BUILDING RESILIENCE FOR FOOD & NUTRITION SECURITY

2020 CONFERENCE PAPER 5 • MAY 2014

ARE SHOCKS REALLY INCREASING?

A SELECTIVE REVIEW OF THE GLOBAL FREQUENCY, SEVERITY, SCOPE, AND IMPACT OF FIVE TYPES OF SHOCKS

Laura Zseleczky

Sivan Yosef

AUTHORS

Laura Zseleczky (l.zseleczky@cgiar.org) is senior research assistant in the Director General's Office (DGO) of the International Food Policy Research Institute (IFPRI), Washington, DC.

Sivan Yosef (s.yosef@cgiar.org) is program manager in the DGO of IFPRI, Washington, DC.

IFPRI and its 2020 Vision Initiative appreciate the generous support of and active engagement with the consortium of partners for the 2020 conference.

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2033 K Street, NW, Washington, DC 20006-1002 USA | T. +1.202.862.5600 | F. +1.202.467.4439 | ifpri@cgiar.org | www.ifpri.org

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ABSTRACT

Recent policy statements refer to increasingly frequent and intense shocks as one of the main reasons for focusing attention and investments on building resilience for food and nutrition security. This paper investigates whether shocks have actually increased in frequency, severity, scope, and impact by looking at historical 25-year trends for five different types of shocks: conflicts, natural disasters, climate change, food price volatility, and health crises related to food safety and agriculture. Through its limited review, the paper finds that while some shocks have not increased, others have become more severe or intense and are projected to continue in the same direction in the near future, posing risks to the food and nutrition security of poor and vulnerable people around the world.

Keywords: shocks, trends, resilience, conflict, climate change, natural disasters, volatility, food safety, pandemics

1. INTRODUCTION

The concept of resilience within food and nutrition security has gained increased recognition among governments, nongovernmental organizations, civil society, and research institutions. As these actors grapple with how to define, measure, and build resilience, an assessment of the historical trends, both long- and short-term, of shocks and risks is necessary. Many reports and statements refer to increasingly frequent and intense shocks as one of the main reasons for focusing attention and investments on resilience at the individual, community, and country levels in the future (DFID 2011; USAID 2012; World Bank 2013). But what does the landscape of shocks actually look like? Have shocks increased or become more severe and far-reaching? This paper will examine the frequency, severity, scope, and impact of five types of shocks: conflicts, natural disasters, climate change, food price volatility, and health crises related to food safety and agriculture.

Shocks more generally are defined as disturbances from a certain equilibrium.[1] Different fields define shocks more contextually: psychology defines shocks as adversity; material sciences looks at them as deformities that exceed a certain threshold; and ecology frames them in a more neutral way, defining shocks as changes that may not even need human intervention (Dahlman 2011; Grady 2011). This paper frames shocks within a development context, defining them as external short-term deviations from long-term trends, deviations that have substantial negative effects on people's current state of well-being, level of assets, livelihoods, or safety, or their ability to withstand future shocks. These negative effects may be short-lived or longer-lasting. The onset of many shocks is unexpected, but in some cases, such as drought or conflict, the shock may be expected year after year, though the individual, community, or system lacks the resilience to prepare for or mitigate it. In other cases, such as climate change, the general shock could be expected but the effect on a particular individual, community, or area could be unexpected.

This paper has a number of limitations. First, it is not meant to be a systematic or exhaustive review of shocks; rather, it is a selective review of a limited number of shocks. The categories of shocks were selected based on the outcomes of an internal consultation within the International Food Policy Research Institute for the formulation of its 2013–2018 strategy, as well as planning for its 2020 policy consultation titled "Building Resilience for Food and Nutrition Security." Based on this consultation, many shocks were excluded due to time limitations, such as systematic financial crises and health pandemics. Additionally, the following were determined to be long-term trends but not necessarily shocks: shifting diets, scarcity of land and water, globalization, migration, population growth, rising incomes, urbanization, and social movements. The following were considered to be impacts of shocks and not shocks themselves: day-to-day adversity and poverty, malnutrition, and hunger.

The time frame for the assessment of trends was originally set as 1990 to the present. In the course of the research process, however, this time frame was found to be somewhat arbitrary, since a longer historical view is needed in most cases to draw meaningful conclusions on trends. Therefore many of the trends are presented over several decades, depending on the data available.

[1] *Merriam-Webster's Collegiate Dictionary,* 10th ed., s.v. "shock."

2. CONFLICTS

The nature of conflict has changed since the First and Second World Wars and the Cold War. While the number of conflicts has, in general, decreased or remained stable and the numbers of battle-related deaths have decreased, different forms of conflict may cause concern for future trends. Moreover, the costs of conflict—on human capital, economic growth, poverty reduction, and more—continue to exact a heavy toll on countries around the world.

STATE-BASED CONFLICT

Based on data from the Uppsala Conflict Data Program (UCDP), Themnér and Wallensteen (2013) found a total of 32 state-based armed conflicts[2] throughout the world in 2012, resulting in a best estimate of 37,941 battle-related deaths (low estimate: 37,175; high estimate: 60,260), more than 15,000 of which occurred as a result of the conflict in Syria. Of these conflicts, 6 were considered wars, with 1,000 or more battle-related deaths, and 3 were new within the year. The authors noted that the number of armed conflicts in 2012 represents a relative low over the last 25 years; from 1989 to 2012, armed conflicts reached a high of 52 in 1991 and 1992, decreased to a low of 31 by 2003, and began to increase again from 2004 to 2011, with another low of 31 in 2010. Overall, however, the first decade of the present century experienced the least conflict as a decade since the 1970s. Of the 141 state-based armed conflicts that took place from 1989 to 2012, 47 took place in Africa and 42 took place in Asia. Europe experienced 23 armed conflicts during this period while the Middle East and Americas experienced 15 and 14, respectively (Themnér and Wallensteen 2013). Marshall and Cole (2011) found that since 1986, some form of armed conflict has occurred in 83 of the countries they reviewed.

While conflicts have declined, many conflicts that persist are related to previous conflicts. All civil wars initiated after 2003 were resumed from previous civil wars, and 90 percent of conflicts since 2000 have been in countries that have already experienced a civil war (World Bank 2011). The Human Security Research Group (HSRG 2012) reports that battle-related deaths have decreased by 76 percent in the post–Cold War era since 1989 and the number of wars has decreased by nearly 50 percent from the 1980s to the first decade of this century. The nature of conflict has changed over the decades, with wars—conflicts leading to particularly high numbers of fatalities—accounting for a decreasing share of global conflict: only 19 percent from 2000 to 2009 as compared with 25 percent during the 1990s (HSRG 2012). Conflicts in which external governments provide military support to one of two interstate warring parties, known as internationalized intrastate conflicts, are on average twice as deadly as similar conflicts without external intervention (HSRG 2012). These internationalized intrastate conflicts account for a growing number of active conflicts throughout the world, having increased from 12 percent during the Cold War period—from 1950 to the end of the 1980s—to 16 percent in the first decade of this century, with a low of 7 percent in the 1990s (HSRG 2012). While state-based conflicts are not increasing, the deadly nature of more internationalized conflicts may be a concerning trend for the future.

NONSTATE CONFLICT

Sundberg, Eck, and Kreutz (2012) reported that between 1989 and 2008, there were 359 conflicts between organized, armed nonstate groups throughout the world. The authors noted that the number of nonstate

[2] UCDP defines a state-based armed conflict as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths in one calendar year" (UCDP 2014, s.v. "armed conflict"). More information on UCDP definitions can be found at http://www.pcr.uu.se/research/ucdp/definitions/.

conflicts[3] remained low from 1989 to 1994 but began to increase and fluctuate after 1994, with an average of 28 conflicts per year from 1994 to 2008 and a high of 39 conflicts in 2000. These nonstate conflicts resulted in a best-estimate 80,174 battle-related deaths from 1989 to 2008. Such fatalities peaked in 1993 with fighting between the Hutu and Hunde in the Democratic Republic of Congo (DRC), and with the conflict between the Sudan People's Liberation Movement/Army and the Southern Sudan Defense Force in Sudan. Hema-Lednu fighting in the DRC also caused peaks in nonstate armed conflicts in 1999 and 2003. While these peak years result in an annual average of 4,009 deaths caused by nonstate conflict, more than 96 percent of conflict years experienced fewer than 1,000 fatalities (Sundberg, Eck, and Kreutz 2012). Nonstate conflicts are much shorter in duration than state-based conflicts; more than 50 percent of nonstate conflicts from 1989 to 2009 lasted a year or less (HSRG 2012). Sundberg, Eck, and Kreutz (2012) found that Africa south of the Sahara experienced 74 percent of the total fatalities from nonstate conflicts during the 1989–2008 time period, while Europe was the most peaceful region. Fighting between groups in Pakistan's tribal areas, Afghanistan, India, and Sri Lanka accounted for the majority of nonstate conflict fatalities in Asia during this time period, while Iraq and Lebanon experienced the bulk of fatalities from nonstate conflicts in the Middle East and North Africa, and Mexico and Colombia accounted for the most nonstate conflict fatalities in the Americas.

ONE-SIDED VIOLENCE

In a UCDP report (Sundberg 2009) on one-sided violence, or violence directed at unarmed civilians by a government or formally organized group, this form of conflict was found to have caused an estimated 635,050 deaths between 1989 and 2007, or an average of 33,423 per year. A significant portion of these deaths occurred during the genocide in Rwanda in 1994; removing this event lowers the number of fatalities due to one-sided violence to an annual average of 7,107 civilians. Sundberg (2009) found that between 1989 and 2007, there were a total of 576 actor-years, or years in which a government or armed group killed 25 or more civilians in a calendar year. During this time period, 166 different actors perpetrated one-sided violence with a relatively constant average of 30 actors committing such violence each year. In 2002 and 2004, peaks of one-sided violence in Africa (primarily in the Great Lakes region) and Asia (primarily in India, Indonesia, and the Philippines) resulted in 40 different actors' committing one-sided violence each year.

THE COSTS OF CONFLICT

The World Bank's (2011) review of trends in conflict, security, and development for the 2011 World Development Report revealed that civil war and high levels of violence can cost countries 2 to 3 percent of gross domestic product (GDP) due to lost production, and this is a conservative estimate that does not include loss of assets or human capital. This report also found that it takes countries 14 years to return to their original levels of growth after experiencing civil war. Trade takes even longer to recover, requiring an average of 20 years, although this can be less, depending on the severity of the conflict. Even countries that do not experience civil war themselves but happen to border on a country that does lose an estimated 0.7 percent of annual GDP growth for each neighbor engaged in civil war. Moreover, every three years of violence experienced by a country costs 2.7 percentage points in poverty reduction compared with countries not affected by violence. The report also found that fragile and conflict-affected states, including those recovering from conflict, account for 60 percent of the undernourished, 70 percent of infant deaths, 65 percent of people without access to safe water, and 77 percent of children not enrolled in primary school. As of 2011, none of these countries had achieved any of the Millennium Development Goals, though causality could not be established.

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[3] UCDP defines nonstate conflicts as "the use of armed force between two organised armed groups, neither of which is the government of a state, which results in at least 25 battle-related deaths in a year" (UCDP 2014, s.v. "non-state conflict"). More information on UCDP definitions can be found at http://www.pcr.uu.se/research/ucdp/definitions/.

Refugees and internally displaced persons (IDPs) represent one of the enormous costs of conflict. In 2012, the United Nations High Commissioner for Refugees (UNHCR) recorded 1.1 million refugees, the highest number since 1999. An additional 6.5 million people were displaced within their own countries that year, the second-highest number in the past decade and almost twice the number of newly displaced persons in 2011 (UNHCR 2012). The Internal Displacement Monitoring Centre (IDMC) reported that more than half of the new displacements in 2012 were the result of conflicts in Syria (2.4 million people) and the DRC (1 million people) while another 500,000 people were internally displaced in Sudan and India (Albuja et al. 2012). In total, IDMC recorded 28.8 million people internally displaced due to armed conflict, generalized violence, or human rights violations in 2012; this is the highest number the center has ever recorded. Despite these high numbers, the mean population of refugee camps has decreased since 2003: more than 15,000 people on average lived in each refugee camp in 2003 but this dropped to a low of 8,800 people in 2009 (UNHCR 2012). By 2012, the average had started to increase again, with the growing number of refugees in Jordan, Turkey, Ethiopia, and Kenya, to an average of 11,400 people per camp. The gendered impacts of conflict are evident in refugee and IDP populations, 80 percent of whom are women and children (World Bank 2011).

Violent conflict impacts food security and nutrition in a variety of ways. Conflicts may disrupt food production, trade, and access to food supplies; destroy infrastructure and the environment; and drive food prices up in local and international markets. Refugees and displaced persons reduce the agricultural labor force in some areas and increase pressure on food availability in others. Following the 2003 conflict in Iraq, 60 percent of Iraqi refugees in Syria and 46 percent of Iraqi refugees in Jordan reported that their household food situation had deteriorated since arriving (Doocy et al. 2011). The effects of conflicts were also evident in the 1998–2000 conflict between Ethiopia and Eritrea, during which more than 1 million people were displaced from agricultural lands, and food assistance, agricultural inputs, and fuel were cut off by the border closure (White 2005). Evidence suggests that agricultural production levels are around 10 percent lower in the years during and after a conflict, and that conflict-affected developing countries experience an annual average of some US$4.3 billion[4] in agricultural value-added losses (Pingali, Alinovi, and Sutton 2005). Political instability and macroeconomic decline following the 2011 revolution in Egypt—combined with the food, fuel, and financial crises of 2009 and increased food prices in 2010—led to an increase of combined food insecurity and income poverty from 14 percent of the population in 2009 to 17.2 percent, or 13.7 million people, in 2011 (WFP 2013). While the majority of households in the Greater Cairo area were food secure in 2009, 3.5 million people in the area had poor access to food by 2011. In Yemen, political crisis and conflict have led to precipitous economic decline since 2011 and associated threats to food security; 60.1 percent of children younger than five are malnourished (Breisinger et al. 2012), and child wasting increased from 12.9 percent in late 2011 to 17.5 percent in late 2012.

While food insecurity is often a consequence of conflict, it can also be a driver of conflict; links have been observed between food insecurity and democratic breakdown, rioting, and civil and communal conflicts. Pinstrup-Andersen and Shimokawa (2008) found that poverty, poor health, and poor nutritional status—measured in terms of head-count poverty index, under-five child mortality, and under-five child malnutrition—are more significantly associated with the onset of armed conflict than GDP per capita, GDP growth, and the ratio of primary commodity exports over GDP.

[4] All dollar amounts are in US dollars.

3. NATURAL DISASTERS

DROUGHTS

Droughts are normally classified into meteorological droughts (deficits in precipitation), hydrological droughts (deficits in reservoir water, surface water, and groundwater), agricultural droughts (deficits in soil moisture), and socioeconomic droughts (whereby the demand for water outstrips the supply) (Damberg and AghaKouchak 2013). There is not much agreement in the assessment of historical trends of drought. Many point measurement–based and climate and hydrological model–based studies of droughts conclude that all types of droughts have been increasing during the past few decades, although the former lack sufficient geographic coverage to offer strong conclusions. Dai (2011) found that the percentage of land areas in drought ranged between 14 and 20 percent from 1950 to 1982 and then increased by 10 percent due to the 1982–1983 El Niño, which decreased precipitation. The author concluded that increases in anthropogenic greenhouse gases (GHGs) have contributed to drying trends over land. GHGs are also likely to have played a part in the warming in the Indian Ocean and tropical Pacific, which contributed to increased drying in Africa and Asia, respectively.

Observation- and satellite-based studies are more mixed in their conclusions. Dorigo and colleagues (2012) used a multisatellite (remotely sensed) dataset on surface soil moisture to analyze global wetting and drying trends over the period 1988–2010. They found subtle drying trends in the southern United States, central South America, central Eurasia, the Middle East and northern Africa, Mongolia and northeast China, northern Siberia, and Western Australia. Their analysis showed wetting trends in southern Africa and the subarctic region. These trends were not consistent through all seasons. Dorigo and colleagues (2012) compared model-based surface soil moisture datasets with a vegetation dataset, which generally confirmed these findings, with the exception of northern and southeastern Australia and with some differences in the spatial extents of drying and wetting in other regions. A precipitation dataset that was used as an additional comparator did not show these trends. Sheffield, Wood, and Roderick (2013) countered that the current index used to measure droughts, the Palmer Drought Severity Index, which shows a decrease in global moisture alongside an increase in drought areas during the past four decades, may overestimate these trends, since it does not account for changes in energy, humidity, and wind speed as drivers of potential evaporation. Taking these factors into account, the authors suggested there has been little change in the total area affected by drought during the past 60 years. The analysis by Sheffield, Wood, and Roderick (2013), however, did not account for trends in soil moisture, and needs to be confirmed by other independent analyses. Damberg and AghaKouchak (2013) analyzed the amplitude and frequency of meteorological droughts and drying areas from space, based on satellite precipitation observations. Their results, which covered the past three decades, showed that droughts are more variable in land within the Southern Hemisphere than land within the Northern Hemisphere. They found a significant positive trend in droughts over land in the Southern Hemisphere and pointed to a drying trend in several regions, including the southwestern United States, parts of the Amazon, the Horn of Africa, northern India, and parts of the Mediterranean region. Conversely, central Africa, parts of southwest Asia, Central America, northern Australia, and parts of eastern Europe showed a wetting trend.

The contention in assessing historical drought trends is best exemplified by the Intergovernmental Panel on Climate Change's (IPCC's) revision of its 2007 statement that droughts are "likely" to have increased since the 1970s in a later special report that stated instead that "there are still large uncertainties regarding observed global-scale trends in droughts" (Seneviratne 2012). The latest IPCC report (IPCC 2013) confirms a low confidence that there have been *global* increases in the intensity, duration, or both of drought since 1970, but that the frequency and intensity of droughts are likely to have increased in the Mediterranean and West Africa and likely to have decreased in central North America and northwest Australia since 1950. Looking forward, the report notes a high confidence that drying in the Mediterranean, southwestern United States, and southern Africa is likely as global temperatures increase under the IPCC's representative concentration pathway (RCP, or climate scenario) RCP8.5. Decreases in runoff are likely in southern Europe and the Middle East. Increased runoff is likely in high northern latitudes. There is low confidence in a human role in changes in drought over global land during the past 60 years (IPCC 2013).

It can be assumed that drought has adverse impacts on food and nutrition security through decreases in water availability and crop yields, but data on direct impacts on food security are scarce due to differences in the scope of the event, the regional context, and the methodology, as well as the inextricability of drought and factors that it accompanies or compounds, such as conflict, poverty, and other climate phenomena such as rising temperatures. These confounding factors apply to the other types of natural disasters in this section as well.

The secondary effects of drought, such as food price spikes triggered by restrictive trade policies and panic purchases following a drought, may impact food security more seriously than the direct impact of production cuts on the global supply of food (Kallis 2008). The 2010 drought in Russia, for example, accompanied by the warmest July temperatures in Moscow in 130 years and more than 550 wildfires, destroyed 13.3 million hectares of grain crops, more than 30 percent of the agricultural area in affected regions. Despite Russia's having enough grain reserves to meet domestic demand, market speculation and an export ban led food prices to spike not only domestically but around the world (Wegren 2013). Similarly, critical drought conditions in the winter of 2011 across much of eastern China affected some 35 percent of land devoted to wheat cultivation, caused $2.3 billion in economic losses, and impacted the food security of 35 million people. Furthermore, the fear that the drought would eliminate the country's wheat reserves caused the Chinese government to purchase wheat on the world market, possibly resulting in the doubling of international wheat prices, which were already high due to the Russian drought and other weather events around the world. This affected the food security of individuals in wheat-importing countries, contributing to social unrest in countries such as Egypt (Stemberg 2012). In other case studies, the 2009 drought in Kenya, emblematic of the recurring, near-annual droughts within the Horn of Africa, cut wheat yields by 45 percent compared with the more stable harvest the following year (FAO 2012). A multiyear drought in Australia over 2002–2010 caused wheat yields to drop by 46 percent (FAO 2012). And in Malawi, the 2001–2002 drought, compounded by other factors, slashed the national harvest by 32 percent, forcing affected households to find off-farm sources of food for 6–8 months instead of the usual 3–4 months (Devereux 2007).

FLOODS

Studies that look back at the past few decades show an increase in global precipitation and runoff, which greatly contribute to flooding. Westra, Alexander, and Zwiers (2013) reviewed changes in extreme rainfall during the past 30 years based on more than 8,000 weather-gauging stations around the world. They found an increase in rainfall extreme averages globally, as well as an estimated 7 percent increase in extreme rainfall intensity for every 1°C increase in global atmospheric temperature. The strongest increases were found in tropical countries, which tend to be some of the poorest countries in the world, though most weather stations saw an increase. The authors said they expect flood events around the world to become more frequent. Milly and others (2002) found that the 20th century saw an increased risk of big floods (with discharges exceeding 100-year levels from basins larger than 200,000 km^2) in the northern high latitudes, a trend that may continue. Alexander and others (2006) gridded seasonal and annual climate-change indexes from daily temperature and precipitation data for the period 1951–2003. They found an increase in both maximum and minimum temperatures (see Section 4) as well as changes in precipitation. These changes, while less spatially coherent and not uniformly statistically significant, still showed a widespread increase in the majority of the precipitation indexes except for consecutive dry and wet days. Alexander and others (2006) concluded that, averaged across the world, annual extreme precipitation events have been increasing in frequency. Min and colleagues (2011) went further and linked an increase in extreme precipitation events to human-induced GHG emissions. They compared probability-based indexes of precipitation extremes with model simulations from 1951 to 1999 that partially or wholly accounted for anthropogenic factors (GHGs, aerosols, and so on), although their study was limited to Northern Hemisphere land areas (including North America, Eurasia, and

India). They found that 65 percent of the sampled area showed a positive trend for annual maximum daily precipitation and 61 percent showed a positive trend for five-day consecutive precipitation.

Rising temperatures during the next few decades are likely to increase evaporation and speed up the global hydrological cycle, in the process drying subtropical areas and increasing precipitation at higher latitudes (Schiermeier 2010). Indeed, the IPCC (2013) noted that higher latitudes and the equatorial Pacific Ocean are likely to get an increase in annual mean precipitation by 2100, while mid-latitude and subtropical dry regions will receive less. Hirabayashi and colleagues (2008) used climate-change simulations to look at extremes in global river discharges (both floods and droughts). They noted that river discharge will increase on a global scale, owing to increased precipitation and reduced evapotranspiration, and projected that the frequency of floods will increase over many regions except North America and central to western Eurasia. Drought frequency was projected to increase globally except in regions in northern high latitudes, eastern Australia, and eastern Eurasia. Some regions will have increases in both floods and droughts.

The impacts of floods on food and nutrition security can be best seen through case studies because, again, global data are not readily available. The Pakistan floods of 2010, for example, reportedly caused $1 billion in damage to crops, killed 200,000 head of livestock, and submerged not only grain reserves but also 7 million hectares of the country's most fertile agricultural land (Batty and Shah 2010). In the 1998 floods in Bangladesh, exposed households experienced crop losses of 24 percent of the total value of their expected annual production. Food consumption in affected households was 227 daily calories per capita less than in nonaffected households, and rates of wasting and stunting increased among preschool children due to reduced access to food and lack of proper childcare and feeding practices, with the nutritional status of these children likely to remain poor in the long term (Del Ninno, Dorosh, and Smith 2003). A cross-sectional study of child nutritional status in flooded and nonflooded villages in eastern India showed that children in flooded households were more likely to be stunted and underweight, especially if they were exposed to floods during their first year of life (Rodriguez-Llanes et al. 2011). The implications of such studies are troubling, especially when considering the long-term physical and cognitive effects of malnutrition into adulthood and into the next generation.

HURRICANES/CYCLONES

Whether hurricanes or cyclones have increased in frequency is the subject of much debate, due to large fluctuations year to year and decade to decade, as well as an incomplete historical record for many of the world's ocean basins. Many studies, especially those relying on climate models, offer conflicting results on storm frequency. Research, however, suggests that the *intensity* of hurricanes or cyclones may have increased during the past few decades. In an analysis of global tropical cyclone activity between 1970 and 2004, for example, Webster and others (2005) showed that globally, the number of category 4 and 5 hurricanes, the strongest types, doubled between the 1970s and the first decade of this century, while the number of weaker hurricanes has remained constant. The largest increase in strong hurricanes occurred in the North Pacific, Indian, and southwest Pacific Oceans. Emmanuel (2005) found a large increase in power dissipation (the amount of energy expended by a storm) between 1975 and 2005, due to longer storm lifetimes and greater storm intensities, a record that is highly correlated with sea surface temperatures. Elsner, Kossin, and Jagger (2008) noted that while Atlantic tropical cyclones have indeed increased in intensity during the past 30 years, the historical observational record for other ocean basins is not as complete. Estimating based on satellite data, they found increases in the maximum wind speed cyclones achieve in their lifetimes in all basins except the South Pacific Ocean, with the greatest increases in the North Atlantic and northern Indian Oceans. The results were statistically significant only in the North Atlantic Ocean.

Regardless of the consensus on historical trends, many studies have consistently shown a correlation between the warming of sea surface temperatures and storm intensity (Webster et al. 2005; Emmanuel 2005; Knutson et al. 2010), though attribution will require more work. This means that as sea surface temperatures increase, as fully expected due to climate change according to the latest (*Fifth Assessment*) report from the

IPCC (IPCC 2013), storms may become stronger and more destructive, posing a threat to developing and industrialized countries alike.

Hurricanes or cyclones impact food and nutrition security in a number of ways. They cause a high number of fatalities among humans as well as livestock, injuries, loss of livelihoods, forced migration, and long-term homelessness. They damage agricultural lands, through direct wind effects that defoliate crops, strip fruits, and snap trees, as well as through heavy rains that cause leaching, erosion, and flooding (Hammerton, George, and Pilgrim 1984). They also destroy infrastructure, including housing, shelter, water, and sanitation, and disrupt access to services such as schools and health facilities. Though data on hurricanes' global impacts on food security are scarce, a number of case studies illuminate the impact on food and nutrition status. Stansbury and others (2008) found elevated levels of acute and mild to moderate malnutrition among young children in populations affected by Hurricane Mitch in Honduras in 1998, which they attributed to the social disarticulation, economic marginalization, and food insecurity in the resettlement areas where affected families were located. A study on Cyclone Sidr, which caused 2.51 million acres of crop damage in Bangladesh in 2007, found static levels of nutrition insecurity pre- and postcyclone due to a strong humanitarian response (and a low baseline level of nutrition). Fisherfolk, however, were found to be most vulnerable to nutrition insecurity in the postcyclone period (Paul, Paul, and Routry 2012). A recent study on the effects of Cyclone Sendong in the Philippines in 2011 found that within four months of the cyclone event, children living in totally affected houses did not show higher levels of wasting and stunting than those living in partially affected or nonaffected houses. Children living in totally affected houses had a lower risk of being underweight, apparently because the majority of those more heavily affected were moved to evacuation centers where humanitarian aid was more efficiently distributed (Rivero 2013).

EARTHQUAKES

The frequency of earthquakes has seemingly remained somewhat constant since record keeping began. The US Geological Survey (USGS 2012) projected that over the course of one year, the world will see 1 earthquake of magnitude 8 (8M) or higher, 14 of 7–7.9M, 134 of 6–6.9M, 1,319 of 5–5.9M, 13,000 of 4–4.9M, 130,000 of 3–3.9M, and 1.3 million of 2–2.9M. While earthquakes may not be increasing in frequency, a pertinent question is whether they are causing and will cause more fatalities in the future. Bilham (1995) reviewed earthquake fatality numbers for the past 2,000 years; he found that from 1500 to 1994, a tenfold increase in the global population was accompanied by a tenfold increase in the mean rate of fatal earthquakes (from 0.7 annually prior to 1500 to 7 annually currently). Daniell (2013) calculated the total number of damaging earthquakes over the period 1900–2010 to be 3,000, and the number of fatal earthquakes to be 1,673. He noted that the earthquake fatality rate is not keeping up with population growth. The average number of damaging earthquakes was approximately 45 until 1960, when the number rose to 70 annually, but this increase is attributed to better reporting and media coverage. Nichols and Beavers (2008) counted 1,010 fatal earthquakes in the period 1900–1999. They noted that the average annual number of fatal earthquakes has been increasing throughout the 20th century at a rate of 0.14 earthquakes per year, an increase that they attributed to population growth and increasing urbanization.

Looking to the future, the frequency of earthquakes with fewer than 5,000 fatalities can be reliably predicted, while those with fatality counts of more than 30,000 are too irregular for reliable predictions, even though they account for most of the total fatalities. As the world urbanizes, earthquakes are more likely to hit supercities (with more than two million residents), especially since many of the world's largest cities, or 30 percent of the world's megacities (with more than eight million residents), are currently growing along plate boundaries. Eighty percent of these at-risk supercities are located in the developing world (Bilham 1995; Nichols and Beavers 2008). This situation suggests that earthquake fatalities may outpace global population growth, due to the clustering of people in areas with poor infrastructure, lack of building codes and regulations, poor disaster management, and nonexistent services such as emergency medical care. Indeed, there have been nearly no earthquake-related fatalities from 1900 on in countries with a human development index greater than 0.8, presumably those with good infrastructure, building codes, and healthcare. If the damaging effect of these events were to increase as projected, this would be troubling news, especially considering that since the beginning of record keeping, more than 11,600 earthquakes have likely caused some 8.47 million deaths, and that earthquakes from 1900 to date have likely caused some $1.8 trillion in damages (Daniell 2013).

Though data are scarce, a few studies show a link between earthquakes and poor nutritional status. A study of communities affected by the 2005 earthquake in northern Pakistan suggests an increased prevalence of both acute and chronic child malnutrition in the affected areas, with 18 percent of children reported to be wasted, 47 percent stunted, and 39 percent underweight (Hamid, Bhakta, and Gilchrist 2008). In China after the Wenchuan earthquake, preschool children had a higher prevalence of stunting (but not wasting) and micronutrient deficiencies, including iron-deficiency anemia and lower levels of iron, zinc, vitamin A, and vitamin B_{12} than the national rural average (Dong et al. 2014). The impact of earthquakes on people is thus presumably similar to that of other natural disasters in terms of probable negative effects on food access and utilization due to disruptions to food availability, health services, and access to water and sanitation.

4. CLIMATE CHANGE

Climate change is any variation in climate by magnitude, frequency, or persistence, over a period of time, usually a few decades or longer (IPCC 2013). The warming of the world's climate is "unequivocal" and "human influence on the climate system is clear" (IPCC 2013, 15). The world has seen a dramatic rise in atmospheric levels of GHGs, resulting in a rise in global mean temperatures and a positive net change in the Earth's energy balance (known as positive radiative forcing). Many of these changes can be attributed to human activities that affect the climate, including the burning of fossil fuels and land use changes (Wheeler and von Braun 2013). The (latest) *Fifth Assessment Report* from the IPCC (2013) described a number of alarming trends (summarized in Jones and Yosef, forthcoming). During the past three decades, surface temperatures during each decade have been higher than in the previous decade. From 1957 to 2009, the upper layer of the ocean, from 0–75 meters, warmed by 0.11°C, and global average sea level rose by 1.7 mm per year over the period 1901–2010 and 3.2 mm per year over 1993–2010. The pH level of ocean surface water has decreased by 0.1 from preindustrial times. The mean rates of increase in the atmospheric concentrations of carbon dioxide and methane are unprecedented in the previous 22,000 years—the levels of these two GHGs now surpass preindustrial levels by 40 percent and 150 percent, respectively.

Alexander and others (2006) gridded seasonal and annual climate change indexes from daily temperature and precipitation data for the period 1951–2003. They found an increase in both maximum and minimum temperatures, with more land area showing significant change in minimum temperature extremes than in maximum temperature extremes. More than 70 percent of the land area in the sample exhibited a significant decrease in the annual frequency of cold nights, and vice versa, a significant increase in annual warm nights. The largest change in minimum temperature occurred in Eurasia. North Africa and northern South America saw a more than doubling in the frequency of annual warm nights during this period. The authors' results indicated significant warming throughout the 20th century. The IPCC (2013) confirmed these findings, noting that it is very likely that on a global scale since 1950, the number of cold days and nights has decreased and the number of warm days and nights has increased.

The IPCC's 2013 RCPs, or climate scenarios, project these trends to continue or even worsen (IPCC 2013). Under the business-as-usual scenario of continued high GHG emissions (RCP8.5), increases in global mean surface temperatures from 2081 to 2100 over those of 1986 to 2005 are projected to range from 2.6°C to 4.8°C, and the Arctic Ocean would be nearly ice-free in September by the middle of the 21st century. Under a scenario of aggressive GHG mitigation (RCP2.6), the rise in global mean temperatures would still be 0.3°C–1.7°C.

Climate change may benefit farmers in some regions while devastating others (Nelson et al. 2010). The effect of hotter surface temperatures on crop yields depends on prevailing soil moisture and precipitation. In areas with plentiful precipitation, warmer temperatures may be a boon to farmers because they can lengthen the growing season and reduce frost damage. Warmer soil temperatures can also enlarge plants' root surface area, increasing nutrient uptake by 100–300 percent, but only in moist soils (St. Clair and Lynch 2010). In arid and semiarid regions, warmer temperatures may worsen droughts, exacerbating heat stress for crops and reducing their yields (St. Clair and Lynch 2010). Each degree-day above 30°C in the period 1980–2008 reduced maize yields in Africa by 1 percent under ideal rainfed conditions and 1.7 percent under drought conditions (Lobell et al. 2011).

More recent climate projections, including those in the 2010 World Development Report, back up the general prediction that climate change will worsen food insecurity in regions of the world that are already food insecure, such as Africa and South Asia, with the worst yield losses occurring in maize, millet, sorghum, and wheat (Wheeler and von Braun 2013; World Bank 2009). If temperatures rise by 2.2°C–3.2°C, at the lower range of RCP8.5 (the business-as-usual scenario), global wheat and maize yields are projected to decline by 14–25 percent and 19–34 percent, respectively, over the period 2000–2050 (Deryng et al. 2011). A literature review undertaken by the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) showed varied climate-induced effects on 22 crops. Homing in on the world's largest staple crops shows that the most dramatic maize yield losses will be in southern Africa due to climate-induced warmer temperatures and more frequent exposure to high-temperature events. Maize in 2030 in that region is projected to drop to 50 percent of its average yield in 2000. Rice may be affected through increased flooding (especially in South and Southeast Asia) and high nighttime temperatures, as well as drought and salinity stresses. By 2025, 15–20 million hectares of irrigated rice may encounter water scarcity. Wheat may also be affected, by as much as 7.2 percent mean losses in Africa, but with no significant change for Asia (Thornton and Cramer 2012).

Nelson and colleagues (2010) combined three scenarios in income and population growth with five climate change scenarios, resulting in 15 plausible outcomes on food security. With regard to food security, a scenario that presumes high per capita income growth and perfect climate mitigation will give developing countries access to 85 percent of the calories available to developed countries by 2050. The optimistic scenario, which envisions rapid growth by the poorest countries, gives them the same caloric availability as today's middle-income countries. That same scenario shows a 37 percent decline in the number of malnourished children in low-income countries over the years 2010–2050, and a 50 percent decline in middle-income countries. However, even under this optimistic scenario, the number of malnourished children in 2050 is projected to be 76–84 million. Conversely, the pessimistic scenario shows a decline in caloric availability in all regions and an 18 percent increase in child malnourishment in low-income countries (Nelson et al. 2010).

Relying on the calorie availability estimates of Nelson and colleagues (2010), Lloyd, Kovats, and Chalabi (2011) used national food availability and undernutrition data to create a global model based on estimates of the relationship between lack of food and stunting. They found that climate change, as compared with a "perfect mitigation" scenario (no climate change), will lead moderate stunting rates in 2050 to increase by 1 percent in central Africa, 9 percent in both eastern and western Africa, 23 percent in southern Africa, and 29 percent in South Asia. Their analysis found that the numbers of severely stunted children will be most impacted by climate change: they estimated that severe stunting rates will increase by 23–55 percent in the various African regions and 61 percent in South Asia.

5. FOOD PRICE VOLATILITY

The world has seen two major food price crises during the past six years. The prices of staple commodities in local and international markets rose steadily between 2006 and 2007, and then sharply in the beginning of 2008. They decreased significantly by the end of 2008 but then rose again in 2010, with another, less pronounced peak (after adjusting for inflation) being reached in February 2011 (Torero 2012). Prices remain high, second only to the heights reached in the 1970s. International prices of grain, including maize, rice, and wheat, were significantly more volatile in 2007–2010 than in 2003–2006. Going back even further, the volatility of international rice and wheat prices doubled from 1980–2006 to 2007–2010 (Minot 2013). In their review of the literature, von Braun and Tadesse (2012) claimed that a rising medium-term price trend has triggered dramatic short-term price spikes and increased volatility.

Regional studies have probed the extent to which international price volatility is transmitted to regions and countries. Minot (2013), for example, looked at a group of 11 countries in Africa and found that although food price volatility is high, it has not increased during the past few years. Of the 67 prices of staple foods tested, two-thirds had no statistically significant change in volatility between 2003–2006 and 2007–2010, 7 prices had significant increases in volatility, and 17 showed significant decreases in volatility. Nevertheless, the average volatility of African grain prices as measured by a coefficient of variation is still high, at 0.12, compared with 0.06–0.08 for international volatility. Lanchovichina, Loening, and Wood (2012) looked at the transmission of higher food prices to countries in the Middle East and North Africa, and estimated that on average a 1 percent increase in world prices increases domestic food prices by some 0.2–0.4 percent, but with much cross-country variation.

Assessing the impact of volatile food prices on the welfare of poor people needs to be approached with caution because it is necessarily reliant on, inter alia, modeling and projections (Swinnen and Squicciarini 2012). Green and colleagues (2013) investigated the impact of higher (but not necessarily more volatile) food prices in a systematic review of the literature, estimating that a 1 percent increase in cereal prices results in a 0.61 percent reduction in cereal consumption in low-income countries (versus a 0.43 percent reduction in high-income countries). Tiwari and Zaman (2010) looked at the effect of price volatility on undernourishment rates in all developing-country regions. Their preferred estimate, assuming a partial (80 percent) price transmission from international to national markets, suggested that the 2008 crisis may have increased the total global undernourished population by some 63 million people. Anriquez, Daidone, and Mane (2013) analyzed short-term effects of a staple commodity price increase on household undernourishment in eight countries. They found that price spikes decrease mean calorie levels but that the cohort that is hurt the most (for example, rural households, poor urban households) varies by country.

The factors that are believed to have contributed to recent international price volatility are still at work, suggesting that volatility is likely to continue at least until the end of the next decade (Headey and Fan 2010). In response to government subsidies and mandates, farmers are increasingly producing biofuel crops, making food markets more and more dependent on normally volatile energy markets (see, for example, Torero 2012). Biofuel production has a lower impact on food prices when it relies on nonfood crops that do not compete with food crops for water and land resources (Zilberman et al. 2013).

As outlined above, climate change is likely to lead to more intense, more destructive, and in some cases more frequent, extreme weather phenomena, deleteriously affecting crop productivity and production, and contributing to higher and more volatile prices. Indeed, the 2007–2008 crisis was compounded in some places by climate, such as a drought in Australia and weather shocks in Ukraine (Headey and Fan 2010). Nelson and others (2010) suggested that growing incomes and population, combined with climate change–induced reductions in agricultural productivity, will cause real agricultural prices to rise between 2010 and 2050. These price increases are judged by those authors as occurring even in the “perfect mitigation” scenario, that is, even if today’s climate does not change for the worse.

Agricultural commodity futures contracts are being traded at a higher volume than ever, but only 2 percent of futures have materialized into the delivery of real agricultural goods, highlighting the amount of speculation that abounds (Torero 2012). Although some observers (for example, von Braun and Tadesse 2012) have identified speculation as a leading cause of volatility, especially of short-term price spikes, the causality between futures trading and volatility is hard to discern. Some of the other factors that have been cited as contributing to volatility include export restrictions undertaken by governments in the face of crisis, the depreciation of the US dollar, and low interest rates (see, for example, Headey and Fan 2010).

6. HEALTH CRISES RELATED TO FOOD SAFETY AND AGRICULTURE

Health crises related to food safety and agriculture have direct impacts on food security and nutrition. Such crises are often caused by pathogens' being transmitted from animals to humans or through contaminated food or water. These pathogens create public health threats when ecological, social, and biological factors compound one another, such as through increased density and movements of human and animal populations, changes in farming systems, or climate change and variability (Bett 2011).

Zoonotic diseases—diseases that can be transmitted from animals to humans—can represent a significant risk to human health. Common examples include salmonellosis, bovine spongiform encephalopathy, Rift Valley fever, and the influenza virus. Zoonoses account for 60.3 percent of emerging infectious diseases and are significantly increasing over time (Jones et al. 2008). Zoonoses may have a global burden of disease similar to that associated with malaria or tuberculosis, although exact numbers are unknown (see, for example, Torgerson and Macpherson 2011). Some estimates suggest that there are one billion cases of endemic zoonoses each year and millions of deaths caused by these diseases annually (Karesh et al. 2012). Zoonotic agents are the most common cause of foodborne diseases and pose increased risk of being passed to humans in areas with intensified animal production or when inadequately composted manure is used on food crops for humans (see, for example, Todd and Narrod 2006). Zoonotic diseases can be devastating to poor households whose livelihoods depend on livestock, such as when their animals die from these diseases or a family member responsible for their care is struck down by the disease (Catelo 2006).

In a review of the global burden of zoonotic parasites, Torgerson and Macpherson (2011) estimated that cystic echinococcosis (CE), primarily transmitted to humans through domestic dogs and farm animals, and causing cysts in the liver and lungs, costs at least 1 million disability-adjusted life years (DALYs) per year and as much as $2 billion in losses to the global livestock industry annually. While North America and northern Europe experience low levels of CE, the disease has been increasing in eastern Europe and countries of the former Soviet Union since the 1990s. CE levels are high in Latin America but are beginning to decrease, while they remain high in western China, central Asia, the Middle East, North Africa, Ethiopia, and the Turkana region of Kenya.

A recent zoonotic threat, highly pathogenic avian influenza caused by the H5N1 virus, spread quickly throughout the world and illustrated the far-reaching impacts on human health, agriculture, and trade posed by zoonotic diseases. First identified in geese in southern China in 1996 and then detected in humans in 1997 in Hong Kong, the virus spread through poultry and captive wild birds from 2001 to 2003, and its range extended from Hanoi to Shanghai (Jutzi and Domenech 2006). The virus spread through East and Southeast Asia, Mongolia, southern Russia, and the Middle East from 2003 to 2004, and by 2005–2006 it had reached Europe, Africa, and South Asia, causing 93 deaths and 173 outbreaks (Catelo 2006; Jutzi and Domenech 2006). This outbreak was particularly threatening because there was no vaccine, and the only drug that seemed to be effective was experimental and far too limited for widespread use (Catelo 2006). In 2011 the World Health Organization (WHO) still listed avian influenza as having human pandemic potential due to its continued circulation in poultry populations, the lack of immunity to H5N1 among most humans, and the severe effects, including fatality, of the disease when transmitted to humans (WHO 2011).

Foodborne diseases are a major underlying factor for malnutrition and, when experienced repeatedly, can have long-term impacts on infant and child growth and immune system health, leading to further susceptibility to infection and vulnerability to malnutrition (Käferstein 2003). Evidence on the global burden of disease for foodborne illnesses is lacking, and the WHO has started an initiative to estimate this burden and fill the data gaps (Kuchenmüller et al. 2009). The WHO (2008) estimated that 2.16 million children die annually from diarrheal diseases, often caused by contaminated food and water. Todd and Narrod (2006) described the links between agriculture and foodborne disease, noting that waterborne pathogens such as *E. coli*, hepatitis A, or *Giardia* can be transmitted through contaminated water when, for example, wastewater is inadequately treated and used in irrigation on crops. Livestock products also bear the threat of foodborne diseases. While antibiotics offer a common and widespread solution, their increased use in animals presents the risk of antibiotic-resistant strains of pathogens that can threaten humans (Catelo 2006). Stricter food safety standards can reduce these risks but are often too costly or technical for small-scale producers in developing countries. Newell and others (2010) reviewed trends in foodborne diseases based on the applicable data that exist. They found that outbreaks of infection from strains of *Salmonella* associated with poultry eggs increased in the developed world during the 1980s but effective control reduced these rates during the 1990s. However, by the first decade of this century, outbreaks of salmonellosis began to increase again, in some part due to egg-associated strains but also due to strains that adapted to colonize on fresh produce, much of which is produced in developing countries. *E. coli* outbreaks have been recorded since the 1980s and, despite producer education and production regulations, continue to emerge in new forms, indicating the bacteria's ability to evolve and develop into new strains. Newell and others (2010) suggested that foodborne pathogens such as *Salmonella* and *E. coli* may continue to evolve, causing outbreaks and new public health challenges such as antibiotic resistance, and that new diseases, often zoonotic, will likely emerge to cause new threats in the future.

Mycotoxins, or the highly toxic natural byproducts of molds that grow on crops, also pose a threat to human and animal health by building up in response to a variety of factors including drought, high rains, or high moisture. In addition to compromising human health and the health of animals that humans depend on for food and income, mycotoxin contamination threatens food security by reducing crop quality and causing economic losses. Aflatoxin, a common carcinogenic mycotoxin, develops in drought-stressed maize and groundnuts, and grows when storage conditions are hot and humid (see, for example, Todd and Narrod 2006). Acute outbreaks of aflatoxicosis in Kenya in 1981 and 2004 were likely caused by aflatoxin-contaminated maize and resulted in 317 illnesses and 125 deaths, respectively (Wu 2013). Moreover, evidence suggests that aflatoxins are a likely cause of child stunting (Leroy 2013). High incidences of aflatoxins have been reported in years following severe droughts in semiarid countries such as parts of Kenya, while warm countries may experience dangerous levels of these toxins with rains at or near harvest (Shiferaw et al. 2011). As climate change increases temperatures and precipitation or drought in some areas, the threat of mycotoxin contamination of major staple crops presents a serious threat to food and nutrition security for many temperate and tropical developing countries (see, for example, Magan, Medina, and Aldred 2011).

7. CONCLUDING REMARKS

This paper has examined the trends in a selected set of shocks throughout the world over the past 25 years or longer. Although this is not an exhaustive review of shocks, the evidence suggests that while some shocks have not increased, others have become more severe or intense and are projected to continue in the same direction in the near future.

While conflict between states and between organized groups, and violence against civilians have decreased or remained relatively stable over the past three decades, the effects of conflicts continue to be great. The number of refugees and IDPs has reached new heights, and continued external military support in many state-based conflicts makes wars particularly deadly. The influx of refugee populations in neighboring countries and the costs of internal displacement and conflict-related fatalities will likely increase pressure on food production and availability for many countries. Moreover, disruptions to services and destruction of infrastructure due to conflict could threaten nutrition security.

The evidence surrounding increasing frequency of natural disasters is more mixed, but the intensity and impacts of these events present clear threats for the future. There is uncertainty regarding whether droughts are increasing, but the evidence suggests that as global temperatures increase, so will drying in at least some parts of the world. Tropical countries, many of which are poor, are also predicted to experience the impacts of continued increases in precipitation and runoff in the form of floods. In some countries, extreme precipitation events will occur alongside increased droughts to cause a range of problems for food security. Hurricanes have become increasingly severe and will continue to do so as sea surface temperatures rise due to climate change. While the number of earthquakes has remained stable over the past 25 years, increasing population growth and the emergence of supercities along major plate boundaries will likely place a growing number of people at great risk in the coming years.

Clear evidence reveals rising global temperatures, rising sea levels, and the influence of humans on climate change. These trends are projected to continue. While some farmers may be able to increase production due to the confluence of increasing precipitation and warmer temperatures, many will struggle to maintain existing levels of production. Climate change is projected to affect or lead to declines in major staple crops including wheat, maize, and rice. These changes will impact food availability and nutrition, and are predicted to increase severe stunting rates.

Food prices have risen, causing short-term price spikes and volatility. While more evidence is needed, this trend has caused at least slight food price increases for poor countries. Higher food prices are estimated to have caused increased undernourishment of poor people, but this varies between and within countries. The factors that are believed to be contributing to food price volatility are still at play, suggesting that volatility may continue, at least in the short-term future. Moreover, improved communication flows and increased globalization have increased the pace at which these shocks may be transmitted across countries.

While outbreaks of zoonotic and foodborne diseases are intermittent, they can take a heavy toll on countries' food production, trade, and health. Population growth, urbanization, and climate change will continue to change the way humans and animals interact and the vectors through which food- and agriculture-related pathogens move to affect human health. As people live in more densely populated areas and technology continues to increase the speed at which people can travel across the world, the potential for transmission of these diseases and outbreaks of agriculture-related public health crises also grows.

These trends illustrate some of the range of risks that developing countries face. Many of these shocks intersect with one another, increasing the complexity of threats to food and nutrition security. As countries, institutions, communities, and individuals assess the capacity they have to predict, prevent, and recover from these shocks, it will be necessary to develop solutions that bring together policy action, innovative technologies, and social support programs. Additional research and evidence are also needed, requiring investments in continued monitoring and tracking of shocks as well as new tools and methods to improve early detection and early transmission of information to build resilience.

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