



Climate-related migration and the climate-security-migration nexus in the Central American Dry Corridor

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Abstract

The Central American Dry Corridor (CADC) is among the most climate-vulnerable regions worldwide. Climate change, commonly referred to as a “threat multiplier” of pre-existing socioeconomic issues, already undermines rural livelihoods by reducing agricultural yields and income opportunities. This paper provides a review of climate-related migration in the CADC region while identifying the specific pathways by which climate change manifests itself as a threat multiplier to migration. Different forms of human mobility (seasonal/temporal/permanent and internal/international migration) are increasingly attempted as adaptation strategies by affected households to diversify incomes and offset climate impacts. Preferred intra-regional migrant destinations tend to be less climate-vulnerable and also less violent. Notably, climate change is not isolated from socioeconomic and political migration drivers. Erosion of rural livelihoods reduces the costs of engaging in illicit coping strategies (e.g., illegal crop production) and simultaneously favours rapid urbanisation, which is linked to (forced) gang recruitment, primarily affecting the youth. These processes contribute to extraordinarily high violence levels, which are a major push factor for migration on their own, ultimately challenging state authority. Moreover, as outmigration from the region is projected to increase, the observed securitisation of borders, particularly along the USA-Mexico border and the Mexico-Guatemala border, while unfit to limit migration attempts, make migration more desperate and dangerous, allowing organised crime to step in and exploit migration as an economic undertaking. Thus, for the CADC, the depoliticised and simplistic narrative of migration serving as adaptation must be questioned. Policy coherence and state capacity for addressing climate-security-migration nexus challenges are critical needs.

Keywords Migration · Human mobility · Climate change · Adaptation · Central American Dry Corridor · Securitisation

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1 Introduction

The idea of climate change driving human migration is well-established and migration itself, including for environmental reasons, has occurred in Central America for millennia (Arnauld et al. 2021). The last two decades have seen growing interest in how climate variability affects human mobility and its consequences (Felgentreff and Pott 2016) but with inconsistent conclusions. Key questions include whether migration constitutes a viable adaptation strategy or a maladaptive coping strategy and how many people may relocate as a direct consequence of ongoing human-induced climate changes (Ferris 2020; Hunter et al. 2015). Climate change has sometimes been depicted as a singular driver of (forced) migration, but social scientists, and especially migration scholars, argue that migration is seldom monocausal but results from the interplay of economic, social, political, cultural *and* environmental dimensions (Piguet et al. 2011). Similarly, alarmist narratives of “climate refugees” have been criticised for oversimplifications, portraying those affected by climate variability as passive victims without agency, while disregarding other migration- and/or conflict-inducing elements such as inequality, social exclusion, and conflict/violence (Scoville-Simonds et al. 2020). Despite this, it is undeniable that climate change *does* affect human mobility, including by exacerbating pre-existing migration drivers.

The effects of climate change on migration are complex, with seemingly similar settings facing apparently similar climate challenges and comparable deteriorating climatic conditions producing different migration outcomes: while (seasonal) droughts in one setting may increase migration flows, in another setting impoverished populations can become trapped due to rising poverty levels, resulting in a lack of resources required to move (Burzyński et al. 2022). Slow-onset climate events such as coastal erosion, temperature increase or altered precipitation patterns also have differential impacts. Being longer-lasting, slow-onset climate change is more likely to drive permanent resettlement than rapid-onset events which may allow a possible return afterwards (Delavelle 2013).

Understanding impacts on agriculture are crucial to understanding likely outcomes of climate change (Cai et al. 2016; Feng et al. 2010). Critically, the roles of climate change in migration do not obviate other migration-inducing factors (e.g., socioeconomic drivers, conflict, violence), which can also mutually interact (Savelli et al. 2022, Detges et al. 2020). Thus, terms such as “threat multiplier” or “risk multiplier” are increasingly attributed to climate change concerning both observed and projected impacts on human mobility (Nett and Rüttinger 2016).

The threat-multiplying effect of climate change is very relevant to the Central American Dry Corridor (CADC), which is amongst the most climate-vulnerable regions of the world (Castellanos et al. 2022). The region is highly dependent on agriculture for employment and GDP and is afflicted by gang violence, inequality, social marginalisation, and low institutional capacity: a powerful cocktail of migration-pushing factors. However, analyses of migration in the region have generally focused on individual factors, although some have explicitly considered them in combination (Läderach et al. 2021; Pacillo et al. 2021). In addition, these do not always consider the ways in which climate change acts as an accelerant of pre-existing drivers. Notably, while research on climate-related migration has been growing quickly, a particular focus has been placed on sub-Saharan Africa, South Asia, and Latin America, with fewer studies addressing this issue in Central America (Hoffmann et al. 2021). Even fewer studies are focused explicitly on the CADC, which is a surprising gap given the fact that the region is

characterised by even higher levels of climate vulnerability, conflict, (extreme) poverty, and insecurity and violence (Pacillo et al. 2022; FAO 2022).

This literature review focuses on four aims. Firstly, to shed light on how climate change impacts different forms of migration in the CADC as the available literature is far from being extensive (Sects. 3 and 4). Secondly, we seek to untangle the complexity and context-specificity through which climate change can interact with and amplify other powerful pre-existing migration drivers (Sect. 5). As Cattaneo et al. (2019) point out, so far “the majority of studies seek to examine *whether* climate influences migrations; very few contributions examine *why* and *how* climate change may affect migration”. Specifically, this relationship is addressed by calling attention to possible impacts on violence and organised crime (Sect. 5.1) and partly consequential implications on securitisation processes and human security (Sect. 5.2). Thirdly, by focusing on the CADC, we aim to contribute to an improved understanding and awareness of “unquantified”, “poorly understood” or even “unidentified” climate risks, amongst other factors resulting from complex feedback mechanisms of climate and social risks and the paucity of interdisciplinary collaboration between natural and social science communities (Rising et al. 2022). Crucially, this includes “the potential for climate change impacts to drive social discontent, dislocation and relocation, and instability and conflict, (which) are all deeply uncertain, but potentially crippling” (ibid.). Fourthly, by linking climate-related migration to an increasing securitisation of international borders and a resulting exploitation of migration by highly prevalent organised crime, we challenge the often uncritical “migration as adaptation” narrative which, in the case of the CADC, tends to overlook the social and political dimensions in which migration occurs.

Methodologically, this paper is based on a literature review of interdisciplinary theoretical and empirical literature, drawing from a wide range of disciplines such as agronomy, biology, economics, meteorology, political sciences, and sociology. While acknowledging the limitations of the narrative approach, we consider an interdisciplinary review is needed to comprehensively identify genuine research gaps (Cattaneo et al. 2019) and the potential feedback mechanisms of interacting but difficult to quantify climate and social risks (Rising et al. 2022).

2 Climate variability: a growing factor in human mobility

Climate changes affect human migration, yet the notion of climate-related migration remains contested and is often considered to oversimplify the complex subject of migration (Piguet et al. 2011). In particular, complex relationships have been found between climate, migration, and the agricultural sector. Cai et al. (2016) have reported significant positive relationships between temperature increases and bilateral international migration flows, but only in countries with large rural populations or where agriculture is a major economic pillar. However, Cattaneo and Peri (2016) analysed migration in 115 countries between 1960 and 2000 and concluded that higher temperatures did indeed negatively affect agricultural productivity, driving migration toward urban areas or internationally, but only in middle-income countries. In low-income countries, temperature increase can reduce outmigration, indicating the liquidity constraints and the likely emergence of “poverty traps”, preventing the poorest households from migrating (Rigaud et al. 2018). While climate change greatly impacts migration-impacting factors such as poverty and inequality, the main forms of migration are often internal or regional rather than long-distance international movements

(Burzyński et al. 2022). The diversity of findings (e.g., increased migration versus trapped populations under seemingly similar conditions) in relation to climate and migration flows is unsurprising given the vast range of differing contexts in which analyses take place (Beine and Jeusette 2021).

Migration can be considered as a potential strategy for income diversification, possibly enabling adaptation when agricultural livelihoods are eroded by deteriorating environments or growing climate unpredictability, so-called “migration as adaptation” (Gemenne and Blocher 2017). Indeed, it is suggested that the migration of rural households’ members can provide a strategy for risk-management and an informal insurance against climate impacts on yields, incomes, or employment opportunities (Loebach 2016, Carte et al. 2019). It is possible that remittances sent and/or savings brought back by migration-engaging household members may be fundamental as climate financing for in-situ climate adaptation (Angelsen et al. 2020; Davis and López-Carr 2014). Notably, migration does not necessarily imply the abandonment of agriculture but rather migration can provide the necessary means to maintain farming and agricultural practices (Adger et al. 2018). However, migration can also be considered as a maladaptive response. This can occur when there are major social or poverty implications of migration in destination locations or can occur in origin locations when there is a reduced workforce for labour-intensive agriculture (Gemenne and Blocher 2017).

3 Climate-related migration in the Central American Dry Corridor

The CADC is among the most climate-vulnerable regions in the world. It is home to ~11 million people and stretches from Panama via Costa Rica, Nicaragua, Honduras, and El Salvador to northern Guatemala. The CADC includes almost all Central American countries, except for the northernmost Belize. However, the percentage of country territory within the CADC ranges considerably, with only 5% of the territory of Panama lying within the CADC, rising to 84% of El Salvador (Gotlieb and Girón 2020; Figs. 1, 2). Although internal movements of people, mainly headed toward urban centres, are the most prevalent form of migration in Central America (Baez et al. 2017), the region has also been a hotspot of international migration for the past 30 years (increasing by 137% from 6.82 to 16.2 million between 1990 and 2020; UNDESA 2020). Consequently, while regional migration patterns have been assessed, most quantitative studies have focused on individual drivers (e.g., conflict, violence, poverty, inequality). While all these are powerful push factors for migration (Sandoval-García 2017), climate variability fuelled by climate change, especially natural disasters and extreme weather events (of increasing frequency and/or intensity), have been found to be interrelated via multiple pathways while *also* being a driver of migration on their own (Läderach et al. 2021; Pacillo et al. 2021). Consequently, climate change is a “threat multiplier”, exacerbating risks in a region marked by conflicts, gang violence and excessively high homicide rates, severe economic inequalities, (rural) poverty, and low state capacity (*ibid.*), all of which increase both insecurity and likelihood of migration.

Generally, socioeconomic characteristics affect the specific form of migration. In Guatemala and El Salvador, the majority of migrants tend to be (young) men (Angelsen et al. 2020), while in Honduras and Nicaragua, sexes of migrants tend to be equally distributed (Ayales et al. 2019). For some areas, climate pressures significantly increase women’s workloads as they must care for their families, while also pursuing “traditional” tasks like farming (Silva Rodríguez et al. 2021). Men, due to cultural norms, are expected to provide

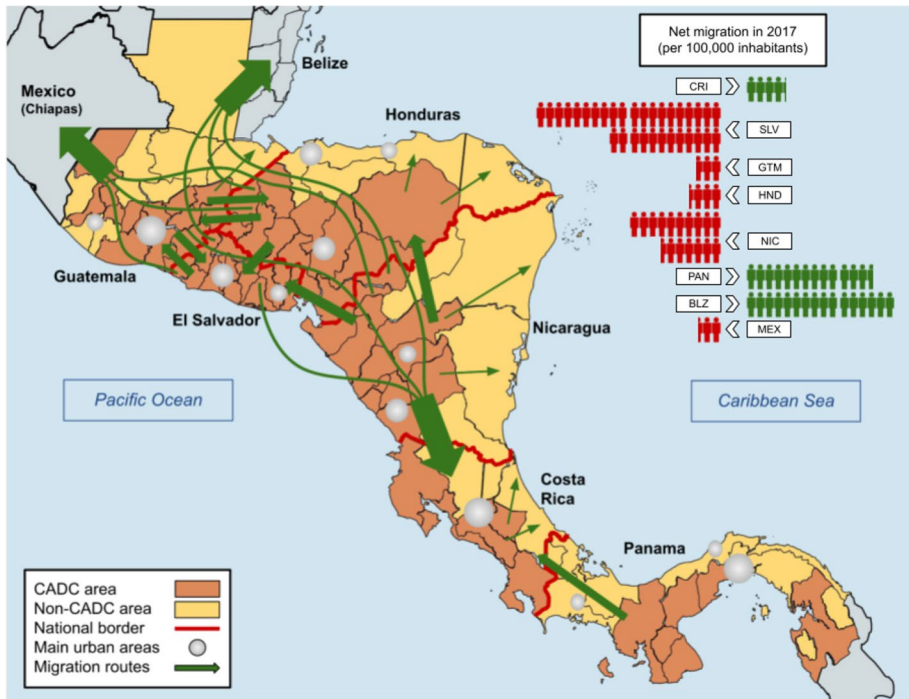


Fig. 1 Reported destinations and migration routes within and from the CADC. As there is only one planting season, most mobility is intra-regional or internal and either directed toward coffee and sugarcane growing areas, facilitated by the Central American 4-visa system (including El Salvador, Guatemala, Honduras, and Nicaragua), or rural–urban. Net migration indicates the main intra-regional destinations, usually less climate-vulnerable and less violent. Each silhouette represents 100 migrants per 100,000 inhabitants with green or red (+/–) signifying whether emigration or immigration dominated. Data: UN Population Division (last available year: 2017)

sufficient capital before starting a family (Angelsen et al. 2020). Findings from Guatemala indicate that migration-engaging households are significantly wealthier (counter to the narrative of migration as a “last resort”) but also more reliant on agriculture (ibid., 12). In contrast, rural Nicaraguan households with at least one family member abroad were not only less engaged in agricultural labour, more food secure, but also more engaged in migration (Cortes et al. 2017). For Nicaragua and Honduras alike, temporal migration of the *whole* family is more likely, particularly during the coffee-picking season, as there is high demand for workers. However, this may result in children (commonly part of the household workforce in poorer families) missing school for months at a time (Ayales et al. 2019). Because of increased heat exposure, young unskilled women, assuming important roles within industrial production (e.g., textile), increasingly migrate toward urban areas, usually outnumbering men (Baez et al. 2017; Delavelle 2013). Another finding is that South-North migration, predominantly bound to the USA or Canada, is more likely to be pursued by better educated and wealthier households/individuals due to the high costs to finance such movement (Klaiber 2014). In El Salvador, for instance, agricultural shocks increase the likelihood of households engaging in international migration to the USA, as well as the dependency on remittances (Halliday 2006). However, after particularly severe shocks,

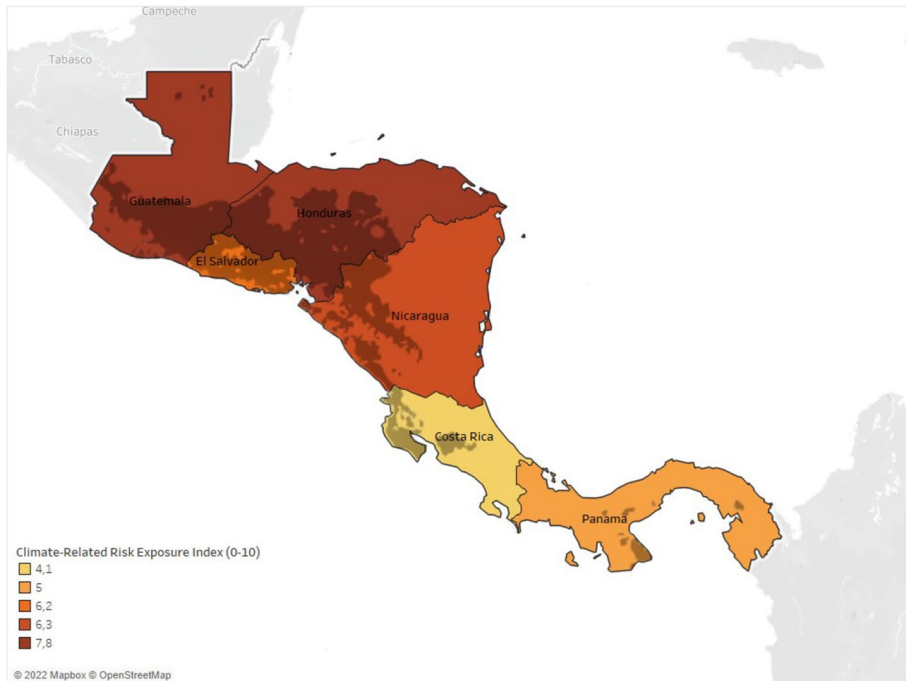


Fig. 2 Climate-related risk exposure in Central America. Values range from 0 (very low risk) to 10 (very high risk). Variables constituting the index value address exposure to climate-related hazards, (floods, environmental degradation and drought, tropical cyclones, epidemics). The CADC is darker with geographic locations adapted from Gotlieb and Girón (2020, 4). Data: Index for Risk Management (INFORM) 2020 Latin American and the Caribbean

migration actually decreases as liquidity constraints hinder engagement in costly long-distance migration (*ibid.*).

Generally, outmigration from the CADC has increased significantly in recent years, also because of climate change. The World Food Program (WFP) estimated that between 2010 and 2015 alone, the number of people leaving the region increased five-fold, with nearly 10% of emigrants citing extended periods of extreme weather as their primary reason to leave (Ruiz Soto et al. 2021). However, only a limited number of studies have quantified the correlation between climate/environmental variables and migration (Baez et al. 2017). Importantly, most studies do not address the CADC specifically, but instead focus on Latin America and the Caribbean as a whole or consist of country-specific case studies. Using census data to study inter-provincial migration in South America for instance, Thiede et al. (2016) observed that between 1970 and 2011 exposure to monthly temperature shocks has the most coherent effect on migration patterns (compared to monthly rainfall shocks or slow-onset climate changes).

Somewhat comparable to the CADC, but addressing rural–urban migration in Mexico, Nawrotzki et al. (2017) found that after a threshold of 34 months, each additional drought month increases the likelihood of rural–urban migration by 3.6%, highlighting the non-linear nature of climate-related migration. Agriculture is a major linkage since the temperature-migration relationship connects to yield reductions and crop losses (Feng et al. 2010).

Natural disasters have a similarly differentiated impact on migration in the CADC. In the aftermath of Hurricane Mitch, for Nicaragua Loebach (2016) observed no effect on overall likelihood of cross-border migration to Costa Rica, yet Mitch was associated with increased migrant selectivity according to the access of pre-existing migrant networks in the destined relocation areas. It was concluded that cross-border migration is not a last-resort strategy for the particularly vulnerable, a finding consistent with other studies, but rather becomes increasingly inaccessible if social and financial capital constraints occur. Instead, those with fewer resources tend to move temporarily and over short distances (Fussell et al. 2014). In Costa Rica, hydrological emergencies increased migration rates mainly toward urban centres less dependent on agriculture (Robalino et al. 2015). One important limitation of this is that particularly severe events with high mortality or major infrastructural destruction decreased levels of migration.

Notable, yet understudied, types of migration are cases of South-South migration toward neighbouring countries and rural-rural migration, both of which can provide important livelihood strategies (Melde et al. 2014). For instance, in Nicaragua, members of smallholder farming households (particularly the poorest) commonly provide seasonal labour in El Salvador, the resulting income supporting subsistence farming on marginal lands (Carte et al. 2019). Survey data for Nicaragua shows that the land-poorest particularly engage in such migration, with remittances used to help acquire farm inputs (e.g., fertilisers and herbicides). Regarding rural-rural migration, outmigration from CADC regions toward rural non-CADC regions (see Fig. 1) can contribute to deforestation and soil erosion, as deleterious land-use practices from the CADC are replicated. This appears to be increasingly the case in the humid Caribbean coastal forests (Gotlieb and Girón 2020; López-Carr and Burgdorfer 2013), where there is growing deforestation to clear land for cash cropping, ranching, or herding as these activities provide more lucrative prospects of generating income. This is a potential source of further conflict and has repeatedly spiralled into violence as these ecologically fragile areas are predominantly inhabited by indigenous peoples. (e.g., the Miskitu areas in Nicaragua; Robles 2016). Climate-related migration in the CADC is predominantly short-distance (internal or regional), additionally coinciding with rapid urbanisation (Silva Rodríguez et al. 2021), as illustrated by Fig. 3. Climate change increases the trend towards rural–urban migration, with urban areas being marked by high levels of gang control and violence. The context-specificity of climate-related migration is shown for the region, mainly depending on the socioeconomic characteristics of households and the type and severity of climate impacts.

4 Vulnerability and (migration as) adaptation to climate change in the CADC

As agriculture plays fundamental roles in rural economies, climate change endangers rural livelihoods (Bouroncle et al. 2017). Smallholder and subsistence farmers make up the majority of agricultural producers (~60%), yet own only 6.5% of agricultural land in the region (ECLAC et al. 2018). They mostly cultivate in unproductive and rainfed systems, translating to a high vulnerability to climate and weather shocks (Jaramillo et al. 2020). For farmers relying on rainfall, only one planting season is possible during the rainy season. Thus, shocks and droughts, especially associated with the El Niño/Southern Oscillation (ENSO), drastically increase food insecurity (Beveridge et al. 2019). In 2018, for instance, extended droughts led to losses of 82% of maize and bean yields (Lejtregger 2019). The

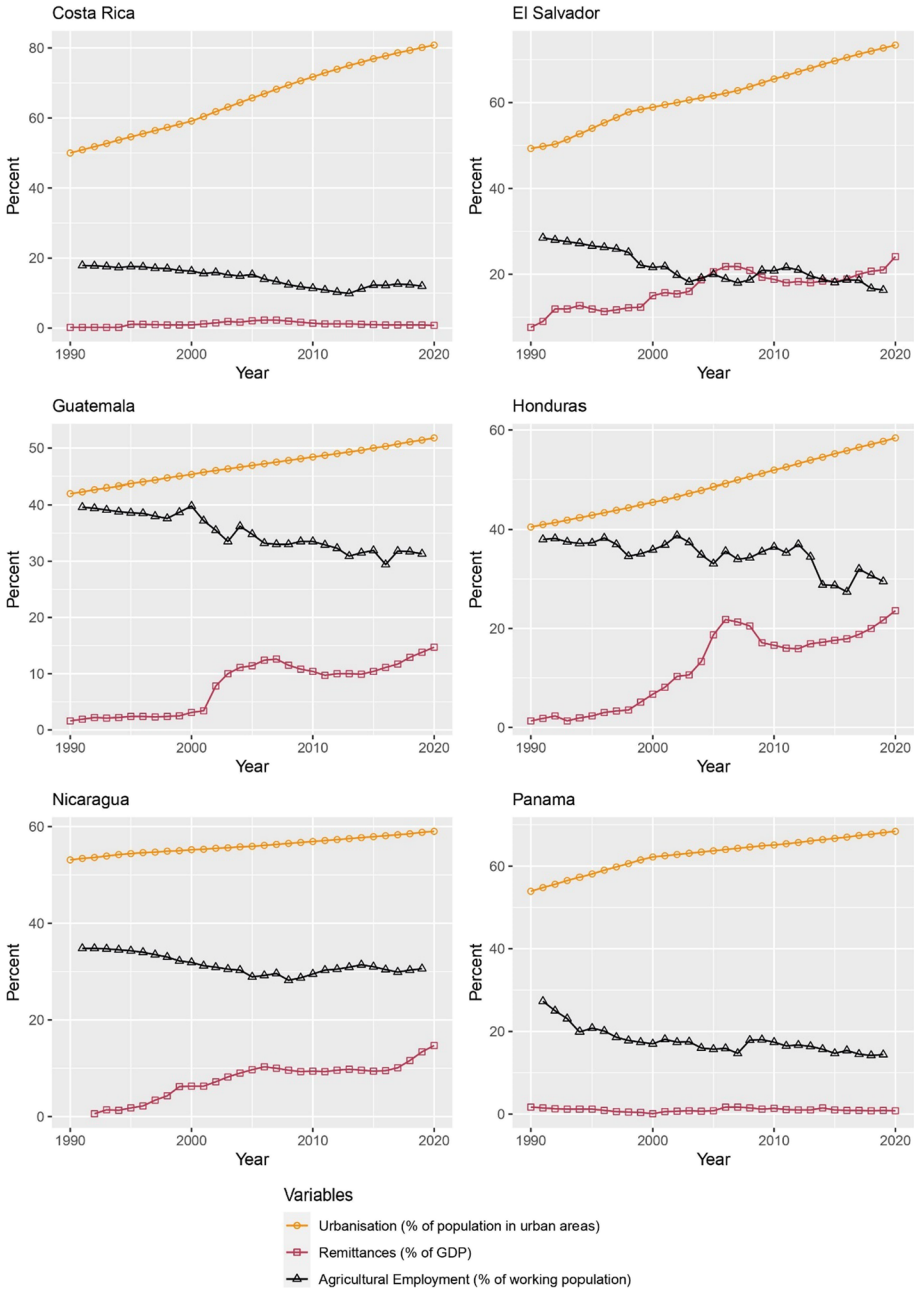


Fig. 3 Urbanisation rates (a proxy for internal migration), personal remittances received (share of GDP), and agricultural employment (share of working population) for CADC countries. Data: urbanisation (United Nations Population Division 2022), remittances (Migration Data Portal, KNOMAD/World Bank 2022), agricultural employment (ILO, model estimate 2021)

FAO estimates that 73% of the CADC population live in poverty, with 7.1 million people being severely food insecure (ibid. 2022). Critically, drought impacts are projected to worsen significantly, eventually leading to a drastically reduced suitability for key staple crops such as maize, beans, and plantains, which are fundamental for nutrition and food security, and cash crops like coffee and cocoa, which are an important source of income and capital, including for education. Depsky and Pons (2020) project that under moderate to high GHGE scenarios, mean annual rainfall will decrease by 8–14%, while seasonal-scale droughts lengthen by 12–30%, intensify by 17–42%, and increase in frequency by 21–24% by the 2071–2100 period. Existing drought risks are compounded by other climate-related events projected to increase in frequency and intensity, including floods, tropical cyclones, epidemics (e.g., plant pathogens), and hurricanes (most recently Eta and Iota in 2020, FAO 2020).

In their survey of Central American smallholder coffee and basic grain farmers, Harvey et al. (2018) found that 95% of the 860 surveyed participants experience climate change impacts and 32% report food insecurity due to extreme weather. The room for manoeuvre regarding climate adaptation is undermined by pre-existing factors such as insecure land tenure, particularly for women (Ayales et al. 2019). Continuing environmental degradation is often spurred by harmful coping strategies, such as illegal deforestation (Gotlieb and Girón 2020). While government adaptation strategies have focused on irrigation, stress-resistant crop varieties, and sustainability, smallholder adoption is hindered by resource limitations and inadequate extension services (Harvey et al. 2021).

In the absence of other adaptation strategies, migration is pursued to adapt to growing climate stresses, especially to generate remittances. For rural Nicaragua, Cortes et al. (2017) observes that households with better-situated food security tend to be less farm-oriented, less engaged in agricultural wage labour, and, crucially, engage more in migration. Analysing several neighbouring municipalities in Guatemala and Mexico, Angelsen et al. (2020) found positive correlations between reliance on agriculture and the dichotomic variable of a household having one or several members abroad, thus highlighting the importance of migration for smallholder agriculture. One-fifth of households reported remittances as their main source of income (ibid.), often for purchasing farm inputs to alleviate climate pressures or to purchase additional holdings (Davis and López-Carr 2014). Contrary to some reports (e.g., Lustgarten 2020; Markham 2019, World Food Programme 2017), the generation of remittances does not necessarily finance an exit from agriculture but in fact allows the continuation of farming (Angelsen et al. 2020; Adger et al. 2018, Carte et al. 2019). As can be seen in Figs. 2 and 3, the relatively more climate vulnerable CADC countries have a higher and more rapidly growing dependence on remittances, which supports the importance of migration to obtain the financial means to stay in agriculture. While this finding has also been observed in other parts of the world where households adapting through on-farm in-situ investments become less likely to engage in migration, only few empirical analyses have been conducted to date (Cattaneo et al. 2019). This trend is sometimes referred to as “new rurality”, which includes increasing livelihood diversification, shifting household income shares toward non-agricultural activities, and a growing role of remittances in rural economies (Hecht 2010).

Furthermore, Figs. 2 and 3 illustrate that the three most climate-risk exposed CADC countries (Guatemala, Honduras, Nicaragua) have higher population shares employed in agriculture (for 2019, 31%, 29%, and 31%, respectively), while remittances constitute significant shares of GDP (for 2020, 14.7%, 23.6%, and 14.7%, respectively). Interestingly, the three relatively less climate-related risk exposed CADC countries (Costa Rica, El Salvador, Panama) had the highest urbanisation levels (for 2020, 80.8%, 73.4%, and 68.4%,

respectively), which likely correlates to more non-agricultural employment opportunities. Without implying a direct causal relationship, the overall trend for all countries between 1990 and 2019/2020 is for agricultural employment to decrease, urbanisation to rapidly grow, and remittances (except in Costa Rica and Panama) becoming increasingly vital. These observations are consistent with findings highlighting the importance of country-internal migration (mostly destined toward urban areas) for rural livelihoods dependent on agriculture (Robalino et al. 2015; Baez et al. 2017).

Clearly, while the “migration as adaptation” narrative holds some truth for the CADC, migration can also be a maladaptive strategy. For example, outmigration from marginalised Garífuna communities in Honduras after hurricane Mitch in 1998 undermined the recovery of social-ecological systems due to “downgrading effect(s)” of “keystone producers” in the rural economy (Wrathall 2012, 585). Hence, a production-based economy shifted toward a more dependent remittance-based one, increasing inequalities in the sending community and opening poverty traps for those without access to remittances (ibid.). South-North migration from Nicaragua (predominantly to the USA) can be similarly positively affected by higher incomes and better education, restricting this option (Loebach 2016; Funkhouser 2009). Additionally, migration and remittances sometimes cause increased demand for agricultural land (often linked to forest clearings) which can contribute to environmental degradation, as in Guatemala (Angelsen et al. 2020). Furthermore, while remittances generally improve food security, under some circumstances, migration leads to contrary outcomes. In Guatemala, household surveys identified the absence of household heads, who (for cultural reasons) are more likely to migrate, as one driver of food insecurity (Beveridge et al. 2019).

4.1 Agricultural dependence and its impact on migration: the example of the coffee leaf rust epidemic

Coffee is a key cash crop in Central America, including in the CADC, where it plays a fundamental part in rural livelihoods and economies (Harvey et al. 2021). Smallholders, who often combine coffee farming with cultivation of annual staples and small-scale livestock, make up 80% of the region’s coffee producers and derive most of their income from coffee (McCook 2019).

Coffee Leaf Rust (CLR) is a fungus (*Hemileia vastatrix*) that causes the leaves of the coffee tree to develop orange-coloured lesions which subsequently leads to damaged/dead branches which are unable to produce fruits. The CLR disease reached Latin America around 1970 and subsequently spread to the Central American coffee plantations. While CLR was responsible for yield losses, it could initially be contained by spraying with fungicides and was not considered a major agricultural problem. This changed in 2012, later termed the “Big Rust”, when CLR began infecting areas where it had not previously occurred and simultaneously strains emerged which began to resist fungicides. CLR is highly temperature-sensitive. As most of the coffee plantations were at cooler higher altitudes, initially the fungus could not cause extensive damage. However, warming temperatures along with more erratic but intense rainfalls facilitated fungal spread, hastening its reproductive cycle (Ward et al. 2017), and allowing it to overcome fungicides and varieties that were hitherto considered to be rust-resistant (McCook 2019). Ultimately the CLR epidemic caused yield losses of 10–55%, translating into dwindling incomes which sometimes did not even cover input costs (Libert Amico et al. 2020). In turn, this caused the widespread erosion of livelihoods and severe deterioration of food security of smallholder

coffee farmers and labourers, which frequently engaged in negative coping strategies, such as selling land and assets (McCook 2019).

The Big Rust had also implications for migration, with smallholders abandoning land and migrating to urban areas, while those who struggled to continue to work their land often engaged in remittance-seeking labour migration. Between 2012 and 2014, according to the US Federal Office for Refugee Settlement, the number of minors from Central America migrating to the USA doubled, a strategy of coffee-farming households to diversify eroding incomes (Kumari Drapkin 2014, Semple 2019), confirmed by research in Guatemala CLR (Dupre et al. 2022). However, CLR is not an isolationist migration driver but again exacerbates pre-existing vulnerabilities mainly caused by continuously falling coffee prices following open-market agricultural policies which dismantled state-sponsored subsidies, extension services, and land tenure (Sandoval-García 2017). Coffee farmers reap the beans, while international roasters and retailers reap the profits. Thus, Ruiz-de-Oña et al. (2019) conclude that price levels are the main drivers of migration and that “emigration continues to be a route for improving the family economy”.

While remittances play important roles in smallholder adaptation to climate change, adaptation strategies in the coffee sector often encounter “wicked” problems. Coffee agronomy improvements involving the adoption of CLR-tolerant varieties (mainly less popular Robusta varieties rather than higher-quality but susceptible Arabica) are restricted by lack of credit (Ward et al. 2017), while some varieties begin losing their resistance to CLR over time (Avelino and Anzueto 2020). In addition, government programmes instigating substitution processes to aid adoption of resistant varieties are frequently marked by inefficiency, insufficient information, and weak extension provision (Ruiz-de-Oña et al. 2019). Other measures, such as value chain interventions intended to increase smallholder resilience have been identified as potential *sources* of vulnerability due to the market’s preference for speciality- and eco-certified coffee, which incentivises farmers to maintain rust-prone Arabica varieties and limits fungicide applications (Ward et al. 2017). Hence, while successful climate change adaptation could reduce migration, migration paradoxically also can finance less successful attempts.

Furthermore, the potential for remittances increasing inequality between households (able or unable to engage in migration) is problematic. In the coffee-growing border regions between Guatemala and Mexico, remittance-receiving households from Guatemala have been observed to illegally acquire coffee plots on the Mexican side of the border, spurring nationalist reactions among Mexican farmers (Ruiz-de-Oña et al. 2019).

In summary, the CLR epidemic confirms some of the generalised key inferences of the previous section, namely that (1) beyond a threshold, slow-onset climatic changes can trigger rapid-onset shifts; (2) without easily accessed adaptation strategies, households can employ migration in compensation; and (3) separating climate impacts from other economic, political, or social factors can grossly oversimplify migration and make adequate policymaking challenging.

5 The climate-security-migration nexus: interplays between climate and stability in the CADC

As with migration, the role of climate change in causing instability and conflict has received ever-increasing attention in recent years (Busby 2018; Carleton et al. 2016). Climate change is frequently associated with reduced access to natural resources

(Nordås and Gleditsch 2015) which can spur conflict in settings characterised by inequalities. Indeed, three of the CADC countries (El Salvador, Guatemala, and Nicaragua) have experienced civil wars associated with a highly unequal land distribution. Bundled with long-lasting colonial experiences (European-descended populations still own the vast majority of land compared to indigenous populations) and often repressive agricultural reforms (often instigated by foreign land-holding corporations), outcomes have led to highly inequitable post-conflict societies with little trust in government authorities which are considered to have failed to deliver on promises made in peace agreements regarding land redistribution (Brockett 2019). Indeed, land tenure issues even sparked an interstate war (the so-called Football War) in 1969 between El Salvador and Honduras in which migration played a key role. While the inertia effects from past conflicts are not subject to pressures from climate change, inequality in the CADC remains unaddressed and is now further exacerbated by climate change (Delavelle 2013; Bouroncle et al. 2017).

In the Honduran region of Bajo Aguán, for instance, a dispute over land between agroindustry palm oil companies and small-scale farmers escalated into violent conflict in 2009. Reports found multiple Human Rights violations including killings, reportedly committed by private security companies hired by the corporations, yet the detection rate remained virtually non-existent (Human Rights Watch 2014). Notably, one root of the conflict was Hurricane Mitch in 1998, which León Araya (2019) described as “the fuse of a set of land occupations” (ibid., 139). While conclusive research on how natural disasters and climate pressures can translate into increased levels of so-called land-grabbing is limited, clearly, more frequent global crises affecting food, energy, and the environment (all significantly driven by climate change) lead to revaluations of land tenure. Indeed, the land, water, and labour of the Global South are perceived by some “as sources of alternative energy production (primarily biofuels), food crops, mineral deposits (new and old), and reservoirs of environmental services” for national or transnational stakeholders, corporations as well as governments (Borras et al. 2011, 209). Climate change will likely further exacerbate these problems and affect conflict and inequality as a pre-existing migration driver.

Such developments have affected rural populations in every CADC country but are most pronounced in Guatemala and Honduras, arguably the two most climate-vulnerable countries in the region (Fig. 2). For the Bajo Aguán region, palm oil expansion on land claimed by smallholders has induced migration and eroded trust in state institutions—including conflict-resolution mechanisms (Villafuerte Solís 2018). Where state capacity is weak and social, economic, or political exclusion occurs, climate impacts may trigger violent conflict (Detges et al. 2020). Similarly, Ide et al. (2020) highlight that disasters (e.g., Hurricane Mitch) do not increase conflict risk by definition, but do so context-specifically, often in combination with limited state capacities. The specific pathways of climate manifesting itself as a risk factor for conflict remain contested, yet there is some consensus that climate change impacts more influential drivers such as low socioeconomic development, poverty, and state capability (Mach et al. 2019). As climate variability and extreme weather already challenge the abilities of states to deliver services (e.g., extension services, disaster relief measures) and stability, this may prove fertile ground for recruitment by non-state armed groups (NSAGs), including organised crime, and engagement in illegal coping strategies (Nett and Rüttinger 2016, Detges et al. 2020), all of which are particularly prevalent in the CADC.

5.1 Climate change and its reinforcements of insecurity, violence, and organised crime

The Northern Triangle of Honduras, El Salvador, and Guatemala has been described as the most lethal region outside of warzones, due to suffering from extraordinarily high homicide rates. Much of this violence is attributable to drug traffickers and gang violence. Forced displacement and migration due to organised crime, despite its alarming extents, are almost entirely absent from policy discourses, and studies examining this relationship are rare (Cantor 2014). Once again, the links between climate change and violence are manifold and non-linear.

Remote rural areas in the CADC, where state presence and capacity is low, with poverty and food insecurity omnipresent, provide fertile grounds for narco-traffickers in three ways. Firstly, the lack of law enforcement or other state presence allows organised crime to do their business relatively unharmed, with the remoteness of the locations providing infrastructure for production as well as trafficking (Cantor 2014). Secondly, the low state presence, capacity and hence basic service provision leaves a void that narco-traffickers can fill by establishing state-like structures to gain authority and support from local populations (for Guatemala, see Nett and Rüttinger 2016). Thirdly, and favoured by rural poverty, climate change pressures increase the likelihood of smallholder farmers engaging in illicit coping strategies, such as coca cultivation (Detges et al. 2020). Linking back to coffee rust, Harvey et al. (2021) reported coffee farmers switching to coca as, ironically, prices are more stable and profitable, sometimes increasing farmers' income significantly. Moreover, growing interest among criminal organisations in the acquisition of (agricultural) lands has generated a further driver of displacement. This development can be observed in rural areas of Guatemala and Honduras, where drug-trafficking organisations force smallholder farmers to sell their land to obtain control over strategic areas for cross-border trafficking, use it for drug production, or exploit natural resources that facilitate their businesses (Cantor 2014). In Honduras, for example, drug production has expanded significantly in recent years (Huber 2020, 2021, 2022). Illegal logging, timber trafficking, and cattle ranching, often connected to drug trafficking, have also significantly expanded, which becomes a source of displacement if these lands are inhabited and/or used by rural communities (Silva Ávalos 2020; Montoya 2022). Refusal to cooperate is strategically met with (the threat of) violence, which is another migration driver.

Similar challenges affect urban areas, as many Central American cities (particularly in the Northern Triangle of El Salvador, Guatemala and Honduras) are plagued by gang violence, while struggling to accommodate the basic needs of growing populations (Rüttinger et al. 2015; Kunkeler and Peters 2011). As climate change primarily erodes rural livelihoods in the CADC, internal migration and relocation to urban centres accelerate, ultimately lowering the opportunity costs for engagement in illicit coping strategies and the costs of (forced) gang recruitment in rural as well as urban settings. With climate change further eroding the viability of rural agricultural livelihoods, the demand for rural–urban migration grows, yet gang control and extraordinary high levels of violence make this kind of migration increasingly untenable. As it is primarily the youth from resource-stricken households engaging in this kind of migration, and with youth unemployment rates often more than twice as high as national averages, it is the youth that is the most prone to (forced) gang recruitment (Bergmann 2019, Kunkeler and Peters 2011). The likely consequence is even more frequent escalations of violence, as can already be observed. Tragically, those who are recruited by organised crime share key socioeconomic

characteristics with the migrants they traffic, extort, and threaten (i.e., young, poor, marginalised) (Bergmann 2019). Crucially, as climate change increases overall migration, so does the occurrence of human trafficking, kidnapping, and gang extortion, for instance during the humanitarian crisis at the Mexico-USA border unfolding from 2014 onward (Isacson et al. 2014). Gang violence has been observed to spread along migration corridors (Ambrosius 2021), as organised crime identifies migrants as lucrative sources of income (Sanchez and Zhang 2018). Climate change adds to this vulnerability of migrants, particularly as the securitisation of borders and the decline of legal pathways for international migration provides the opportunity for organised crime to exploit migration and trafficking as an economic undertaking. Ultimately, vicious and reinforcing cycles of climate impacts, vulnerability, violence, fragility, and migration may be set in motion.

5.2 The conflict between securitisation and human security at Mexico's southern and northern border

Considering the “migration as adaptation” narrative, the criticism it faces for overlooking the political dimension of migration (Ruiz-de-Oña et al. 2019) certainly seems valid for outbound migration from the CADC, particularly across borders. Although less prevalent than internal migration, disproportional attention from policymakers, the media, and general public is paid to international migration (McLeman 2019). These impacts have led to climate change increasingly being considered a (national) security threat, which policy responses addressing migration often fail to acknowledge. Ultimately, this may lead to an appropriation of the discourse regarding the climate-security-migration nexus by policymakers and security providers, with a focus on the national security dimension only and thus severely undermining the human security of migrants by targeting migration as environmental and security threat alike (McDonald 2013; Hartmann 2010). Unsurprisingly, restrictive border policies can increase the vulnerability and exposure of populations to climate change (Benveniste et al. 2020, Piguet 2022). With the USA being the primary international destination for Central American migrants, the subversion of human security due to securitisation measures has been openly observable along the USA-Mexico border for decades and more recently at the Guatemala-Mexico border (Isacson et al. 2014). As Massey et al. (2016) suggests, for Americans, the Mexican border is “the preeminent symbolic line separating Americans from any external threats” with “reflexive policy response offered by politicians to reassure citizens (being) more border enforcement” (1563). Climate change and climate-related migration are no exceptions.

Most migrant apprehensions at the USA-Mexico border are from Mexico or Central America and although the number of unauthorised immigrants in the US slightly declined from 2007 (Lopez et al. 2021), this is not reflected in policymaking, which massively increased funding for border fortification (\$2278 million in 2007, \$4896 million in 2021) (American Immigration Council 2021). The fact that between 1986 and 2008, US Border Patrol funding had already increased 20-fold while the number of the unauthorised immigrant population actually increased demonstrates that border fortification and anti-immigrant policies neither effectively prohibit nor limit migration in the slightest (Massey et al. 2016). Instead, they make migration more difficult, dangerous, and desperate. While the technologization of border surveillance prompts migrants to avoid using cell phones, making them less likely to receive assistance in emergencies (Newell et al. 2016), the militarisation of the border shifts the locations of border-crossing attempts towards more remote

locations, many controlled by organised crime seeking to exploit migrants through human trafficking, extortion and kidnapping, with relatives in their origin or destination countries expected to pay fees and ransoms (Walker 2018).

Even comparatively small migrant flows (e.g., following the outbreak of the climate-induced CLR epidemic in 2012, eventually contributing to the humanitarian crisis at the Mexico-US border in 2014) have caused political turmoil in the USA. Fuelled by misanthropic rhetoric, the resulting anti-immigrant sentiments resulted in increased border fortification and the further criminalisation of migration, which in fact did not limit migration attempts but made them more desperate and dangerous, while allowing organised crime to step in to exploit the migrants' vulnerability (Isacson et al. 2014). This again highlights the reinforcing impacts of seemingly isolated migration drivers such as climate, poverty, violence, and hardening borders in the era of climate change (McLeman 2019), trends that are highly likely to continue.

As climate change is projected to significantly exacerbate existing migration drivers and thus increase migration (attempts), the trend of undermining human security in favour of border securitisation is unlikely to have reached its culmination. This trend is exceptionally visible in the CADC.

6 Conclusions and implications for policy and future research

This review provides an overview of how climate change affects migration in the CADC and thus contributes to recent calls for context-specific, detailed, qualitative, and interdisciplinary research (Hoffmann et al. 2021; Rising et al. 2022), the latter focus distinguishing this paper from previous work. We have aimed to achieve this goal by qualitatively comparing the pathways through which climate change not only is a migration driver itself in the form of more frequent, intense, and severe extreme events and natural disasters, but crucially affects, exacerbates, and reinforces pre-existing migration drivers which were prevalent in the CADC long before climate change was considered to be a factor. We consider that this helps to entangle and illuminate the interrelationships between climate and social thresholds and tipping points, which, if overlooked, add to the underestimation of the total risks set in motion by climate change. As Cattaneo et al. (2019) point out, most studies seek to examine whether climate influences migration while disregarding why and how this predominantly indirect relation constitutes itself. Thus, we support Rising et al.'s (2022) appeal for more interdisciplinary collaboration between natural and social sciences to address the knowledge gaps emerging from complex non-linear feedbacks and interactions of seemingly isolated social and climate risks.

For the CADC, amongst the most climate-vulnerable and sensitive regions globally, this has several implications. Pre-existing migration drivers such as poverty, inequality, conflict, and violence are not isolated from each other, even though this correlation is far from being direct and/or linear. Climate change accelerates the erosion of rural livelihoods which heavily depend on agriculture for income and food security. This, in turn, has implications for the demand of different forms of migration. Climate change is also likely to limit the scope and selectivity of households seeking to engage in any form of migration as poverty impacts the (financial) resources needed, particularly for South-North migration with the USA as the primary destination.

The adaptive potential of rural-urban migration is undermined by urban gang violence, especially in the Northern Triangle. Predominantly, the rural and often marginalised youth

affected by high levels of unemployment and a lack of livelihood-generating opportunities become even more prone to (forced) gang recruitment, as this option may even appear attractive for providing income and a sense of social identity. The same holds for the involvement of international drug-trafficking organisations. Climate change reduces the engagement costs for illicit coping strategies, such as illegal crop cultivation (e.g., coca), as it affects the viability of key staple and cash crops. Moreover, drug trafficking-organisations have sometimes relied on forcibly displacing communities to obtain control over valuable (agricultural) land. Consequently, climate change may amplify exposure to violence in multiple ways, which can lead to further migration.

In addition, deleterious land use practices such as deforestation are repented to pursue adaptation strategies like cash cropping, farming, or herding. This has become a source of conflict in the sparsely populated Western jungle regions of Central America as these activities harm the livelihoods of mainly indigenous communities inhabiting these regions. In the near or long term, these conflicts, fuelled by climate change making former agricultural lands unsuitable, can spur further migration.

With climate change projected to further intensify in the CADC, the main international migrant destinations will likely become more inaccessible due to restrictive migration policies and border securitisation of migrant-receiving countries such as the USA. This opens the door for organised crime to step in and exploit migration through human trafficking, extortion, and kidnapping. Notably, these exploitations have significantly risen after surges of migrants heading for international borders, for instance in the climate-induced outbreak of the coffee leaf rust epidemic.

In conclusion, many migration drivers in the CADC region are indirectly impacted by climate change, yet such drivers are commonly not considered to be specifically climate-related. We have termed this complex relationship accordingly as the climate-security-migration nexus. In consequence, the often employed “migration as adaptation” narrative can be questioned for overlooking the social and political dimension in which migration in the CADC increasingly takes place.

More research is needed to assess the interrelationship of migration drivers, specifically in regions where a multitude of these drivers coexist. Furthermore, it will be important to learn if and how climate adaptation measures can contribute to limit migration (Cattaneo et al. 2019), particularly in circumstances where distress migration occurs and where migration implies grave risks for the well-being and lives of migrants.

In the policymaking arena, the good intentions expressed in key global and regional documents, for example the United Nations Global Compact for Safe, Orderly and United Nations (2018) which explicitly mentions migration due to climate change, are rarely matched in practice as “few nations show any interest in giving legal recognition to people who move for climate-related reasons” (McLeman 2019, 911).

While international institutions such as the International Organisation for Migration (IOM) and its member states increasingly consider climate-related migration (Murray 2021), for the CADC states there is little policy coherence linking climate impacts to security or migration (Läderach et al. 2021, 20–23). Similarly, there has been little consolidation of progress in integrating human mobility into climate change strategies, including the CADC countries (Lejtregger 2019). Ultimately, the isolation of climatic from political, social, and economic contexts will likely results in inadequate policymaking. Fundamentally, the integration of migration into climate change policies (and vice versa) must be dramatically improved to break up reinforcing vicious circles of climate impacts, poverty, insecurity, violence, and migration.

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Declarations

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