Routledge
Taylor & Francis Group

Environment: Science and Policy for Sustainable Development

ISSN: 0013-9157 (Print) 1939-9154 (Online) Journal homepage: http://www.tandfonline.com/loi/venv20

The Perilous Nature of Food Supplies: Natural Hazards, Social Vulnerability, and Disaster Resilience

Susan L. Cutter

To cite this article: Susan L. Cutter (2017) The Perilous Nature of Food Supplies: Natural Hazards, Social Vulnerability, and Disaster Resilience, Environment: Science and Policy for Sustainable Development, 59:1, 4-15, DOI: 10.1080/00139157.2017.1252603

To link to this article: http://dx.doi.org/10.1080/00139157.2017.1252603

The Perilous Nature of Food Supplies:

Food security is a complex and intertwined problem of reliability, quantity, and affordability of nutritious food, including the costs of production. It is a problem in developing and developed nations alike, where deficits in the availability and quality of food lead to hunger and malnutrition, impairing the health of millions. The global interdependence of food supply chains is well known—when one part of the food production chain is affected (e.g., contamination, poor harvests, natural hazards, conflict) the consequences reverberate globally, with reductions in supply and increased prices. Moreover, global patterns of urbanization are fundamentally altering food systems and more significantly food preferences, which is also reducing the food security of the planet's 6.5 billion urban dwellers.[1]

Within national or regional food supply systems, natural hazards can cause disruptions not only in the food resource supply itself, but also in the

Natural Hazards, Social Vulnerability, and Disaster Resilience

by
Susan L. Cutter

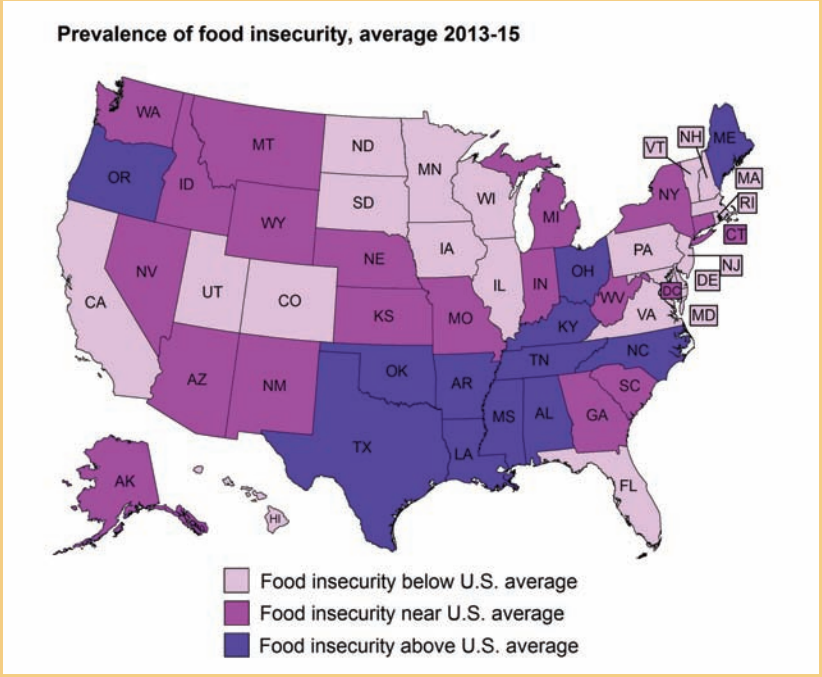
iStock/Marcophoto

Devastated corn field as a result of long time drought.

supply chain infrastructure and transportation to and from markets, thus reducing the availability and affordability of food. A recent analysis found that within developing nations, for example, 22% of the total economic impact of hazards and disasters was from the agricultural sector—crops, livestock, fisheries, and forestry.[2] However, global data are scarce, so little is known about the subnational impacts of hazards on the agricultural sector and the disproportionate burden placed on people reliant on agriculture for their livelihoods. There is no consistent accounting for direct and indirect agricultural losses from natural hazards in any of the primary global hazards databases, although some national databases do separately record agricultural losses.[3]

This article examines food security and the disproportionate impact of disruptions in food supplies on vulnerable populations in a developed world context, the United States. A short detailed case study of the 2015 flood in South Carolina and its impact on the

Figure 1. Food insecurity in the United States, 2015.



Hazards & Vulnerability Research Institute, University of South Carolina, based on USDA data.

Source: Calculated by ERS, USDA, using data from the December 2013, 2014, and 2015 Current Population Survey Food Security Supplements.

agricultural sector is used to illustrate the nexus of food security, natural hazards, vulnerable populations, and resilience at a localized scale.

Food Security and Food Production

In the United States, food security is mostly an economic condition where households or individuals lack money or resources to acquire food. A typical American household spends 37% of its average annual income expenditures on housing, followed by transportation (19%), food (14%), and health care (9%).[4] The majority of Americans purchase food at grocery stores and supermarkets or from restaurants and other food vendors outside the home. The amount of money spent on food by households is a good indicator of their relative level of food security. The U.S. Department of Agriculture (USDA) found per-capita median weekly expenditures for food of $37.50 or less produced food-insecure individuals.[5] About 15.8 million households (or roughly 42.2 million people) were food insecure at some time during the year (skipped a meal, did not eat for a day or more) because of insufficient money for food. The majority of these households contained single women with children under 18 years, individuals below the poverty line, African-American and Hispanic heads of household, and households living in inner cities and rural areas. The highest rates of food insecurity are in the southern half of the country (Figure 1), regions with significant poverty and with minority populations living in both rural and urban areas.

There is an abundance of food produced in the United States, which is a food-exporting nation. U.S. exports include grains/feed, soybeans, and livestock products, primarily to Asia (China, Japan, South Korea), the European Union, and North American neighbors (Canada and Mexico). Food production in the United States is geographically determinant, depending on the crop. For example, California has the most diverse range of crops and is the largest agricultural producer in the nation. Grains are grown almost everywhere but are especially prevalent in the Great Plains states. Corn (used for food, silage, and fuel) is grown everywhere, but concentrated in the traditional Corn Belt states, stretching from southern Indiana west to Iowa. Peanuts are concentrated in Georgia; citrus in Florida, California, Arizona, and the lower Rio Grande Valley; potatoes in Idaho; rice in Arkansas; and apples in Washington and New York.

While food is plentiful, access to healthy and affordable food is problematic for many Americans, especially those in inner-city neighborhoods and those in rural areas. The lack of access creates food deserts—defined as areas with limited access to affordable and nutritious food. Food deserts arise due to the absence of a large supermarket within the community (within a mile [1.6 km] in urban areas; within 20 miles [32 km] in rural areas) or the lack of transportation to a supermarket or large grocery store located farther away. The combination of no large grocery stores or supermarkets (with lower prices and greater choice) close by and a lack of transportation to go there defines food desert areas for more than 23.5 million Americans (7% of the population).[6]

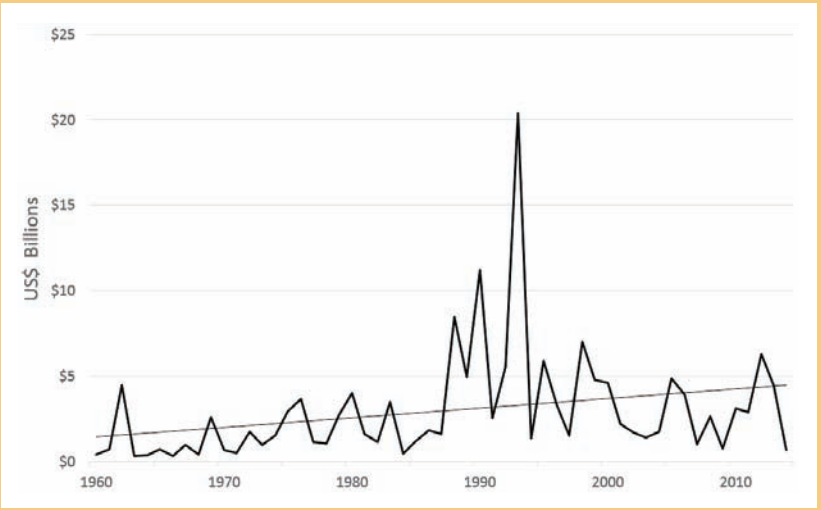
Short-term disruptions in food supplies exacerbate the insecurity for many households, influencing not only the availability of food supplies, but also food quality, and most importantly the prices. For example, the state of Alaska imports nearly 90% of its produce due to the short growing season, making food expensive to begin with in that state. The summer of 2013 was very warm in Alaska and demand for power for cooling homes and businesses soared. As is true in many regions, residents of this rural state subsist on their hunting and fishing for protein and freeze the meat and fish for later consumption (around 25% of total food consumption). When the power demand for home cooling

soared because of the warm weather, there were blackouts and shortages of electrical power that caused a loss of refrigeration and spoilage of the meat and fish.[7] The electrical shortage caused a loss of a protein source for many households. This was significant, given that meat is prohibitively expensive and most of the Alaskan fisheries catch is exported and not available for domestic state consumption. In addition to high prices for produce, Alaskans also had to pay for meat and fish, stressing many household budgets beyond their breaking point. While the example points to a singular heat event, the food insecurity of the indigenous populations in Alaska is becoming dire as climate change—coastal erosion, thinning sea ice—is destroying traditional hunting livelihoods and food systems, and also displacing entire coastal communities.

Another example is the 2012 drought that affected nearly 60% of U.S. farms, primarily the production of corn and soybeans used in livestock feed. Within the United States there were short-term price increases the following year, especially for beef, dairy, and poultry products, but the 3% average increase was well below inflation-driven increases of the past.[8] Local farmers and ranchers reduced their herds as a mitigation measure to reduce costs in the short term. However, with the increasing global demand for meat, the reduction in herds has increased the price of U.S.-exported beef and dairy products. The demand for meat continues to increase globally, especially in cities, creating greater food insecurity for importing nations because of higher meat prices. Local changes in farming practices are occurring globally, where agricultural land is increasingly being used to produce food for animals rather than food for people. In the United States, agricultural land is increasingly being used to produce fuel (ethanol), not food.[9]

The disproportionate impact of food insecurity on lower income households has a direct bearing on adverse health outcomes such as obesity. This is especially true in children, whose diets in food-insecure communities lack healthy foods such as fresh fruit and vegetables, whole grains, and low-fat dairy products. The cost of healthy food in low-income communities is often much higher than food with more calories, such as fast food or foods with high fat, sugar, and carbohydrates that are more filling. Low-income families are forced to make the calorie-per-unit-cost calculation, opting to purchase low-quality, less nutritious food to stave off hunger. This ultimately compromises long-term health by forcing overconsumption of calories and overeating, increasing the incidences of chronic conditions such as obesity, diabetes, and cardiovascular disease in children and adults.[10] Childhood obesity rates in the United States are at their highest point ever, with more than one-third of children overweight or obese. Adult obesity rates hover around 20% nationally. Poor nutrition, especially in food-insecure households, affects the health of everyone in the family.

Figure 2. Crop losses (adjusted to 2014 dollars) during 1960–2014.



Hazards & Vulnerability Research Institute, University of South Carolina, based on SHELDUS data.

Fast food contributes to food insecurity in many communities because more nutritious food is often more expensive and less available.

istock/dolgachov

U.S. Disaster Losses

In the United States, food security reflects the price and availability of nutritious food, so interruptions in the supply (affecting price or availability) have important consequences. Since 1960, crop losses in the United States due to natural hazards have averaged $3.0 billion annually. This represents roughly 24% of the total losses from natural hazards over the same time period. Crop losses due to natural hazards have steadily increased, along with property losses, even when adjusting for inflation and population growth.[11] As crop losses are weather dependent, the increasing frequency of more extreme weather events produces greater losses. Coupled with better documentation of such losses, we see a steady upward trend (Figure 2) in crop losses over the past 50 years.

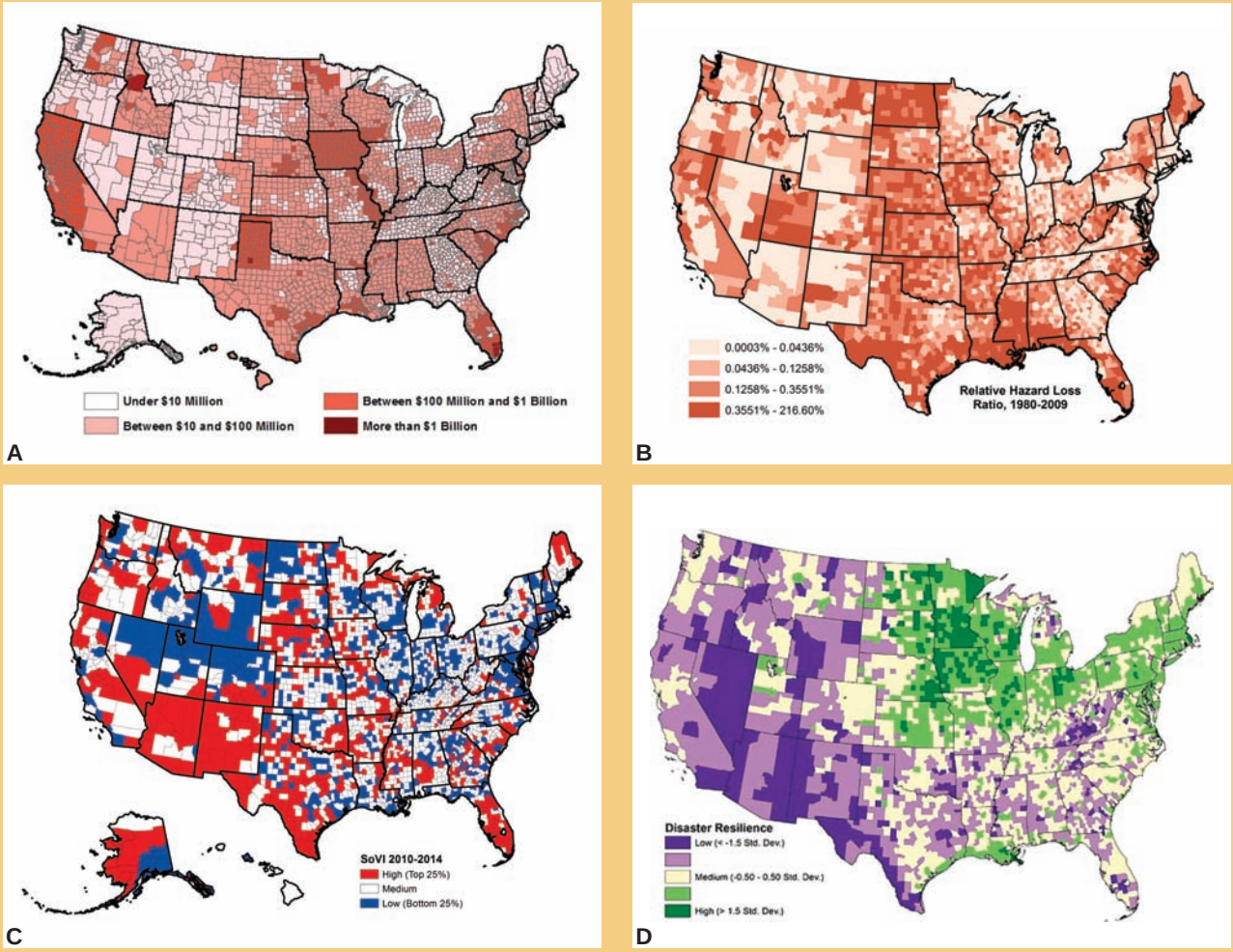
Crop losses were at their highest in 1993 as a consequence of the Mississippi Floods of 1993 (Missouri and Mississippi basins), where nearly 20 million acres (8 million hectares) were flooded and not harvested or planted.[12] Damages to the Mississippi River shipping infrastructure were also recorded. Flooding in the same region in 2011 also resulted in more than $1 billion in agricultural damages in Arkansas, Mississippi, and Missouri alone. Major drought episodes in 1989, 2006, and 2011–2012 in Midwestern and Plains states occurred with significant losses in the corn, sorghum, and soybean crops. Freezes in December 1998 affected fruit and vegetable crops in California, and again in 1990. Hurricane Katrina (2005) not only damaged crops, but also the ports in New Orleans, LA, and Gulfport, MS. The Port of New Orleans is the terminus of the inland waterway system for the United States—the primary transportation infrastructure for transporting bulk cargo such as grain, timber, cotton, and rice. The Port of Gulfport was completely destroyed by Hurricane Katrina and has been slow to rebuild. The agricultural significance in the Port of Gulfport is its role as the gateway for imported fruits and vegetables from Latin America, especially bananas, to U.S. markets in the eastern half of the country.

The spatial patterns of crop losses are quite variable, but again are concentrated in the central United States in the largely rural areas (Figure 3A). Drought and flooding are the primary

FEMA/J.T. Blatty

Floodwater causes agriculture damage in Pointe Coupee Parish, Louisiana.

Figure 3. Spatial patterns of damages, social vulnerability, and community resilience: (A) total crop losses, 1960–2014 (in 2014 dollars);[11] (B) relative property loss ratio;[13] (C) Social Vulnerability Index (SoVI®);[14] and (D) Baseline Resilience Indicators for Communities (BRIC) Index.[17]



Hazards & Vulnerability Research Institute, University of South Carolina.

Figures 3B and 3D used with permission from Elsevier.

perils influencing crop losses in the central United States, followed by severe storms, including hail. Freezes and extreme cold are regionally important in California and Florida.

Measuring Social Consequences: Impact, Vulnerability, Resilience

The social consequences of hazard losses are a function of the exposure and the sensitivity of the populations to those losses. The burdens of disasters can be offset by enhancing the resilience of communities.

Impact

Exposure is the degree to which property (including crops) is at risk for damage from hazards. Exposure can be viewed as the pattern of losses in individual places, as well the relative impact of such losses on the economic base of the local area. Data for such assessments are scarce globally, but we do have reasonably good data in the United States for such computations. The ratio of hazard losses to gross domestic product (GDP) (or its equivalent) affords the opportunity to refine impacts beyond simple dollar damages. For example, the effect of a million-dollar loss in one locale that has a robust and large economic base is very different than the same million-dollar loss in a place with a smaller and struggling economy.

iStock/FrankvandenBergh

Harlem, New York City. Many poorer neighborhoods lack access to high quality, less expensive food.

As a larger percentage of the GDP, the impact is greater and not only reduces the capacity to absorb and recover from the disaster, but may require an influx of external aid to assist in recovery. For the United States as a whole, the average relative loss ratio is 0.15% of GDP during the period 1980–2009.[13] Even with costly events such as Hurricane Sandy, the overall impact on the country is minimal as there is sufficient capacity to absorb and recover from the event at the national scale. Regional and local recovery, however, is another story. The mean annual relative loss for the central United States (one of the prime agricultural areas), for example, is slightly more than 4% of county GDP, well above the national average. The relative impact in this region is largely driven by recurring losses from flooding and severe weather (Figure 3B). In the hurricane coast along the northern Gulf of Mexico, losses represent 3% of county GDP, largely attributed to periodic tropical cyclones: again, a relative loss significantly above the national average. The relative impact ratios account for the temporal and geographic differences in economic capacities of places, which in turn influence the overall social consequences of hazards at subnational scales.

Social Vulnerability

Social vulnerability is a measure of the susceptibility to harm from disasters. It permits the examination of the abilities of individuals and places to prepare for, respond to, recover from, mitigate, and adapt to hazards. The Social Vulnerability Index (SoVI®) is a county-based analytical tool that provides a comparative assessment of social vulnerability for the United States.[14] Based on social and demographic variables that the research literature confirms as contributors to increasing the community's susceptibility to hazards, SoVI® provides an empirically-based measure of social vulnerability. When mapped, SoVI® scores graphically illustrate the geographic variability in social vulnerability, highlighting those places where additional resources might be necessary to reduce vulnerability, and, more significantly, areas where hazard recovery might lag. In disaster response and emergency planning in the United States, SoVI® is used by many state governments in hazards mitigation planning and recently became part of the suite of geospatial products used in federal response to disasters to aid in determining the most socially-vulnerable areas—areas requiring additional resources for response and recovery.

Regionally, levels of high social vulnerability are concentrated in the middle of the United States, stretching from Texas in the south to the Canadian border—the Great Plains states.

Other agricultural producing areas also exhibit high levels of social vulnerability, such as the lower Mississippi Valley, the Southwest, and southern Florida (Figure 3C).

Community Resilience

Enhancing community resilience is one mechanism designed to reduce the impacts of natural hazards on people and places. Resilience as a concept has a variety of meanings and applies to many different sectors and components of communities—economic, infrastructure, social. This article uses the definition of resilience proffered by the U.S. National Research Council—"the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events."[15] There are many different approaches to assessing resilience, ranging from qualitative to quantitative approaches. Some focus solely on assets or baseline conditions, while others look at characteristics or capacities. There is no dominant methodological approach to resilience assessment and no geographic scale preference (local to global). The lack of a core set of resilience indicators has defined disaster resilience research to date, especially in the United States.[16]

Notwithstanding the lack of consistent methodologies or core indicators, one empirically based measure of resilience, Baseline Resilience Indicators for Communities (BRIC), has gained some traction as a policy prescriptive approach in the United States. BRIC assumes that communities are systems of systems with different components working individually and collectively to produce the preexisting (or inherent) resilience within places. In other words, BRIC measures the baseline of disaster resilience existing within a community before the hazard event occurs and is useful for taking stock of capacities and assets. Six different components are measured—social, economic, institutional, infrastructural, community, and environmental—using a subindex structure. Each subindex has a number of variables used as proxies, and these variables are normalized and then averaged to create the subindex score. Each composite subindex score is then summed to produce values ranging from 0 (low resilience) to 6 (high resilience).[17] The BRIC scores can then be mapped to display the spatial distribution or disaggregated to examine the specific drivers of disaster resilience for individual study areas. The latter is significant as it can highlight where investments could be made to improve baseline conditions in disaster resilience.[18]

The geography of disaster resilience in the United States shows an interesting pattern, with the highest levels of disaster resilience in the central United States in the northern Plains and Midwest states (Figure 3D). High levels of disaster resilience are also found along the Gulf Coast extending from Texas to Louisiana. A second concentration is in the urbanized Northeast. What is interesting about the pattern of disaster resilience is the distribution of higher levels of resilience in portions of rural America—especially in the food production region in the central United States. These are the same areas that have significantly vulnerable populations and major crop losses from natural hazards, and experience the greatest relative impact of hazards on the local economy (Figure 3). Resilience in the agricultural heartland may help offset some of the consequences and enable faster recovery after a disaster.

Disasters and Food Insecurity: Local Experiences

The intersection of natural hazards, food security, and socially vulnerability populations is most pronounced at local scales—especially in regions with livelihoods dependent on agriculture. One such local example is South Carolina and its experience with flooding in 2015.

Inherited Inequalities

Located in the southern United States, South Carolina is one of the original 13 colonies and was the eighth state to ratify the U.S. Constitution. It has a varied political history that explains some of the present day social and economic inequality patterns within the state. For example, in the colonial period (18th century) South Carolina was a wealthy state—known for its natural harbor, Charleston, and the fertility of the coastal soils. The cultivation of indigo and rice fueled by slave labor from West Africa made South Carolina one of the most prosperous states in the United States at the time. Intolerance for slavery by Northern states and the 1860 election of President Abraham Lincoln, who opposed the expansion of slavery, led to South Carolina's secession from the United States and the beginning of the American Civil War (1861–1865). After being soundly defeated, South Carolina never regained it economic dominance and continues to be among the poorest and most disadvantaged states in America.

With a land area of 32,020 square miles, South Carolina is roughly the same size as Austria. The 4.8 million people are located in the three major metropolitan centers—Columbia (the state capital), Charleston (along the coast), and Greenville–Spartanburg (in the Upstate). Most of the state retains its rural character—the remnant from its agrarian past. The state population is 64% white, 28% African American, 5% Hispanic, 2% Asian, and 1% mixed race/ethnicity. The coastal counties contain the greatest disparities in wealth and racial makeup. Along the coast, wealthier and white residents maintain vacation and year-round homes with recreation and tourism the dominant economic drivers (along with manufacturing and shipping in Charleston, and the military in Beaufort). Further inland is the coastal plain and the historic cotton-growing region. Still largely agricultural, these counties contain significant African American populations and are among the most economically disadvantaged counties in the state. The Central Midlands (where Columbia is located) and the Upstate are more diversified in terms of economic livelihoods and

Table 1. Agricultural Production 2014/2015

	2014			2015			Percent Change 2014/2015		
	Acreage Planted (Acres)	Production	Yield/ Acre	Acreage Planted (Acres)	Production	Yield/ Acre	Acreage Planted	Production	Yield/ Acre
Cotton	280,000	528,000 bales	912 bales	235,000	155,000 bales	547 bales	–16.1	–70.6	–40.0
Soybean	450,000	15,400,000 bushels	35.0 bushels	475,000	9,805,000 bushels	26.5 bushels	+5.6	–36.3	–24.3
Peanuts	112,000	410,400,000 pounds	3,800 pounds	112,000	262,400,000 pounds	3,200 pounds	0	–36.1	–15.8
Corn	295,000	32,760,000 bushels	117.0 bushels	295,000	24,180,000 bushels	93.0 bushels	0	–26.1	–20.5

Source: USDA.[22]

racial makeup, although the percentage of African Americans in the Upstate is the lowest of all the regions. The private sector contributes 83% of the total economic output for the state, followed by government at 17%, with the latter including several large military bases and federal facilities, in addition to state and local governments.

Despite its agrarian past, agriculture only contributed 0.8% of the state's total 2014 GDP of $190 billion (or $1.52 billion).[19] Regionally, however, agriculture is significant. The most important commercial crops grown in terms of acreages are soybeans, followed by corn, cotton, and wheat. Most of the farms in the state are family owned and operated. The average size of farms is 180 acres (73 hectares), but the majority of farms are smaller than this (10–49 acres in size; 4–20 hectares). For 62% of the farms, direct sales are less than $5,000 annually.[20] There is ample food production in locally based farming on small plots and in backyard gardens. With an average growing season of 220 days (between first frost and last frost), both cool-season and warm-season crops are grown, with surpluses sold in local farmers markets or roadside stands.

The Event

An unprecedented rainfall event during October 1–5, 2015, resulted in more than 27 inches of rainfall along the coast and inland. A combination of a stalled cool frontal system and a slowly moving low pressure system to the south brought tropical moisture from the Caribbean into the state, and this in turn interacted with moisture from Hurricane Joaquin hundreds of miles away to the southeast. These two streams of moisture coalesced into an atmospheric river of moisture that continually dumped rainfall into South Carolina over four days. During the most intense period of rain, 16.6 inches of rain was recorded, breaking the 24-hour records throughout the state. The atmospheric river of moisture resulted in catastrophic flash flooding in the urban areas, and riverine flooding downstream affecting many of the rural agricultural counties. The state received a Presidential Disaster Declaration (PDD), which included 75% of the state's counties (35 out of 46 counties).

The disproportionate impact of food insecurity on lower income households has a direct bearing on adverse health outcomes such as obesity.

In October 2016, the state was hit by Hurricane Matthew, causing damage all along its coast with storm surge and high winds. Rainfall amounts of 6–10 inches in counties away from the coast, especially the northeastern section of the state, led to swollen rivers. Unable to absorb the volume of rainfall in the 24-hour period, riverine flooding occurred for a second October in a row, affecting many of the same communities as in the 2015 floods.

Economic Impact

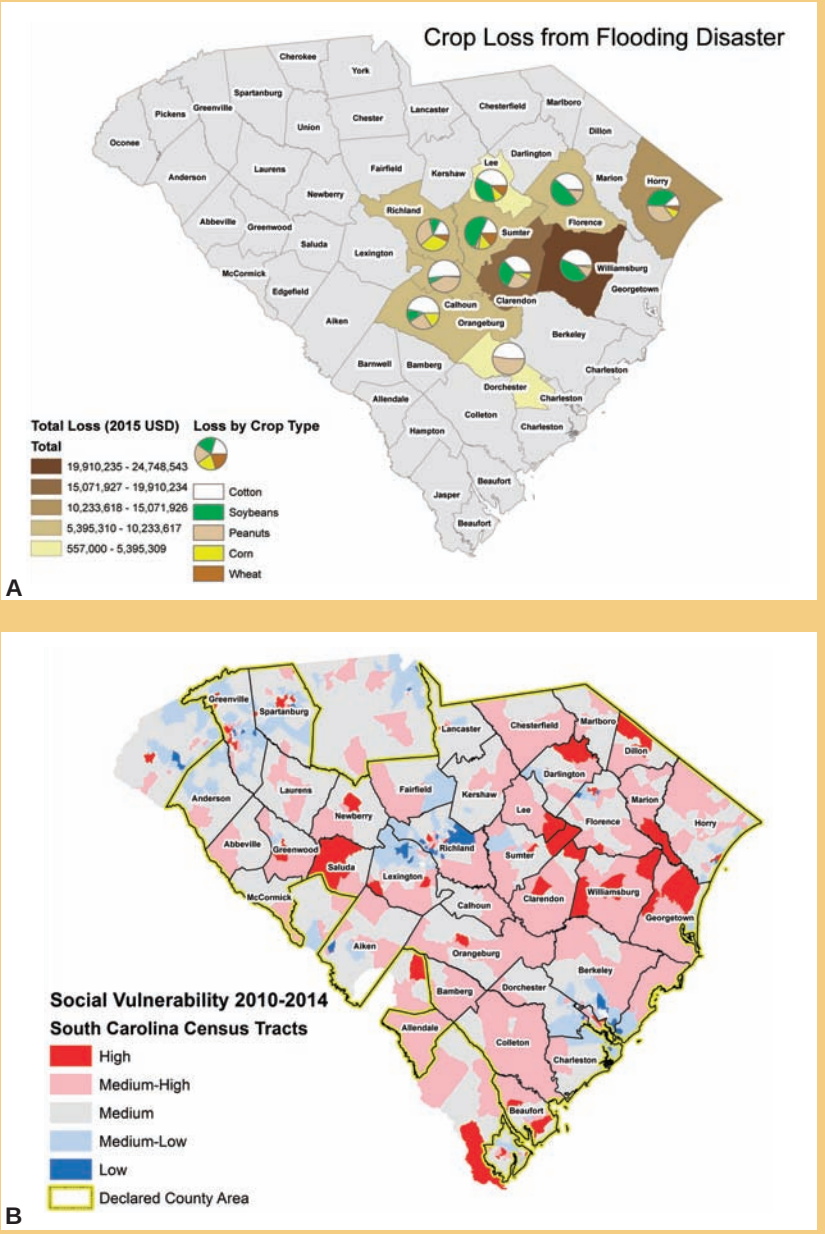
Flood losses are over $1.2 billion, less than 1% of the state GDP in 2014, well within the range of low relative impact, based on national averages.[21] Estimates of agricultural losses are in the $600 million range, which represents about 5% of the annual cash receipts for all agricultural commodities. Agricultural crops were already stressed by a summer drought with harvests expected at half of normal before the flooding. Forestry was also depressed due to the decline in the paper market, but was on the verge of recovery after a long recession. Beyond direct crop damage and loss, additional losses were incurred as a result of soggy fields prohibiting the fall and spring planting of winter wheat, vegetables, and fruit. The major crops affected were peanuts, soybeans, corn, and wheat and the cash crops of cotton, tobacco, and

timber. Cotton, peanuts, corn, and soybeans are planted in April and harvested in early October. The timing of the flood right before harvesting resulted lower yields for all four crops (Table 1). Preliminary estimates of 2016 planted acreages compared to 2015 plantings illustrate the effect of the floods: corn (up 8%), cotton (down 19%), peanuts (down 2%), soybeans (down 7%), and winter wheat (down 47%). Geographically, the most affected counties contained some of the most socially vulnerable populations (Figure 4A).

Most of the farmers did not have any type of agricultural insurance as they were too small. The state legislature allocated $40 million to help farmers recover from the flood, a bill that was vetoed by the Governor but upheld by the legislature. No other sector received such support from the state in the aftermath of this disaster. To qualify, farmers must have incurred more than a 40% loss of their crop and the farm had to be located in a flood-disaster-designated county. It is too early to assess the number and effectiveness of payments to farmers in terms of their recovery.

In addition to crop damage, the transportation infrastructure damage was significant for most of the state. In the immediate aftermath of the flooding, there were more than 365 road closures and 166 bridges damaged. This included more than 90 miles of interstates, including Interstate 95—the main corridor for commerce along the U.S. East Coast. The costs of infrastructure repairs of publicly own assets come from federal resources under the federal disaster declaration. Many of the secondary roads also were damaged, delaying harvesting of crops that were not directly affected by the rainfall and flooding.

Figure 4. Impact of 2015 South Carolina flooding: (A) crop losses and commodity and (B) location of the most socially vulnerable residents, with many living in the rural agricultural counties with significant flood losses.



Social Impacts

The flooding resulted in 17 fatalities, most due to drowning while trying to drive through high water, especially in the urban areas. The largest social impact was damage to homes. In the Columbia metropolitan area, flash flooding and small dam failures created a geographic concentration of housing damage that disproportionately affected moderate to higher income communities (in Richland County, shown in blue on Figure 4B). Downstream riverine flooding was the cause of housing damage in the rural agricultural areas, and disproportionately affected lower income and African American residents (shown in pink and red on Figure 4B). Most of the damaged housing did not

have flood insurance, so recovery is progressing slowly, especially in the rural counties. While nearly 100,000 households applied for federal assistance for housing and home repair, only 28% of those have been approved. Because of the unmet need, the state established the South Carolina Housing Trust Fund Flood Initiative (using private, nonprofit, and state funding) to assist low-income residents with the highest need to begin repairs. To date, at least $1.7 million has been spent to repair such homes for the most socially vulnerable populations.

Food insecurity in these agricultural regions has increased in the aftermath of the flooding. The numbers of households receiving food subsidies including distributions from food banks increased, although exact numbers are not known. Because of declining fuel prices, the price of food, however, remained unchanged from the year before. As recovery is still occurring, the availability of supermarkets and grocery stores damaged by the floodwaters is unknown as well.

Lessons Learned and Relearned

Direct losses from natural hazards to agriculture and food supply systems happen everywhere. Some events produce catastrophic and longer term damages both nationally and globally, such as persistent droughts, while other events create short-term variances in supplies that have little impact beyond local to regional scales. Food security is a challenging problem in and of itself, but when natural hazards are added to the mix, the global and regional food systems can become compromised and unreliable, exacerbating hunger conditions in many nations.

At present there is no consistent accounting of agricultural losses due to natural hazards, nor is there any systematically accounting by specific peril. Disaster loss accounting is more of an art than a science at this point. Not all losses are included (e.g., crops), and many are not counted the same way. Until such time as there is a global full-cost accounting of natural hazards losses, we will not know the true extent of the impact of natural hazards on agriculture and global food supply chains. In order to develop mitigation (and longer term adaptation) strategies, such loss-accounting information is vital so actions can be taken to lessen the adverse impacts.

The social consequences of natural hazards are often experienced by the most socially and economically disadvantaged populations, and this is true in both the global North and the South. Empirically based measurement of social vulnerability and community resilience helps to geographically distinguish the likely burdens of disasters, and also illustrates the differential capacities to respond to and recover from natural hazard events, including disruptions in food supplies. As illustrated by the 2015 flooding in South Carolina, there is considerable variability in the capacity of local places to prepare for, respond to, and recover from natural hazards.

While major food disruptions did not occur within South Carolina as a consequence of the October 2015 flooding, the flooding did affect the livelihoods and food security of many residents and small farmers at the local level. While states and even counties can (and do) absorb such disaster losses, the longer term effects on households linger (Text Box 1). The day-to-day hardships over food insecurity (lack of supply of quality food, price spikes, and health impacts) for residents, especially those in impoverished communities, transcend from situation normal to a crisis when they are affected by a disaster. Social inequalities and their geographic manifestations are perpetuated by the downward spiral of poverty and unemployment, while in other instances a hazard event nudges households from being food secure to becoming food insecure as it is faced with making untenable choices

Text Box 1: Hurricane Matthew

In early October 2016, Hurricane Matthew made landfall in coastal South Carolina after wreaking havoc in Haiti, the Bahamas, and Florida as it made its way up the southeast Atlantic Coast. The storm surge affected coastal communities, but it was the persistent rainfall that affected inland areas, especially those in eastern North Carolina and South Carolina. As the swollen inland rivers drain south and east, it is the poorest of the poor that are being affected. Not only are their homes being destroyed by the floodwaters, but so too are the communities themselves, including local businesses including grocery stores and supermarkets. In areas with significant food insecure populations, many more may be added as a consequence of this event. For South Carolina, the flooding is affecting not only one of the most impoverished areas of the state, but the same area that was affected a year earlier by the 2015 flooding. The progression of recovery from the first flooding has been halted and overturned in places by the second flood. Such double jeopardy will have significant longer term impacts on the most vulnerable within these communities—increasing food insecurity and adverse health outcomes and negatively affecting their ability to recover.

among the competing everyday needs for its scarce monetary resources—shelter, food, transportation, or health care. The inequalities produced by the nexus of hazards, vulnerability, and food insecurity are widening everywhere challenging sustainability at very local scales throughout the United States right now.

Climate change will undoubtedly change the production and availability of food at local and global scales. Increased drought and extended drought conditions are projected over the next 30 years. The drought risk in the 21st century will not only affect agricultural production in the U.S. Great Plains, but significantly increase fire risks throughout the Southwest. Water shortages will pit agriculture against thirsty cities in the drought regions. Warmer climates in the Pacific Northwest may produce less mountain snow, which in turn reduces water availability and storage for spring and summer runoff. Not only would agriculture and municipal water supplies be affected but, more critically, so would hydroelectric power generation—a key source of energy in the region. Increases in weather extremes—from rainfall to cold and hot temperatures, as well as more frequent severe storms, including tropical systems—also loom large. Excessive rainfall events produce catastrophic flooding, as we have seen in the last couple of years in the United States. These changes in the climate systems will occur at a time in the United States when it is undergoing a "pivotal period of demographic change." The gap between rich and poor will widen, white populations will age, there will be population growth in the workforce coming from racial and ethnic minorities, and there are movements from central cities to suburban areas, and from rural to urban places.[23] The juxtaposition of climate change and demographic change will alter the social burdens of hazards locally and regionally in ways that we cannot fathom at present, but we must prepare for the eventuality of more extreme events with extreme consequences, especially for the most vulnerable within our society.

Susan L. Cutter is a Carolina Distinguished Professor of Geography at the University of South Carolina and director of the Hazards and Vulnerability Research Institute and the Integrated Research on Disaster Risk (IRDR) International Centre of Excellence (ICoE) on Vulnerability and Resilience Metrics. Dr. Cutter is an elected fellow of AAAS, past president of the Association of American Geographers (AAG), and past president of the Consortium of Social Science Associations (COSSA).

This article is an expanded version of a keynote address at the Vulnerability of Agricultural Production Networks and Global Food Value Chains due to Natural Disasters Conference co-sponsored by OECD Cooperative Research Programme: Biological Resource Management for Sustainable Agricultural Systems (CRP), the Economic Research Institute for ASEAN and East Asia (ERIA), and the Vienna University of Technology, June 20-24, 2016 in Vienna, Austria. A special thank you goes to Erika Pham for graphics assistance.

NOTES

1. K. C. Seto and N. Ramankutty, "Hidden Linkages Between Urbanization and Food Systems," *Science* 352, no. 6288 (2016): 943–45.

2. FAO, *The Impact of Natural Hazards and Disasters on Agriculture and Food Security and Nutrition* (Rome, Italy: Food and Agriculture Organization of the United Nations, 2015). http://www.fao.org/3/a-i4434e.pdf

3. The global insurance loss databases from MunichRe and SwissRe do not include agricultural losses, nor does the EM-DAT (Emergency Events Database) compiled by the Centre for Research on the Epidemiology of Disasters (CRED), Catholic University of Louvain, Belgium. National databases such as UNISDR's DesInventar (Disaster Information Management System, http://www.desinventar.net/index_www.html) or the U.S. SHELDUS (Spatial Hazards Events and Losses Database for the US, www.sheldus.org) do contain crop damages. For a comparison of these databases see M. Gall, K. A. Borden, and S. L. Cutter, "When do Losses Count? Six Fallacies of Natural Hazards Loss Data," *Bulletin of the American Meteorological Society (BAMS)* 90, no. 6 (2009): 799–809.

4. Bureau of Labor Statistics, Consumer Expenditures—2015 (Washington, DC: U.S. Department of Labor, 2015). http://www.bls.gov/news.release/cesan.nr0.htm

5. A. Coleman-Jensen, M. Rabbitt, C. Gregory, and A. Singh, *Household Food Security in the United States in 2015, ERR-215* (Washington, DC: U.S. Department of Agriculture, Economic Research Service, September 2016). http://www.ers.usda.gov/media/2137663/err215.pdf

6. M. Ver Ploeg, V. Breneman, T. Farrigan, K. Hamrick, D. Hopkins, P. Kaufman, B-H Lin, M. Nord, T. A. Smith, R. Williams, K. Kinnison, C. Olander, A. Singh, and E. Tuckermanty, *Access to Affordable and Nutritious Food—Measuring and Understanding Food Deserts and Their Consequences: Report to Congress* (Washington, DC: USDA Administrative Publication No. AP-036, 2009). http://www.ers.usda.gov/publications/ap-administrative-publication/ap-036.aspx

7. E. Hodges Snyder and K. Meter, "Food in the Last Frontier: Inside Alaska's Food Security Challenges and Opportunities," *Environment: Science and Policy for Sustainable Development* 57, no. 3 (2015): 19–33.

8. Economic Research Service, "Impact of 2012 Drought on Beef Prices Lower than Expected" (Washington, DC: U.S. Department of Agriculture, 2013). http://www.ers.usda.gov/data-products/chart-gallery/detail.aspx?chartId=40611&ref=collection

9. See S. Stoll-Kleemann and T. O'Riordan, "The Sustainability Challenges of Our Meat and Dairy Diets," *Environment: Science and Policy for Sustainable Development* 57, no. 3 (2015): 34–48; and S. Wallander, R. Claassen, and C. Nickerson, "The Ethanol Decade: An Expansion of U.S. Corn Production, 2000–09" (Washington, DC: U.S. Department of Agriculture, Economic Research Service, Economic Information Bulletin Number 79, 2011). http://www.ers.usda.gov/media/121204/eib79.pdf.

10. S. Cummins and S. Macintyre, "Food Environments and Obesity—Neighborhood or Nation?," *International Journal of Epidemiology* 35 (2006): 100–4.

11. Data on crop loss trends are from SHELDUS, Spatial Hazard Events and Loss Database for the US, Hazards & Vulnerability Research Institute, University of South Carolina, http://hvri.geog.sc.edu/SHELDUS; see M. Gall, K. A. Borden, C. T. Emrich, and S. L. Cutter, "The Unsustainable Trend of Natural Hazard Losses in the United States," *Sustainability* 3 (2011): 2157–81.

12. S. A. Changnon, *The Great Flood of 1992: Causes, Impacts, and Responses* (Boulder, CO: Westview Press, 1996).

13. K. D. Ash, S. L. Cutter, and C. T. Emrich, "Acceptable Losses? The Relative Impacts of Natural Hazards in the United States, 1980–2009," *International Journal of Disaster Risk Reduction* 5 (2013): 61–72.

14. S. L. Cutter and D. P. Morath, "The Evolution of the Social Vulnerability Index (SoVI)," in J. Birkmann, ed., *Measuring Vulnerability to Natural Hazards,* 2nd ed. (Bonn, Germany: United Nations University Press, 2014), 304–21.

15. National Research Council, *Disaster Resilience: A National Imperative* (Washington, DC: National Academies Press, 2012). Quote is from page 1.

16. S. L. Cutter, "The Landscape of Resilience Indicators in the USA," *Natural Hazards* 80 (2016): 741–58.

17. S. L. Cutter, K. D. Ash, and C. T. Emrich, "The Geographies of Community Disaster Resilience," *Global Environmental Change* 29 (2014): 65–77.

18. Resilience and vulnerability are related concepts, but they are not the inverse of one another. In testing the association between the two as measured by BRIC and SoVI®, Cutter et al. (note 17) found SoVI® only explained 25% of the variability in the BRIC scores. K. Sherrieb, F. H. Norris, and S. Galea, in "Measuring Capacities for Community Resilience," *Social Indicators Research* 99 (2010): 227–47, found only 14% of the variance between SoVI® and their measures of community resilience—economic development and social capital—was shared. While social vulnerability most closely tracks with social and economic resilience, these factors are only part of what constitutes disaster resilience for communities.

19. South Carolina Department of Commerce, Fact Sheet: Gross Domestic Product (2016). http://sccommerce.com/sites/default/files/document_directory/fact_sheet_gdp_2015.pdf (accessed 11 October 2016).

20. USDA, 2012 Census Volume 1, Chapter 1: State Level Data, Table 1. https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/South_Carolina/st45_1_001_001.pdf (accessed 11 October 2016).

21. A. O'Connor, "Damage Estimates Rising From South Carolina's 'Record-Breaking' Storm," *Insurance Journal,* November 2, 2015. http://www.insurancejournal.com/magazines/features/2015/11/02/386418.htm (accessed 11 October 2016).

22. U.S. Department of Agriculture, "USDA's National Agricultural Statistics Service South Carolina Field Office" (2016). https://www.nass.usda.gov/Statistics_by_State/South_Carolina/Publications/County_Estimates/index.php)

23. See B. I. Cook, T. R. Ault, and J. E. Smerdon, "Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains," *Science Advances* 1, no. 1 (2015): e1400082. http://advances.sciencemag.org/content/1/1/e1400082; W. H. Frey, *Diversity Explosion: How New Racial Demographics are Remaking America* (Washington, DC: The Brookings Institution, 2015).