White Paper
A Systems Approach for Disaster Risk Reduction:
Exploring the Nexus of Energy, Food, and Human Mobility in the Northern Countries of Central America
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I- Introduction

Globally, disasters and their impacts have been characterized by increasing frequency and changing patterns. Global warming effects, including climate change, have exacerbated the severity and frequency of hydrometeorological and oceanographic, and other risk factors or drivers, such as population growth, urbanization, limited access to resources, inadequate infrastructure, and prevailing structural development conditions, putting additional lives and infrastructure in danger. Additionally, COVID-19 highlighted the lack of resilience in many areas and led to the first rise in global poverty since 1998 [1]. The Sendai Framework for Disaster Risk Reduction 2015 - 2030, the first major agreement of the post-2015 development agenda, sets forth seven targets for disaster resilience to be met by 2030. The framework seeks to substantially reduce disaster mortality, the number of people affected, economic losses, and damage. At the same time, the framework aims to increase the prevalence of disaster risk reduction strategies, as well as the availability of and access to early warning systems, and enhance international cooperation. At the halfway point, the Sendai Framework targets have seen some progress, but a significant part of it has been affected by multiple factors including pandemic-related setbacks, limited financial resources, inadequate institutional capacities, governance issues, political barriers, and competing development priorities [1].

The Sendai Framework’s targets are especially relevant for Central America. The Northern countries of the Central America region, comprising El Salvador, Guatemala, and Honduras, are some of the most vulnerable to climate change and disaster risks, at a global level. Due to their coastlines on, or proximity to, both the Pacific and Atlantic oceans, the variability of seasonal rainfall is accompanied by high exposure to a range of hazards, including hurricanes, floods, landslides, and droughts [2]. Furthermore, extreme weather events are increasing in frequency and severity due to climate change [3, 4], thus accentuating the vulnerability of these countries. The region has experienced increasing temperatures since the 1970s, as well as unpredictable precipitation patterns and rising sea levels. The number of disasters has been growing by an average of 6% per year compared to the 1970s [5]. Those are explained by risk drivers such as poverty, inequality, and poor urban development, among others, along with underlying political, economic, and social challenges. This mix of increased occurrence of hazards, underlying conditions, and vulnerabilities threatens the sustainability and resilience of already fragile economies and social systems. When individuals and communities are already on the verge of poverty, struggling with precarious livelihoods, and facing various socio-economic challenges, even a minor disruption can have devastating consequences on people’s lives and well-being, with many people pushed over the edge, experiencing loss of livelihoods, food insecurity, and displacement, among other possible adversities.

Acknowledging the susceptibility of Northern countries of Central America to disaster risks underscores the importance of disaster risk reduction for achieving sustainable development in the region. Disaster risk reduction and prevention are equally or less costly than management and recovery after disasters [6, 7]. Investing in disaster risk reduction not only saves lives but also safeguards critical development gains and increases resilience in the future. By reducing the vulnerability of communities and enhancing their capacity to cope with disasters, the region can protect livelihoods, ensure food security, promote sustainable economic growth, and prevent displacement.

This white paper argues that improving the region’s resilience and sustainability requires a holistic, systems approach and integrated prospective action that recognizes the impact of the various underlying conditions and vulnerabilities on amplifying disaster risks, and their link to growing trends of interconnected food and energy insecurities, and migration [8, 9]. In this white paper, we specifically:

1. Identify the impact of social, economic, and political underlying conditions and vulnerabilities on the interconnected energy-food-human mobility nexus under growing hazards in the Northern countries of Central America.

2. Propose a systems framework to support evidence-based decision-making by disaster-risk-threatened communities across scales.

3. Identify prospective action areas and interventions for disaster risk reduction and improving community resilience.
II- Underlying Social, Economic, and Political Conditions in the Northern countries of Central America

In order to better address the challenges facing the interdependent food, energy, and human mobility nexus under growing disaster risks and disasters, it is important to understand the role of underlying conditions in fueling and amplifying risk drivers. This process would allow us to better address root causes for disaster risks and guide better risk reduction strategies through cross-sectoral decision-making. However, relating the different risk drivers to certain underlying structural dependencies and causal relations is not easy, as they often operate in combination with other risk drivers to cause disasters. Following the FORIN analysis, we identify fundamentally strong drivers as contributing or compounding risk drivers [10]. High levels of poverty and inequality influence many factors, including food insecurity, the ability to invest in new technology, and the ability to access training and financing. 32.5% of the population in Honduras lives in extreme poverty [11]. A study in Guatemala found severe food insecurity to be associated with poverty, agricultural employment, and drought, but also social factors such as illness, social marginalization, and the absence of a household head, highlighting the varied interconnections and consequences of poverty [12].

Crime, violence, and gang activity increase the challenges faced by the region and push people to migrate away from insecure situations. The Northern countries of Central America have some of the highest homicide rates in the world; in 2021 Honduras recorded nearly 40 homicides per 100,000 people [13]. Transnational gangs and trafficking routes run through the Northern Triangle to take advantage of corruption and political instability [13]. Violence has historically increased as a reason to migrate; the percentage of migrants who stated that they moved to flee violence increased from 33.7% before 2011 to 71.2% between 2011-2016 [14].

Guatemala is the most ethnically diverse country in Central America, with 24 ethnic groups. In addition, over 44% of its population belongs to indigenous groups [15]. Honduras and El Salvador also have large indigenous and Afro-descendant (in Honduras) populations. Indigenous groups disproportionately face higher levels of poverty, inequality, and food insecurity, and lower education and health indicators. Following an intersectional analytical approach, these factors tend to be worse for individuals in multiple vulnerable groups, such as rural indigenous informal workers, or indigenous women and children [15].

The Northern countries of Central America face gender inequality and discrimination, with women and girls facing higher levels of violence and limited opportunities for empowerment. In 2019 in Honduras, 6.2 out of 100,000 women were murdered as a result of femicide, the highest rate in Latin America and the Caribbean [16]. Women are also likely to experience food insecurity more acutely and have less productive agricultural land compared to land worked by men, likely due to worse access to financing and technology [17].

Vulnerable demographics are impacted by the limited availability of social safety nets and support systems. In many cases, vulnerable families do not have access to basic services such as education, healthcare, and social protection. Price shocks, such as those felt during the COVID-19 pandemic, can make basic goods less affordable for low-income consumers. Shocks affecting crop production are felt most acutely by those who depend on agriculture for food, such as subsistence farmers, or for employment [17].

Economic inequality and the concentration of wealth in the hands of a few exacerbates social disparities. Foreign direct investment to all three countries has been decreasing, and the lack of access to finance is a significant barrier to the growth of small and medium-sized enterprises [18]. Over 10% of the three countries’ combined GDP is from agriculture, and
25% of the population is employed in the agriculture sector [18]. The region’s reliance on agriculture and services prevents economic diversification into more valuable industries.

Many households rely on remittances to mitigate the lack of financial or food security, especially when income or food sources fluctuate seasonally [13, 17]. This entrenchment of remittances in the economies of the Northern countries of Central America serves as a stable source of income. Paradoxically, remittances motivate some people to migrate, in order to provide for their families, while simultaneously allowing others to remain in otherwise financially unsustainable conditions.

Several examples of weak governance structures have been reported in the Northern countries of Central America. Corruption, inefficiency, and lack of transparency have allowed organized crime to thrive in the region. Guatemala, Honduras, and El Salvador were ranked 101, 116, and 84 respectively among 128 countries examined in the World Justice Program’s Rule of Law Index, and they also share some of the lowest rankings on Transparency International’s 2020 Corruption Perception Index, where their respective ranks were 149, 157, and 104 out of 180 countries. In Honduras, in 2009, the military organized a coup when the government was nearly bankrupt, which weakened security institutions [14]. Guatemala suffers from a very weakly institutionalized political system; most political parties are less than a decade old and few have an ideological basis. Additionally, many political parties are participating in each election, and no two parties have ever returned to presidential power. These frequent changes in government leadership make it difficult for the country to make and implement long-term plans [19]. Guatemala’s recent presidential election was plagued with corruption charges, untransparent disqualification of candidates, and a difficult candidate certification process [15]. In El Salvador, in contrast, the strong right-wing and left-wing parties have endured and have had nationally recognized brands and networks over the last 25 years, which has given the country more political polarization but much-needed stability1 [21]. The Northern countries of Central America are often made to choose between investing in security or social welfare. International investments have tended to focus on security. As a result, social security nets and public services are often underfunded or implemented inconsistently [22].

The prevailing socio-political instability and violence in these three countries can be attributed in part to challenges in governance mechanisms, characterized by a historical inclination toward accommodating large-scale international businesses. These governments encounter difficulties in enforcing policies and face challenges in delivering essential social services [13, 23]. These trends stem from historical legacies. Across the three countries, there is a history of wealthy large-scale landowners, first during colonial systems and then by large international fruit companies. During the peak of fruit company land control, the United Fruit Company owned almost half of the land in Guatemala [24]. As a result, there has been historical conflict between wealthy landowners and initiatives for radical land distribution. In many cases, governments, including international governments, sided with wealthy landowners [22]. At present, the Northern countries of Central America are still marked by unequal land distribution and inefficient land tenure systems.

Land tenure systems in the region have systematically favored large international landholders and agribusinesses over smallholder farmers, contributing to a concentration of land ownership and a lack of access to land for many rural families2. Market dynamics tend to favor large-scale production and export-oriented agriculture while neglecting small-scale and subsistence agriculture. Additionally, smaller farms tend to feel price shocks and growing competition more acutely [27]. The historical takeover of agricultural land by large international companies broke traditional land ownership and stifled rural employment and subsistence opportunities. Now, access to land, credit, and technology remains low, preventing rural farmers from participating fully in agricultural markets and value chains [28]. These features contribute to an overall lack of economic opportunities for smallholder farmers, further fueling migration. During the pandemic, measures to prevent the spread of COVID-19 slowed supply chains and sales. Although all agricultural endeavors were affected by these measures, large corporate farms and subsistence farms showed the most resilience.

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1 Recently, the legislative elections have given the president an absolute majority, which has led to fewer checks and balances but has allowed for more heavy-handed approaches to address violence [20].

2 Many vulnerable populations, especially women and indigenous people, have low rates of formal land tenure. Land tenure documents are not accessible in rural areas and may not be available in indigenous languages. Similarly, there are few financial and legal resources for vulnerable populations, which puts them at risk of displacement by large-scale farms, extractive projects, and criminal organizations [25,26].
and ability to adapt. Large corporate farms were able to find alternative supply chains, and subsistence farmers who are less reliant on external supply chains or consumers were less affected. Medium-scale and small-scale entrepreneurs were the most affected, as they were more reliant on the specific supply chain surrounding their business [29].

It should be emphasized that these underlying conditions are interconnected and mutually reinforcing, contributing to the region’s inability to address the disaster risks it faces. Addressing these underlying conditions is essential for creating an enabling environment that can improve the region’s ability to reduce disaster risk, as well as its resilience.

### III- Vulnerabilities

Geographically, the Northern countries of Central America are flanked by both the Pacific and Atlantic oceans, making them especially vulnerable to extreme weather. Additionally, a continuous area called the Central American Drought Corridor stretches through all three countries (and on through Nicaragua, Costa Rica, and Panama), and represents an area that is particularly vulnerable to extreme climate events and irregular weather, especially drought [30]. Irregular rain prevents water sources from replenishing and dries out subsoil, which leads to soil erosion and eventually lower agricultural capacity [5]. The conversion of forest land to agricultural land through deforestation and overgrazing, as well as an over-reliance on a limited range of crops and inadequate infrastructure, has led to soil degradation and erosion [31, 32].

Monocultures are more prone to disease and deplete the soil of nutrients, leading to soil degradation and reduced water retention capacity. In Honduras, large farm monocultures of African palm and pineapple reduce water tables and force small- and medium-scale farmers to rely on inconsistent rain or inefficient irrigation systems [33].

The three countries trade and depend on each other for many resources. El Salvador in particular is reliant on food and agricultural imports. During the 2017-2018 season, Guatemala exported 92% of its corn exports to El Salvador [34]. Guatemala itself is a net importer of both corn and rice, mostly from the United States [34, 35]. El Salvador also relies on imports of processing ingredients to sustain its food processing sector. During the pandemic, El Salvador’s food industry continued steadily; in 2020 it imported 10% more agricultural intermediate products than in 2019 [36]. El Salvador imported the highest proportion of consumer-oriented products, constituting 22% of its imports, from Guatemala. Additionally, it exported the largest share of consumer-oriented products, accounting for 38% of its exports, to Guatemala.

The region’s electricity networks are also interconnected; the Central American Electrical Interconnection System (SIEPAC, by its acronym in Spanish) network has connected seven Central American countries since 2013, including those of the Northern Triangle. The SIEPAC allows for intra-regional exchange between the countries but also makes infrastructure failures regionally consequential [33, 37]. These geographic vulnerabilities directly affect agricultural productivity and indirectly influence migration decisions.

The three countries’ growing population, estimated to increase to 65 million by 2050, could be considered by itself a vulnerability factor that would lead to additional vulnerabilities [38]. The growing population will likely continue to follow the trend of rural-urban migration—an estimated 10.5 million climate migrants are expected to move from rural to urban areas in Mexico and Central America by 2050—which will likely lead to informal and unplanned settlements around urban areas [39]. The limitations of urban planning and the growth of informal settlements are expected to increase these areas’ vulnerability to disasters and hazards, as the infrastructure and resources available will be weaker or more inaccessible.

With a staggering 77% of total employment in the three countries being informal, job insecurity becomes a pressing concern [18]. Informal jobs provide fewer safety nets, tend to be more seasonal, and are less consistent than formal work. Formal unemployment for each of the three countries...
increased between 2019 and 2020, partly as a result of the COVID-19 pandemic [18]. Youth unemployment is even higher; around 28% of the youth population is unable to find a formal educational, employment, or training arrangement. This is in part because of the high percentage of youth compared to the total population; over 28% of the population in each of the three countries is between 15 and 29 years of age [18]. Women are also especially financially vulnerable; a disproportionately large number of women are informally employed. Between 2006 and 2015, women were the heads of 26% of households in the Northern Triangle [33].

The Northern countries of Central America generally have weak infrastructure. In Honduras, transportation infrastructure is a particular area of concern. Infrastructure investment in Guatemala is less than 1% of its GDP, one of the lowest in Latin America [40]. Disasters are detrimental to already weak infrastructure, and since infrastructure construction and repair can be quite costly, many inadequate infrastructures and resources are left in poor states [41]. In line with the three countries’ funding challenges, disaster preparation competes with security, welfare, and infrastructure for national funding. Although much international focus goes on disaster responses, far less goes to preparation, risk prevention, and reduction or adaptation. 75% of international climate-oriented finance in the region during the first two decades of the century was allocated to mitigation efforts rather than new adaptations [33].

The Northern countries of Central America’s dependence on imported energy and inconsistent energy sources makes the region vulnerable to price shocks and supply disruptions. El Salvador imports a quarter of its electricity, making it the largest importer of electricity in the region [42]. El Salvador and Honduras have no domestic fossil fuel sources and are reliant on imports for most of their total energy supply [43, 44]. Both El Salvador and Honduras get most of their non-renewable energy from oil and oil derivatives, mostly imported from the United States, although El Salvador has more recently begun importing electricity from Guatemala [43, 45]. Guatemala has produced crude oil, but since oil prices dropped in 2014, petroleum exports have decreased [46]. Now, Guatemala imports most of its oil, which makes up 81% of its non-renewable energy, from the United States [45]. In addition to the challenges stemming from energy price shocks, consumers are faced with high electricity costs. Electricity costs for Guatemalan households were ranked the 15th highest in the world in 2021 [46]. The three countries have much to gain from increasing energy access and quality, but the resulting increase in energy intensity and the increased reliance on electricity services would make the region even more vulnerable to supply disruptions [47].

IV- Energy-Food-Migration Nexus

Energy and food systems

Climate change, socio-political factors, and the availability of social safety nets, all play a role in shaping the relationship between food systems, energy systems, and migration. There are many linkages between energy and food systems in the Northern countries of Central America.

Firstly, food systems in the three countries are highly dependent on energy, as much of food production and processing requires electricity. The food and beverage processing sector in Guatemala is one of the largest in Central America, and El Salvador is known for being the regional leader for certain processed foods (snacks, juices, and carbonated beverages) [48]. As a result, unreliable electricity has implications for the agriculture industry at a large scale, as well as for individuals in food production employment, usually in urban areas. The lack of reliable and modern sources of energy means that the food supply chain in the region is vulnerable to disruption. Food can get spoiled because of unreliable transportation, ineffective storage methods, and
time-consuming manual processing. Manual food processing is inefficient and labor-intensive, which leads to higher food costs, reduced availability of food, and less return on investment for farmers.

Secondly, much of the rural population and marginalized communities lack access to reliable sources of electricity, which can lead to a variety of negative outcomes [49, 50]. This affects food security by limiting food storage capacity, disrupting food supplies, and preventing the usage of farming technology. This rural population is engaged in small-scale farming. Small-holder farmers make up 50% of agriculture exports in the Northern countries of Central America [18]. Limited access to modern inputs such as fertilizers and irrigation systems leads to low agricultural productivity. This low productivity is directly linked to the lack of access to modern energy sources, as many technological solutions, such as electric pumps for irrigation, cooling and storage facilities for food, and processing equipment, require a consistent source of electricity. These factors, when combined with food price shocks, contribute greatly to the unsustainable conditions that lead to migration.

The causes of migration and displacement

The causes of migration and displacement in the region are multi-faceted. The energy sector itself is a source of migration and displacement, especially for marginalized and indigenous groups. Large-scale energy projects such as hydroelectric dams, wind farms, and oil and gas extraction sites can have significant impacts on local communities, including the loss of land and livelihoods, environmental degradation, and social conflict. These impacts can often lead to migration and displacement, as people are forced to leave their homes and communities in search of new opportunities or to escape the negative effects of energy development [25].

Food insecurity is often a contributing factor to migration, usually stemming from financial insecurity and economic hardship [12]. There is a complex interplay between food and energy systems and migration in the region: many families depend on agriculture for their livelihoods—either through subsistence farming or employment in commercial agriculture—and many rely on remittances from migrant family members to ensure food security [13]. Money from remittances can also be used to purchase electricity access or fuel for transportation. Subsistence farmers represent almost 60% of the farmers in the three countries. These farmers own just 6.5% of the growing surface, most of which is considered low-yield [5]. Food insecurity is a long-standing problem and a large driver of migration, especially in Guatemala which has high rates of chronic childhood malnutrition. According to a joint report by the Migration Policy Institute, the UN World Food Program, and the Massachusetts Institute of Technology, food-insecure people in the Northern countries of Central America are three times more likely to make concrete plans to migrate than people who are not [52].

Migration can also have negative impacts on food and energy system improvements. Migration can decrease demand for improved energy systems by decreasing the population, especially in rural or otherwise already marginalized areas. In rural areas,
decreasing agricultural yields will reduce employment, causing the rural poor people to seek other options like migrating to cities or other countries to find work. The loss of agricultural labor from migration can contribute to reduced crop production and reliance on imported food, which can increase food prices and undermine food security [28]. In urban areas, decreasing labor forces lead to stifled economic growth more broadly, whereas at the same time, those migrating to cities will encounter deteriorating security conditions and lack of employment opportunities, leading them to migrate further or join the informal sector.

V- Disaster risks faced by the Northern countries of Central America

Despite the minimal contribution of the Northern countries of Central America to global greenhouse gas emissions (approximately 0.15%), climate change has emerged as a considerable challenge, further complicating the situation in this highly vulnerable region [53]. German Watch’s global climate risk index listed many countries in the Central American region within the top 20 countries most affected by climate change for the decade after 1994. Since 2004, countries in the region have been more frequently rated in the top ten most affected countries³ [5].

This Central American region is highly vulnerable to a range of climate-related hazards, including hurricanes, floods, droughts, and landslides [2]. During the past two decades, the instances of flooding in the region have more than doubled (compared to the two decades previously), the number of hurricanes has exceeded the historical trend in frequency and intensity, and short-term tropical storms have increased in frequency [5]. When Tropical Storms Amanda and Cristóbal struck El Salvador in 2020, they caused 30 fatalities and affected almost 30,000 families [54]. Later that year, Hurricanes Eta and Iota swept through Honduras and Guatemala, having devastating impacts on the region, including loss of life, infrastructure damage, and disruption of livelihoods. Cost estimates for damages and economic losses associated with these hurricanes reached $1.9 billion in Honduras and $780 million in Guatemala [33]. In Honduras alone, the hurricanes adversely affected 4.6 million people, exacerbating pre-existing food insecurity and reducing the country’s GDP by almost 1% [55].

Risks due to climate change are related to increasingly intense and frequent extreme weather events, mainly connected with decreased rainfall and increased temperature. These events have significant and varied impacts on agriculture, which is a crucial sector for the region’s economy, and food security. Most far-reaching are the changes in climate averages that affect livelihoods and crop production to a permanent and likely increasing degree. Increasing temperatures, irregular rainfall, and increased chance of blight and disease lead to gradually worsening opportunities for agriculture. More long-term and permanent global warming and climate results, such as increasing sea levels, changing biomes, and decreased water availability will also alter the region’s long-term potential. In addition to these consistent climate factors, the increased frequency of non-routine extreme weather and erratic rainfall patterns have led to crop failures, loss of livestock, and increased food insecurity, and have ultimately boosted migration further. Furthermore, the impact of climate risks on other sectors, such as energy, water resources, and health, has also been observed. The high exposure to natural hazards, combined with structural root causes related to social, political, and economic factors and limited adaptive capacity, has made the Northern countries of Central America particularly vulnerable to disasters, which further undermines development gains. Disasters have a disproportionate impact on the poor and vulnerable communities, hindering progress toward achieving the Sustainable Development Goals (SDGs) in the region.

³ DARA’s Climate Vulnerability Monitor listed El Salvador and Honduras as severely vulnerable countries in 2010 and predicted all three countries will be either severely or acutely vulnerable by 2030 (acutely vulnerable is the monitor’s most vulnerable level, and severely vulnerable is the second-most vulnerable level) [5].
VI- Disaster impacts on energy, food, and migration in the Northern countries of Central America

The distinction between disaster impact and disaster risk is essential in comprehending the effects of catastrophic events on food, energy, and migration. While risk represents latent conditions influencing decisions, disaster impact refers to the tangible consequences when risks materialize. Understanding the distinction helps analyze the immediate and long-term implications of hazards in these domains. Additionally, disasters can create new risk scenarios, further influencing future impacts. Recognizing this differentiation is vital in unraveling the complex dynamics between disasters, risks, and their societal consequences.

In the case of migration, disaster risk impacts involve decisions made based on the anticipation of future disasters and the potential severe consequences they may bring. For instance, individuals may choose to relocate preemptively due to their understanding of the imminent risks. Conversely, disaster impacts on migration occur when people are directly affected by events such as floods or droughts, causing the destruction or severe disruption of their livelihoods. Often this results in forced displacement or, in other cases, migration becomes a response to the immediate consequences experienced, as individuals seek to restore or secure their well-being.

Similarly, in the context of energy, disaster risk impacts would involve decisions made to mitigate potential electricity shortages or disruptions due to foreseen disaster events. On the other hand, disaster impacts on energy occur when power infrastructure is damaged or compromised during a disaster, leading to immediate outages and long-term consequences.

Regarding food security, disaster risk impacts manifest in decisions to invest in or avoid risk-prone agricultural areas based on the anticipation of future hazards. In contrast, disaster impacts on food security occur when crops fail or food systems are disrupted due to the direct effects of disasters, leading to immediate food shortages and the need for emergency relief.

These examples demonstrate how disaster risk and disaster impact differ, highlighting the distinct decision-making processes and consequences associated with each concept in the specific domains of migration, energy, and food security. The following sections primarily serve to highlight examples of disaster impacts and current trends leading to greater disaster risks in the region.

| a. Disaster impacts on energy |

The Northern countries of Central America are rapidly growing. The region’s GDP is expected to double over the next three decades, with a population estimated to increase to 65 million by 2050 [38, 56]. Total final energy consumption in the region was 1245 petajoules in 2018, with Guatemala consuming the most energy, 41%, and Honduras and El Salvador consuming 14% and 10%, respectively [56]. Per capita energy consumption in El Salvador and Guatemala has increased at a steady rate since 2010 and is expected to increase more rapidly through the next two decades, while per capita energy consumption in Honduras has increased at a slower rate [56].

Access to electricity is relatively high across the region: access in El Salvador, Guatemala, and Honduras was 98%, 92%, and 85%, respectively [56]. These statistics can be misleading, however, as the accepted definition of “access” requires only four hours a day of access to electricity [57]. Indeed, many areas of the three countries receive inconsistent electricity; in Honduras, a majority of the population faces more than four power outages a week, often lasting over two hours [49]. In Guatemala, grid network expansion was not paired with sufficient investments in electricity transportation, which has resulted in lower quality electricity, and the pace of electricity generating capacity has not been sufficient to match demand in the long term [58, 59]. A majority of Guatemala’s energy comes from biofuel and hydropower, while most of El Salvador’s and Honduras’s comes from
oil derivatives [43, 44, 60]. Hydropower and biomass, which make up much of the region's energy supply, vary by season based on rainfall, storage capacity, or agricultural yields [49, 50, 61]. In El Salvador, the transportation sector consumes most of the energy, followed by the industrial sector and the residential sector [43]. In Guatemala and Honduras, the residential sector consumes the most energy, followed by transportation [62, 63].

**Extreme or inconsistent weather** further threatens reliable energy access by impeding electricity distribution and production systems. **Insufficient investment in transmission and distribution infrastructure** has contributed to increased vulnerability. From 2009 to 2014, average electricity loss amounted to 25 percent in Honduras, 14 percent in Guatemala, and 12 percent in El Salvador. High losses in Honduras have resulted in an estimated 1 to 2 percent reduction in GDP on average. **Technical losses and infrastructure damage** due to hurricanes, tropical storms, and floods are substantial, especially in rural areas [64].

As a result of insufficient investment in resilience, transmission, and distribution networks face potential collapse during extreme weather events. In Honduras, Hurricane Eta brought down many transmission lines, towers, and substations [65]. Moreover, six national power grids in the region are interconnected through the Central American Electrical Interconnection System (SEIPAC), thus extreme weather events in one area can affect the larger region. In 2017, heavy rain caused a disruption of a transmission line in Panama, which led to a blackout affecting 15 million people in Central America (60 percent of the region’s population), including parts of El Salvador, Guatemala, and Honduras [33].

b. **Disaster impacts on food**

There are numerous challenges from extreme weather events in ensuring food security, including damage to livestock, crops, and food processing facilities. **Flooding and drought**, often occurring in succession, have led to significant decreases in agricultural yield or sometimes have wiped out entire harvests [30]. Especially in recent years in the Dry Corridor in El Salvador, Guatemala, Honduras, and Nicaragua, extreme flooding followed by months-long droughts has affected agricultural yields for subsistence farmers, resulting in a humanitarian crisis [30]. After an irregular rainy season in Guatemala in 2018, farmers lost almost 80% of corn grown in the highlands. In El Salvador, 50% of corn and bean farmers lost half of their crop following Tropical Storms Amanda and Cristobal in May and June 2020. Permanent shifts in temperature, rainfall, wind, and evapotranspiration due to climate change led to more consistent agricultural damage. **Crop blights** have more frequently affected crops due to the **increasing temperature and erratic rain**, which has exacerbated both **food insecurity** and **financial insecurity** [66]. Although some crops may see short-term improvements due to rising temperatures, long-term productivity losses for crops and livestock can be expected [28]. Rainfall has come with more intensity and for shorter periods, which forces farmers to extend the planting period to match delayed rainfall starts. Floods and droughts put pressure on limited water supplies and lead to **water supply shortages**, particularly in poor communities, and even **conflicts in urban areas**. On the coasts, rising sea surface temperatures and coral bleaching, in addition to overfishing, diminish the ability of fishermen to maintain their livelihoods [28]. Episodes of acute malnutrition within the Central American Dry Corridor (CADC) have been attributed to cycles of the El Niño–Southern Oscillation (ENSO) with extended drought occurring in El Niño years, as well as to the variability in market prices for coffee, maize, and beans, and recently also the impact of coffee rust, a fungal disease that drastically reduced the harvest of coffee, the main cash crop in the area [12].

c. **Disaster impacts on migration**

Migration in the Northern countries of Central America is increasingly complex and multi-dimensional. On average —pandemic years not included— 407,000 people leave the three countries annually [13]. These outflows have occurred in parallel with a multiplicity of ongoing economic, social, and political conditions (e.g., food insecurity, income opportunities, lack of safety and security, etc.), but also environmental hazards and disasters, drought and other slow-
onset climate and environmental processes in all three countries [67]. Hurricanes Eta and Iota, which hit Central America in 2020, affected a total of four million people in Honduras and 2.4 million people in Guatemala and created an estimated 1.5 million new displacements in the region, including 937,000 in Honduras and 339,000 in Guatemala [68, 69]. Many individuals were also displaced in El Salvador [68]. The high levels of migration from the Northern countries of Central America to the United States have drawn attention to the need for comprehensive approaches to climate adaptation and mitigation efforts, economic opportunities, and sustainable development in the region, and international attention has sought to address these issues [13].

The region's vulnerability to the impacts of climate change and disasters intensifies other factors such as poverty, inequality, and food insecurity. In many cases, extreme weather events such as floods or hurricanes, which can destroy homes, infrastructure, and agricultural production, serve as the final push to migrate on top of complex and multifaceted existing vulnerabilities and risk conditions. According to a recent joint report from the International Organization of Migration (IOM) and the World Food Program (2022), exposure to natural hazards was determined to have a significant association with recent migration, for households exposed to the coffee rust disease, as well as with people's desire to migrate permanently to another country at some point in the future, something that could become a trigger for migration if exposure in the future is more frequent and severe [67]. In recent years, migration dynamics in the subregion have increasingly been studied alongside climate variability, disasters, food security, violence, and other thematic areas to better understand the factors that drive people to leave their homes. However, these issues are often examined separately rather than together [67].
VII- Framework of energy-food-human mobility nexus and disaster risks, underlying conditions, and vulnerabilities

The Northern countries of Central America grapple with a complex web of challenges at the intersection of food security, energy access, and migration, all within the context of heightened disaster risks and systemic disaster impacts and effects. Addressing these interconnected issues necessitates a comprehensive approach that goes beyond isolated disciplinary perspectives. This white paper emphasizes the need for a coordinated and integrated systems approach, acknowledging that no single discipline or sector can adequately tackle the complexity involved. To effectively reduce disaster risks in the region, it is essential to engage in system-level planning and interventions that target the root causes and drivers of these risks. Enhancing community resilience in the region requires significant investment in enabling environments that foster better coordination among cross-sectoral partners. By establishing robust mechanisms for collaboration and information-sharing, stakeholders can develop a comprehensive understanding of the intricate relationships between food security, energy access, and migration patterns. Furthermore, fostering innovative research and decision-support tools that transcend traditional sectoral and disciplinary boundaries is crucial for generating novel solutions and advancements at the interface of these fields. This white paper underscores the importance of recognizing the multifaceted nature of disaster risk reduction and proposes a framework for the Northern countries of Central America to address these challenges holistically, laying the groundwork for a more resilient and prosperous future.

Migration decisions are influenced by the availability of basic resources, while disasters have both immediate and long-lasting impacts on energy and food systems, both directly and indirectly. Communities heavily reliant on these essential resources face heightened vulnerability when confronted with scarcity and the loss of livelihood resulting from the destructive effects of disasters. It is critical to acknowledge the interconnections among migration, disasters, and energy and food insecurity, whether through direct or indirect relationships. While identifying the trade-offs within this nexus and understanding that the risks posed by disasters are crucial, our previous analysis highlights the significance of comprehending the underlying social, economic, and political root causes that sustain and amplify the drivers of risk and vulnerabilities within the interconnected energy-food-migration nexus, particularly in the face of escalating hazards. Such understanding is essential for effective risk reduction, decision-making, and the pursuit of sustainable development.

By reducing community vulnerability and enhancing disaster coping capacity, the region can safeguard livelihoods, ensure food security, foster sustainable economic growth, and prevent and mitigate displacement. Expanding existing models to capture individual and combined shocks is necessary. The impacts and urgency of these phenomena will vary across regions, depending on factors such as the availability of disaster response plans, integrated planning among agencies, local human and institutional capacities, and technological resources. Considering these factors is essential when evaluating preparedness to respond to potential disaster scenarios and their implications for resource security, as well as exploring options for structural risk reduction and prevention. Figure 1 summarizes the cited and observed interconnections outlined in this paper.
VIII- Prospective areas of intervention for disaster risk reduction and improving community resilience

Addressing the underlying conditions and vulnerabilities related to interconnected food and energy security and human mobility is crucial for disaster risk reduction and improving community resilience in the Northern countries of Central America. While vulnerability is often emphasized, it is important not to overlook the fact that exposure to hazards is largely socially constructed through human decisions or obligations related to location and poor climate mitigation ambition. Moreover, many hazards are also socially constructed as a result of interventions in the environment and the degradation of ecosystems and ecological areas.

This highlights the interconnectedness between human actions and the creation of hazardous conditions. Recognizing the social construction of exposure and hazards is crucial in understanding the underlying factors that contribute to disaster risk and the need for comprehensive risk reduction strategies. By investing in projects that target the root causes and drivers of vulnerability, exposure, and hazard (where these are non-natural) while linking disaster reduction and development, we can achieve sustainable and long-lasting impacts. It is imperative to prioritize addressing these root causes and drivers rather than merely treating the symptoms of disaster
risks. To achieve effective and sustainable disaster risk reduction, we must go beyond addressing the immediate impacts and symptoms of disasters and focus on understanding and tackling the underlying factors that make communities and regions exposed and vulnerable. This approach allows for more comprehensive and transformative interventions that create lasting change and build resilience at its core.

Disaster risk reduction would play a vital role in achieving the Sustainable Development Goals of the three countries. By effectively integrating disaster risk reduction measures into development initiatives, we can enhance the region’s ability to build resilience, promote inclusive growth, protect livelihoods, and ensure the well-being of communities. This set of recommendations provides a roadmap for prospective areas for intervention, emphasizing the need for a system-level approach that brings together cross-sectoral stakeholders across community, national, and regional scales. By focusing on integrated approaches, multi-sectoral collaboration, community empowerment, and innovative financing mechanisms, these recommendations aim to address the complex challenges faced by the region. Through these concerted efforts, a more resilient and prosperous future can be fostered for the regions, where communities are better equipped to withstand disasters and achieve sustainable development.

1. **Mainstream System-level Informed Disaster Risk Reduction in Development Planning**

   - **Strengthen Early Warning Systems:** To enhance disaster preparedness and response in the Northern countries of Central America, it is crucial to strengthen early warning systems while integrating system-level analysis. Investing in the enhancement and expansion of early warning systems, utilizing advanced technologies such as weather forecasting, remote sensing, and data analytics, is essential to accurately detect and predict potential disasters. By providing timely alerts and actionable information to communities, the effectiveness and reliability of early warning systems can be improved, enabling better preparation and response to hazards. Concurrently, recognizing and integrating system-level analysis into disaster risk reduction efforts is vital. Understanding the complex relationships and interdependencies between energy security, food security, and migration is necessary to develop comprehensive strategies that address root causes and enhance resilience across interconnected systems. This holistic approach allows policymakers and practitioners to identify vulnerabilities, assess interdependencies, and create strategies that mitigate risks and reduce the impacts of disasters on energy and food security.
2. Build an enabling environment for cross-sectoral cooperation and integrated planning approaches

- **Promote Risk-Informed Decision-Making.** Strengthen the capacity of decision-makers at all levels to make informed choices that consider disaster risk reduction and resilience. This includes providing training and technical support to government officials, community leaders, and financial institutions to assess and incorporate risk information into investment decisions. This also includes investing in the enhancement of already existing methodologies, such as the Response Capacity Index developed to measure disaster preparedness at the municipal level in Honduras [70].

- **Promote Comprehensive Risk Reduction Measures for Small-Scale and Recurrent Events.** To enhance community resilience, it is crucial to prioritize comprehensive risk reduction measures that address both extreme events and smaller-scale recurrent events. Therefore, the recommendation is to integrate community-based risk reduction measures that encompass both extreme and smaller-scale recurrent events. This includes investing in early warning systems, capacity-building initiatives, and infrastructure that can withstand and mitigate the impacts of these events. By adopting a holistic approach, communities will be better equipped to anticipate, prepare for, and respond to a wide range of hazards, whether they are large-scale disasters or smaller, but frequently occurring, events.

- **Integrate disaster risk reduction considerations into regional and national development plans, policies, and budgets.** This will ensure that disaster reduction measures are systematically included in development initiatives, such as infrastructure projects, agricultural programs, and poverty reduction strategies.

- **Encourage Multi-Stakeholder Partnerships** between governments, civil society organizations, private sector entities, and international actors to pool resources, knowledge, and expertise. Establish platforms for dialogue, coordination, and joint action to align investments and financing with disaster reduction and development goals.

- **Advocate for Policy Coherence** at the national and regional levels, ensuring alignment among disaster reduction, development, and climate change agendas. Engage in policy dialogues and negotiations to promote an integrated approach that addresses the underlying conditions and vulnerabilities in a comprehensive and coordinated manner. This could be facilitated through the development of collective outcomes, which can aid in aligning different efforts and improving their coherence.

- **Enhance Regional Cooperation:** Foster collaboration and information sharing among the three countries to address common challenges related to food and energy security, migration, and disaster risk reduction. Establish regional platforms for knowledge exchange, joint research, and the development of regional policies and strategies, while benefiting from existing mechanisms including the Central American Integration Systems.
3. Increase Investments and Financing for Integrated Projects Addressing Underlying Root Causes, Linking Disaster Reduction and Development

- Establish a dedicated funding mechanism that increases investments and financing for integrated projects addressing the underlying root causes of vulnerability while linking disaster reduction and development. Such a mechanism would bring together public and private resources to support initiatives that prioritize comprehensive risk assessments, foster multi-sectoral collaboration, empower local communities, mainstream disaster reduction into development plans, leverage innovative financing mechanisms, and strengthen institutional coordination for sustainable and resilient outcomes.

- Implement social protection programs and livelihood diversification strategies to reduce food and energy insecurity and address economic vulnerabilities. Implementing social protection programs involves developing and executing initiatives that directly target vulnerable populations, such as small-scale farmers, rural communities, and marginalized groups. These programs can encompass a range of measures, including targeted cash transfers, conditional cash transfers, and food assistance programs. By providing direct support to individuals and households, social protection programs alleviate immediate food and energy insecurity, ensuring access to essential needs during times of crisis. In parallel, livelihood diversification strategies should be pursued to promote economic resilience. This entails offering vocational training programs and facilitating income-generating activities that are less susceptible to climate and market shocks. By empowering individuals with new skills and alternative income sources, livelihood diversification strategies enhance economic stability, reduce dependency on vulnerable sectors, and promote sustainable livelihoods. Additionally, strengthening market linkages, facilitating access to markets and value chains, and promoting climate-smart practices contribute to the success of these strategies.

- Strengthening governance structures and promoting inclusive decision-making processes that involve local communities, marginalized groups, and relevant stakeholders. This includes ensuring the participation of women and indigenous communities in climate and energy policies, disaster risk management, and food security planning. It also requires the presence of appropriate mechanisms that allow for coordinated governance that cuts across the interconnected food and energy sectors.

- Mobilize Domestic and International Resources: Secure domestic and international financial resources to support investments in disaster reduction and development. Encourage governments, private sector entities, and international development partners to allocate sufficient funds and leverage innovative financing mechanisms, such as public-private partnerships, impact investing, and climate finance. Investments should be directed towards modernizing agricultural practices by promoting the adoption of advanced technologies and sustainable farming techniques. Concurrently, efforts should be made to invest in renewable energy infrastructure to enhance energy security, reduce reliance on fossil fuels, and promote the integration of clean energy solutions into the agricultural sector. Access to finance and technology for smallholder farmers and local energy entrepreneurs should also be enhanced through specialized financing mechanisms and targeted support programs. Through coordinated investments and sustainable practices, the agriculture and energy sectors in the Northern countries of Central America can be transformed, leading to improved food and energy security, environmental sustainability, and long-term resilience.
4. Address human mobility caused by the region’s vulnerability to extreme weather events and underlying conditions

- **Leveraging remittances for improved resilience**: Remittances to the Northern countries of Central America amount to nearly a quarter of the $150 billion in 2022 remittances to Latin America. While remittances initially decreased at the onset of the pandemic, since then they have rebounded and are now significantly surpassing foreign aid. These remittances play a crucial role in supporting numerous households in the region, granting people direct access to essential necessities, and even fostering economic stability. Remittances, along with foreign aid and targeted programs, can be an important part of a strategy to improve the resilience of vulnerable communities. There is a need to develop policies that promote the strategic use of remittances for disaster preparedness, sustainable livelihoods, and local infrastructure while empowering households through financial literacy and inclusion initiatives for lasting resilience. Furthermore, new designations and redesignations of the Temporary Protected Status (TPS) from the U.S. to the three countries may help the families of TPS holders to meet their basic needs, fund recovery efforts, and build economic security.

- **Improve displacement management through better evacuations and shelter**: In light of the projected increase in extreme weather events, exacerbated by factors such as population growth, poverty, conflicts, weak governance, and environmental degradation in the region, which are expected to escalate disaster displacement, it becomes imperative to not only develop and implement comprehensive evacuation plans that prioritize the safety and well-being of affected populations but also invest in resilient shelters and temporary housing, ensuring they provide protection and essential services to displaced individuals and communities. This multifaceted approach can significantly contribute to addressing the specific needs of those at risk of displacement, enhancing disaster risk reduction preparedness, response, and recovery activities, and ultimately strengthening overall resilience. Moreover, to ensure a coherent approach, there is a pressing need for improved coordination between regional disaster risk reduction structures and cooperation mechanisms, which can effectively support governments in reducing disaster displacement risk while providing the necessary assistance and support for displaced populations.

- **Planned relocation and settlement**: As climate-induced environmental change affects the Northern countries of Central America, mitigation and in situ adaptation may not be sufficient in vulnerable areas. The three countries may consider planned relocation as a viable last resort in their climate change plans and strategies. Sharing good practices can help the three countries to adapt successful cases to their national scenarios. The use of existing or the development of new Toolboxes could also help in identifying a series of important factors to be considered when designing planned relocation processes. This would include providing adequate support, including access to livelihood opportunities and social services, to facilitate the successful resettlement of affected populations.

- **Conflict prevention**: Conflict is a principal driver of population displacement. There is a need for implementing tailored, context-specific measures that address underlying social, economic, and political tensions, increase participation, and strengthen social cohesion, to reduce the risk of conflicts exacerbating disaster impacts. The three countries in collaboration with IOM and other UN Agencies may leverage already existing practices and design strategies that consider and address the underlying causes of violence and instability before conflicts and crises can break out or deteriorate. These efforts may improve lives and livelihoods in the process.

- **Strengthening the rule of law**: Violence, corruption and weak rule of law are arguably one of the greatest challenges of the Northern countries of Central America to enable an adequate and comprehensive approach to the structural causes that continue to generate unprecedented levels of migration. Breaking this vicious cycle requires a holistic, long-term approach that brings together governments, civil society, and businesses under a common anti-corruption agenda with innovative, and locally driven policy solutions, supporting institutional resilience and inclusivity, and reducing migration.
IX- Multi-stakeholder consultation meeting - Highlights

The United Nations Office for Disaster Risk Reduction – Regional Office for the Americas and the Caribbean organized a multi-stakeholder consultation meeting to discuss the developed systems framework and its potential role in guiding evidence-based decision-making while considering the impact of social, economic, and political underlying conditions and vulnerabilities on the interconnected energy-food-human mobility nexus in the Northern countries of Central America. Stakeholders and representatives from country offices from the three countries participated in the discussion. In addition to the dialogue, participants were provided the opportunity to share their thoughts, in writing, about information related to the systemic interdependencies of food, energy, and human mobility with implications for climate action and disaster risk reduction interventions and impactful interventions for replicating or scaling up.

The discussion highlighted several interconnected challenges in the region, including the overexploitation of land and the dominance of monopolistic monocultures, particularly in sugar, coffee, and corn production, which contribute to the region's difficulties. Participants stressed the urgent need for a regulatory framework that not only protects individuals but also safeguards the environment against such practices. Moreover, there was a call for enhancing systems thinking and capacity building at the institutional level, with an emphasis on government responsibility. This entails strengthening the application of the rule of law to rectify the negative influence of powerful entities and promote sustainable practices that can alleviate many of the interconnected challenges faced by the region.

Apart from these challenges, the discussion shed light on how people in vulnerable areas are profoundly affected by extensive agriculture conducted by large companies empowered by existing legal frameworks, leading to the depletion of natural resources, illegal chemical use, and long-term land infertility. The adverse environmental impacts extend to mining activities and unsustainable fishing practices, pushing communities to migrate. What is more, a significant portion of the population grapples with extreme poverty, posing a major barrier to disaster risk reduction efforts.

To navigate these complex challenges effectively, participants highlighted the importance of reducing inequalities through long-term educational interventions and ensuring access to basic services as part of local, multisectoral interventions. It was also suggested that efforts should be concentrated in a focused manner on fewer communities to bring about structural changes rather than a segregated approach. Strengthening institutional response capacities was deemed essential, as individuals alone have limited capability in the face of disasters.

The insights underscored that migration is not merely an aftermath of disasters but should involve a comprehensive process of return, with migrants integrated as part of the community. Training programs and the development of indices, such as in Honduras, to measure municipal disaster response capacities were recognized as valuable tools. Besides, indicators for biological threats and hazards were deemed useful, emphasizing the importance of continuity in staff to avoid knowledge loss. Ultimately, addressing these multifaceted challenges requires not only creating favorable conditions for agricultural improvements but also fostering a social movement to deter migration. Phenomena at the intersection of social and environmental issues must be closely analyzed to develop comprehensive solutions.

Participants also highlighted several noteworthy initiatives and projects during the discussion, offering valuable insights for replication and scaling up. One successful example cited was from the Global Network of Civil Society Organizations for Disaster Reduction (GNDR), which showcased the effective incorporation of displaced populations into the development of community response and sustainability plans. In El Salvador and Honduras, displaced individuals integrated into host communities, working collaboratively to enhance health conditions and resilience against disasters. Additionally, there was a focus on productive income-generating projects that
simultaneously implemented climate-smart activities to contribute to environmental sustainability. The extension strategy, as exemplified in the Costa Viva project [71] in La Libertad, El Salvador, demonstrated the potential for replicating regenerative agriculture practices. Moreover, the engagement of young people in technology and agriculture, as seen in the Raíces project in Ahuachapán [72], illustrated the importance of involving the youth in initiatives aimed at fostering sustainable development and resilience. These initiatives collectively underscored the potential for holistic approaches to address the complex challenges faced by the region.

X- Conclusion

By championing integrated systems approaches, fostering multi-sectoral collaboration, empowering communities, and exploring innovative financing mechanisms, the prospective action areas and recommendations highlighted in this white paper strive to holistically address the intricate challenges facing the region comprehensively. Through these concerted efforts, we can work toward a future characterized by greater resilience and prosperity, where the disaster risk is reduced through multifaceted interventions that recognize the tight interconnectedness between different social, economic, and environmental systems. Moving forward, a critical imperative lies in the operationalization of the developed framework through the development of planning and decision-making tools. These tools will play a pivotal role in guiding evidence-based decision-making for effective interventions aimed at reducing disaster risks and forging a clear pathway toward sustainable development in the region. By equipping stakeholders with the means to make informed choices and implement strategies rooted in sound data and analysis, we can collectively work towards a more resilient and prosperous future for the communities within the region.
XI- Bibliography


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