate exacerbates drivers of conflict and insecurity (Section 1). We continue with a social media and policy coherence analysis to explain how the linkages between climate and conflict are perceived by the public (Section 2) and represented in public policies (Section 3). We then describe the linkages between climate and security for Honduras, El Salvador and Guatemala (Section 4). This is followed by an overview of indicators summarizing the state of climate security in Central America and the Dry Corridor and a discussion of the limitations of such indicators (Section 5). We then present existing research for development efforts and discuss their potential to contribute to climate security by mitigating its drivers (Section 6). We offer entry points for improving climate security in the Central American Dry Corridor (Section 7) and finally, Section 8 proposes entry points for incorporating climate security dimensions into rural development and regional and national security policy and research agendas.

The paper shows that interconnected climate, security, and migration crises are being managed as separate challenges in the Central American Dry Corridor. Through well-targeted support that complements humanitarian, political, social, and security-focused solutions, agricultural research and development can help rural populations adapt to and mitigate climate change impacts, stabilize agriculture-based livelihoods, and increase peace and security.

A spatial analysis of drivers of conflict demonstrates clearly that climate has the potential to exacerbate conflict, insecurity and migration. However, a social media and policy coherence analysis shows the disconnected discourses of climate and security both in the public discourse and in policies. The analysis of peace, security and climate risk indicators situates the Central American Dry Corridor countries vis-a-vis other countries globally and uncovers the disconnect among the indicators in terms of climate security, human wellbeing, and peace. In this fragmented context, we argue that investing in agriculture research and development, with its focus on enhancing resilience of agricultural production and rural livelihoods in response to climate change impacts, can contribute to reducing conflict and out-migration.

KEY MESSAGES

Key entry points for incorporating climate security dimensions into rural development and regional and national security policy and research agendas are:

- Foster inter-ministerial and inter-sectoral dialogue to overcome currently siloed perspectives, develop a shared understanding of problems, and agree on coordinated and joint actions.
- Leverage existing efforts to bring together a range of partners, to comprehensively quantify interrelated social, economic, and environmental challenges and business cases to target public and private sector investments, including in research.
- Build on existing regional networks and knowledge transfer platforms to re-think and re-design community-based approaches that can effectively serve a range of interrelated objectives, including capacity development aspects.

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INTRODUCTION

What is Climate Security and Why is it Important for the Central American Dry Corridor?

The changing climate is having severe negative impacts on livelihoods in developing countries. A key reason is that most economic and labor opportunities depend on the agricultural sector, which is increasingly affected by rising climate variability throughout the equatorial areas of the world (Beg et al. 2002; Campbell et al. 2016; Vermeulen et al. 2012). Some regions are especially prone to extreme climate events, among them the Central American Dry Corridor (CADC) (FAO 2017), where Guatemala, El Salvador, Honduras and Nicaragua are projected to be more frequently affected by extreme precipitation variability and intense droughts (Stocker et al. 2013).

The more frequently occurring droughts and floods in the CADC are posing a growing 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" [*i.e., increasing climate impacts*] "is impeding our efforts to eliminate our poverty and imperiling food security" (United Nations 2020b). Growing food insecurity threatens peace. Without peace, there is no end to hunger. And without climate-sensitive actions for peace and security, none of these efforts will succeed. Climate-related security risks manifest themselves when the impacts of climate change aggravate the drivers of insecurity and violent conflict (Brauch and Scheffran 2012).

To unpack the complex non-linearities of how aspects of climate and security relate, we begin with the premise that climate change is increasingly recognized as a “threat” or “risk multiplier”, with the potential to exacerbate effects of existing stresses and insecurities (Rüttinger et al. 2015). This can be particularly relevant for contexts characterized by fragility, that is "periods of instability” that “emerge when states or institutions lack the capacity, accountability, or legitimacy” to mitigate risks of violence (World Bank 2011). ; in other words, “the combination of exposure to risk and insufficient coping capacity of the state, system, and/or communities to manage, absorb, and mitigate those risks” (Desai and Forsberg 2020).

Although there is a growing body of academic and grey literature examining the climate security nexus, there is no consensus on a holistic definition of climate security. We draw on the existing understandings to present a comprehensive conceptual framework of climate security that can be useful for a wide range of audiences and stakeholders, including researchers, policymakers, development practitioners, government officials, and humanitarian actors.

The idea of security has been framed in multiple ways and at multiple scales, including national and international security, human security and environmental security. Our climate security framework mainly attempts to draw from the human security framework, which centers on people rather than states as key actors. Instead of the traditional understanding of security as territorial and constructed around the nation-state, the human security approach recognizes the need to integrate “freedom from fear” with “freedom from want” and legitimize security concerns of ordinary people facing threats of disease, hunger, unemployment, political repression, environmental hazards and human rights abuse (Liotta and Owen 2006). Violent conflict can be one of the ways through which insecurity manifests itself in situations characterized by instability and fragility.

Climate-related security risks can be viewed as systemic risks that emerge through interactions between ecological, social and political economic dimensions. The interactions are “driven by one or more climatic stressors that directly and/or indirect impact human security and that challenge the peace and stability of states and societies” (Weathering Risk 2020). Key components integral to a climate security framework are: 1) climatic stressors and their impacts on systems (climate lens); 2) drivers and actors informing economic, social, and political stability and insecurity in specific contexts (conflict lens); 3) context-specific interactions between climate impacts and peace and insecurity risks (pathways); and 4) context-specific structural factors shaping climate-conflict vulnerabilities and resilience, including gender inequality and social stratification (cross-cutting themes). The report, ‘A New Climate for Peace’, identifies seven specific climate fragility risks (Rüttinger et al. 2015) . These climate fragility risks describe the potential pathways by which climate impacts may interact with local insecurities to produce conflict outcomes:

- **Local resource competition:** When the pressure on natural resources increases, competition can lead to instability and even violent conflict in the absence of effective dispute resolution or resource sharing mechanisms.
- **Extreme weather events and disasters** will exacerbate fragility challenges and can increase people's vulnerability and grievances.
- **Sea-level rise and coastal degradation** threaten the viability of low-lying areas, potentially leading to social disruption, displacement and migration.
- **Transboundary water management:** Frequently a source of tensions, as demand grows and climate impacts affect quality and quantity, competition over water will increase pressure on existing governance structures.
- **Unintended effects of climate policies:** As climate adaptation policies are more broadly implemented, the risk of unintended negative side effects, particularly in conflict- fragile contexts, is increased.
- **Volatile food prices and provision:** Climate change is likely to disrupt food production in many regions, increasing prices and market volatility and thereby heightening the risk of protests, rioting, etc.
- **Livelihood insecurity and migration:** Climate change can increase the insecurity of people who depend on natural resources for their livelihoods, which may push them to migrate or turn to illegal sources of income.

Through these channels, climate impacts not only imperil food security, but can also trigger conflict, by compounding pre-existing sources of insecurity such as poverty, inequality and overall socio-political fragility (Koren and Bagozzi 2016). In the CADC, persistent extreme weather events and disasters, as well as long-term degradation, have given rise to compound fragility risks related to livelihood insecurity and attendant migration, local resource competition given the lack of resource sharing and dispute resolution mechanisms, as well as volatile food prices and food insecurity. These compounded risks have contributed to domestic and internal conflicts, such as gang violence, homicides, robberies and increasing participation in recruitment of armed groups that are endangering human security (Fogelbach 2011; Tellman et al. 2014). The main underlying drivers are economic instability and a lack of employment opportunities, loss of agricultural land, and lack of funding for education. The latter particularly affects local youth, increasing the likelihood that they are drawn into illegal groups and violent activities (Olate, Salas-Wright, and Vaughn 2012; Williams and Castellanos 2020).

The interacting social, economic, and political effects of increasing climate variability also affect both the nature and rate of human mobility. Climate-related migration is the product of individual and household level decision-making, as well as larger group dynamics (McLeman 2018). The tipping point at which migration occurs – and the point at which migration rates become non-linear – are situated downstream from a number of other critical thresholds; those that individuals, households, and communities cross as they adjust to shifting climatic conditions (Adger et al. 2009). Firstly, climatic shifts create a tipping point to which an adaptive response is required, where previously it was not. A second threshold occurs when such adaptive measures cease to have any beneficial effect. Finally, a third threshold occurs when the changed nature of the human-ecological relationship demands substantive changes in land use and/or livelihood strategies (Adger et al, 2009). McLeman (2018) identifies further thresholds specifically regarding migration: the first occurs when in situ adaptation is no longer possible and migration is the only valid adaptation option. Climate variability can give rise to reduced access to arable land, water shortages, decreased agricultural yields, and an associated loss of income and nutrition, thereby fundamentally undermining the viability of (rural) livelihoods. This can push people over a decision threshold. This threshold is the product of interactions between climate impacts and social, political, economic, and cultural processes. Whilst environmental hazards can act as a primary driver of migration, e.g., out-migration due to environmental catastrophe (Naik 2009), individuals most commonly cite social and economic factors as reasons for migrating. Climate or environmental hazards rarely appear as the primary driver (Black et al. 2011; Null and Risi 2016). Climate impacts may combine with market vulnerabilities, for instance, to undermine the viability of livelihoods and cause unemployment, which in turn gives rise to a migratory threshold.

The second tipping point (McLeman 2018) happens when migration rates themselves become non-linear. This is more readily apparent at the local scale and intimately related to the kind of climatic impacts a community is experiencing. A fast-onset climate disaster, for example, is likely to result in an immediate non-linear surge of movement, whereas slow-onset impacts exhibit significant time lags before migration rates become non-linear. This makes the influence of climate harder to empirically verify but does not mean it is absent. A third threshold occurs when migration rates cease to be non-linear, as migration group dynamics eventually cause rates to ebb.

Migration undertaken as a result of climate factors is likely to feed into pre-existing systems of migration, while at the same time potentially creating new ones (Ide 2020). In the Central American Dry Corridor, climate impacts are set to accelerate already ongoing socio-economic trends, such as permanent urbanization and people relying upon circular rural-urban migration. This has the potential to overwhelm already overstretched urban governance systems: demand for infrastructure and services in urban areas outpaces provision, thereby exacerbating pre-existing service deficiencies and housing scarcities (Rüttinger et al. 2015). Migrant populations often find their personal security undermined, as they are forced to accept employment in often unregulated and exploitative informal sectors. Stagnant economic and social conditions can also give rise to a variety of forms of unrest.

Adopting such a risk-based understanding invites us to consider how systems can become more resilient to climate fragility risks. At its simplest, resilience is the ability of a system to 'bounce back' to its previously stable state, following an external shock (Chesterman, Neely, and Gosling 2020). However, deploying this rather narrow conceptualization may undermine the very capacities that resilience building activities seek to create. Operationalizing the concept of resilience requires answering questions such as whose resilience, resilience to *what* and in *which* context and '*who decides, basis on what value system*?' (Cote and Nightingale 2012; Leach 2008).

A broad typology of resilience conceptualizations exists, defined differently depending on the actors involved, the scale at which resilience building is understood to take place, and the modalities under which it is undertaken. We apply the following taxonomy (Ferguson 2019; Methmann and Oels 2015):

- **Absorptive capacity:** Primarily, this is the ability of a system to bounce back to a previously stable state when subject to the impact of an exogenous shock. In the context of building resilience to climate shifts, this may include undertaking an early harvest to reduce food insecurity
- **Adaptive capacity:** The ability of a system to adjust, modify, or change itself to mitigate future dangers. In terms of climate, this may include, for instance, the introduction of drought-resistant seeds.
- **Transformative capacity:** A system creates a fundamentally new system that is not susceptible, or at least less susceptible, to climate change impacts, by reorganizing itself at a fundamental level to reduce exposure, vulnerability, and susceptibility.

Resilience is essential to understanding how climate fragility risks, under specific conditions, may not only inform the climate-fragility-conflict nexus, but how the risks may relate to a possible climate-resilience-peace nexus. This risk-resilience framing integrates both a negative cycle, moving from fragility to vulnerability, human insecurity and potential for violent conflict, and a positive, or virtuous cycle, where stable and inclusive institutions can enhance a society's resilience to generate pathways to human security and peace. To realize and operationalize the double dividend of resilience in terms of climate change and peace, one needs to factor in context-specific complexities and socio-economic dynamics, overcome institutional and political barriers and communicate across thematic and regional silos. Adaptation efforts would then be peace-positive and development and peacebuilding initiatives climate-sensitive (Vivekananda, Schilling, and Smith 2014).

This requires any planned activity to articulate *what kind of resilience* it is seeking to imbue, and in what way that type of resilience acts to mitigate both the immediate and long-term risks of conflict. Given how the drivers of climate-resilient peace (sustainability and resilience) are also those that underpin a positive peace (such as inclusive and accountable institutions), integrating a climate security-sensitive lens into CGIAR interventions would not only help ensure such interventions do no harm, but would also help articulate exactly how such interventions could contribute to the broader, system-wide transformation required to truly build climate resilience and contribute to a climate-resilient peace at scale. This brings us back to the questions, '*resilience of what type, and for whom*?' and '*who decides, basis on what value system*?' (Cote and Nightingale 2012; Leach 2008).

Can agricultural research for development (AR4D), which aims to support rural populations to adapt to and mitigate climate change impacts, contribute perspectives, knowledge and solutions to the peace and security research community and policymakers? How could these solutions become complementary components to humanitarian, political, social and security-focused solutions? In recent years, scholars have been discussing the relationship between climate and conflict, confirming that with droughts and increased rainfall variability and a history of civil wars, communities are more susceptible to acts of violence (O'Loughlin et al. 2012; Raleigh, Choi, and Kniveton 2015). *These conditions have been strongly present in CADC, though research focusing specifically on the climate-food security-conflict nexus in this geographical area remains scarce* (Adams et al. 2018). 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, Choi, and Kniveton 2015) *leaving the question about the linkage between climate-induced food insecurity and conflict unanswered*.

We see a major opportunity to combine insights from climate change literature and food security studies and demonstrate their relationship to the wider climate security nexus. But most actors, institutions and interest groups in the CADC *do not consider climate and security as critically linked, thus treating them as separate, if complex challenges*. This position paper shows that there are important linkages of food systems, climate, security and migration specific to the dry corridor, identifies entry points for policy and programming that aligns climate, food systems and peace objectives, and explains the role of agricultural research and development for promoting peace and security.

CLIMATE SECURITY IMPACT PATHWAYS

1. What are the Main Climate Security Impact Pathways in the Central American Dry Corridor?

The climate security impact pathways are informed by the climate fragility risks, as outlined in the introduction. These pathways visualize and map interactions of key variables and conditions by which a potential climate fragility risk is likely to emerge and play out in the CADC region. Operating within a risk-based framework, the pathways demonstrate how such interacting variables, conditions and characteristics, across a range of system (societal) dimensions and scales, may heighten the emergence of unstable, insecure and conflict-related outcomes.

Central America is highly vulnerable to the impacts of climate variability due to its geographic location, soil type, atmosphere dynamics, and terrain (Pachauri et al. 2007). The region is strongly affected by increasing temperatures, extreme drought, and destructive tropical storms, and Guatemala, El Salvador, Honduras and Nicaragua all rank within the top 50 countries that have shown to be most impacted by the climate risks from 1999-2018 (Eckstein et al. 2019). Such climate dynamics are set to continue undermining access to, and the availability and productivity of, key natural resources, thereby contributing to local competition – and potentially violence – over access and usage (Detges et al. 2020). This is particularly significant in the context of the Dry Corridor, given the extent to which the regional economy is dependent on smallholder agriculture: In Guatemala, Honduras, and Nicaragua, more than two thirds of the population rely on agriculture, the viability of which is intimately tied to ecosystems increasingly threatened by climate variability (Bouroncle et al. 2017; Baca et al. 2014). At the same time, demand for food products is expected to increase, with Guatemala and Honduras amongst the top three countries experiencing the fastest demographic growth in Latin America and the Caribbean between 2009 and 2019 (IOM 2020).

Local competition is set to increase against the backdrop of a fragile social and institutional environment characterized by a history of social, economic, and political exclusion and marginalization. Previous conflicts in Central America, such as the Salvadoran Civil War (1979-1992) and the Guatemalan Civil War (1960-1996), effectively destroyed social cohesion and trust amongst sections of the population. In El Salvador, almost 80,000 people were killed during the civil war, 550,000 were internally displaced, and 500,000 became refugees in other countries (Manz 2008). During the 36-year civil war in Guatemala, more than 200,000 people were killed or disappeared and an additional 1.5 million were displaced, with much of the violence directed at indigenous communities protesting economic, social, and political inequality and marginalization (HMH 2020). A lack of institutional trust remains pervasive amongst many indigenous communities to this day, partially due to a continued absence of restorative justice for affected communities and individuals. Climate impacts are therefore set to increase pressure on contexts already characterized by low social trust, low institutional capacity, and high degrees of socio-economic marginalization, thereby lowering the prospects of climate-induced competition being resolved equitably and peacefully (Detges et al. 2020). These conditions also make Central America vulnerable to agricultural shocks, disruptions in food prices, and food insecurity. Estimates show that more than 5.2 million people were severely food insecure between 2016 and 2018 (FAO et al. 2019). There is strong evidence to suggest that rapidly rising food prices and attendant food insecurity can combine with other political pressures and grievances to generate protests, political unrest and violence (Lagi, Bertrand, and Bar-Yam 2011; Sternberg 2012).

Climate variability may also impact social stability, peace, and security through other impact pathways. Increasing pressure on rural livelihoods negatively impacts food security and the availability and profitability of on- and off-farm employment opportunities, thereby reinforcing existing human mobility trends, most notably internal rural-urban migration. The relationship between (slow onset) climate shifts and migration are inherently complex. It is likely that the effects of climate will manifest themselves through intermediary channels and act as a driver of migration only in combination with other drivers, often by exacerbating the severity of other, perhaps more primary, migratory incentives (Black et al. 2011). Furthermore, migration – whilst in many cases serving as a viable coping strategy (Bosetti, Cattaneo, and Peri 2020) – is not an adaptive strategy open to everyone. The decision to migrate is tempered by intervening obstacles and facilitators such as the cost of moving, context-based factors such as the presence of conflict, and institutional and legal frameworks that may constrain or enable movement. Similarly, the exact nature of migratory movements (should the decision to migrate be made) will likely be determined by both household-level characteristics and broader contextual factors. Migratory movements may, for example, occur over longer or shorter distances and timescales, and can be circular or seasonal in nature. Furthermore, as outlined by Fréguin-Gresh et al. (2019), the role played by migration in generating household income and access to sources of food must be considered within a multi-situated activity system, in which dispersion of household members across different income generation strategies is the norm (Fréguin-Gresh et al. 2019). These income strategies are deployed across different scales and units, including on farm-activities, off-farm activities at the local level, and off-farm activities that are further afield. Risk is therefore diversified across multiple income streams, and remittances likely already contribute a significant amount to overall income for many households. However, as in-situ risk-management or climate adaptation strategies become increasingly strained in the face of climate-related pressures (causing, for instance, a lack of agricultural inputs and reduced yields), the relative importance of migratory incomes is likely to increase. Others without the capacity to move during times of crisis may end up 'trapped' in climate vulnerable areas (Milan and Ruano 2014; Freeman 2017), or stuck in spaces of detention and transit like migrant shelters, especially during the pandemic (Vega Villaseñor and Camus Bergareche 2021). Further, recent mass deportation of Central American migrants by the US government not only amplified risk of COVID-19 contagion, but also resulted in severe insecurities related to food and health confronting the migrants (Hanlon and Nolin 2021).

Increasing and unregulated movement – whether permanent or temporary, over short or longer distances – may create new challenges in receiving areas. Already overstretched city infrastructure and services may not be able to keep up with population growth, which, combined with poor labor market absorption, can give rise to growing poverty and socio-economic marginalization (Detges et al. 2020). Migrants are also often forced to work in informal, poorly regulated sectors such as construction, transport, or household services, leaving many open to exploitation and abuse. Such conditions in turn create potential sources of tension, conflict and anti-government grievances, particularly if horizontal socio-economic fault lines between groups emerge or are exacerbated (Buhaug and Urdal 2013; Østby 2008). Stagnant or exploitative economic conditions also lower the opportunity cost of engaging in criminal activity, a phenomenon that has already become apparent across the region. In Guatemala, El Salvador and Honduras, for instance, the prominence of youth street gangs and violence is growing rapidly in urbanizing areas (Kunkeler and Peters 2011).

Informal and irregular migration, especially when it occurs across borders, can feed smuggling networks often overseen by international crime groups (Sanchez 2018), with large numbers of migrants forming both a source of income and a cover for the expansion of drug-related activities. Smuggled migrants are known to frequently fall victim to predatory practices and sometimes violence (IOM 2020). As the following section outlines in more detail, most of the cross-border migration from the Dry Corridor has been northwards. Many if not most of these migrants intend to reach the United States in pursuit of livelihood opportunities, access to goods and services, and, above all, safety and security. The exact degree to which climate shifts have contributed to such movements is difficult to ascertain. However, research on the relationship between the rate of Mexican migration to the United States and climate variability found that numbers pulsed upwards during periods of drought (Feng, Krueger, and Oppenheimer 2010). This suggests that climate is likely to play at least an additive role in incentivizing migratory movements, and the degree to which even comparatively small numbers of migrants has fed into political turmoil in the United States is further evidence of how the diffuse and indirect impact of climate can contribute to new, or exacerbate existing, tensions.

Finally, climate impacts may undermine peace and security by pushing vulnerable communities into illegal coping mechanisms, such as the production of illegal cash crops (Detges et al. 2020). Especially in Central America, the vulnerability of rural livelihoods has been exploited by non-state criminal armed groups. A limited number of accessible livelihoods not only incentivizes turning towards more lucrative but illegal crop choices, but also provides criminal groups with a fertile recruitment ground, particularly among young people (Nillesen and Verwimp 2009; Nett and Rüttinger 2016). Beyond offering payment, armed groups may also seek to exploit political grievances or a lack of social cohesion within and between communities. In certain cases, such groups may also become the de-facto authority in a particular area, capitalizing on the absence of state supported services such as education, healthcare, and food provision (Fulton and Nickels 2017).

Figure 1 maps the complex interactions and emergent causal pathways within the climate security nexus in the Central American context. It does so by charting the pathways identified above through which climate-induced ecological shifts impact socio-economic systems that can subsequently lead to violent conflict. Represented in yellow are several theoretical entry points, within which R4D interventions may contribute to mitigating and stabilizing functions, ideally combined with socioeconomic and political security-enhancing interventions.

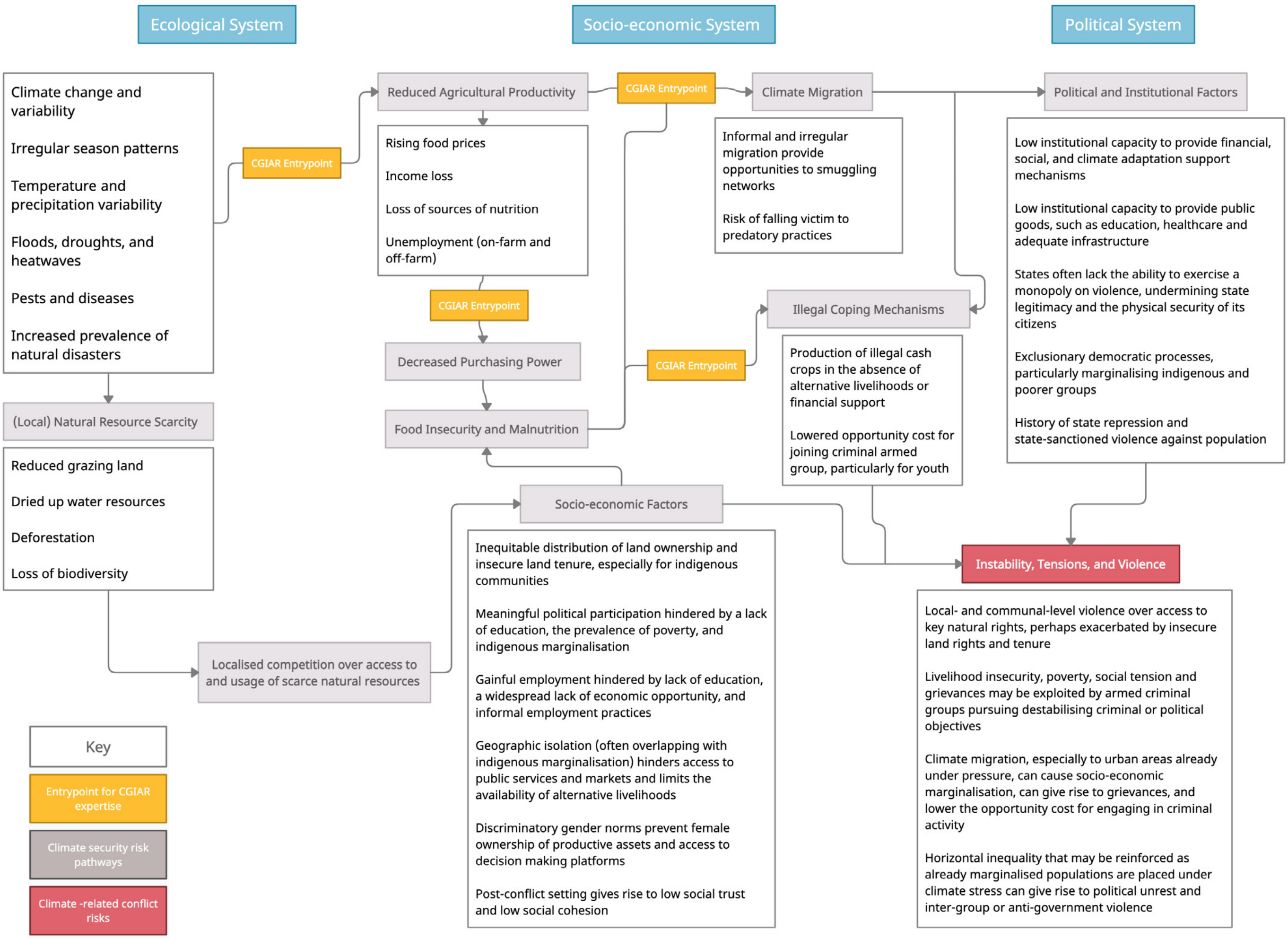


Figure 1. Mapping climate security interactions and emergent causal pathways.

Photo: Adriana Varón

PUBLIC PERCEPTIONS OF CLIMATE SECURITY

2. What are Public Perceptions of Climate Security in the Central American Dry Corridor?

In 2020, there were around 580,000 refugees and asylum-seekers from the northern region of Central America, due to the worsening crime and violence at home, along with fragile institutions and increasing inequalities (UNHCR 2021).

Hurricanes Eta and Lota affected approximately 7.3 million people in Guatemala, Honduras, and Nicaragua and caused devastation in staple food production just before harvest time (UNICEF 2021). Natural disasters such as droughts, hurricanes and fires leave people without a livelihood, especially those who were already vulnerable.

Social inequalities and climate change are closely linked. The triangular relation between poverty-migration-climate change in the CADC is an ever-pressing and growing challenge. However, it appears that the general public does not understand these relationships in the same way, even though past breadbasket failures and social unrest have been clearly matched to conflicts (Granados Martinez 2017). We analyzed, as a case study, 30 recent media bulletins from six major newspapers in Mexico, selected by searching for keywords *climate change* and *agricultural production*, and *migration* and *political instability*. Recurring word counts were used to generate word clouds for both searches. These clearly demonstrate the lack of overlap between migration and climate change narratives. Journalists and readers did relate climate change to biodiversity and natural resource conservation, agriculture, soils, related greenhouse gas emissions, and food security. But even when COVID-19 was incorporated into the discussions on agricultural productivity in relation to climate change, only minimal reference was made to issues around displacement, migration and vulnerability of people and poverty. Development issues and political references to global trade were slightly more common (Figure 2a,b).

Media discussions of migration and political instability show similar patterns of dis-connect. The migration problematic was unambiguously present in the whole CADC, as evidenced by the high number of recurring mentions of all the relevant countries. Migration issues revolved mainly around gender violence and organized crime. Especially in this context, it was surprising to find a complete absence of the food security narrative: economic difficulties and income-related problems, as well as the disruptions due to the pandemic, only appeared in the background. This absence may in part be explained by the high concern about feminicides in Mexico and the journalistic (e.g., tabloid) reporting style (Figure 2).

The general conclusion is clear: in the mainstream media outlets, the climate security nexus is seldom identified as such – and seldom seen as an underlying driver of socio-economic instability. We implemented a more in-depth exercise investigating social media postings (Twitter), to see whether policymakers in their communications make a connection between climate and conflict. We used network analysis to identify keywords and terms that occur in proximity and to visualize the strength of their relationship (Jacomy et al. 2014). Keywords

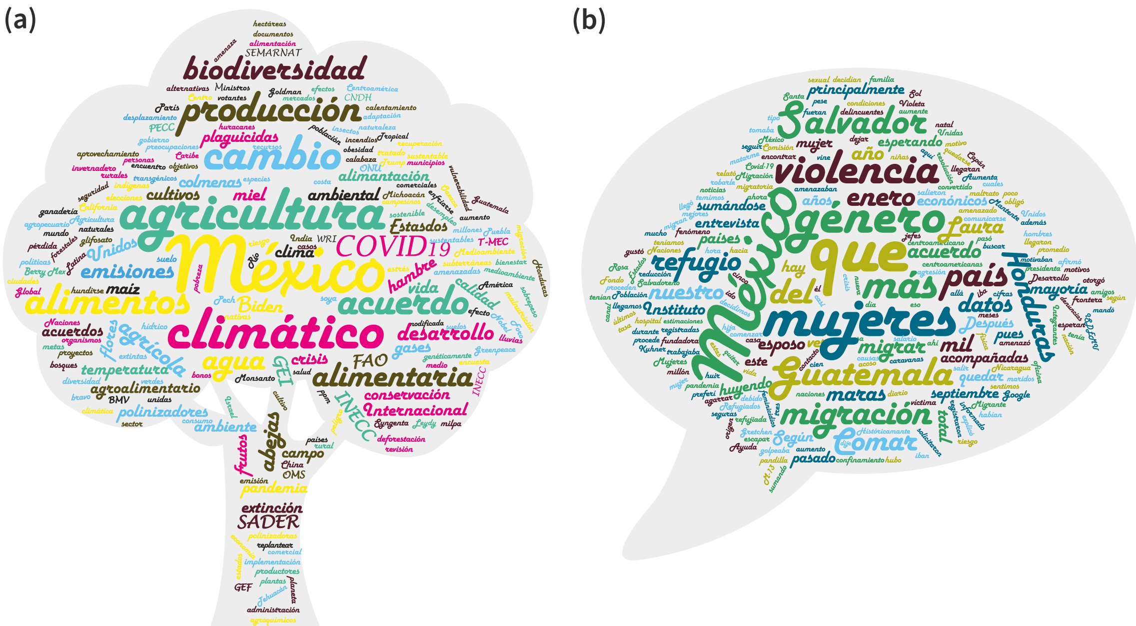
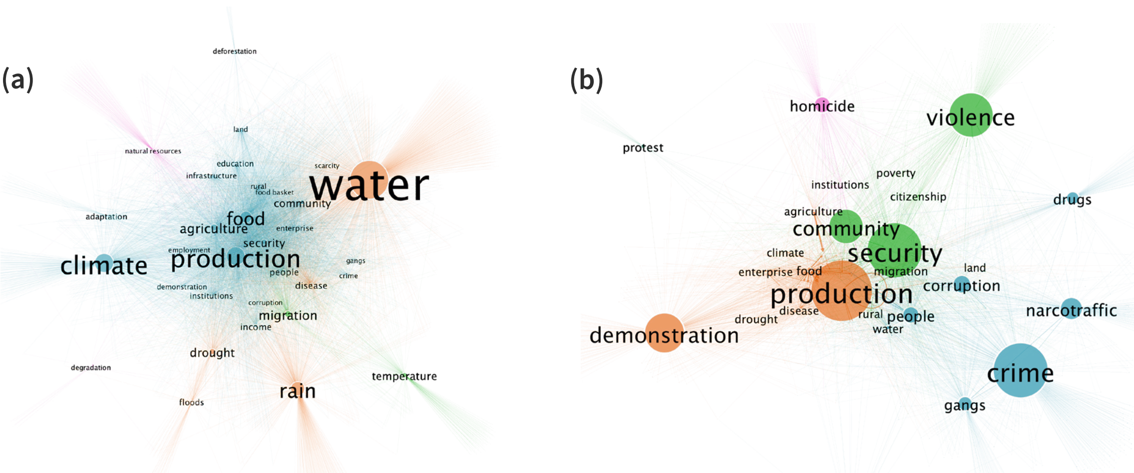


Figure 2. Mapping keywords about (a) *climate change* and *agricultural production* and (b) *migration* and *political instability* in Mexican newspaper bulletins.

related to climate, conflict and socioeconomic drivers were identified based on terms present in the Impact Pathways. In this case, the nodes of the network were composed of words present in the corpus of tweets. We ran this analysis for a selection of Twitter accounts maintained by national ministries and the central governments of Guatemala, Honduras, El Salvador and Nicaragua.

Figure 3a, b presents network visualizations of terms related to climate (a) and terms related to conflict (b) for the CADC countries. Overall, the keywords for each topic appear on the edges of the networks, such as “climate”, “crime” or “violence”. Terms in the center of the networks are those which have been detected to appear in proximity to the keywords within tweets. Our results show that the central themes of climate-related tweets, water, rain, and climate, were frequently associated with agricultural productivity, poverty, food security and migration. Conflict-related words such as “security” and “gangs” do appear in the climate network, suggesting some policymakers are aware of the linkages between climate and socio-political insecurities.

How significant is the perceived linkage? The conflict graph (Figure 3b) is dominated by security as a central theme. There is a clear connection between violence and community security, as shown by the green cluster. We also find evidence that some of the climate security drivers, represented by the word “production”, are sometimes linked to the discourse around national security. On the other hand, in the climate graph (Figure 3a), looking at the largest cluster in blue, one notes that the strongest connections for “security” are in relation to “food”, “agriculture”, and “production", which means that the word appears in the climate network mostly related to “food security”, rather than conflict-related security. This suggests that government actors’ awareness of the implication of climate impacts on conflicts and security is not remarkably high.



Network visualisations of word collocates for keywords related to (a) climate and (b) conflict in tweets by government actors in the Dry Corridor. Force-directed graph, with node size partitioned by betweenness centrality and colored by modularity class.

Figure 3. Mapping social media discussions of (a) *climate change* and (b) *conflict*.

3. Do Policies in the Central American Dry Corridor Support Climate Security?

The climate crisis requires policymakers to clearly understand when, where, and how climate impacts can translate into insecurities. They need to have a closer look at policies that address existing insecurities and how these interact with the climate crisis. Some policies will need to be re-designed using climate security lenses; some will need to be newly developed.

Therefore, we ask: To what extent have climate and national security policies been designed and implemented with a climate security lens? To answer this question, we analyzed policy documents at the national and regional levels. At the national level, we analyzed 28 policy documents from eight countries in the region: Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama, spanning across the Central American Dry Corridor and including Colombia and Mexico. We also analyzed four policy documents of the Central American Integration System (SICA in Spanish) for the regional level.

National policy documents correspond to current development plans, migration policies, national security policies, and disaster risk management policies. At the regional level, we sought similar policies in the same categories. We collected the data using a web search of documents, mainly on the official sites of governments.

To perform the research, we used data science and text mining to obtain a database of words from the processed texts (Silge and Robinson 2016; Statsoft 2020). To generate patterns, trend metrics, etc., we applied unstructured data cleaning processes such as: eliminating stop words (prepositions, articles, etc.), symbols, and numbers, among other elements from documents that are not part of the narrative analysis. Finally, we quantified the frequency of words in the processed texts.

To integrate the climate security lens into the analysis, we looked for keywords related to climate, safety, and socio-economic drivers in each type of policy document. The keywords used for the analysis are:

- **Climate:** Climate change, climate variability, temperature, rain, drought, disease, flood, deforestation, degradation, scarcity, adaptation, natural resources, disaster risk management, losses.
- **Socioeconomic drivers:** Land tenure, poverty, food security, nutrition, migration, displacement, agriculture, rural, malnutrition, community, food.
- **Conflict:** Conflict, drugs, cartel, demonstration, protest, drug trafficking, homicide, gang, crime, violence, security.

We measured the importance of each keyword by its presence or absence in the texts. We calculated the level of use of these words in the processed texts as a rate (%). The results are summarized in Figure 4 for national policy documents and Figure 5 for regional policy documents.

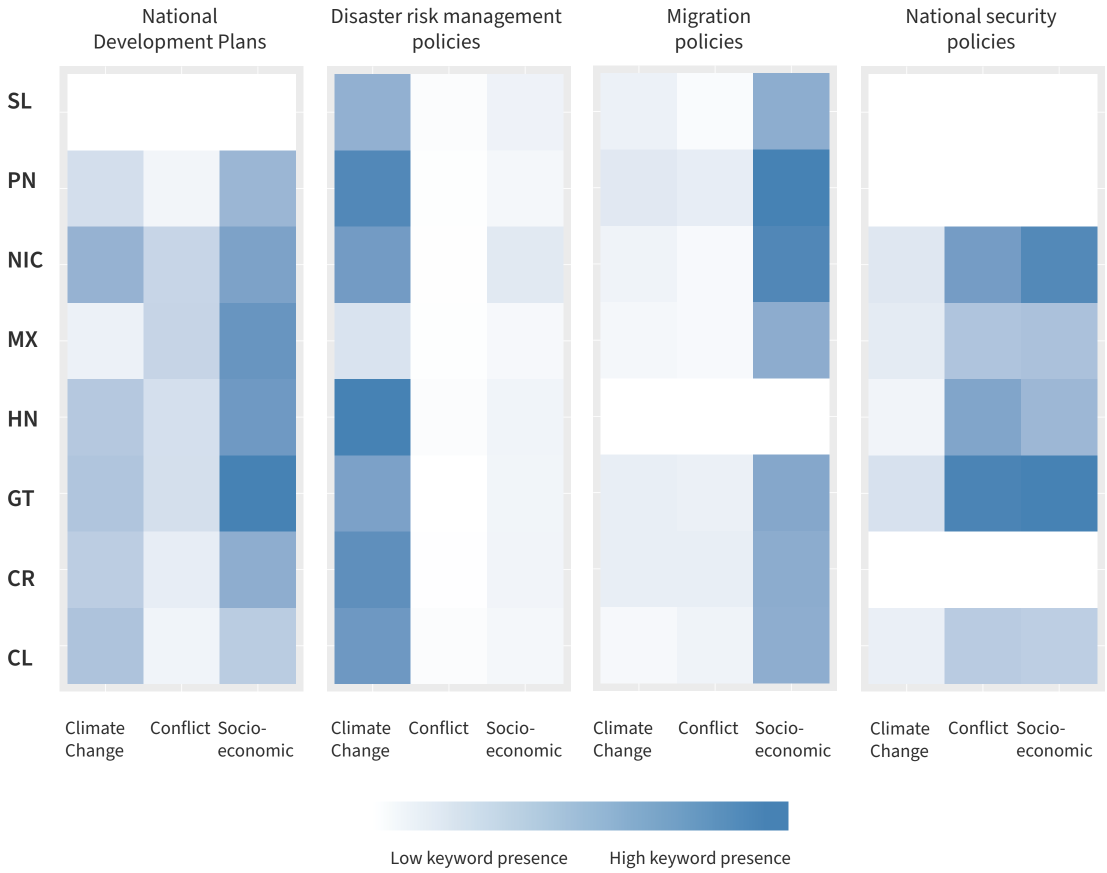
- **National development plans** broadly integrate climate change, security, and socio-economic drivers. However, socio-economic drivers have more intensity in the documents followed by climate change and conflict drivers. Some striking findings correspond to the lack of integration of climate topics in Mexico and conflict issues in Colombia and Panama.
- **Disaster risk management policies** broadly integrate climate drivers; however, there is a gap regarding socio-economic and conflict drivers. Countries that most incorporate climate change are Panama, Honduras, and Costa Rica, in contrast to Mexico, which integrates climate to a small extent. The latter may be because disaster risk management issues fall under the general civil protection law, which addresses broader issues.
- **Migration policies** essentially respond to socioeconomic factors; however, they poorly integrate climate change and conflict issues. Panama, Guatemala, and Costa Rica integrate the categories of climate change and conflict to a greater extent than others; however, its presence is not strong.
- **National security policies** broadly integrate conflict and socioeconomic drivers; however, they do not consider climate topics. Climate topics are present to a greater extent in countries such as Nicaragua and Guatemala.

Regional policies[1] respond mainly to socio-economic and climate change issues. The regional policies with the greatest inclusion of climate change are the Central American Policy for

[1] Regional policies included in the study are: The Central American Policy for Integral Disaster Risk Management (PCGIR), SICA Regional Integral Social Policy (PSIR) 2020-2040, Central American Strategy for Rural Development (ECADERT), Agricultural Policy for the SICA Region (PAR) 2019-2030.

Integral Disaster Risk Management (PCGIR) and the Agricultural Policy for the SICA Region (PAR). The PCGIR has the highest level of inclusion; this reflects the nature of the policy since it is mainly linked to risks generated by climate. The PAR integrates the climate change issue to a large degree since it is crucial not to ignore that agricultural activity is highly vulnerable to changes in climate. Despite the above, conflict issues only appear slightly in the SICA Regional Integral Social Policy (PSIR), suggesting possible gaps regarding conflict issues in the policies, especially those that combine and strongly integrate socio-economic and climate change issues.

In general, it is evident that climate, conflict, and socio-economic categories are disconnected from each other in most documents. Nevertheless, the climate crisis is a reality. Every day, it impacts the countries in the region more severely, so national and regional authorities must begin to recognize that these negative impacts can translate into insecurities, exacerbating the challenges that they currently face concerning socio-economic and conflict issues.



Key: CL: Colombia, CR: Costa Rica, GT: Guatemala, HN: Honduras, MX: México, NIC: Nicaragua, PN: Panamá, SL: El Salvador.
Source: Authors, using R programming and several packages of text mining visualization.

Figure 4. Results of analysis of national policy documents.

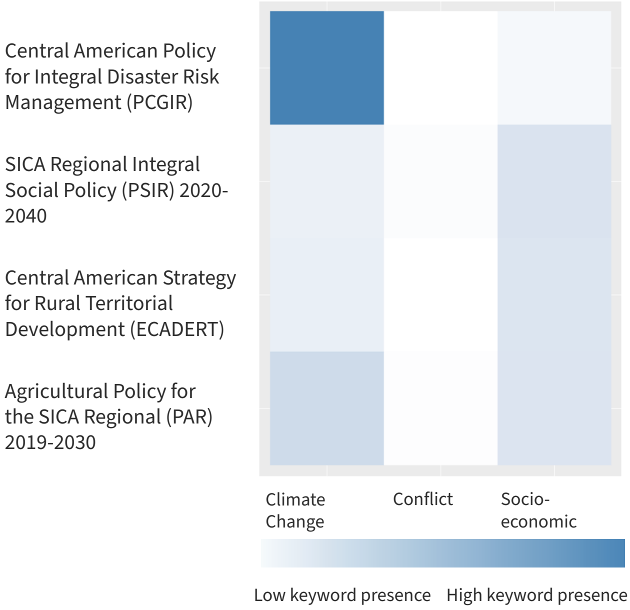


Figure 5. Results of analysis of regional policy documents.

4. What are the Drivers of Climate Security in the Central American Dry Corridor?

Building on the results of the impact pathway analysis, this section maps climate security hot spots and their underlying drivers to inform policy and programming.

Three countries were analyzed, Guatemala, Honduras, and El Salvador over the period for which data were available (2018–2020) in the Armed Conflict Location & Event Data Project (ACLED) Database (ACLED n.d.). We distinguish between conflict intensity, measured by the total number of events, and diversity, measured by the number of different type of conflicts. We found that conflict intensity is generally greater in Honduras, followed by Guatemala and then El Salvador. In these countries, gangs and non-state armed groups are by far the leading violent actors, as they are responsible for virtually all the battles (armed clashes) and violence against civilians (mostly attacks).

The spatial characterization of the climate security nexus aims to identify localities where climate, conflict and other insecurities co-occur. The approach used in this analysis recognizes the spatial variability of climate, conflict, food insecurity and the other drivers, but attempts to synthesize this variability into a manageable set of groups or classes per dimension of interest (e.g., climate, food insecurity, natural resources) that can be used to identify spatial hotspots. The information on these localities can be used to inform geospatial prioritization and targeting of interventions. For this purpose, we identify hotspots of climate and conflicts and then we overlay other existing insecurities, namely, natural and farm resources and socio-economic vulnerability. The next sections explore the spatial variation in conflict, climate, food insecurity and other drivers (Figures 6-8).

GUATEMALA

In Guatemala, climates with short Mid-Summer Drought (MSD) dominate, but they vary widely in intensity across the country and within conflict clusters. The extreme and high conflict clusters are both dominated by climates with short MSDs but extreme drought (100% and 82% of municipalities, respectively). In the moderate conflict cluster, conversely, these short MSD and extreme drought conditions occur in only 5% of the municipalities, but short MSDs 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 climate with extreme drought, followed by short MSD with mild drought (27%).

The departments of Baja Verapaz, Huehuetenango and Quiché show the greatest nutritional insecurity problems. In many of the areas in which undernutrition hotspots are identified, inequality is also a problem. Particular attention should be given to western Guatemala due to the significant occurrence of gender gaps.

Low productivity hotspots are mainly concentrated across the subsistence farming areas, south of Quiche, Huehuetenango, and departments of Chimaltenango, Totonicapan, Solola and Quetzaltenango, and to a lesser extent in the south.

High conflict areas are associated with high accessibility of mining concessions, and to a lesser extent, the combination of mining and cash crops, and the combination of these with deforestation areas. In moderate conflict areas, we note more prevalence of deforestation access spots (Peten department) and cash crop presence (south).

In conclusion, 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.

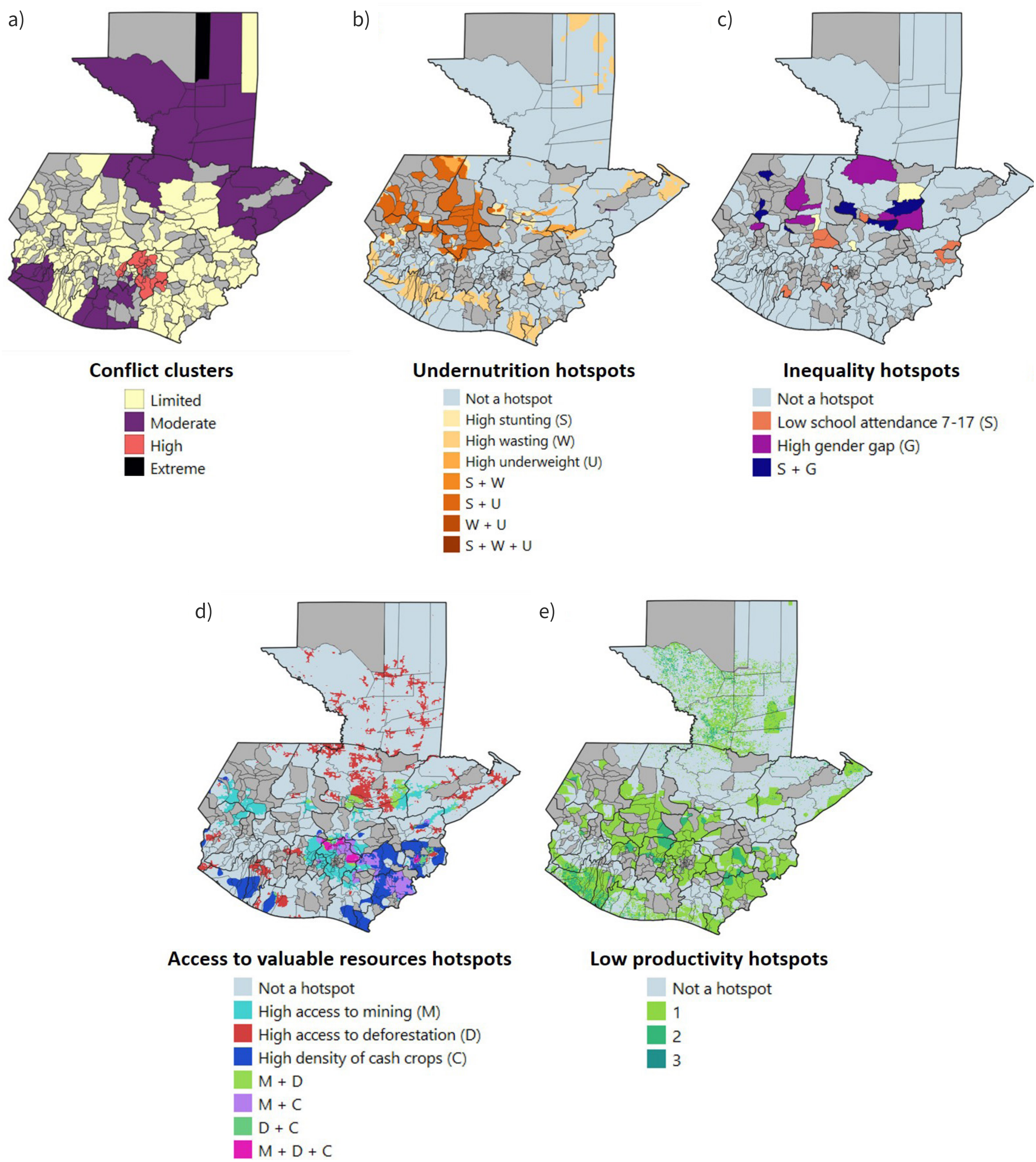


Figure 6. Maps show a) geographic distribution of conflict clusters of Guatemala, b) undernutrition hotspots, c) inequality hotspots, d) hotspots of access to valuable resources, and e) low productivity hotspots.

HONDURAS

In Honduras, long and extremely dry MSD conditions dominate in all conflict clusters, but especially in the high diversity – high intensity cluster (75% of municipalities). As conflict intensity and conflict diversity reduce, so does the dominance of this type of climate, with 43.3% of municipalities having long and extremely dry MSD in the moderate conflict diversity cluster – low intensity conflict cluster, and 27.7% municipalities in the low diversity – low intensity conflict cluster.

High nutritional insecurity is found in the west in the 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 many of the areas in which undernutrition hotspots are identified, inequality is also a problem. Particular attention should be given western Honduras due to significant occurrence of gender gaps.

Hotspots occur toward the south (Fonseca Gulf) but also in the west, where undernutrition and inequality are problematic. Similarly, in both Guatemala and Honduras, high conflict and moderate conflict co-occur with mining and/or mining – cash crop density areas.

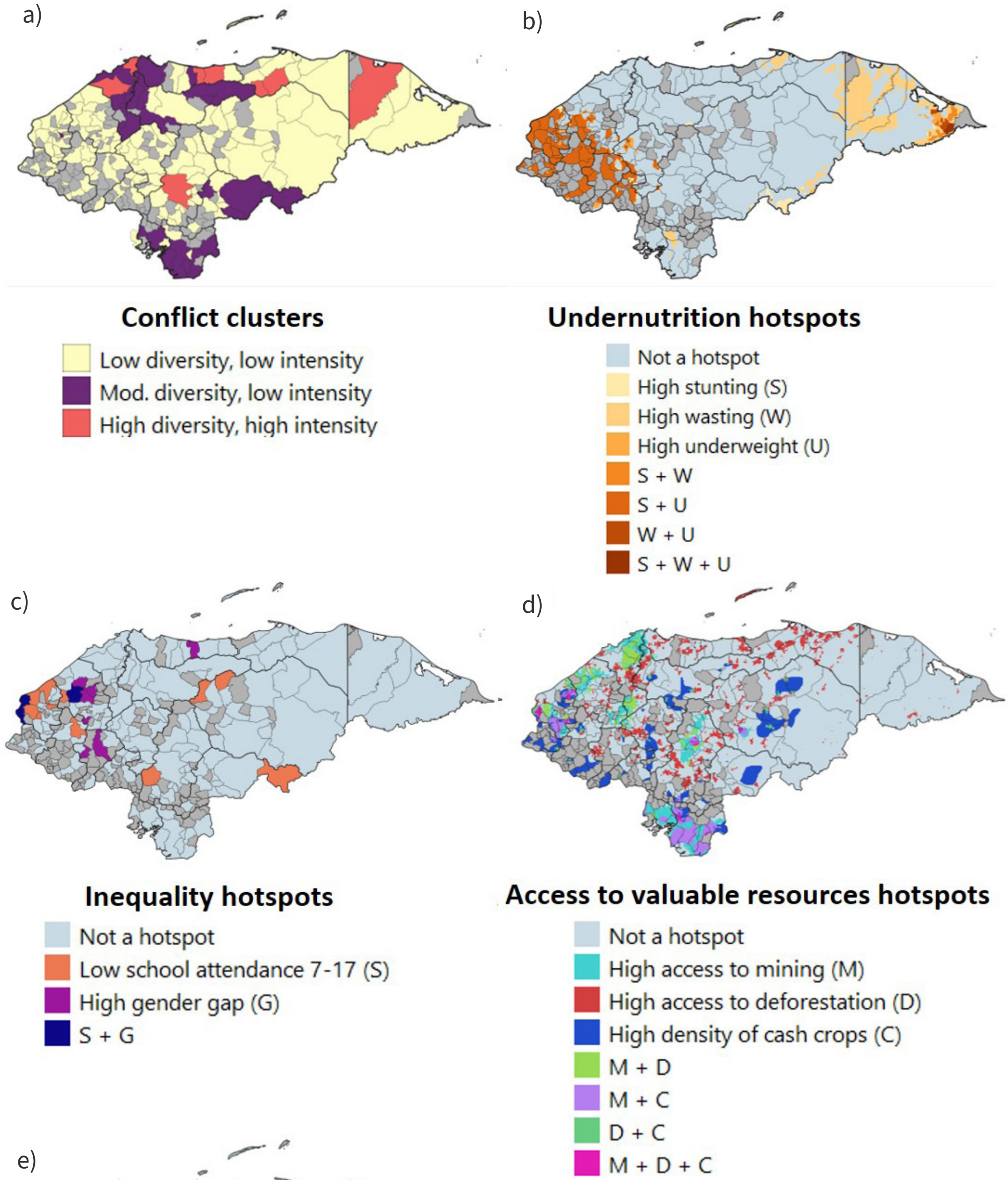
In conclusion, the southern areas of Honduras (Choluteca department) show significant social and biophysical vulnerability, while also showing moderate to high conflict. In these areas, we find low productivity staple crop systems combined with high accessibility to mining concessions and some presence 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.

EL SALVADOR

El Salvador shows the most favorable climate conditions of the three countries. Across the conflict clusters, short MSDs 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.

Nutritional insecurity problems are concentrated toward the borders with Honduras and Guatemala, suggesting a likely relationship with migration. In many of the areas in which undernutrition hotspots are identified, inequality is also a problem. Particular attention should be given to south-western El Salvador due to the significant gender gaps.

Low productivity is concentrated towards the west of the country, on the border with Guatemala. High diversity conflict tends to co-occur near deforestation areas, whereas moderate conflict is more likely in areas of high cash crop cultivation.



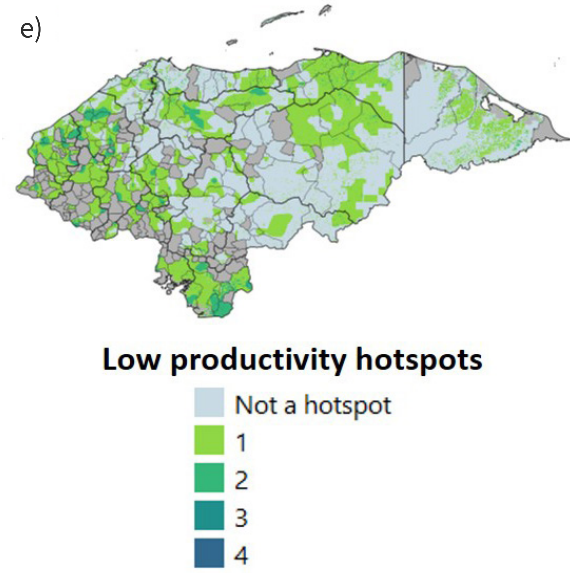


Figure 7. The maps show a) geographic distribution of conflict clusters of Honduras, b) undernutrition hotspots, c) inequality hotspots, d) hotspots of access to valuable resources, and e) low productivity hotspots.

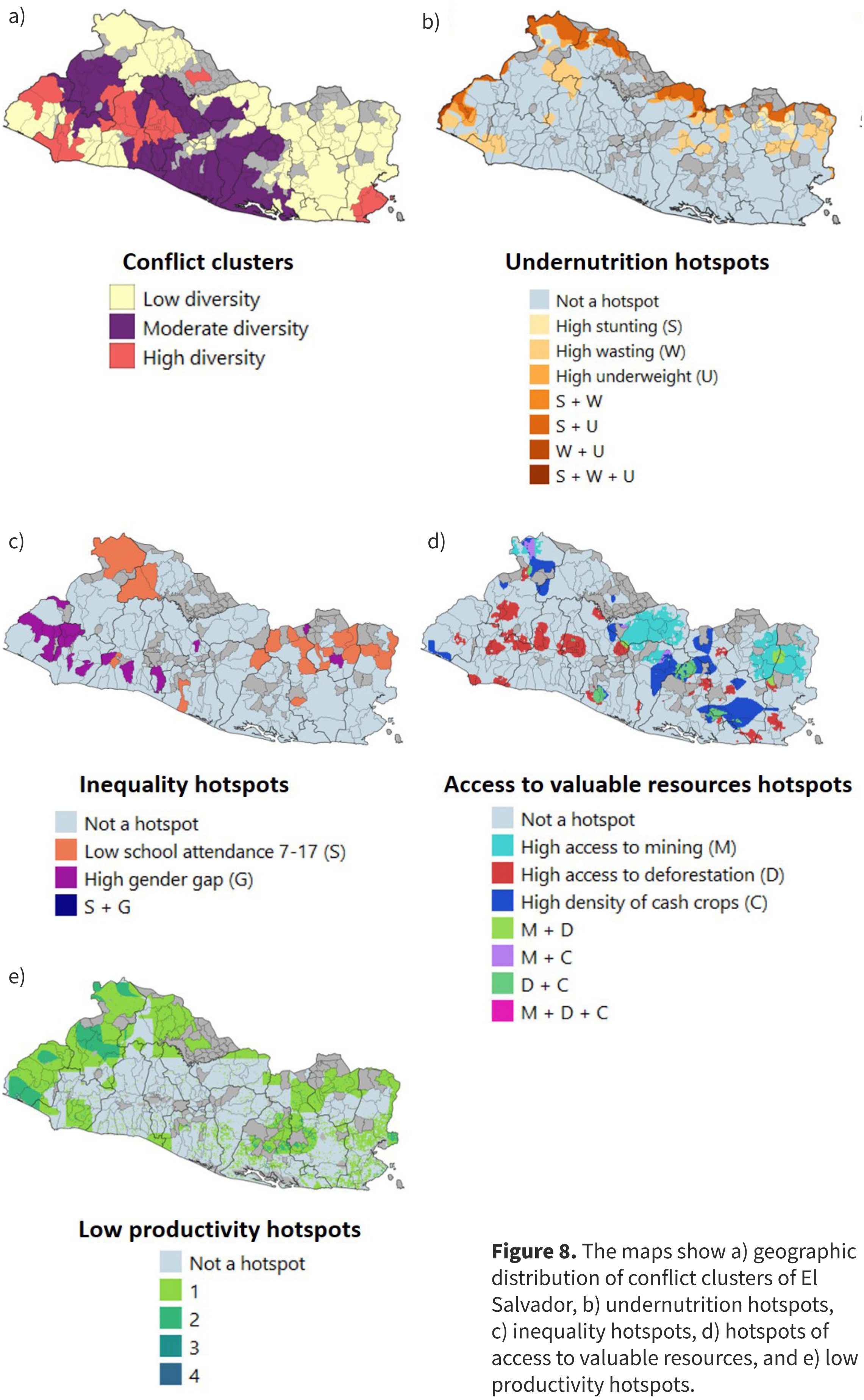


Figure 8. The maps show a) geographic distribution of conflict clusters of El Salvador, b) undernutrition hotspots, c) inequality hotspots, d) hotspots of access to valuable resources, and e) low productivity hotspots.

In conclusion, vulnerability hotspots tend to cover border areas (with both Honduras and Guatemala). Though these areas do not show high conflict, they do show a high prevalence of stunting. High conflict areas of El Salvador tend to be associated with access to forest resources, whereas the moderate conflict cluster shows low agricultural productivity for staple crops, high density of cash crops, and to a lesser degree, access to forest resources.

In summary, 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**, 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).

Photo: Neil Palmer / CIAT

CLIMATE AND PEACE INDICATORS

5. What do Climate and Peace Indicators Tell us about Climate Security in the Central American Dry Corridor?

Conventional evaluations and indices that measure the extent and quality of peace and security usually fail to acknowledge the role that climate can play in insecurity and conflict. As already mentioned, climate has the potential to threaten the stability of states and societies by exacerbating socio-economic and political risks, vulnerabilities and insecurities, such as food insecurity, poverty, forced migration, displacement, and inequality that are ultimately the root causes of instability, tensions and conflicts. Despite the growing recognition of the role of climate as a “threat multiplier”, current indicators of peace and security do not accurately quantify the impacts of climate change or variability on existing risks, vulnerabilities and insecurities that can increase the risk of conflict. This is particularly important in many developing countries, including those in the CADC region, that are highly exposed and vulnerable to climate extremes and hazards. Even many peaceful countries in the CADC region are regularly exposed to diversified risks that have a remarkably high destabilizing potential at country, regional and local level. And yet, security and peace indicators do not properly measure this risk, or at best, do it marginally.

Similarly, practitioners, donors, investors, and national and international policymakers from the climate and security community have thus far worked in isolation, not fully aware of the complex and multifaceted interlinkages between these two dimensions, and therefore ignoring the implications of climate for security and vice-versa. On the one hand, climate adaptation and resilience programs are often conflict-blind, which can lead to unintended consequences and trade-offs such as reinforcing structural and contextual drivers of conflict.

Several examples exist of conflict-insensitive adaptation measures that have increased the potential for conflict by damaging economic prospects, undermining political stability, and amplifying social inequalities and grievances (Krampe, Smith, and Hamidi 2021; Baysal and Uluç Karakaş 2017). This is, for instance, the case of the Salma Dam in Afghanistan that, despite being built as an effort to increase renewable energy production, reduce GHG emissions and enhance irrigation schemes, adversely impacted peace in downstream communities. The deficient management of the dam, which ignored the needs of some of the farmers, increased grievances over water access and increased the level of local instability and conflict (Krampe, Smith and Hamidi, 2021; Baysal and Karakaş, 2017).

On the other hand, traditional peacebuilding approaches tend to be climate-insensitive, not accounting for the complex climate-conflict connections, and therefore ill-equipped to respond to the increasingly complex security environment in which they operate (Krampe 2019). Therefore, this section makes the case for development of improved indicators and measurements that are sensitive to both climate and conflict. Such an effort will help practitioners, donors, investors, and policymakers to gain a better understanding of how climate and conflict dynamics play out in specific contexts, identifying the areas and groups that are most vulnerable to climate induced insecurities, and inform appropriate climate security-sensitive strategies that integrate the linkages between climate, conflict, agriculture and migration.

Indices are useful tools to facilitate the analysis, study and comparison of complex realities by creating a visual numeric representation of said reality. The main challenge is the definition of the concepts, given the lack of consensus on the conceptualization of peace and security. Even so, peace and security indices are still a valuable tool to inform academics, practitioners, donors, investors, and national and international policymakers about a complicated and heterogeneous reality. To illustrate the peace and security context of countries in the CADC region, this analysis will use two indices that enable comparison with the existing natural and socio-economic risks of those states.

The Institute for Economics and Peace (IEP) made a useful contribution to the field by developing the Global Peace Index (GPI) and the Positive Peace Index (PPI), two of the most relevant peace and security indicators. The GPI is an annual estimate of negative peace – defined by Galtung (1996) as the absence of violence (Galtung 1996) – that ranks a list of 163 states and territories according to their peacefulness. It uses 23 indicators and three main criteria: ongoing domestic and international conflicts, societal safety and security, and militarization. For its scoring system, the GPI uses both qualitative and quantitative data provided by some of the most renowned institutions in the field of conflict and security, including the Uppsala Conflict Data Program (UCDP), the Stockholm International Peace Research Institute (SIPRI), the United Nations Office on Drugs and Crime (UNODC), the United Nations Committee on Contributions, the Economist Intelligence Unit (EIU) and the World Prison Brief, among others (Institute for Economics & Peace 2020a).

The PPI is an annual measure of positive peace which is defined as "the attitudes, institutions and structures that create and sustain peaceful societies" (Institute for Economics & Peace 2020b). It is based on eight main pillars, including well-functioning government, sound business environment, acceptance of the rights of the others, free flow of information, high levels of human capital, low level of corruption, equitable redistribution of resources, and good relations with neighbors. The IEP regards positive peace as a proxy of a country's level of socio-economic resilience. In other words, it is viewed as a bulwark that may help to neutralize or mitigate potential risks or threats to sustain peace. For its scoring system, the PPI uses both qualitative and quantitative data provided by highly respected sources, including the United Nations Development Programme (UNDP), the World Tourism Organization (WTO), the International Labour Organization (ILO), the World Health Organisation (WHO), UNESCO, the World Bank, Freedom House, and the World Economic Forum (Institute for Economics & Peace 2020b).

The INFORM Risk Index is a well-regarded measurement of states' risk of suffering from humanitarian crises and disasters that could overwhelm national response capacity. It was developed by a partnership of UN agencies, NGOs, donors, and research institutes and has already been incorporated into the internal decision-making processes of several UN agencies (e.g., World Food Program and UNICEF), as well donor agencies, including USAID and FCDO. The INFORM Risk Index combines a total of 54 indicators into three risk dimensions: hazards and exposure to them; vulnerability; and lack of coping capacity (Marin-Ferrer, Vernaccini, and Poljansek 2017). For this analysis, only a few variables were selected to show different natural and socio-economic risks as well as existing coping capacities. The selected variables help to illustrate how most of the countries of the Latin American and Caribbean (LAC) region – even some of the most peaceful ones – lack strong coping capacities while facing different natural hazards. This could act as a threat multiplier, impacting existing socio-economic vulnerabilities and potentially leading to insecurity or even conflict. However, this reality is not adequately measured by existing peace and security indicators which should become more climate-sensitive and incorporate the risks posed by the climate crisis to appropriately measure peace and security.

Table 1 outlines the countries from the CADC region and the entire LAC, regarding natural hazards, socio-economic vulnerabilities, security risks and coping capacities. The GPI and the PPI values shown in the table are the ranking of the countries in the two indices. They are highlighted in the table according to the state of peace of the countries defined by the IEP (2020a, 2020b), which range from very low to very high depending on their score. For facilitating the visualization, the table merges the categories "very high" and "high" into a single one – highlighted in dark red – and the "very low" and "low" category into another one – highlighted in light red. The rest of the variables, extracted from the INFORM Risk Index, illustrate values that estimate different risks ranging from 0 to 10. Specifically, values from 0 to 3.5 are considered low, values from 3.5 to 5 are considered medium – highlighted in light red – and values from 5 to 10 are deemed high – highlighted in dark red (Marin-Ferrer, Vernaccini, and Poljansek 2017).

Table 1. Peace indicators, natural hazards, socio-economic vulnerabilities, security risks and coping capacities of countries from the CADC and LAC.

COUNTRY	GPI full rank (2020)	PPI full rank	Natural hazards risk rank LAC	Flood	Environmental degradation and drought	Conflict risk	Violence RISK	Development and deprivation	Inequality	Dependency risk	Socio-economic vulnerability	Lack of coping capacity	INFORM risk score
RANKING/SCORE	1-163	1-163	1-23	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10
CENTRAL AMERICAN DRY CORRIDOR													
Costa Rica	32	37	9	3.8	4.3	0.1	5.2	3.4	3.6	1.6	3	3.3	4.1
Panama	56	54	11	3.5	5	0.2	4.6	3.7	6.2	4	4.4	5.1	5
El Salvador	113	88	16	3.4	8.7	4.3	9.3	5.3	5	7.9	5.9	7.2	6.7
Guatemala	115	111	21	6	9.3	5.9	8.4	8.9	7.1	9.1	8.5	7.6	8.2
Honduras	119	109	22	6.7	9.5	4.6	9.3	8.4	7.5	8.2	8.1	7.9	8.1
Nicaragua	135	105	19	7.2	8.4	8	4.4	5.8	7.1	7.9	6.7	6.3	6.6
LATIN AMERICA AND THE CARIBBEAN													
Uruguay	35	29	1	5.2	2.5	0.1	4.2	2.3	3.6	3.4	2.9	2.9	2.9
Chile	45	41	8	7	3.7	2.9	4.3	1.9	4.1	1.8	2.4	2.8	3.6
Argentina	74	57	4	7.9	5.6	1.7	5.3	3.6	4.3	3.4	3.7	3.8	4.1
Paraguay	75	94	3	6.3	6.9	2.5	4.8	4.5	5.7	5	4.9	5.3	4.8
Dominican Republic	76	78	17	5.6	4.6	4.1	5.6	4.2	5.1	7.3	5.2	6.3	5.7
Jamaica	80	47	10	3.8	3.9	1.8	9	3.9	7.8	7.5	5.8	6.8	5.7
Guyana	82	91	5	8.4	3.9	0.8	4.8	4.6	8	8.3	6.4	5.8	5.2
Peru	84	76	14	8.1	5.7	2.5	5.6	4.4	6.4	6.1	5.3	5.5	6
Cuba	86	69	12	4.1	6	2.5	4.2	3.8	3	1.1	2.9	3.6	4.4
Bolivia	86	105	7	7.4	6.8	5.7	4.5	6.2	6.9	8.3	6.9	6.8	6
Trinidad and Tobago	88	59	2	0.4	1.7	0.7	8.7	2.4	2.9	1.3	2.3	5.6	4.8
Ecuador	90	82	15	9.2	5.6	0.6	4.7	3.8	5.3	6	4.7	5.4	5.8
Haiti	111	149	23	5.1	8.4	6.2	5.2	10	7.3	9.5	9.2	9	8.5
Brazil	126	78	6	8.9	6.3	7	10	3.7	5.7	1.8	3.7	4.4	5.6
Mexico	137	71	20	8.1	7	9	9.3	4.4	4.6	3.4	4.2	4.5	6
Colombia	140	82	18	8.3	4.5	7	8.7	4	6.4	4.8	4.8	6	7
Venezuela	149	135	13	6.6	4.4	6.6	9.7	4.9	8.1	3.5	5.4	6.9	7.2

Sources: the GPI (2020), the PPI (2020) and the INFORM Risk (2020) .

INFORM. 2019. "Latin America and the Caribbean - INFORM Risk Index 2020". Luxembourg. Available at: https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Subnational-Risk/Latin-America-and-Caribbean/moduleId/1800/id/368/controller/Admin/action/Results

Table 1 shows that most of the CADC countries face numerous climate-related risks that could exacerbate existing socio-economic risks and vulnerabilities. Examples include poverty, inequality and violence, among others, that are ultimately the root causes of instability, insecurity and conflicts. This is particularly worrisome, as, despite being severely affected by natural hazards, most of the countries show a low level of resilience, measured by their low coping capacity. This is an indicator that estimates the level of available resources to alleviate the impact of hazards and vulnerabilities based on existing physical infrastructure, communications, governance, access to a health system, and Disaster Risk Reduction implementation. Except for Costa Rica, all of the countries in the CADC show a low level of coping capacity. This is especially alarming because the countries that are most vulnerable to natural hazards are also those most affected by conflict and violence. However, even some of the most peaceful countries in the LAC region have a low level of resilience despite facing a series of climate-related risks. Specifically, Uruguay and Chile are the only two countries with a high level of coping capacity. This shows how even the most peaceful countries are not completely safe amidst a climate crisis that is already impacting everyone.

Regarding natural hazards, flood risk is a common feature in both groups of countries: El Salvador and Trinidad and Tobago are the only states from the CADC and LAC with a low level of flood risk. This phenomenon is especially alarming in Nicaragua, Honduras and Guatemala – scores of 7.2, 6.7 and 6 respectively – where thousands of people, including at least 70 deaths, were affected by floods last year (UN News 2020; VOA 2020). Environmental degradation and drought are other serious climate related risks, particularly in CADC where five countries face a high risk and the other three face a medium risk. El Salvador, Guatemala, Honduras and Nicaragua experience alarming levels of drought that, along with COVID-19 and other natural hazards, have quadrupled hunger and pushed thousands of people to migrate (Noticias ONU 2021).

Regarding human hazards, conflict risk[2] is comparatively lower than violence risk[3] in both groups of states. Most of the countries from the second group have a low level of conflict risk but all of them face high or medium risk of violence, as estimated using the intentional homicide rate and the intentional homicide count indicators from the United Nations Office on Drugs and Crime (Marin-Ferrer, Vernaccini, and Poljansek 2017). Likewise, two of the CADC states have a high risk of conflict while four face a high risk of violence: Panama, Guatemala, Honduras, Nicaragua and El Salvador. These data demonstrate that, despite not having open armed conflicts in any of the countries, the risk of violence is a core problem in the region. In relation to socioeconomic vulnerabilities, which estimates the (in)ability of people to afford safe and resilient livelihood conditions and well-being, Costa Rica is the only CADC country that shows a low level of exposure, while the rest, especially Guatemala and Honduras, show high or medium levels of exposure.

[2] Conflict risk is estimated using the national power conflicts and the subnational power conflicts indicators from the Conflict Barometer of the Heidelberg Institute for International Conflict Research (HIIK) as well as the probability of violent conflict and highly violent conflict indicator developed by the Global Conflict Risk Index (GCRI).

[3] The risk of violence is estimated using the intentional homicide rate and the intentional homicide count indicators from the United Nations Office on Drugs and Crime.

Using the development deprivation risk, which estimates socio-economic capabilities and deprivation by combining the Human Development Index and Multidimensional Poverty Index, four CADC countries show high levels of risk: El Salvador, Honduras, Guatemala and Nicaragua. The dependency risk, which measures sustainability in development growth as related to economic instability and humanitarian crisis by a combination of the estimates of public aid per capita and the net official development assistance received in percentage of gross national income, is also very high in four CADC countries and seven from the whole LAC region. In addition, inequality is clearly one of the most common and alarming risks as Latin America is the most unequal region in the world. A total of eleven countries from the LAC region and five of the CADC states have a high inequality risk. In fact, there are only two countries that show a low level of inequality: Cuba and Trinidad and Tobago. Inequality is a worrisome risk as it may lead to slower economic growth and poverty reduction, limited upward mobility, mistrust of institutions, and growing unrest (United Nations 2020a).

The risks are likely to be exacerbated by the natural hazards present in all of the countries characterized by climate variability and extremes. In this context, the threat multiplier effect of climate change will intensify existing vulnerabilities such as violence and inequality. This negative potential of climate variability and extremes is particularly worrisome due to the widespread low level of climate resilience.

In conclusion, the combination of high exposure to climate-related risks, generally low resilience to natural disasters, and low coping capacity implies that even the most peaceful countries in the CADC and LAC regions are not completely safe amidst a climate crisis that is already impacting everyone. Even if some of these countries are comparatively less vulnerable and have lower levels of risks in some of the variables, they still face the threat of climate variability and various natural hazards which can aggravate existing socio-economic and political vulnerabilities. This, in turn, could lead these countries to instability or even violent conflict.

Peace and security indicators such as the GPI and the PPI by themselves do not accurately measure the potential impact of climate change and variability on socio-economic risks and insecurities that can increase the risk of conflict. Improved peace and security indicators and measurements that are climate sensitive should be developed to help practitioners, donors, investors, and policymakers to gain an adequate understanding of how climate and conflict complex dynamics play out in specific contexts and identify appropriate strategies that integrate climate adaptation and peacebuilding activities in environmental programming.

RESEARCH FOR DEVELOPMENT

6. How can Research for Development Contribute to Climate Security in the Central American Dry Corridor?

This section presents three case studies on how local community-based and participatory processes for addressing climate change and variability contribute to addressing the main drivers of climate-food security-conflict impact pathways. Figure 9 indicates which drivers the climate-smart villages (CSV), the local technical agroclimatic committees (LTAC) and the Integrated Agri-food System Initiatives in Latin America, described below, directly or indirectly address. For each case we explain the concept and the drivers addressed in the context of migration and security challenges rural farmers are facing on top of climate change impacts. The Figure shows the main drivers of climate-food security-conflict impact pathways addressed in each case study. The green circles in the figure correspond to the CSV approach, the red ones to the LTAC approach, and the blue ones to the Integrated Agri-food System Initiatives in Mexico and Colombia. Solid lines in the figure refers to a direct relation of the case studies with each driver pointed, and dotted lines to an indirect relation.

6.1. Participatory community-based adaptation: Climate Smart Villages approach

Since 2011, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS[4]) has led the Climate-Smart Villages (CSV) approach together with CGIAR centers and key partners in five world regions (Latin America, East Africa, West Africa, Southeast Asia, and South Asia)[5] . Since 2015, CCAFS has implemented the CSV approach in four Latin American countries: Colombia, Honduras, Guatemala, and Nicaragua.

[4] About CCAFS: https://ccafs.cgiar.org/
[5] About CSV globally: https://ccafs.cgiar.org/climate-smart-villages#.W3bjss70mMo

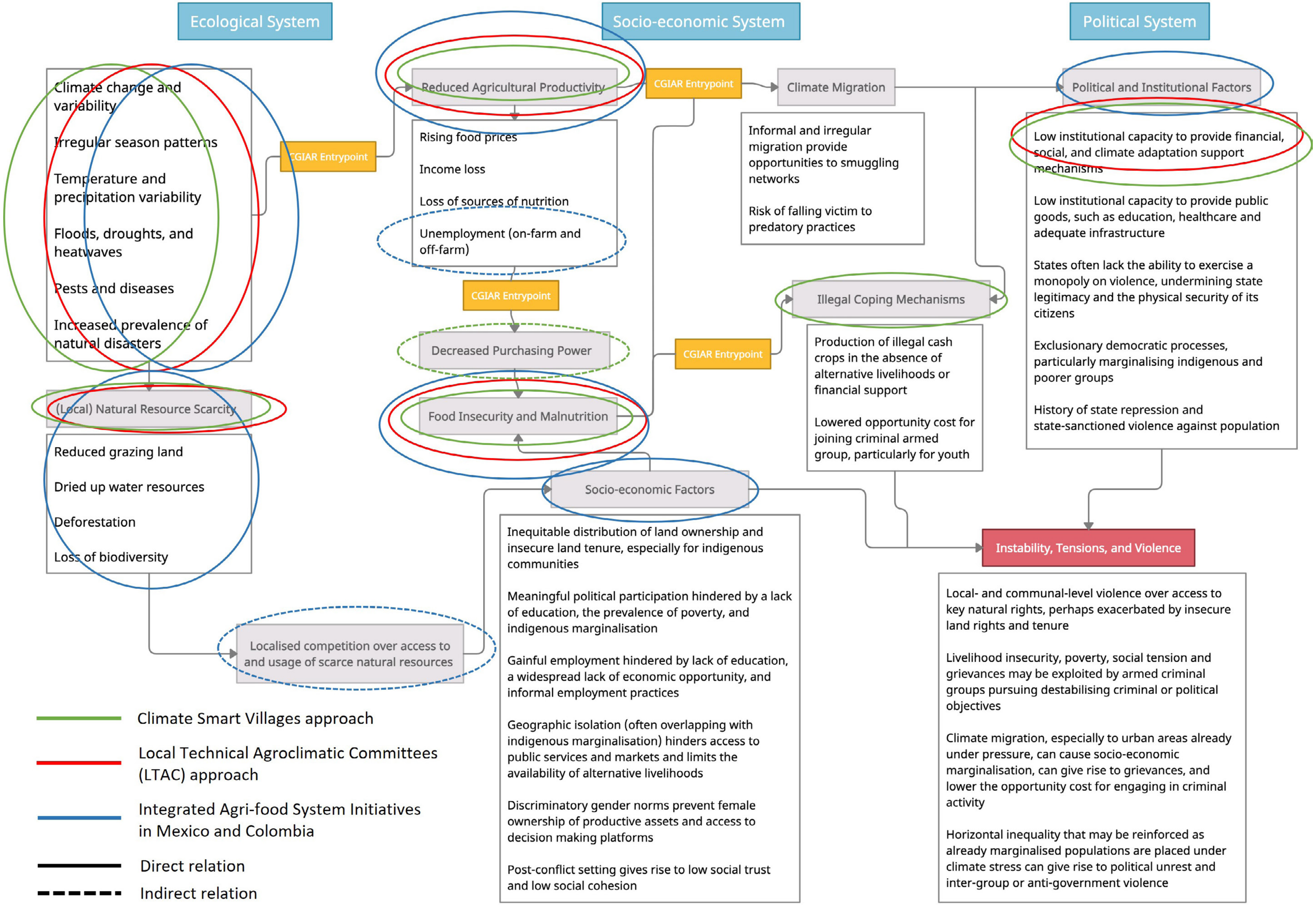


Figure 9: Drivers of climate-food security-conflict impact pathways addressed in each case study.

The CSVs are living laboratories that generate evidence about how, in a given territory, different actors (farmers, researchers, government, private sector, civil society) can most effectively co-develop, test, adapt, and evaluate portfolios of integrated and innovative options that promote climate-smart agriculture and improve the rural population's livelihoods in a context of climate variability and change. The CSV approach addresses the main impact pathways through which climate variability can affect peace and security of rural populations engaged in agriculture (food and nutrition security) and ecosystem services.

CSVs contribute to different climate-food security-conflict impact pathways. Through understanding and use of agroclimatic information, farmers in CSVs are better prepared to face climate variability. The use of agroclimatic information allows them to be informed and prepared for the next cropping seasons and reduces the likelihood of having production losses, income reductions, and food insecurity. Implementing climate smart agriculture (CSA) practices can increase agricultural productivity and reduce natural resource scarcity[6] (Almentero et al. 2019a; 2019b; 2019c). The CSV approach aims to enhance adaptive and transformative resilience.

Adaptive resilience of local institutions, rural communities and farmers in the CSVs is improved by strengthening their knowledge and skills on CSA practices and technologies. Capacity building and knowledge exchange are crucial to increase social capital and cohesion, which will ensure long-term benefits and sustainability in the territories, while scaling the approach to more smallholder farmers and communities.

Improving the climate resilience of farmers has a positive impact on the stability of their income and livelihoods year after year; moreover, farmers feel more attached to their land and motivated to change and improve their agricultural production and livelihoods, which strengthen their roots to their territory. Thus, farmers are less incentivized to migrate and the likelihood of getting involved in illicit activities such as the production and processing of illegal crops (coca and marihuana) is lower.

In Cauca, Colombia for example, cultivating illegal drugs is an activity that often constitutes the only possibility for rural youth to earn money. CSV communities are constantly exposed to these activities due to their geographic location where climate and biophysical conditions are suitable for the development of these crops. Moreover, it is one of the corridors through which illicit drugs are mobilized for sale to other regions of the country and abroad. Farmers are often reached by illegal groups to allow them the transport illicit products and lease their land for growing coca crops. However, despite both the illicit and climate pressures, farmers have resisted due to their courage, increased social capital and empowerment, as well as the improvement of their livelihoods and income as a result of the implementation of the CSV approach (Martinez-Barón, n.d.; Sarruf Romero 2020; Ortega and Martínez-Barón 2018).

[6] CSA practices include crop diversification, intercropping, organic fertilizers, drought-tolerant seeds, water harvesting (cisterns, tanks, reservoirs), climate-smart home gardens (which include water harvesting systems, drip irrigation, and organic fertilizers), among others.

6.2 Climate services increasing local resilience: Local Technical Agroclimatic Committees (LTAC) approach

Local Technical Agro-climatic Committee (LTAC) is an approach that seeks to facilitate dialogue among diverse local stakeholders to understand and discuss weather and climate forecasts and reports on the likely crop response to the climate for specific conditions in a specific time and space (Loboguerrero et al. 2018). Through crop models and both local farmer and expert knowledge, crop choice and management options are discussed and after consensus is reached, these are included in the Local Agroclimatic Bulletin to be shared throughout LTAC participants' networks to reach a large number of farmers. The discussion is not only focused on climate, but also markets for the produce and availability of inputs.

Since 2015, when the approach was developed by CCAFS and partners in Colombia, LTACs have rapidly expanded across Latin America and now involve about 350 institutions[7]. Currently, an estimated 250,000 farmers receive tailored agro-climatic information through 50 LTACs in 11 countries of Latin America (Giraldo-Mendez D et al., 2021: 5) incorporating it into their decision-making processes (Ramírez Villegas et al. 2020). These farmers have documented changes in their management practices. Common changes observed on farms include changes in planting dates to take better advantage of good climatic conditions or to avoid losses, and the use of varieties more suitable for the expected climatic conditions. The LTAC approach has also focused on strengthening capacities to co-produce, translate, transfer, and use climate information for agriculture at over 300 institutions in Latin America[8].

LTACs mitigate different climate-food security-conflict impact pathways. They reduce crop losses by providing higher confidence and quality climate and agro-climatic information, allowing its incorporation into agricultural decision-making and planning process, and thus mitigating unpredictable climate variability. LTACs democratize agro-climatic knowledge by making the information known, understandable, and connected. LTACs also increase knowledge on CSA practices. Knowing future climate patterns supports implementing climate-smart production, avoiding or reducing production losses and increasing food security. Finally, LTACs increase institutional adaptive capacity, significantly influencing national and institutional policy changes, fostering inter-institutional alliances to deal with climate risks. Overall, LTACs significantly increase adaptive and transformative resilience capacities (Hiles, Navarro-Racines, and Giraldo Mendez 2020).

The LTAC approach is today an excellent example of the successful implementation of climate services in the SICA (Central American Integration System) region. It has allowed countries to move towards a more resilient agriculture in response to climate challenges. Motivated by the success and progress of the approach, the Central American Agricultural Council (CAC, in Spanish) has strongly emphasized the CSA Strategy for the SICA region, which includes a "Comprehensive Risk Management and Climate Adaptation" component (Martínez-Barón et al. 2021).

[7] LTACs participants include Ministries of Agriculture; Ministries of Environment; producers' associations; Meteorological Service Institutes; academy and research institutions; subnational governments; international cooperation and civil society.

[8] For instance, CCAFS has worked with partner organizations in Colombia, Honduras, and Guatemala to assess seasonal forecast modeling skills and to develop and build capacity in the use of novel climate and crop prediction tools to enhance the quality of seasonal forecasts, and to tailor forecast information for agricultural decision-making.

Moreover, the Regional Committee on Water Resources and CAC are working together to establish a regional technical agroclimatic committee. The financial and insurance sectors are also participating in the LTACs, which offers an important opportunity to inform the design and implementation of financial instruments and insurance programs that consider agroclimatic information.

6.3 Integrated Agri-food System Initiatives in Mexico and Colombia

More integrated, research-based responses by public policy, agricultural value chains, and finance are often constrained by short-termism and zero sum thinking. In contrast, Maize for Mexico and Maize for Colombia represent structured efforts to build inter-disciplinary coalitions that make use of tools such as modelled predictions and scenarios, to synchronize public and private action at the national level toward sustainable and inclusive agri-food systems (Govaerts et al. 2021). The transformative resilience-building potential lies in the replicable approach to stakeholder engagement over time. Maize for Mexico (Govaerts et al. 2019) is a joint institutional effort with more than 70 different stakeholders, while Maize for Colombia involves more than 30 different stakeholders. The two Integrated Agri-food System Initiatives (IASI)[9] began with an assessment of business as usual, in which high uncertainty and low coordination prevented transformative investments. Using a systems lens, the IASI methodology develops scenarios based on available models and data to engage diverse stakeholders in design thinking.

Maize for Mexico builds on the 10-year MasAgro program, to further scale out sustainable agriculture practices and enabling conditions. MasAgro had focused on improving value chains (e.g., farmers seized competitive opportunities to engage in local markets) and validating sustainable agriculture practices and their adoption and impact pathways. Farmers' demands, interests and concerns were incorporated into a hub-based innovation model, through the interaction of organizations of agricultural producers, educational institutions, technology generators and agents of change.

The Maize for Mexico five strategic lines of action promote productivity, improved risk management in value chains and representation of farmers' interests via the 1) adoption of better seed varieties; 2) climate-smart agriculture systems; 3) technical assistance hubs for innovation; 4) access to markets and 5) an expanded partnership space with participatory tracking of progress. Implementation efforts rely on all involved value chain actors having access to key information that facilitates decision-making at every stage. A decision support system for small and medium-sized producers of maize, wheat, beans and other crops is being set up. An action and monitoring framework for private-public partnerships will incorporate inclusivity (small- and medium-sized farmers) and the above-mentioned innovations into the value chains.

[9] Integrated approaches to agri-food system challenges draw upon a wide range of existing and emerging technologies, social change strategies, and policy tools, and financial investment.

Crops for Mexico (of which Maize for Mexico is part) responds to the objectives stated in the National Development Plan 2019-2024 and focuses on food self-sufficiency and rural development. It is closely linked to government social programs, such as Production for Welfare, and Guarantee Prices and Mexican Food Security, to name a few. The governmental initiatives address several climate security-relevant challenges (Granados Martinez 2017), most urgently hunger, with three out of ten rural inhabitants not eating enough (Gobierno de México 2012). Taking a mid-term view to 2050, rising average temperature-induced impacts in the region may push up food insecurity and child malnutrition (Inter-Agency Standing Committee 2009).

Investments in agri-food system innovation empower people to meet their own needs while participating in the wider economy, enabling stable, peaceful communities. Yet, Mexico's Secretary of Agriculture and Rural Development warned in December 2020 that "for the first time in many years since Borlaug defeated hunger in Southeast Asia, millions of people are at risk of starvation in Africa, Asia and Latin America" (Curiel 2020). The Government of Mexico, together with the Nobel Peace Center and the International Maize and Wheat Improvement Center (CIMMYT), issued a joint call to action to overcome the main challenges to human development under pressure from conflict, organized crime, forced migration and climate change: #AgricultureForPeace. CIMMYT's host country has taken the next steps with the Crops for Mexico project, building on the 10-year MasAgro experience (2011-2021), whose model has earned recognition from several international development organizations, funding agencies and governments.

Colombia's maize self-sufficiency stands at just 26%. By 2030, it may deteriorate to a production gap of up to 6.2 million tons. The Colombian National Agriculture Planning Office (UPRA for its acronym in Spanish) initiated this IASI process in June 2019. It involves a two-phase interaction with key maize value chain actors, resulting first in a policy guideline and action plan, based on a thorough situation analysis of the value chain; and secondly, the actors' participatory validation of analyses, results and a draft Productive Management Plan of the Maize Chain 2022-2041. The UPRA-led process was guided by IASI/Maize for Colombia methodology and tools, to address climate security-relevant challenges. There is a high future likelihood of having too much or too little water for agriculture (i.e., increased annual precipitation rate scenarios for the Andean and Pacific regions, whilst Orinoquia and Amazon region precipitation decreases) (Galeano et al. 2019) and, by 2030, maize production areas being no longer suitable, largely due to elevated temperatures, not precipitation[10].

The IASI methodology, as applied in Mexico and Colombia, has demonstrated its effectiveness in overcoming typical barriers and advancing multiple objectives simultaneously (e.g., improvement in crop yield and quality; farmer livelihoods; environmental protection). Progress made through a "network-of-networks" approach builds connectivity and stability at every step. Action toward climate and food security in the Central American Dry Corridor can benefit from IASI-type participatory planning and innovation hub networks.

[10] By 2030, maize production will increase by 4.3% in the status quo, but the growth will not be significant considering the increase in the expected total demand for maize by 2030 (27.4%) in the same scenario, including both yellow maize (33.2%) and white maize (13.9%). (CIMMYT-CIAT, 2019).

7. The Added Value of Agricultural Research for Development

This paper is part of a larger undertaking to articulate the role and value of Food Systems AR4D before, during and after conflicts: How can stakeholders achieve and benefit from peace dividends at the preventive, reactive and reconstruction stages? Can AR4D contribute perspectives, knowledge and solutions to national security research and policymaking? How can those solutions become complementary components to humanitarian, political, social and security-focused solutions to sustain rural livelihoods?

CGIAR, for example, in its new One CGIAR strategy addresses the key SDGs of the Climate Security nexus, namely SDG2 on achieving Zero Hunger, SDG13 on Climate Action and SDG16 on Peace, Justice and Strong Institutions. CGIAR believes AR4D for land, water and food systems can contribute significantly to peace and security. Imagine for a moment that a well-coordinated development intervention succeeds in establishing inclusive governance from national to municipal level, much improved policing, functional social programs, and effective conflict resolution approaches. It also fosters renewable energy solutions and programs that enhance the skills of youth. But what about the knowledge and know-how required to sustainably live off and with the land under climate change, to continue contributing to national food, and nutritional security? Adding this perspective, or layer, is what comprehensive climate security is about.

The CGIAR Centers delivered research and enabled outcomes that also provided peace and security benefits, or spill-over effects, before the term climate security was coined. Examples include a 2013 study on Sudan's vulnerable areas (Calderone, Maystadt, and You 2013) with particular biophysical characteristics and vulnerable populations; emergency seed multiplication in Ethiopia (CIMMYT 2016), and research on how forest-biomass is affected by armed-conflicts (Castro-Nunez et al. 2017).

CGIAR Focus Climate Security has conducted a literature review on climate security to establish an overview of conflict drivers and pathways, serving as a base for mapping CGIAR and partner research in the context of climate security through a portfolio review (CGIAR FOCUS Climate Security n.d.). Conflict pathways, including drivers related to food systems, such as agricultural outputs, rural livelihoods, poverty and food insecurity, as well as migration and displacement and weak governance were among the most studied conflict drivers found in the literature. The same drivers are also most studied by CGIAR and addressed by conveying knowledge and tools on disaster-risk reduction, climate change adaptation and livelihood resilience, among others (Figure 10) (Liebig et al. 2021).

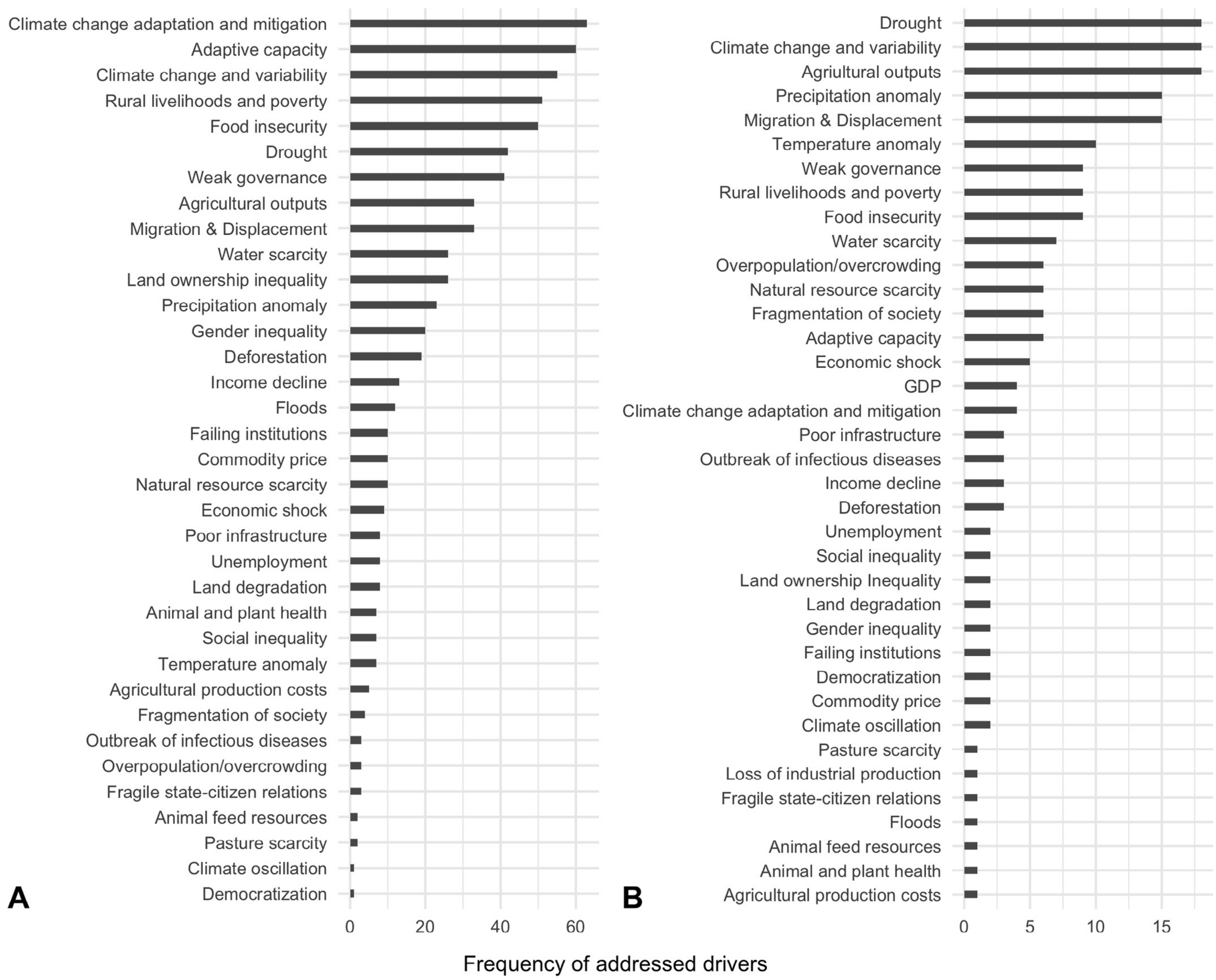


Figure 10. Addressed drivers of conflict found in portfolio and literature review.

CLIMATE SECURITY ENTRY POINTS

8. Climate Security Entry Points for the Central American Dry Corridor

To identify sensible entry points, it helps to take a national security experts' (CNA 2007) perspective on destabilizing climate change impacts. They see reduced access to fresh water, impaired food production, health catastrophes, and land loss and flooding associated with displacement of major populations. The experts point to these security consequences: greater potential for failed states (and terrorism), mass migration adding to global tensions, and potential escalation of conflict over resources. This definition of climate security from a national security perspective matches well with the AR4D perspective: To understand the drivers behind human security consequences for rural agriculture-based communities facing changing climates and environmental degradation that affect food and nutrition security and their ability to manage a finite pool of natural resources (Maru et al. 2018; Olarinde et al. 2013). Inclusive governance, functional social programs, effective conflict resolution approaches and highly skilled youth are critical assets but not enough to maintain climate security; it is equally important to understand how to use the land and its resources sustainably even in the face of growing climate stress.

In this paper we have shown that interconnected climate, security, and migration crises are being managed as separate challenges in the Central American Dry Corridor. Through well-targeted support that complements humanitarian, political, social, and security-focused solutions, agricultural research for development can help rural populations adapt to and mitigate climate change impacts, stabilize agriculture-based livelihoods, and increase peace and security.

A spatial analysis of drivers of conflict demonstrated clearly that climate has the potential to exacerbate conflict, insecurity and migration. However, a social media and policy coherence analysis shows the disconnected discourses of climate and security both in public discourse and in policies. The analysis of peace, security and climate risk indicators situates the Central American Dry Corridor countries vis-a-vis other countries globally and uncovers the disconnect among the indicators in terms of climate security, human wellbeing, and peace. In this fragmented context, we have argued that investing in agriculture research for development can contribute to reducing conflict and out-migration, with its focus on enhancing resilience of agricultural production and rural livelihoods in response to climate change impacts.

We therefore propose the following entry point for incorporating climate security dimensions into rural development and regional and national security policy and research agendas:

1. **Foster inter-ministerial and inter-sectoral dialogue to overcome currently siloed perspectives and develop a shared understanding of problems and agree on coordinated and joint actions.** In many cases, inter-ministerial dialogue remains superficial (e.g., knowledge exchange versus joint learning and actions), budgets uncoordinated and national security institutions continue to act separately from each other and from research providers). A sensible starting point is to connect national mitigation and adaptation and security plans to related AR4D-identified rural opportunities and pathways, demonstrating what has worked where and documenting successful approaches for technology and process-know-how transfer from other countries or regions. This paper has shown that in Dry Corridor countries, there are currently no such discussions. Most actors, institutions and interest groups do not consider climate and security as critically linked and treat them as separate challenges.
2. **Leverage existing efforts to bring together a range of partners to comprehensively quantify interrelated social, economic, and environmental challenges and business cases to target public and private sector investments, including in research.** Climate security opportunity costs, externalities and rural development potential need to be assessed and inclusive business cases based on natural resource or environmental economic accounting built. In this paper, we have provided examples of externalities in the environmental, social and economic spheres that are interrelated (resource degradation and food insecurity leading to migration and conflicts).
3. **Build on existing regional networks and knowledge transfer platforms to re-think and re-design community-based approaches that can effectively serve a range of interrelated objectives, including capacity development** (e.g., the IASI framework). When taking a multi-sector and inter-generational view, one observes much fragmentation among rural education efforts. Focusing on agriculture, rural education and training is often project-driven (i.e., not institutionalized over a longer-term), delivering specific, oftentimes siloed, technology transfer (e.g., improved varieties and seeds, but not relevant farming practices). However, the sustainability of climate security solutions depends on the ability to manage train-the-trainer approaches over time (e.g., certified extension

agent programs), build different kinds of business models (e.g., for ecosystem services, service providers, cooperatives), manage community networks, and perform advocacy and political dialogue (e.g., to improve enabling conditions). Such longer-term education programs could in future go hand-in-hand with currently unconnected One Health and conflict resolution/mediation training programs. This paper has featured several such approaches, including Local Technical Agroclimatic Committees, Climate-Smart Villages, MasAgro innovation hubs, that offer promise in the Central American Dry Corridor.

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