



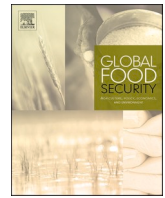
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Contents lists available at ScienceDirect

## Global Food Security

journal homepage: [www.elsevier.com/locate/gfs](http://www.elsevier.com/locate/gfs)

# COVID-19, Climate Change, and Conflict in Honduras: A food system disruption analysis

Jonathan Lara-Arévalo<sup>a,\*</sup>, Lucía Escobar-Burgos<sup>b</sup>, E.R.H. Moore<sup>c</sup>, Roni Neff<sup>c,d</sup>, Marie L. Spiker<sup>a</sup>

<sup>a</sup> Nutritional Sciences Program, University of Washington School of Public Health, Seattle, WA, United States

<sup>b</sup> World Food Programme, Tegucigalpa, Honduras

<sup>c</sup> Department of Environmental Health & Engineering, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States

<sup>d</sup> Johns Hopkins Center for a Livable Future, Baltimore, MD, United States

## ARTICLE INFO

## Keywords:

Food security  
Food systems resilience  
Fault tree  
Food supply chains  
Food access

## ABSTRACT

In Honduras, as in many settings between 2020 and 2022, food security was affected by the COVID-19 pandemic, climate change, and conflicts—what some refer to as “The Three Cs.” These challenges have had overlapping impacts on food supply chains, food assistance programs, food prices, household purchasing power, physical access to food, and food acceptability. This article applies a food system disruption analysis—adapted from a fault tree analysis originally developed for a municipal context in the United States—to the context of Honduras to systematically examine how the Three Cs affected food availability, accessibility, and acceptability. This article demonstrates the value of approaching food security through a disruption analysis, especially for settings impacted by multiple, interconnected, ongoing crises.

## 1. Introduction

The past two years (2020–2022) have delivered multiple, overlapping challenges to food security including climate change, conflicts, and the COVID-19 pandemic—what some refer to as the “Three Cs” (Hendriks et al., 2022; Red Cross Red Crescent Climate Center, 2022)—with inequitable impacts in low- and middle-income countries (LMICs). Honduras has not only faced the COVID-19 pandemic but has also been impacted by Hurricanes Eta and Iota in November 2020 and is projected to be disproportionately impacted by volatility in food, agricultural input, and energy prices related to tensions between Russia and Ukraine (Lara-Arévalo and Vega, 2022). This article uses Honduras as a case study for how these disruptions have affected food security in Latin America, and for the importance of preparing food systems for crises.

This article expands and updates a food system disruption analysis originally developed for the context of Baltimore City, Maryland, USA, as a fault tree analysis (Chodur et al., 2018). In Baltimore City, the fault tree analysis was a decision-support tool developed through a collaborative process between researchers and city planners in order to incorporate food security into disaster and resilience planning (Biehl et al., 2017). Here we shift away from the language of the fault tree—an engineering tool originally developed by Bell Telephone Laboratories to

explore system-level failures—and towards a framework that recognizes a broader range of operational outcomes within food systems beyond “failure” and “success.” In this article, we expand the framework beyond its original setting—an urban area in the United States—to be more broadly applicable to a range of high-, middle-, and low-income country settings and a range of scales. Additionally, we demonstrate how a fault tree analysis can be applied to multiple, overlapping disruptions in LMICs, ranging from acute shocks (e.g., hurricanes) to chronic stressors (e.g., prolonged droughts, or the continuing and evolving impacts of the COVID-19 pandemic) and their cascading impacts on food insecurity. We use Honduras as a case study.

The Food and Agriculture Organization (FAO) defines the four main dimensions of food security as availability, accessibility, utilization, and stability, and more recently a six-dimensional framework also includes agency and sustainability (HLPE, 2020). As shown in Fig. 1, the food system disruption analysis is visually represented as a tree with three branches—food availability, accessibility, and acceptability—each of which could hypothetically lead to population-level food insecurity on its own. We use the terminology *food acceptability* to refer to cultural acceptability, food safety, and ability to promote nutritional status—which encompasses both utilization (referring to the biological uptake of nutrients, which is dependent on health status) and the nutritional

\* Corresponding author. Raitt Hall, Box 353410, Seattle, WA, 98195-3410, United States.

E-mail addresses: [jlara4@uw.edu](mailto:jlara4@uw.edu) (J. Lara-Arévalo), [lucia.escobar@wfp.org](mailto:lucia.escobar@wfp.org) (L. Escobar-Burgos), [emoore45@jhu.edu](mailto:emoore45@jhu.edu) (E.R.H. Moore), [rneff1@jhu.edu](mailto:rneff1@jhu.edu) (R. Neff), [msspiker@uw.edu](mailto:msspiker@uw.edu) (M.L. Spiker).

<https://doi.org/10.1016/j.gfs.2023.100693>

Received 20 October 2022; Received in revised form 11 April 2023; Accepted 16 April 2023

Available online 17 April 2023

2211-9124/© 2023 Elsevier B.V. All rights reserved.

quality of foods (including medically appropriate foods). As in the model of Chodur et al. (2018), the food system disruption analysis does not include stability as a branch of the tree, as we consider stability as an outcome of resilient food systems, rather than a contributor to system disruptions after adverse situations.

A food system disruption analysis illustrates connections between system disruptions and their contributing causes; events lower on the tree can lead to events higher on the tree. For example, the occurrence of local shocks (such as droughts or flood) or stressors (such as conflict) can affect different food supply chain actors, hindering efficient supply chain operations. This can result in physical and economic disruptions in the food supply chain, leading to price volatility, food losses, or food shortages which contribute to population-level food insecurity and malnutrition (Béné, 2020). A food system disruption analysis provides a structured, logical approach that enables planners and other stakeholders to comprehensively review and anticipate a range of hazards that may hinder food security. These hazards may include natural disasters, disease epidemics, and non-natural hazards related to resource shortages, conflict, terrorism, civil unrest, and other political or economic changes.

We situate the disruptions to food security in Honduras within its national context. The country’s challenges include high income inequality; a lack of adequate food system infrastructure, which impairs delivery of the food supply, especially to rural areas; and dependence on agriculture. The agricultural sector in Honduras employs 35% of the country’s economically active population and generates almost 13% of the Gross Domestic Product (GDP) (Derlagen et al., 2019).

The following sections use food system disruption analysis to examine how the COVID-19 pandemic, climate change, and conflict, as independent and confluent crises in Honduras from 2020 to 2022, have

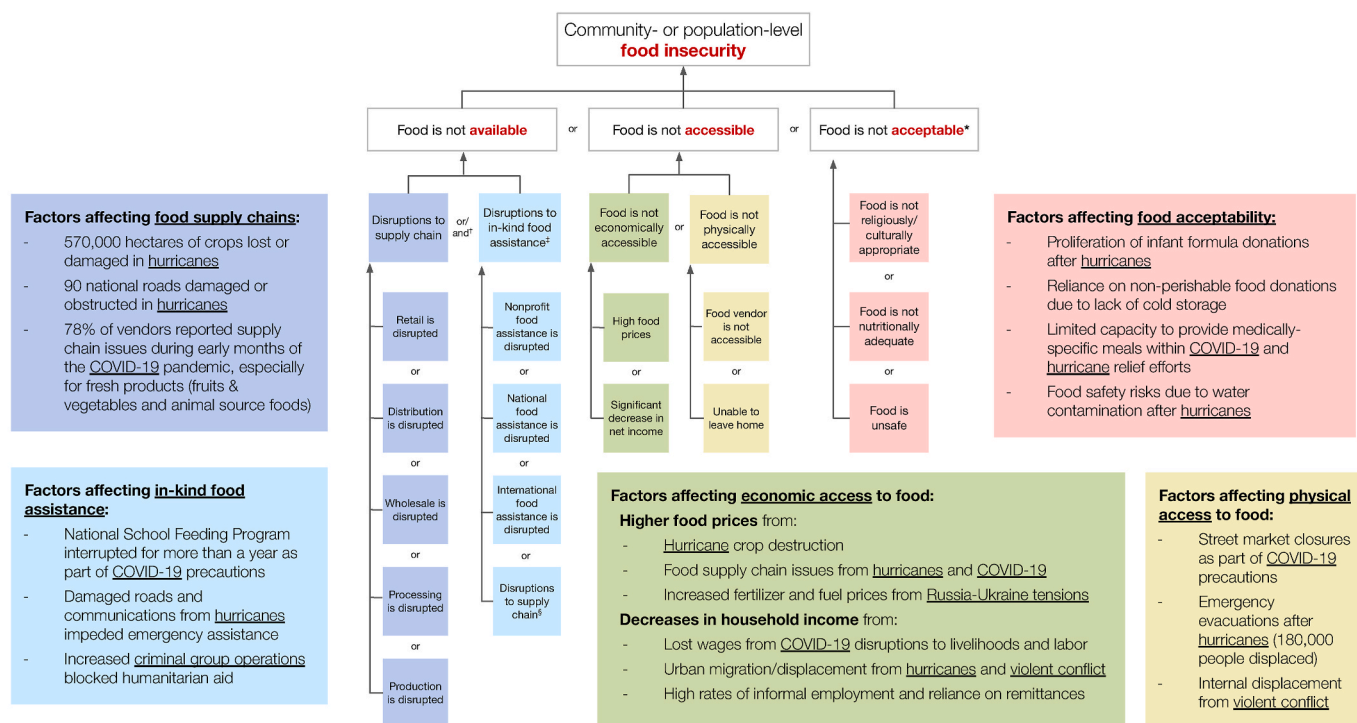
impacted food availability, accessibility, and acceptability. This case study incorporates data from national and international sources, peer-reviewed publications, and expert knowledge, highlighting relevant parts of the food system and their interconnections rather than covering each component of the food system exhaustively.

## 2. Honduras case study

### 2.1. COVID-19 pandemic

#### 2.1.1. Food availability

As in all countries worldwide, the COVID-19 pandemic introduced disruptions throughout food supply chains in Honduras. Though policies were implemented to protect food production, such as microcredit loans and debt refinancing for farmers, food production was impacted considerably. Food vendors encountered unexpected shifts in both food supply and demand: 78% of food store owners reported supply issues in April 2020, particularly with dairy, meat, vegetables, and fruit juices (Programa Mundial de Alimentos, 2020), and poultry farmers reported a 40% reduction in poultry product sales (Diaz-Bonilla et al., 2021). Given the supply chain disruptions for fresh products, an increase in the consumption of less nutritious energy dense foods was observed in the region (FAO and ECLAC, 2020a). Retail disruptions such as market closures or reduced business hours that affected physical access to food (detailed below) also affected the food supply by exacerbating food waste. In Honduras, as in many countries across Latin America, COVID-19-related drivers of retail-level food waste included market closures (and accompanying loss of customers), panic buying, and subsequent overstocking from both retailers and consumers (FAO and ECLAC, 2020b).



\* "Acceptability" includes the concept of utilization, as well as nutritional adequacy (including medically appropriate foods), cultural acceptability, and food safety.  
 † This is "or" for populations under an income cut-off, but changes to "and" for populations above an income cut-off.  
 ‡ Includes (but is not limited to) food banks or pantries, federally assisted school meal programs, and provisioning of food commodities or other food aid products  
 § See the events that contribute to "disruptions to supply chain"

**Fig. 1. Updated food system disruption analysis.** This is an adaptation of the simplified “fault tree” that appears in the Baltimore Food System Resilience Advisory Report (Biehl et al., 2017). A more technical version with detailed sub-trees can be found in Chodur et al., (2018). This food system disruption analysis illustrates connections between system disruptions and their contributing causes; events lower on the tree can lead to events higher on the tree. For example, a disruption to food production could lead to a supply chain failure that makes food unavailable, ultimately contributing to population-level food insecurity. There are also connections between the “branches” of the tree, detailed in the text. In this figure, the peripheral boxes describe the impacts of the COVID-19 pandemic, climate change, and conflict on food security in Honduras from 2020 to 2022; these are a selection of illustrative examples described more fully in the text.

Schools are one of many provisioning points within food supply chains in LMICs. The pandemic caused the closure of schools and school cafeterias globally, leading to substantial nutritional consequences for children (Béné et al., 2021). In Honduras, the National School Feeding Program—which supplies universally free meals to more than 1.2 million children each year—experienced interruptions due to school closures to prevent the spread of COVID-19 starting in March 2020 (Tosta, 2020). These interruptions included reductions in assistance days, new modalities of distribution such as take-home meals, and limiting meals to a smaller range of commodities (e.g., beans and dates) or more targeted populations (e.g., food insecure, indigenous regions). At the time of writing, the program is slowly resuming pre-pandemic levels of food assistance. The meals are being accompanied by additional nutrition-sensitive activities (e.g., nutrition education) at school sites, in light of the serious malnutrition risks for children who depend on school meals for their caloric and nutrient requirements.

### 2.1.2. Food accessibility

Evidence suggests that the biggest impact of COVID-19 on the different dimensions of global food security was on food access (Béné et al., 2021). As in most countries, COVID-19 had major impacts on both physical and economic food access in Honduras, with particularly visible impacts in the early months of the pandemic. Shortly after the first diagnosed case of COVID-19 in March 2020, government authorities imposed a national lockdown, allowing people to leave their homes once every two weeks based on the last number of their identification cards. Moreover, physical access to food was limited by quarantine measures, the closure of street markets, and interruptions to public transportation—issues that can affect not only the quantity but also the quality and diversity of household foods. Interruptions to transportation affected both urban and rural populations, with some rural residents needing to walk 2–3 hours to the nearest market.

In terms of economic access, the COVID-19 pandemic exacerbated food access vulnerabilities that have been in the making for over 15 years within the broader socio-economic context of Honduras. At the beginning of 2020, around 40% of the national workforce was already unemployed (Food Security Information Network, 2021) and 80% of employment was informal—one of the highest rates of informal employment in Latin America (Acevedo et al., 2021). By July 2020, around 2.1 million informal workers had employment disruptions leading to income loss and 67% of formal workers were on labor suspension (Food Security Information Network, 2021), with many in urban areas. Honduras is also one of the top ten remittance-receiving countries in the world, which creates heightened vulnerability when livelihoods are disrupted abroad. At the national level, remittances comprised 23% of the country's GDP in 2020 (Dunnville et al., 2022). At the household level, remittances comprise 33.8%–54.3% of household incomes, with the bulk of this income spent on food (Dunnville et al., 2022). Temporary reductions in remittances due to an increase in unemployment among out-migrated Hondurans from March to June 2020 weakened household purchasing power. At the same time, food prices increased globally (Buchholz, 2021). Ultimately, precarious household incomes and increased food prices affected economic access to foods. Around 89% of respondents to a World Food Programme (WFP) survey did not have food reserves and half of the households were accessing foods using their savings and credit as a coping strategy (Diaz-Bonilla et al., 2021). Other emergency coping strategies, such as reducing quantity and quality of consumed foods, were used to face inflated prices for staples and fresh foods (Famine Early Warning Systems Network, 2020).

### 2.1.3. Food acceptability

The COVID-19 pandemic also triggered drivers of food insecurity related to food acceptability, which includes food safety, nutritional adequacy, and cultural appropriateness. With a collapsed health system, maintaining health standards to prevent foodborne diseases was

exceptionally challenging for authorities responsible for national food safety control systems in Latin America (FAO and ECLAC, 2020c). Staff conducting diverse activities such as inspection of food trade operations, export certification, control of imported food, and food sampling and analysis faced challenges during the first months of the pandemic (FAO and ECLAC, 2020c). Additionally, food aid distributed in the early days of the pandemic included food baskets from the country's many development agencies and humanitarian organizations, and food aid from the Honduran government reached more than 1.5 million beneficiaries in rural and urban areas (Prensa - SDE, 2020). However, due to inadequate cold chain in many parts of the country, food donations were required to be non-perishable and ultimately consisted mainly of grains. As a result, food baskets were composed of limited products, some of which were not culturally accepted countrywide, such as canned sardines. These factors, combined with decreased household purchasing power and a general lack of nutrition knowledge in the population, created a perfect context for many Hondurans to increase consumption of cheap, low nutrient density foods (Lara-Arevalo and Escobar-Burgos, 2020).

## 2.2. Climate change

### 2.2.1. Food availability

Honduras is affected by extreme weather events—it ranked 44th for its climate risk index from 2000 to 2019, and flood and storm events are becoming increasingly severe (Eckstein et al., 2021). Rapidly urbanizing areas around the capital city, Tegucigalpa, are susceptible to landslides and flooding, and many of the country's rural residents (41% of the total population) depend on rainfed agriculture and are thus particularly susceptible to drought. The country declared a national state of emergency in 2018 and 2019 due to extreme drought, and food insecurity has become a recurrent issue in drought-prone regions. In November 2020, in a span of less than two weeks and amid the COVID-19 pandemic, hurricanes Eta and Iota both made landfall as category 4 hurricanes, affecting almost 4 million of the country's 9.9 million residents (Zambrano et al., 2021). The hurricanes impacted food availability via supply chain disruptions, including disruptions to food production, processing, wholesale, distribution, and retail. Food availability was severely impacted as many households lost crops, livestock, or food stocks, with almost 570,000 ha of food crops damaged or lost due to the storms (FAO, 2020). Moreover, almost 90 countrywide roads were obstructed or damaged (Zambrano et al., 2021), resulting in transportation disruptions that also contributed to decreases in food availability.

### 2.2.2. Food accessibility

In the wake of Hurricanes Eta and Iota, the supply chain disruptions described above were compounded by food access issues, especially physical access. Around 200,000 residents were evacuated (Zambrano et al., 2021), and therefore had limited or no access to food vendors. Damaged roads and disrupted communications interrupted not only food purveyors, but also the distribution of emergency assistance. By December 2020, around 330,000 people continued to be unreachable while 95,000 were still living in shelters (Food Security Information Network, 2021). The hurricanes also affected economic access to food. Though rising food prices began to stabilize by August 2020, cropland destruction and supply chain failures resulting from the hurricanes caused food prices to rise again at the end of 2020 (Food Security Information Network, 2021). With a combined national economic impact of over USD\$2.125 billion, the hurricanes increased poverty levels in Honduras (Food Security Information Network, 2021). A large proportion of people working in the informal sector, who lack employee benefits, relied on food assistance to avoid hunger. It's worth emphasizing that these events affected many households already suffering from reduced income sources due to COVID-19 restrictions (Famine Early Warning Systems Network, 2020).

### 2.2.3. Food acceptability

The hurricanes also affected food acceptability. Significant damage to water and sanitation infrastructure led to the destruction of waste management facilities and contamination of water sources. As a result, food safety risks and the occurrence of infectious diseases (including diarrhea and COVID-19) were heightened, especially among those living in shelters (OCHA, 2020). As humanitarian organizations and international aid began mobilizing support, food baskets and other in-kind donations were redirected to those most affected by the hurricanes. With the aim of supporting as many people as possible, well-intentioned international food donations were indiscriminately received and included massive quantities of infant formula. Given that powdered or liquid concentrated infant formula needs to be mixed with water, the proliferation of infant formula combined with post-hurricane water contamination issues exacerbated the risk of infectious disease in infants. As reports of infant formula donations and distribution proliferated, UNICEF and the Pan-American Health Organization released a joint statement to promote breastfeeding and discourage the acquisition of these products (PAHO and UNICEF, 2020). Additionally, within hurricane-related relief efforts there was little to no capacity to provide medically tailored meals and nutritionally adequate foods for people living with chronic diseases and vulnerable groups (e.g., children under 5, pregnant and lactating women).

## 2.3. Conflict

### 2.3.1. International conflict

Violent conflicts have negative impacts on food systems and food security (FAO, 2016). Even amidst the calamitous impact of the COVID-19 pandemic, global armed conflicts were the main driver of worldwide hunger in 2020 (Delgado et al., 2021). The major escalation of conflict between Russia and Ukraine starting in February 2022 has had particular impact on low- and middle-income countries (United Nations, 2022), including major repercussions for food security in Honduras (Lara-Arévalo and Vega, 2022). Prior to the Russia-Ukraine conflict, Honduras imported half of its fertilizer from Russia. As of April 2022, fertilizer prices were 90% higher than the previous year due to global sanctions and armed conflict (OCHA, 2020). Additionally, global fuel prices have skyrocketed since the conflict began and inflation is expected to be the highest since 2000 (Reuters, 2022). Higher fertilizer and fuel prices affect food production and distribution costs, resulting in higher retail food prices which further limit the household purchasing power of communities that have not recovered from the economic hardships of COVID-19 and the 2020 hurricanes. Higher fuel prices also affect the purchasing power of organizations providing in-kind food assistance; in 2022, the cost of importing and mobilizing one metric ton of Specialized Nutritious Foods increased around 50% compared to 2021 (per WFP internal analysis).

### 2.3.2. Domestic conflict

Domestic conflicts have also affected Honduras' food security. Honduras has been classified as one of the most violent countries in the world (United Nations Office on Drugs and Crime); between 2004 and 2018, gang violence led to internal displacement of 247,000 people (Food Security Information Network, 2021). This situation has increased migration to urban areas, which have been unprepared to meet rising demands of resources and employment. Rapid urban migration has implications for both physical access to food (e.g., availability of retailers in new peri-urban areas) and economic access to food (e.g., disruptions to income as households seek new livelihoods). The economic crisis triggered by the COVID-19 pandemic and hurricanes Eta and Iota also gave rise to increased criminal group operations, which blocked humanitarian aid and extorted civilians to benefit from their resources in some communities (Norwegian Refugee Council, 2020), representing challenges to food availability. Overall, the impacts of global and domestic conflict on food security in Honduras are both direct (e.g.,

criminal groups blocking humanitarian aid) and indirect (e.g., increased food prices due to higher input prices) and are interconnected with ongoing vulnerabilities related to both climate change and COVID-19.

## 3. Discussion

The prior sections describe how the COVID-19 pandemic, climate change, and conflict have affected food availability, accessibility, and acceptability in Honduras, approaching each “branch” of the food system disruption analysis separately. Fig. 1 summarizes how each branch has ultimately been impacted by multiple, overlapping crises—for example, in-kind food assistance in Honduras has been affected by the pandemic, hurricanes, and violent conflict. Some disruptions impact multiple dimensions of food security, and there are also interactions between the branches shown in Fig. 1. For example, food production or retail disruptions may influence household income for workers in the food system (Béné, 2020; Martínez and Young, 2022). The closure of markets can have multifaceted impacts on retail-level food availability, physical access to food, and economic access. For example, fruit, vegetable, meat, and poultry producers in Honduras were the most affected by market closures: they had to invest in cold chains to avoid food waste but inevitably had losses (El Heraldo, 2020). Food price changes in multiple countries during the pandemic were driven by a range of factors including supply shortages (influenced in part by shifts in consumer demand and available market channels) and higher distribution costs (influenced in part by labor shortages) (Bairagi et al., 2022; Boyacı-Gündüz et al., 2021; Hirvonen et al., 2021). In Honduras, prices for eggs, red beans, cabbage, potatoes, and cassava experienced a surge of over 10% in 2020 relative to the preceding year (Diaz-Bonilla et al., 2021). Additionally, events that affect food acceptability—such as the need for safe food in the aftermath of hurricane events that contaminate water—can place additional strain on the logistics of food supply chains and in-kind food assistance. In Honduras, infrastructure destruction from Hurricanes Eta and Iota had far-reaching effects on the contamination of water systems such as wells and latrines across Central America, which ultimately exposed over 1.5 million children to infectious disease risk (UNICEF, 2021).

In addition to the interconnected impacts on food security, there are interconnections between “the three Cs.” COVID-19 is one of many emerging infectious diseases with zoonotic origins (Judson and Rabinowitz, 2021), and climate change has been implicated in the spread of zoonotic diseases through its impacts on animal and vector habitats (e.g., as a result of biodiversity loss and habitat fragmentation) and human behavior (e.g., increased human-wildlife interaction, or increased urban density from climate displacement that facilitates disease transmission) (Hueffer et al., 2013; Lorentzen et al., 2020; Mishra et al., 2021; Sachan and Singh, 2010; Wolfe et al., 2005). Climate change may also be linked to conflict, due to resource scarcity and its social and economic consequences (Koubi, 2019). In Honduras, some of the most severe impacts of Hurricanes Eta and Iota were in regions that already had high levels of violence and poverty (UNICEF, 2021), and news outlets reported a lack of protocols for assisting survivors of gender-based violence that occurred in hurricane shelters (Miranda, 2020).

Conflict and COVID-19 are also connected: while the pandemic temporarily attenuated conflict in some settings (e.g., less armed conflict due to curfews, or through opportunities for “disaster diplomacy” between countries), it may have intensified violence in others, (Bloem and Salemi, 2021; Ide, 2021; Lehrs, 2021), and conflict zones already struggling with health systems infrastructure were particularly challenged in carrying out strategies for COVID-19 diagnostics, treatment, and prevention (Dhabaan et al., 2020). For instance, criminal groups in Honduras impeded the provision of humanitarian aid during the COVID-19 emergency and coerced civilians into surrendering resources for their benefit (Norwegian Refugee Council, 2020).

COVID-19 strategies have also been hindered by climate-related events; in the midst of evacuations for Hurricanes Eta and Iota, for

example, physical distancing and other precautions were often not possible in temporary shelters (Fromm et al., 2022). The hurricanes also impeded public health efforts by damaging hospital infrastructure including potable water and cold chain equipment for vaccines (PAHO and WHO, 2020). Gender-based violence, which affects household food security (Okpara and Anugwa, 2022), can be impacted by changing social and economic dynamics within households as a result of both climate change (Caridade et al., 2022) and the COVID-19 pandemic (Chandan et al., 2020); Honduras saw a 14% increase in reports of gender-based violence between February and May 2022 (Fromm et al., 2022). Scholars have described “the three Cs” as “uneven crises” with compounding, inequitable impacts on vulnerable populations including women, lower-income households, racially/ethnically marginalized groups, and communities in climate hotspots (Belsey-Priebe et al., 2021; Sultana, 2021).

This case study illustrates the powerful and intertwined impacts of the COVID-19 pandemic, climate change, and conflict on food insecurity in Honduras. This case study also reinforces the value of a food system disruption analysis, which enables planners, emergency relief providers, policymakers, and researchers to systematically and comprehensively consider how population-level food insecurity can result from a confluence of overlapping acute shocks and chronic stressors to the food system. In this case study, events lower on the tree and closer to the direct effects of crises (e.g., crop losses or movement restrictions) cascaded upward to higher-level system outcomes such as a lack of food access and, ultimately, increased food insecurity. The number of people living in severe food insecurity in 13 comparable departments of Honduras (among 18 departments in the country) rose from 962,000 to 2.4 million between February 2020 and September 2021 (Food Security Information Network, 2022); these estimates do not even reflect the impact of the 2022 Russia-Ukraine conflict, nor do they cover the entire country population. This increase in food insecurity resulted not from a single event, but from the confluence of multiple crises. While a food system disruption analysis can identify and anticipate negative events, it can also identify critical points of intervention and highlight the cascading benefits of positive events. Efforts for livelihood recuperation are underway in areas heavily impacted by Hurricanes Eta and Iota. Development programs implemented by the Honduran government, local organizations and international agencies have prevented thousands from experiencing more severe food insecurity, while also increasing food access, especially among vulnerable populations. Encouragingly, projections for the number of people anticipated to be in Crisis (Integrated Phase Classification Phase 3 and above, indicating acute food insecurity) decreased from 3.3 million projected as of 2021 to 2.6 million projected as of August 2022 (Integrated Food Security Phase Classification, 2022). These more favorable projections have been attributed to multiple factors including economic reactivation (i.e., increased remittances) and development programs. Food systems experiencing multiple crises are not succeeding or failing in a binary fashion; for every negative impact highlighted in this case study are instances of resilience.

Though the food system disruption analysis displayed in Fig. 1 does not capture every single factor contributing to food security, nor every connection between these factors, in detailing the interwoven nature of these food system disruptions and their effects on population-level food security, we hope to amplify the call to action for greater inter-sectoral, inter-agency, and inter-disciplinary collaboration in efforts to strengthen the resilience of food systems to ongoing and future crises. A food system disruption analysis can help stakeholders identify components of food security that are particularly susceptible to disruption and where resilience to crises may require coordinated efforts from multiple agencies or sectors. For example, seeing that economic access to food in Honduras has multiple drivers and impacts across multiple branches of the tree, this is an area that, rather than being the purview of a single government agency or policy, warrants the involvement of multiple stakeholders and strategies. Food system disruption analysis can support

local, national, and global work on food system resilience including work by local governments (Zeuli and Nijhuis, 2017; Biehl et al., 2017); investigations into the impacts of COVID-19 and other disasters on food system resilience (Fan et al., 2021; Béné, 2020; Blay-Palmer et al., 2021); and explorations into the opportunities, challenges, and applications of food systems resilience (Meyer, 2020; Zurek et al., 2022, Miles and Hoy, 2023). New tools based on food system disruption analysis can be used not just for a one-time analysis, but as an ongoing resource to build resilient food systems that promote food security (Moore et al., 2023).

This article presents an updated framework for food system disruption analysis that is intended to be broadly applicable to low-, middle-, and high-income country settings. This application of the food system disruption analysis to Honduras also demonstrates the impact of multiple, overlapping food systems shocks and stressors and interactions across food system components. Here we focused on a national scale, but food system disruption analysis can also be applied to a state/department, region, watershed, or foodshed, for example, for greater granularity and understanding of impacts. This case study illustrates the need to expand our preventative and relief efforts to account for the synergistic impacts of multiple crises on food insecurity; solutions addressing only a single issue are unlikely to meaningfully promote food security. We encourage planners, providers of emergency relief, policymakers, and researchers to use food system disruption analysis to not only diagnose and anticipate a range of hazards that may hinder food security, but to also inform the design of interventions to strengthen food systems resilience.

#### Research support

This research received no external financial or non-financial support.

#### Relationships

There are no additional relationships to disclose.

#### Patents and intellectual property

There are no patents to disclose.

#### Other activities

There are no additional activities to disclose.

#### Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. At the time of writing, J. Lara-Arévalo was supported by a scholarship from The Fulbright Program and E.R.H. Moore was supported by the National Institute of Environmental Health Sciences training program.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data availability

No data was used for the research described in the article.

#### References

Acevedo, I., Castellani, F., Lotti, G., Székely, M., 2021. Informality in the time of COVID-19 in Latin America: implications and policy options. *PLoS One* 16 (12), e0261277.

- Bairagi, S., Mishra, A.K., Mottaleb, K.A., 2022. Impacts of the COVID-19 pandemic on food prices: evidence from storable and perishable commodities in India. *PLoS One* 17 (3), e0264355.
- Belsey-Priebe, M., Lyons, D., Buonocore, J.J., 2021. COVID-19's impact on American women's food insecurity foreshadows vulnerabilities to climate change. *Int. J. Environ. Res. Publ. Health* 18 (13), 6867.
- Béné, C., 2020. Resilience of local food systems and links to food security – a review of some important concepts in the context of COVID-19 and other shocks. *Food Secur.* 12 (4), 805–822.
- Béné, C., Chavarro, M.J., Even, B., Melo, J., Sonneveld, A., 2021. Global assessment of the impacts of COVID-19 on food security. *Global Food Secur.* 31, 100575.
- Biehl, E., Buzogany, S., Huang, A., Chodur, G., Neff, R., 2017. Baltimore Food System Resilience Advisory Report. Baltimore Office of Sustainability & Johns Hopkins Center for a Livable Future, Baltimore (MD).
- Blay-Palmer, A., Santini, G., Halliday, J., Males, R., Carey, J., Keller, L., et al., 2021. City region food systems: building resilience to COVID-19 and other shocks. *Sustainability* 13 (3), 1325.
- Bloem, J.R., Salemi, C., 2021. COVID-19 and conflict. *World Dev.* 140, 105294.
- Boyacı-Gündüz, C.P., Ibrahim, S.A., Wei, O.C., Galanakis, C.M., 2021. Transformation of the food sector: security and resilience during the COVID-19 pandemic. *Foods* 10 (3), 497.
- Buchholz, K., 2022. Food got more expensive in 2020. This chart shows how [Internet]. World Economic Forum. [cited 2023 Jan 16]. Available from: <https://www.weforum.org/agenda/2021/01/global-food-prices-rising-2020/>.
- Caridade, S.M., Vidal, D.G., Dinis, M.A., 2022. Climate change and gender-based violence: outcomes, challenges and future perspectives. In: *InSustainable Policies and Practices in Energy, Environment and Health Research*. Springer, Cham, pp. 167–176.
- Chandan, J.S., Taylor, J., Bradbury-Jones, C., Niranthakumar, K., Kane, E., Bandyopadhyay, S., 2020 Jun. COVID-19: a public health approach to manage domestic violence is needed. *Lancet Public Health* 5 (6), e309.
- Chodur, G.M., Zhao, X., Biehl, E., Mitrani-Reiser, J., Neff, R., 2018. Assessing food system vulnerabilities: a fault tree modeling approach. *BMC Publ. Health* 18 (1), 1–1.
- Delgado, C., Murugani, V., Tschunkert, K., 2021. Food Systems in Conflict and Peacebuilding Settings: Pathways and Interconnections [Internet]. SIPRI [cited 2022 Jun 16] p. 41. Available from: <https://policycommons.net/artifacts/2331278/food-systems-in-conflict-and-peacebuilding-settings/3091903/>.
- Derlagen, C., De Salvo, C.P., Egas Yerovi, J.J., Pierre, G., 2019. Análisis de Políticas Agropecuarias En Honduras. Inter-American Development Bank. <https://doi.org/10.18235/0002274>.
- Dhabaan, G.N., Al-Soneidar, W.A., Al-Hebshi, N.N., 2020. Challenges to testing COVID-19 in conflict zones: Yemen as an example. *Journal of global health* 10 (1).
- Díaz-Bonilla, E., Flores, L., Paz, F., Piñeiro, V., Zandstra, T., 2021. Honduras: the Impact of COVID-19 and Policy Implications: Second Report. *Int'l Food Policy Res Inst.* <https://presencia.unah.edu.hk/noticias/preven-aumento-en-el-precio-de-la-canasta-basica-alimenticia-en-las-proximas-semanas/>.
- Dunnaveil, M., Martínez, N., Parker, C., Smith, R., Thurlow, C., Tasch, W., 2022. Economic Analysis of the Honduras Remittance Ecosystem [Internet]. USAID, p. 89. Available from: [https://pdf.usaid.gov/pdf\\_docs/PA00269J.pdf](https://pdf.usaid.gov/pdf_docs/PA00269J.pdf).
- Eckstein, D., Künzel, V., Schäfer, L., 2021. Global Climate Risk Index 2021 [Internet]. Germanwatch, p. 49. Available from: [https://www.germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021\\_2.pdf](https://www.germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf).
- El Heraldo, 2020. Supermercados, productores y restaurantes resistieron con heroísmo [Internet] [cited 2023 Apr 11]. Available from: <https://www.elheraldo.hn/especial/s/lobuenedel2020/supermercados-productores-y-restaurantes-resistieron-con-heroi-smo-NBeh1432539>.
- Famine Early Warning Systems Network (FEWS NET). El Salvador, Honduras, and Nicaragua - informe de monitoreo remoto: Mon, 2020-08-31 | Famine Early Warning Systems Network [Internet]. [cited 2022 May 30]. Available from: <https://fews.net/central-america-and-caribbean/el-salvador-honduras-and-nicaragua/remote-monitoring-report/august-0>.
- Fan, S., Teng, P., Chew, P., Smith, G., Copeland, L., 2021. Food system resilience and COVID-19 – lessons from the Asian experience. *Global Food Secur.* 28, 100501.
- FAO and ECLAC, 2020a. Food Systems and COVID-19 in Latin America and the Caribbean, Bulletin 10: Food Consumption Patterns and Malnutrition [Internet]. FAO, Santiago, Chile [cited 2022 Jun 22]. 22 pp. Available from: <https://www.fao.org/documents/card/en/c/cb0217en>.
- FAO and ECLAC, 2020b. Food Systems and COVID-19 in Latin America and the Caribbean, Bulletin 9: How to Reduce Food Loss and Waste [Internet]. ECLAC [cited 2023 April 8]. Available from: <https://repositorio.cepal.org/handle/11362/45769>.
- FAO and ECLAC, 2020c. Food Systems and COVID-19 in Latin America and the Caribbean N° 4: Health Risks; Safety of Workers and Food Safety [Internet]. ECLAC [cited 2023 Jan 16]. Available from: <https://www.cepal.org/en/publications/45580-food-systems-and-covid-19-latin-america-and-caribbean-ndeg-4-health-risks-safety>.
- FAO, 2020. The Republic of Honduras | Urgent Call for Assistance : FAO in Emergencies [Internet]. FAO [Cited 2022 July 4]. Available from: <http://www.fao.org/emergencies/resources/documents/resources-detail/en/c/1366326>.
- FAO, 2016. Peace, Conflict and Food Security: what Do We Know about the Linkages? [Internet]. Available from: <https://www.fao.org/3/i5521e/i5521e.pdf>.
- Food Security Information Network (FSIN), 2021. Global Report on Food Crises 2021 [Internet]. Rome, p. 307. Available from: <https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2021.pdf>.
- Food Security Information Network (FSIN), 2022. Global Report on Food Crises 2022 [Internet]. Rome, p. 277. Available from: <https://www.fsinplatform.org/sites/default/files/resources/files/GRFC%202022%20Final%20Report.pdf>.
- Fromm, I., Reiche, A., Saucedo, D., Rivera, E., 2022. Social, environmental, and COVID-19 pandemic-related effects on women's food security and health in Honduras. *SN Soc. Sci.* 2 (9), 1–4.
- Hendriks, S.L., Montgomery, H., Benton, T., Badiane, O., Castro de la Mata, G., Fanzo, J., et al., 2022. Global environmental climate change, covid-19, and conflict threaten food security and nutrition. *BMJ* 378, e071534.
- Hirvonen, K., Minten, B., Mohammed, B., Tamru, S., 2021. Food prices and marketing margins during the COVID-19 pandemic: evidence from vegetable value chains in Ethiopia. *Agric. Econ.* 52 (3), 407–421.
- HLPE, 2020. Food Security and Nutrition: Building a Global Narrative towards 2030 [Internet]. Available from: <https://www.fao.org/3/ca9731en/ca9731en.pdf>.
- Hueffer, K., Parkinson, A.J., Gerlach, R., Berner, J., 2013. Zoonotic infections in Alaska: disease prevalence, potential impact of climate change and recommended actions for earlier disease detection, research, prevention and control. *Int. J. Circumpolar Health* 72 (1), 19562.
- Ide, T., 2021. COVID-19 and armed conflict. *World Dev.* 140, 105355.
- Integrated Food Security Phase Classification, 2022. Honduras: Acute Food Insecurity Situation December 2021 to February 2022 and Projections for March to May 2022 and June to August 2022. [cited 2022 Aug 31]. Available from: <https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1155409/#:~:text=For%20the%20period%20of%20March,to%20about%202.6%20million%20people>.
- Judson, S.D., Rabinowitz, P.M., 2021. Zoonoses and global epidemics. *Curr. Opin. Infect. Dis.* 34 (5), 385–392.
- Koubi, V., 2019. Climate change and conflict. *Annu. Rev. Polit. Sci.* 22, 343–360.
- Lara-Arévalo, J., Escobar-Burgos, L., 2020. Malnutrición en Honduras durante la COVID-19: el ambiente obesogénico y el hambre oculta. *Innovar: Revista de ciencia y tecnología* 9 (2), 120–122.
- Lara-Arévalo, J., Vega, A., 2022. Alternativas ante el impacto del conflicto entre Rusia y Ucrania en la seguridad alimentaria de Honduras. *INNOVARE Cienc Tecnol.* 11 (1), 52–54.
- Lehrs, L., 2021. Conflict and cooperation in the age of COVID-19: the Israeli-Palestinian case. *Int. Aff.* 97 (6), 1843–1862.
- Lorentzen, H.F., Benfield, T., Stisen, S., Rahbek, C., 2020. COVID-19 is possibly a consequence of the anthropogenic biodiversity crisis and climate changes. *Dan Med. J.* 67 (5), A205025.
- Martínez, L., Young, G., 2022. Street vending, vulnerability and exclusion during the COVID-19 pandemic: the case of Cali, Colombia. *Environ. Urbanization* 34 (2), 372–390.
- Meyer, M.A., 2020. The role of resilience in food system studies in low- and middle-income countries. *Global Food Secur.* 24, 100356.
- Miles, A., Hoy, C., 2023. Editorial: achieving food system resilience and equity in the era of global environmental change [Internet]. *Front. Sustain. Food Syst.* [cited 2023 Apr 11]; 6:1126013. Available from: <https://www.frontiersin.org/articles/10.3389/fsufs.2022.1126013>.
- Miranda, B., 2020. Los abusos sexuales a los que están expuesta miles de niñas y adolescentes en albergues de Centroamérica por los huracanes Iota y Eta [Internet]. BBC News Mundo [cited 2023 Apr 11]. Available from: <https://www.bbc.com/mundo/noticias-america-latina-55431077> [cited 2023 Apr 11]. Available from: <https://www.bbc.com/mundo/noticias-america-latina-55431077>
- Mishra, J., Mishra, P., Arora, N.K., 2021. Linkages between environmental issues and zoonotic diseases: with reference to COVID-19 pandemic. *Environ. Sustain.* 4 (3), 455–467.
- Moore, E., Biehl, E., Burke, M., Bassarab, K., Misiaszek, C., Neff, R., 2023. Food System Resilience: A Planning Guide for Local Governments. Johns Hopkins Center for a Livable Future. Available online at: <https://clf.jhsph.edu/sites/default/files/2022-12/the-resilience-planning-guide.pdf>. (Accessed 15 January 2023).
- Norwegian Refugee Council, 2020. Hundreds of Thousands Still Waiting for Humanitarian Aid in Honduras and Guatemala [Internet]. NRC [cited 2022 Jul 6]. Available from: <https://www.nrc.no/news/2020/december/hundreds-of-thousand-s-still-waiting-for-humanitarian-aid-in-honduras-and-guatemala/>.
- OCHA, 2020. Honduras: Tormentas Eta e Iota Informe de Misiones de Evaluación UNDAC (22 noviembre - 03 diciembre de 2020) | HumanitarianResponse [Internet] [cited 2022 Jul 4]. Available from: <https://www.humanitarianresponse.info/es/operations/honduras/document/honduras-tormentas-eta-e-iota-informe-de-misiones-de-evaluaci%C3%B3n-undac>.
- Okpara, U.T., Anugwa, I.Q., 2022. Harms to community food security resulting from gender-based violence. *Land* 11, 2335.
- PAHO, UNICEF, 2020. Declaración Conjunta: Alimentación del Lactante y del Niño Pequeño en Situaciones de Emergencia | Naciones Unidas en Honduras [Internet] [cited 2022 Jun 22]. Available from: <https://honduras.un.org/es/101611-declaracion-conjunta-alimentacion-del-lactante-y-del-nino-pequeno-en-situaciones-de-emergencia>.
- PAHO, WHO, 2020. Evento: Ciclón tropical Eta; País: Honduras; Reporte de situación No. 9 [Internet] [cited 2023 Apr 11]. Available from: <https://www.paho.org/en/documents/pahowho-honduras-response-tropical-cyclone-eta-situation-report-9-onl-y-spanish> [cited 2023 Apr 11]. Available from: <https://www.paho.org/en/documents/pahowho-honduras-response-tropical-cyclone-eta-situation-report-9-onl-y-spanish>
- Prensa - SDE, 2020. Honduras Solidaria ha entregado alimentos a casi 1,5 millones de familias [Internet]. Secretaría de Desarrollo Económico [cited 2022 Jun 1]. Available from: <https://sde.gob.hn/2020/08/16/honduras-solidaria-ha-entregado-alimentos-a-casi-15-millones-de-familias/>.
- Programa Mundial de Alimentos, 2020. Boletín Monitoreo de Mercados COVID-19 [Internet]. Available from: <https://obsan.unah.edu.hk/assets/Uploads/Documento-Boletin-Monitoreo-de-Mercados-COVID-19-PMA-2020.pdf>.

- Red Cross Red Crescent Climate Center, 2022. Annual Report 2021 the Three C's: Covid, Climate, Conflict [Internet]. Available from: [https://www.climatecentre.org/wp-content/uploads/RCCC\\_AR\\_2021.pdf](https://www.climatecentre.org/wp-content/uploads/RCCC_AR_2021.pdf).
- Reuters, 2022. Honduras Enacts Month-Long Gasoline Price Freeze in Inflation Fight. Reuters [Internet] [cited 2022 Jul 6]; Available from: <https://www.reuters.com/article/us-honduras-gas-idAFKBN2O51TR>.
- Sachan, N., Singh, V.P., 2010. Effect of climatic changes on the prevalence of zoonotic diseases. *Vet. World* 3 (11), 519.
- Sultana, F., 2021. Climate change, COVID-19, and the co-production of injustices: a feminist reading of overlapping crises. *Soc. Cult. Geogr.* 22 (4), 447–460.
- Tosta, H., 2020. COVID-19: Teachers in Honduras Get on Their Bikes to Help Deliver School Meals | World Food Programme [Internet]. World Food Programme [cited 2022 May 30]. Available from: <https://www.wfp.org/stories/covid-19-teachers-honduras-get-their-bikes-help-deliver-school-meals>.
- UNICEF, 2021. Huracanes consecutivos en Centroamérica dejaron al menos a 1,5 millones de niños, niñas y adolescentes en riesgo de enfermedades graves debido a la contaminación del agua [Internet] [cited 2023 Apr 10]. Available from: <https://www.unicef.org/lac/comunicados-prensa/huracanes-consecutivos-en-centroamerica-dejaron-1.5-millones-de-ninos-en-riesgo-de-enfermedades-graves>.
- United Nations, 2022. Global Impact of War in Ukraine on Food, Energy and Finance Systems [Internet]. UNEP - UN Environment Programme [cited 2022 Jul 6]. Available from: <http://www.unep.org/resources/publication/global-impact-war-ukraine-food-energy-and-finance-systems>.
- United Nations Office on Drugs and Crime. Intentional homicide victims [Internet]. United Nations. [cited 2023 Jan 9]. Available from: <https://dataunodc.un.org/dp-intentional-homicide-victims>.
- Wolfe, N.D., Daszak, P., Kilpatrick, A.M., Burke, D.S., 2005. Bushmeat hunting, deforestation, and prediction of zoonotic disease. *Emerg. Infect. Dis.* 11 (12), 1822.
- Zambrano, L.I., Fuentes-Barahona, I.C., Henriquez-Marquez, K.I., Vasquez-Bonilla, W.O., Sierra, M., Muñoz-Lara, F., Luna, C., Bonilla-Aldana, D.K., Rodriguez-Morales, A.J., 2021. COVID-19 and hurricanes: the impact of natural disasters during a pandemic in Honduras, Central America. *Prehospital Disaster Med.* 36 (2), 246–248.
- Zeuli, K., Nijhuis, A., 2017. The Resilience of America's Urban Food Systems: Evidence from Five Cities [Internet]. Initiative for a Competitive Inner City. Available from: [https://icic.org/wp-content/uploads/2017/01/ROCK\\_Resilient\\_Food\\_f2.pdf](https://icic.org/wp-content/uploads/2017/01/ROCK_Resilient_Food_f2.pdf).
- Zurek, M., Ingram, J., Sanderson Bellamy, A., Goold, C., Lyon, C., Alexander, P., et al., 2022. Food system resilience: concepts, issues, and challenges. *Annu. Rev. Environ. Resour.* 47 (1), 511–534.