Towards A Resilient Future:
Priorities for Addressing the Vulnerabilities of Miami's Food System

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1. The Importance of Considering Food Systems in Resilience Planning

As cities prepare for responding to climate change, and the associated extreme weather events, they often overlook food systems. The significant food supply disruptions caused by hurricane flooding in New Orleans in 2005 and in the Caribbean and parts of Florida in 2017 suggest that this is a critical oversight. "A Devastated Island's Cry: 'All the Food is Gone'" was the ominous *New York Times* headline describing food shortages in St. Martin in the aftermath of Hurricane Irma in 2017 (Ahmed & Semple, 2017).

Over the last few decades, food industry consolidation and the drive to create a more efficient and more global food system, with "just-in-time" distribution, have created underlying vulnerabilities in urban food systems that lead to such food shortages after extreme weather events. Agriculture production will need to adapt to climate change and increasing local food production to buffer the risks associated with imported food from other regions may be one solution. However, increasing local food production will not mitigate the risks associated with extreme weather events. Creating urban food systems that are resilient to extreme weather events requires a different approach, one that starts by identifying vulnerabilities along the entire food supply chain, especially food distribution and access.

Further, previous studies of natural disasters in other cities, including New Orleans, show that food system disruptions will likely vary by neighborhood because of pre-existing differences in food insecurity and food retail markets, including stores that cater to unique, culturally diverse clients. As a result, food system disruptions can create significant food access issues for populations that are already food insecure or that seek culturally sensitive food. Therefore, cities need to prioritize creating *equitable* resilience.

This white paper provides insights into the vulnerabilities of Miami's urban food system in the face of climate change, including extreme weather events as well as the longer-term sea level rise. The city of Miami cannot prevent all disruptions due to a changing climate and extreme weather. However, a systematic approach to identifying risks and setting priorities can help to minimize the effects of shocks and stresses, especially among vulnerable populations, which are likely to be disproportionately affected by extreme weather events.

2. What is the Greatest Near-Term (2050) Climate-Change Risk to Greater Miami's Food System?

Climate change related flooding is the greatest risk for the food system in Greater Miami. Climate change is predicted to cause rises in sea levels as well as an increase in extreme weather events such as hurricanes. The sea level in Miami-Dade County is projected to rise between one foot and 3.2 feet by 2050 ("Surging Seas Risk Finder: Miami-Dade County, Florida, USA," n.d.). The 2050 projection was used to focus the analysis on the near-term, to identify the most pressing policy priorities.

Very little of Greater Miami's food system would be impacted by the projected 2050 sea level rise. Our analysis shows that in 2050, less than one percent of all food retail stores (supermarkets, grocery stores, convenience stores) in the city of Miami would be impacted by the projected sea-level rise, even during a major flood (Figure 1). Sea-level rise flooding data from the National Oceanic and Atmospheric Administration (NOAA) is limited to coastal flooding and does not include flooding from inland sources, such as rivers, ponds and streams (NOAA Office for Coastal Management, 2017). A sea level rise also will certainly exacerbate flooding from hurricanes, although there is no publicly available research that models this impact.[1]

Therefore, flooding associated with hurricanes is the most significant near-term climate-change related risk facing Miami's food system. To analyze this risk, FEMA's Flood Insurance Rate Map (i.e., the FEMA floodplain) for Florida was used to identify flood hazard areas.[2] The flood hazard areas are defined as the Special Flood Hazard Area's (SFHA) in the FEMA floodplain. These areas will have a one percent chance of being flooded in any given year—what is colloquially termed a 100-year flood risk ("Flood Zones | FEMA.gov," 2019). The FEMA floodplain maps include coastal and inland (fluvial) flooding, but do not account for projected sea-level rise.

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[1] https://www.businessinsider.com/miami-floods-sea-level-rise-solutions-2018-4
[2] Data is available for download from FEMA website: https://www.fema.gov/national-flood-hazard-layer-nfhl.

Figure 1. Sea-Level Rise Projections and Food Retail Risk in Miami (2020-2200)
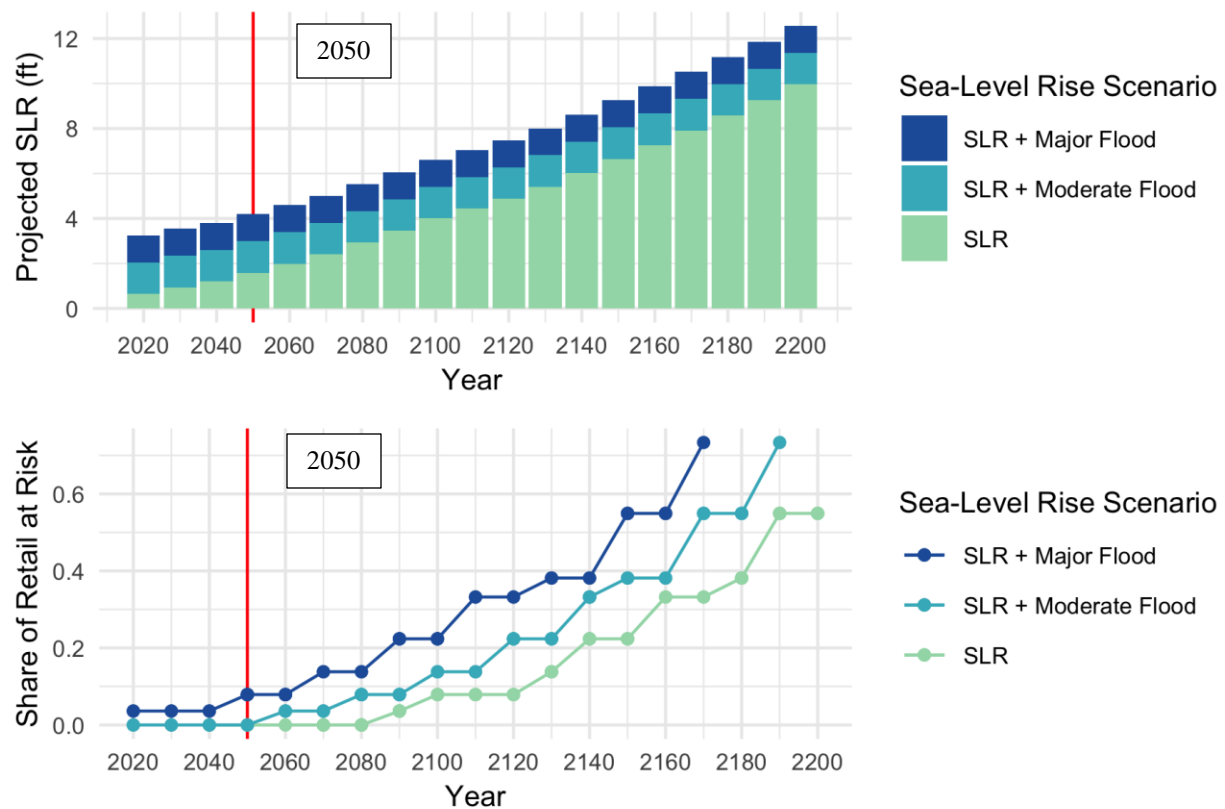

Notes: Projected sea-level rise (SLR) from Climate Central's Program on Sea Level Rise. Share of retail at risk is the share of food retail stores (supermarkets, grocery stores, convenience stores) in the city of Miami that are located in the flooding area of the given year and SLR rise scenario.

Sources: Dun and Bradstreet (2019), FEMA Florida National Flood Hazard Layer (2019), NOAA Office for Coastal Management Sea Level Rise Data (2019), "Surging Seas Risk Finder: Miami-Dade County, Florida, USA" (n.d.).

3. Using an Urban Food System Resilience Framework to Analyze Miami's Vulnerabilities

Food systems—growing, processing, and moving food from farm to table—are incredibly complex, making any risk analysis challenging and potentially overwhelming for city leaders (Figure 2). To address this issue, the author has developed a streamlined approach to identify the most pressing food system vulnerabilities (Figure 3). The framework has already been used to analyze the resilience of food systems in Boston, Los Angeles, New Orleans, New York City and Toronto.[3] It was specifically designed to identify critical urban food system vulnerabilities associated with an extreme weather event or natural disaster striking an urban area.

Figure 2. The Food System
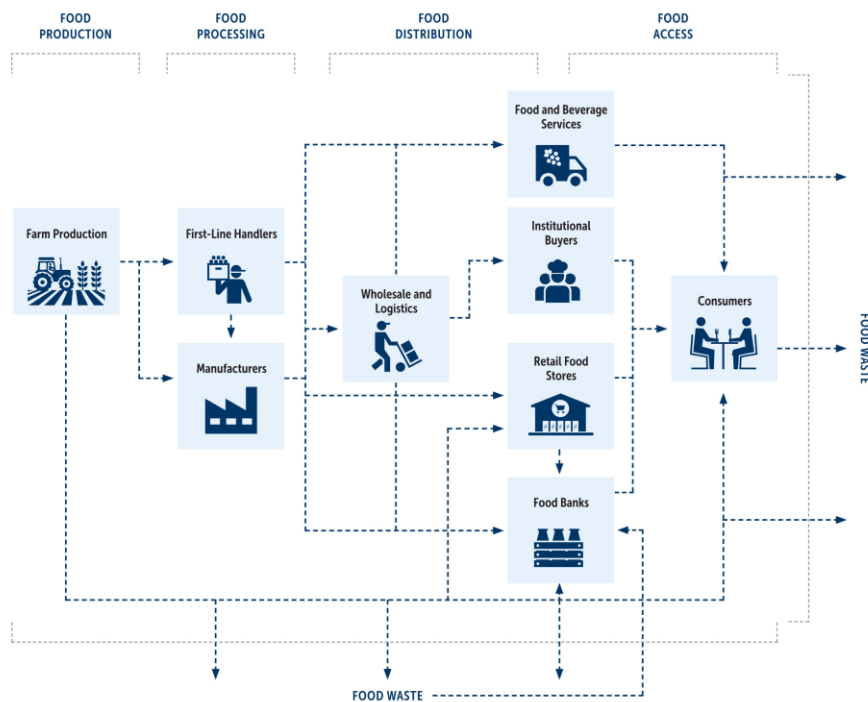
Source: Adapted from Nesheim, Malden C., Maria Oria, and Peggy Tsai Yih, eds., A framework for assessing effects of the food system. National Academies Press, 2015.

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[3] It was also the foundation for the Baltimore analysis.

The framework is focused on food distribution (to and within the city) and food access (retail, restaurants and affordability). These are the key priorities to prevent (or have a plan to manage) food emergencies that city leaders would need to tackle in the immediate aftermath of a natural disaster and during the recovery period.[4] Because of the global nature of urban food systems, a very small share of total food consumed in a city is processed and packaged locally (Paxton, 1994; Weber & Matthews, 2008). While reliable data on food flows is not available, anecdotally, many experts estimate that in major cities such as Miami—with diverse food preferences— locally sourced food from the region may only constitute between 10 to 30 percent of food consumed by all households in a city. Further, most local food processors are exports and serve global markets. As a result, food processing does not typically arise as a major vulnerability for local food availability because most food consumed locally is processed in other regions or countries.[5] Addressing distribution and access priorities will help ensure that a city's food system returns to normal in as short of a period as possible.

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[4] A full description of the framework can be found in *The Resilience of America's Food Systems: Evidence from Five Cites*.

[5] The exceptions are dairy processing facilities and bakeries, which tend to be located near their customers due to the perishability of their products.

Figure 3: **Urban Food System Vulnerability Framework**

Food System Sectors	
Food processing	All food cleaning, packaging, processing and manufacturing facilities.
Food distribution	Primary warehouse suppliers (also known as wholesalers or distribution centers) and secondary suppliers that move food from processing facilities to food retail stores and other food access points (e.g., restaurants, food banks, etc.).
Food retail	Supermarkets, grocery stores, and convenience stores.
Restaurants	Chain and independent restaurants.
Food assistance network	Food banks, food pantries, meal delivery programs, soup kitchens, and mobile soup kitchens that collect and distribute food to communities or individuals.
Food System Interdependent Infrastructure	
Public transportation	Trains, subways, buses and streetcars that allow residents to access food or workers in the food sector to commute to work.
Road network	Interstates, highways, major streets and local roads used to distribute food to retail outlets and allow residents to access food.
Electrical power system	The system of transmission terminal stations, municipal substations, switches, transformers and overhead and underground wires used to provide electrical power to residential, commercial, and industrial customers.
Telecommunications	The network of land, mobile phones and internet service over which communications are transmitted.

Fuel supply transportation, storage and distribution	All infrastructure required to process, transport, store, and distribute liquid fuels. Liquid fuels relevant to the food system include gasoline, diesel, propane and natural gas.

The other unique feature of the framework is the explicit consideration of neighborhood level vulnerabilities. Specifically, food access is analyzed at the neighborhood level to identify variances in impact for specific areas (and populations) within the city. **A resilient food system in Miami will provide all residents with equitable access to food after an extreme weather event.**

Finally, the framework recognizes that the food system is an interconnected system—its functioning depends upon the performance of numerous other systems. The most critical interdependencies include the road network, the electrical power system, telecommunications, public transportation, and the fuel supply transportation, storage and distribution infrastructure. Only the road network is analyzed in Miami because of the limited scope of the study.

Information was collected through a comprehensive literature review, and the analysis of numerous public and proprietary data sets.

Food Distribution Analysis
The distribution of food from processing facilities to consumers is very vulnerable to extreme weather events. Food products follow different pathways depending on the food item and the retailer, making the weaknesses in this segment of the food system difficult to analyze. However, food retailers (i.e., grocery stores and supermarkets) generally receive all of their products from three different distribution channels: (1) a primary warehouse supplier (also called a wholesaler or distribution center), (2) secondary warehouse suppliers (also called local wholesalers or local distribution centers), and (3) direct store delivery (Food Industry Glossary).[6] Supermarkets typically have a vertically integrated supply chain, meaning they own their primary warehouse supplier (Martinez, 2007). Smaller, independent grocery and corner stores generally rely on independently owned warehouse suppliers and direct store delivery.

To assess the food distribution vulnerabilities in Miami, we identified the primary warehouse suppliers (vertically integrated and independently owned) located in the Miami-Fort Lauderdale-

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[6] Food retailers may also use alternative food vendors for certain products (e.g., local produce), but the three categories of food suppliers covers nearly all food distributed to food retailers. Some warehouses may not handle distribution, but food distribution companies fill this gap.

Pompano Beach MSA for the majority of Miami's supermarkets as well as all warehouse suppliers located within Miami-Dade County.[7] We used two different geographies because large warehouse facilities are generally located outside of city and county limits because they serve regional customers, while smaller, secondary warehouses tend to be located within or in closer proximity to the city. Next, we analyzed whether the facilities are located in areas prone to flooding.[8]

We also analyzed the vulnerabilities associated with transportation routes. In cities, nearly all food is distributed by truck, making roads, tunnels and bridges critical points of vulnerability for food distribution. To identify key transportation vulnerabilities in Miami, two factors were analyzed: the existence of redundant major food truck transportation routes into and within the city, and the vulnerability of these routes (including bridges) to extended closures due to flooding.[9] By focusing on major transportation routes, the analysis excludes most of the "last mile" transportation of food within Miami, which relies on secondary highways and local roads. The impact of disruptions in the "last mile" would be significant, limiting the ability of consumers to purchase food, but secondary to the problem to delivering food into the city.

Food Retail and Restaurant Analysis
A neighborhood level analysis of food retail and restaurants is critical because city averages can mask significant disparities in food access. As is the case in most cities, Miami neighborhoods are not equally served by the same number of food options, which creates localized food vulnerabilities. In areas that are underserved, individual store and restaurant closures will have a significant impact on food availability.[10]

Miami neighborhoods also are not equally served by the same type of food retail stores, which also creates localized food vulnerabilities. Food retail stores in Miami include national and regional supermarkets, independent and chain grocery stores and convenience (corner) stores (we exclude general retail stores that sell food, such as Walmart).[11] Supermarket companies have

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[7] Primary warehouses for supermarkets were identified as those publicly listed on websites, annual reports and industry reports. To identify local warehouses operating in Miami, we used supplier data from the 2019 Dun and Bradstreet Database. We identified all businesses classified as NAICS code 4244 (Grocery and Related Product Merchant Wholesales). Primary distributors for supermarkets were cross-referenced with the Dun and Bradstreet Database to remove any duplicate listings. The Florida Department of Health publishes a list of authorized manufacturers, wholesalers, and distributors for which Florida WIC vendors can purchase from (Florida Department of Health, 2019). We did not include this list in our analysis because it includes business locations outside of Florida and does not distinguish between food manufacturers and wholesalers and distributors.
[8] If a single company operates multiple warehouses, we analyzed the location of each warehouse separately.
[9] Major transportation routes were defined as U.S. Interstates and Highways using the 2017 U.S. Census Bureau TIGER/Line Roads shapefile for Florida.
[10] Our analysis is concerned with the availability of food in general, and not the availability of healthy food in particular. Therefore, we do not use food desert data.
[11] Supermarkets are defined as grocery stores with $2 million or more in annual revenue (Supermarket Facts). Convenience stores are small retail stores that sell a limited line of food products that generally include milk, bread, soda and snacks. Food retail data is from 2019 Dun and Bradstreet Database and includes all businesses classified as

greater resources, more robust supply chains and are more likely to have adequate business continuity plans and insurance than smaller, independently owned, grocery stores and convenience stores. Therefore, the smaller stores may face longer periods of closure after an extreme weather event. Even if they have insurance, independent owners of smaller food stores typically need to cover all costs associated with reopening their business while waiting for reimbursement from their insurance companies or assistance from public agencies. For some business owners, these costs may be prohibitive and they will not be able to afford to reopen.

Three characteristics of food retail at the neighborhood level affect resilience to flooding: (1) the number of food retail stores of any kind; (2) the mix of supermarkets, grocery stores and convenience stores; and (3) the location of the stores in flood hazard areas. For each neighborhood in Miami, we compared the number of food retail stores per capita, the share of supermarkets among total food retail stores, and the share of stores in flood hazard areas to the city average.[12]

Restaurants are another important source of food for Miami residents. In the Miami metropolitan area, 41.5 percent of the average household's food expenditures are spent on food away from home ("Consumer Expenditures for the Miami Metropolitan Area," 2018).[13] For each neighborhood in Miami, we identify its restaurants and analyze their location in flood hazard areas.[14]

Food Insecurity Analysis
Analyzing the potential impact of flooding on food access also means accounting for food insecurity, the inability to purchase adequate food because of limited financial resources. In the U.S., roughly 40 million people (or 12.5 percent of the population) are food insecure ("Map the Meal Gap," 2019). In most cities, food insecurity is a significant problem and symptom of

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NAICS code 445110 (Supermarkets and Other Grocery Stores, except Convenience Stores), NAICS code 445120 (Convenience Stores) and NAICS code 447110 (Gasoline Stations with Convenience Stores). Supermarkets include all businesses classified as NAICS code 445110, Supermarkets and Other Grocery (except Convenience) stores with $2 million or more in annual revenue. Grocery stores include all businesses classified as NAICS code 445110, Supermarkets and Other Grocery (except Convenience) stores with less than $2 million in annual revenue.

[12] The City of Miami does not define neighborhood boundaries, but instead uses Neighborhood Enhancement Teams Areas (NETAs) to deliver city services. We use NETAs as proxies for neighborhoods in our analysis. Neighborhood demographic data was constructed by aggregating 2017 American Community Survey (ACS) 5-Year Estimates census tract data within neighborhood boundaries. To identify the corresponding census tracts for neighborhoods, we overlay the neighborhood boundary on census tract delineations to identify all of the census tracts that are wholly included or overlap neighborhood boundaries. Because some census tracts partially intersect neighborhoods, we use census tract weights to allocate demographic data to be attributed to the neighborhood. We constructed weights that incorporated population patterns at the census block group level using the 2017 ACS 5-Year Estimates population.

[13] Food away from home is defined by the U.S. Bureau of Labor Statistics as all meals including tips at fast food, take-out, delivery, concession stands, buffet and cafeteria, full-service restaurants, vending machines and mobile vendors. Also included are board (e.g., school) meals, meals as pay and special catered affairs.

[14] Restaurant data is from 2019 Dun and Bradstreet's Hoover's Database and includes all businesses classified as NAICS code 7225 (Restaurants and Other Eating Places).

growing economic inequality. In Miami-Dade County, 255,680 people (or 9.5 percent of the population) are food insecure ("Map the Meal Gap," 2019).

Food insecurity data is not available at the neighborhood level. Therefore, poverty and Supplemental Nutrition Assistance Program (SNAP) participation rates are used as proxies.[15] The neighborhoods identified as having vulnerable food access are those with vulnerable food retail and higher poverty and SNAP participation rates than the city average.

Natural disasters exacerbate the issue because more residents are pushed into food insecurity due to disaster-related expenses and hardships such as loss of income. The price of some food products may also become more expensive. As a result, in the aftermath of a disaster, demand for food from food pantries, and thus from food banks, is likely to increase for a prolonged period of time. For example, in New York City, 60 percent of food pantries and soup kitchens reported feeding more people at least partially due to Superstorm Sandy a year after the storm (New York City Coalition Against Hunger, 2013). Neither, however, may have the capacity or resources to meet increased demand over a longer time period. Feeding America, a nationwide network of 200 member food banks and 60,000 food pantries, provides food to its members during disasters, but this assistance is meant to be short term ("How do Food Banks Work," 2019).

To analyze the vulnerability of the food safety network, we focus on food bank vulnerabilities since food pantries typically obtain most (approximately 75 percent) of their food from a regional food bank (Thomas, 2007). Feeding South Florida is the food bank serving Greater Miami. It has two locations: the main warehouse in Pembroke Park and Feeding Palm Beach County in Boynton Beach. Feeding South Florida serves 25 percent of the state of Florida's food insecure population, providing direct-service programs and partnering with over 300 local nonprofit agencies to support individuals in need of food assistance ("FAQ'S - Feeding South Florida," n.d.).

To assess food bank vulnerability in Miami, we analyze the location of Feeding South Florida's warehouses in flood hazard areas, to gauge whether they will be accessible after a hurricane, and their capacity and plans to handle increased demand over a prolonged period.

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[15] The two primary federal nutrition assistance programs that subsidize food purchases are SNAP and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), both of which are managed by the U.S. Department of Agriculture (USDA).

4. The Impact of Flooding on Miami's Food System

Road vulnerabilities pose the most serious threat to food distribution in Miami. There are redundant transportation routes in the city: Miami is served by three north-south interstates and U.S. highways (I-95, US-1, US-441) and three east-west interstates and U.S. highways (1-195, I-395, US-41). Trucks are also permitted on all major roads in the city ("Florida Trucking Lane Restrictions," n.d.). However, all the interstates and U.S. highways are partially located in flood hazard areas and could flood during a hurricane event. Further, two interstates (I-95, I-195) and one highway (US-1) have bridges over bodies of water (Miami River and the Atlantic Ocean) that could be susceptible to extended closures during a natural disaster. In the aftermath of a hurricane, moving food into and through Miami would be restricted, leaving some stores and neighborhoods without a reliable supply of food.

The location of food distribution facilities in flood prone areas further compromises food distribution in Miami after a hurricane (Figure 4). Nearly half of the supermarket warehouses and local warehouses are located in flood hazard areas (Table 1). Impassable highways and secondary roads would restrict truck traffic to additional facilities that are not located in flood hazard areas (for example the Aldi warehouse, Figure 5), meaning the majority of warehouses could become inaccessible after a hurricane.

Table 1. Flood Prone Food Warehouses in Miami

|	Total Number	Number Located in Flood Hazard Area	Share Located in Flood Hazard Area
Supermarket Warehouses	7	3	43%
Local Warehouses	1,415	650	46%

Sources: Dun and Bradstreet (2019) and FEMA Florida National Flood Hazard Layer (2019).

The good news for Miami is that it does not have a large, centralized fresh food distribution center (such as Hunts Point in New York City). These centers are often located in flood prone areas, thereby creating a significant food system risk. Further, Miami's smaller fresh food warehouses are not clustered in a single geography (which is the case in Boston).

In terms of food access overall, Miami has fewer supermarkets per capita than the U.S. (0.00005 and 0.00012, respectively).[16] Most of the city's grocery stores and convenience stores are also small: 230 grocery stores and convenience stores in Miami (86 percent) have annual revenues less than $500,000. **These trends make the city's food retail more vulnerable overall than other cities.**

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[16] Analysis using supermarket data for Miami from Dun and Bradstreet Database (2019) and the Food Marketing Institute ("Supermarket Facts," 2019), population estimates from the U.S. Census Bureau American Community Survey 5-Year Estimates (2017).

Figure 4. Hurricane Flooding Risks for Miami's Food System
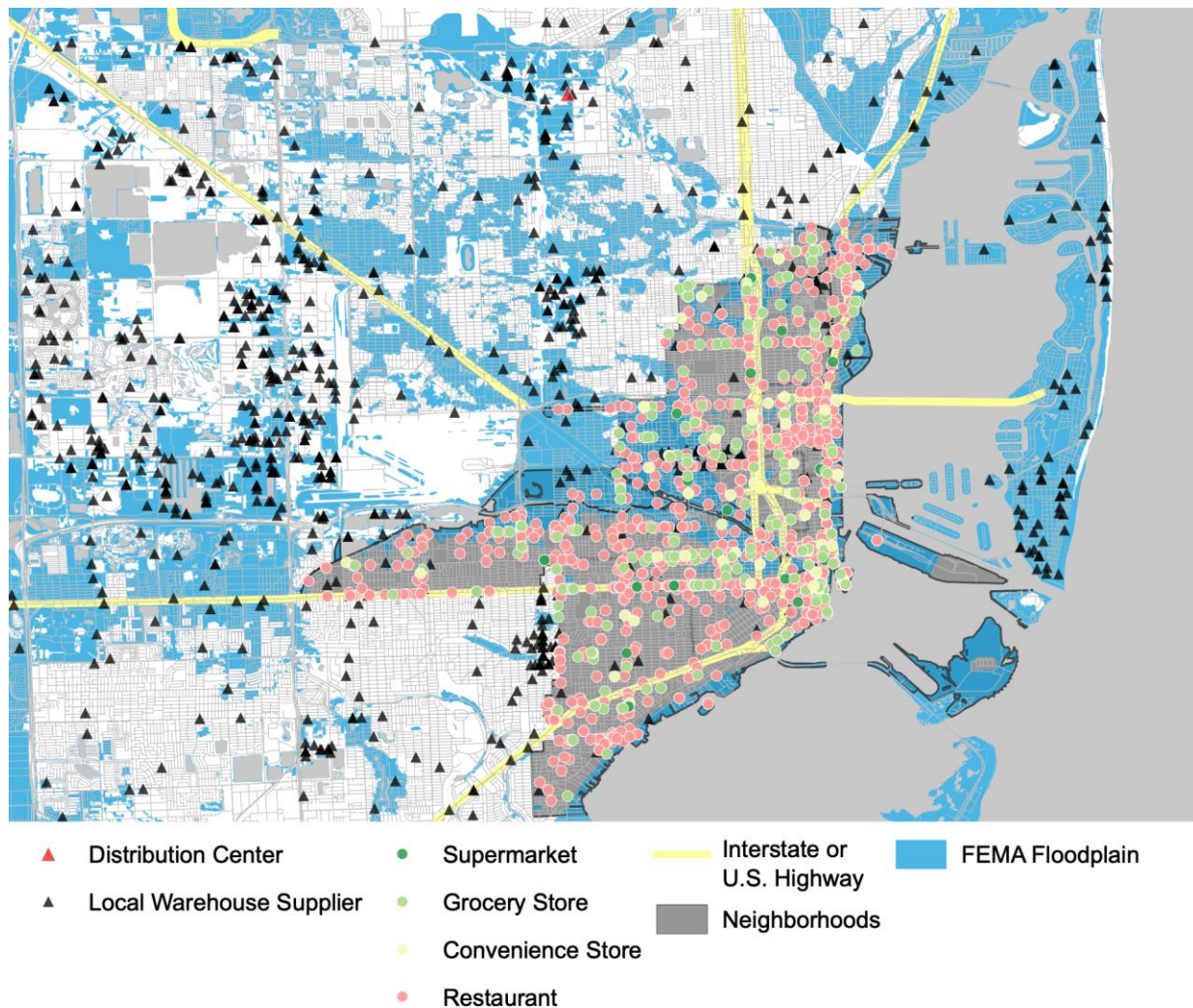
Sources: City of Miami Neighborhood Enhancement Teams Areas (NETAs) (2019), Dun and Bradstreet (2019), FEMA Florida National Flood Hazard Layer (2019), U.S. Census Bureau TIGER/Line Roads (2017).

Figure 5. The Flood Risk Facing the ALDI Distribution Center in Royal Palm Beach

ALDI Distribution Center — Interstate or U.S. Highway   FEMA Floodplain

Sources: FEMA Florida National Flood Hazard Layer (2019), U.S. Census Bureau TIGER/Line Roads (2017).

Overall, only 17 percent of Miami's supermarkets are at risk of flooding from a hurricane. However, the impact would be greater for grocery and convenience stores—over one-third of the stores are prone to flooding. Likewise, over one-third of all restaurants in Miami are likely to be flooded after a hurricane (Table 2).

Table 2. Flood Prone Food Retail Stores and Restaurants in Miami

	Total Number	**Number Located in Flood Hazard Area**	**Share Located in Flood Hazard Area**
Supermarkets	23	4	17%
Grocery Stores	230	88	38%
Convenience Stores	51	18	35%
Restaurants	1,399	535	38%

Sources: Dun and Bradstreet (2019) and FEMA Florida National Flood Hazard Layer (2019).

Neighborhood Food Retail and Restaurant Vulnerability
While this may not be a significant impact for the city overall, certain neighborhoods would be disproportionately impacted by food retail and restaurant closures due to flooding. Overall, only **three neighborhoods in Miami are underserved in terms of food access—**i.e., have fewer food retail stores per capita than the city average**—Coral Way, Flagami and Little Havana** (Table 3). However, the risk of food retail store closures due to flooding in each of these neighborhoods is substantially lower than the city average.

Four neighborhoods face a significant risk of limited food access due to store closures from flooding —**Allapattah, Downtown-Brickell, Model City and Wynwood/Edgewater.** In each neighborhood, a higher share of their food retail stores are located in flood hazard areas than the city average. Allapattah and Downtown-Brickell would also face significant restaurant closures due to flooding after a hurricane; more than 50 percent of their restaurants are located in flood hazard areas.

Since food systems in Allapattah, Downtown-Brickell and Wynwood/Edgewater are also characterized by having a lower share of food retail stores that are supermarkets than the city average, recovery will likely be slower in these three neighborhoods. Wynwood/Edgewater only has one supermarket. In addition, one of Model City's three supermarkets and one of Allapattah's two supermarkets is at risk for flooding.

Table 3. Miami Neighborhoods with Vulnerable Food Retail and Restaurants

Neighborhood	Food Retail Stores Per Capita	Share of Supermarkets*	Share of Food Retail Stores in Floodplain	Share of Restaurants in Floodplain
Allapattah	0.0009	4%	62%	62%
Coconut Grove	0.0008	13%	0%	10%
Coral Way	0.0004	5%	14%	10%
Downtown-Brickell	0.0010	7%	71%	67%
Flagami	0.0003	15%	20%	26%
Little Haiti	0.0009	3%	13%	6%
Little Havana	0.0006	11%	21%	22%
Model City	0.0011	11%	44%	33%
Overtown	0.0013	6%	18%	38%
Upper Eastside	0.0008	10%	30%	27%
Wynwood/Edgewater	0.0010	4%	43%	26%
City of Miami	**0.0007**	**8%**	**36%**	**38%**

Sources: City of Miami Neighborhood Enhancement Teams Areas (NETAs) (2019), Dun and Bradstreet (2019), FEMA Florida National Flood Hazard Layer (2019) and U.S. Census Bureau American Community Survey 5-Year Estimates (2017).

Notes: Neighborhood demographics may not sum to the city of Miami due to rounding associated with using census tracts to derive neighborhood-level demographics.

* The share of supermarkets represents the share of all food retail stores that are supermarkets.

From an equity perspective a different set of neighborhoods surface as facing the greatest risk of limited food access in the aftermath of a hurricane (Table 4). Disparities in food insecurity by neighborhood are particularly pronounced in Miami. Therefore, while the residents of Downtown-Brickell and Wynwood/Edgewater would face more store closures after a hurricane, most would not face significant food access issues because of lower food insecurity rates. Downtown-Brickell has the lowest SNAP participation rates in the city (eight percent) and only 14 percent of Wynwood/Edgewater residents participate in SNAP. Both also have lower poverty rates than the city average.

Allapattah and Model City, conversely, have higher food insecurity (and poverty) rates than the city average. Nearly half of Model City's population participates in SNAP. In addition, Model City has also been designated as a food desert, one of only two food deserts in Miami (the other neighborhood is Coconut Grove).[17] **Allapattah and Model City will be the neighborhoods facing the greatest risk of limited food access in the aftermath of a hurricane** because they have vulnerable food retail as well as higher poverty and SNAP participation rates than the city

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[17] A food desert is defined by the USDA as a low-income census tract with at least 500 people, or 33 percent of the population, living more than one mile from the nearest supermarket or large grocery store ("Food Access Research Atlas Documentation," 2017). Analysis using USDA Food Access Research Atlas data (2015) and City of Miami Neighborhood Enhancement Teams Areas (NETAs) (2019).

average. The Allapattah neighborhood stands out as being the most vulnerable—with a lower share of supermarkets per capita (four percent), a higher share of food retail stores and restaurants at risk for flooding (62 percent for both), as well as higher SNAP participation (46 percent) and poverty rates (34 percent) than the city average.

Several other neighborhoods also face higher rates of food insecurity than the city average—Flagami, Little Haiti, Little Havana and Overtown. However, none of these neighborhoods face disproportionately higher rates of food store closures due to flooding than the city average.

Feeding food insecure households will also be more challenging after a hurricane. While neither of the Feeding South Florida's warehouses are located in a flood hazard area, the secondary roads leading into its Main Warehouse are prone to flooding (Figure 6). Therefore, the food bank would have limited accessibility for food deliveries—into and out of the warehouse—after a hurricane, affecting capacity at neighborhood food pantries.

Table 4. Food Insecurity Indicators in Miami

Neighborhood	Poverty Rate	SNAP Participation Rate
Allapattah	34%	46%
Coconut Grove	12%	9%
Coral Way	20%	26%
Downtown-Brickell	14%	8%
Flagami	21%	39%
Little Haiti	36%	43%
Little Havana	30%	45%
Model City	37%	49%
Overtown	41%	40%
Upper Eastside	22%	15%
Wynwood/Edgewater	21%	14%
City of Miami	**26%**	**32%**

Sources: City of Miami Neighborhood Enhancement Teams Areas (NETAs) (2019) and U.S. Census Bureau American Community Survey 5-Year Estimates (2017).

Figure 6. The Flood Risk Facing Feeding South Florida's Main Warehouse
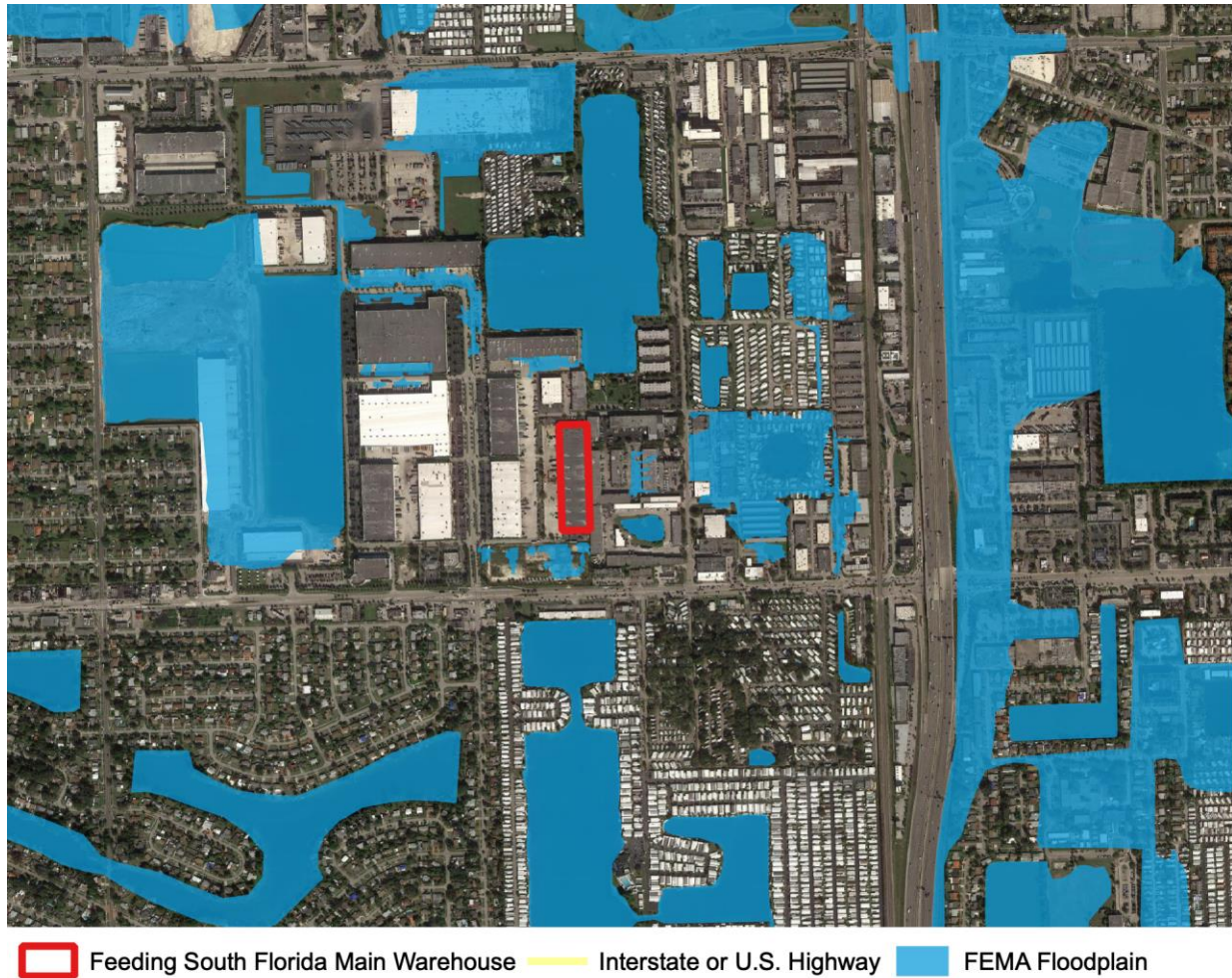
Sources: FEMA Florida National Flood Hazard Layer (2019), U.S. Census Bureau TIGER/Line Roads (2017).

5. Policy Implications

Food distribution and food access in Miami will be significantly compromised from flooding in the event of a hurricane. Road vulnerabilities pose the most serious threat to food distribution. In spite of redundant transportation routes in the city, all the interstates and U.S. highways are partially located in flood hazard areas and could be closed after a hurricane. The location of food distribution facilities in flood prone areas further compromises food distribution in Miami after a hurricane. The majority of warehouses could become inaccessible after a hurricane. As a result, moving food into and through Miami after a hurricane would be restricted, leaving some stores and neighborhoods without a reliable supply of food.

Because of the efficient "just-in-time" delivery methods for food stores, some estimate that food retail stores in urban areas only have three days of fresh food and up to 17 days of all food products in stock (Bristow & Kennedy, 2013; Medical Officer of Health, 2008). With a major hurricane, such as Katrina or Irma, roads will likely remain closed for longer than 17 days, creating at the very least localized food shortages, which would have significant economic, social and political consequences. Not only would food prices would rise, but without sufficient access to food, more people would be forced to leave the city or be inclined to stay away, creating labor shortages and a drop in consumer purchases, prolonging the city's recovery efforts.

In terms of food access, Miami has fewer supermarkets per capita than the U.S. and 86 percent of its grocery and convenience stores are small, meaning they are unlikely to have a robust business continuity plan in place, sufficient insurance or the resources to reopen after a disaster. In certain neighborhoods, however, food access will be disproportionately affected by hurricane flooding because of a lack of large food retail stores, the location of stores and restaurants in flood prone areas, and higher rates of food insecurity. To ensure equitable resilience, policies need to address food system vulnerabilities at the neighborhood level.

Allapattah and Model City—with 84,757 residents (or 19 percent of Miami's population)—will be the neighborhoods facing the greatest risk of limited food access in the aftermath of a hurricane. Nearly half of their households receive SNAP benefits and over one-third live below the poverty line, meaning most face already face food security issues. Flagami and Little Havana also stand out because they are underserved by food retail stores under normal circumstances and have higher rates of food insecurity than the city average. Even though they do not face a disproportionately higher risk of food store closures due to flooding, any food store closures will have a greater impact on food access in these neighborhoods than in areas with more stores per capita and lower food insecurity rates.

In spite of their best efforts, most food banks do not meet current demand—food insecurity keeps increasing, not all food insecure households utilize food assistance from food pantries, etc., and the food they receive may not meet all of their dietary needs. This gap will only widen in the aftermath of a hurricane in Miami, as more households become insecure and for a prolonged period of time—months, not days. At the same time, at least one of Feeding South Florida's warehouses will face restricted access, potentially compromising its ability to support the food assistance organizations it serves.

Recommendations
Addressing Miami's food system vulnerabilities will require action from the public, private and philanthropic/nonprofit sector. Although food systems are primarily comprised of private-sector businesses, they are also interconnected systems—their functioning depends upon public infrastructure. For many households, accessing food also requires public benefits and nonprofit food assistance networks. Further, it is often assumed that private-sector food businesses have the resources and motive to ensure that their operations return to normal as quickly as possible after a disaster and, therefore, they do not require any interventions. This is generally not the case. Evacuations create market uncertainties for large companies and smaller businesses typically do not have sufficient resources to deal with major catastrophes. In Miami, given that the majority of food retail stores are small businesses, public sector interventions are critical.

Strengthening Miami's food system, to ensure that all residents will have equitable access to food after a hurricane, will ultimately require addressing systemic issues of economic inequality and food insecurity. In the near term, the following three recommendations address the most critical vulnerabilities.

1. **Prioritize the resilience of designated food distribution routes into Miami**
An in-depth analysis of the transportation routes from food distributors to food retail stores and food banks is required to identify the best designated routes after a hurricane. Once these are identified, strengthening their resilience to flooding should be a department of transportation priority. Also, plans should be developed on how best to communicate to food companies to route food distribution to these routes after a hurricane and to ensuring that federal Hours of Service regulations for food distribution drivers is suspended.[18]

2. **Target neighborhood food system resilience in Allapattah, Model City, Flagami and Little Havana**
From an equity perspective, these neighborhoods should be targeted for intervention to strengthen the resilience of their food retail stores—including food distribution to the stores. The city needs to make sure that the food retail stores have adequate business continuity plans,

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[18] This is already possible under Florida's SB1288-Post-Disaster Re-Entry legislation passed in 2016.

perhaps backup generators, and sufficient insurance through targeted education and technical assistance initiatives. New insurance programs, or subsidies, also should be considered.

Florida's Small Business Emergency Bridge Loan Program was established to support the recovery of small businesses after a disaster. The program, managed by the Florida Department of Economic Opportunity, provides short-term, interest-free loans to small businesses to help bridge the gap between the time damage is incurred and when a business secures other financial resources, including insurance claims, disaster recovery funds or loans from financial institutions.[19] The Governor enacts the program in the event of a disaster, but outreach about the program needs to happen to the numerous small food retail stores and restaurants in these neighborhoods to ensure they can rapidly access the resources.

The city should also prioritize attracting more national and regional supermarkets to these neighborhoods through zoning and financial incentives. In 2012, the Food Trust published a report recognizing the disparities in supermarket access throughout Miami-Dade County, especially in low-income areas (A Healthier Future for Miami-Dade County). It recommended a grant and loan program to support the development of more supermarkets.[20] Similar programs have been successfully implemented in other states and cities, including Boston, Madison, WI, New York City, and Pennsylvania.

3. Develop plans for expanding the capacity of Feeding South Florida after a hurricane
The federal government provides some support to food insecure households after a disaster. The USDA provides USDA Food to supplement the meals distributed by disaster feeding organizations and, perhaps more importantly, approves states to operate Disaster Supplemental Nutrition Assistance Programs (D-SNAP) ("FNS Disaster Assistance"). D-SNAP provides one month of benefits to households who may not normally qualify for SNAP, but meet certain income criteria and incur disaster-related expenses, such as loss of income, property damage, relocation expenses, and, in some cases, food loss (U.S. Department of Agriculture Food and Nutrition Service). D-SNAP benefits should be reviewed to assess the capacity to meet demand after a hurricane as well as implementation protocols to ensure maximum utilization. Recent challenges to the SNAP program may also limit the availability of D-SNAP.

The private sector may consider a supplemental program that would provide food insecure households with gift cards to purchase food at food retailers. Such a program was used in Toronto after a severe winter storm (Zeuli, Nijhuis and Gerson-Nieder, 2018).

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[19] For more information about the program, visit https://floridadisasterloan.org/
[20] Several bills have been introduced in the Florida Legislature to create a Healthy Foods Retail program (SB 852, filed November 2011; and SB 1658, filed January 2012) that would create a loan and grant financing program for food retail outlets.

Food assistance networks shoulder the greatest burden for trying to address increased rates of food insecurity. Therefore, it is essential that both of Feeding South Florida's warehouses will be accessible after a hurricane or plans are in place for alternative warehouse capacity. In addition, the city needs to work with the food bank to develop plans to support their expanded capacity to meet increased demand over a prolonged period. This could include plans for establishing funding to support more food purchases.

They will also be able to leverage Feeding America. Feeding America plays an active role in recovery efforts following major disasters by providing local organizations with food, water and trained staff, while also providing specialized disaster training for its food banks around the country. Feeding America has a long-standing engagement with other non-governmental organizations involved with disaster relief through National Voluntary Organizations Active in Disaster, an association of organizations providing support services after a disaster. In 2005, Feeding America formalized its commitment to providing aid during times of disaster with FEMA and the partnership was renewed in 2009. Feeding America has a similar partnership with the American Red Cross. In addition, food banks in the Feeding America network may be able to access additional food resources from the U.S. Department of Agriculture's Emergency Food Assistance Program (TEFAP) after some disasters (U.S. Department of Agriculture, 2011). Feeding America provides ongoing expertise and resources to aid long-term recovery.

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