

NO CALM BEFORE THE STORM: IDENTIFYING DAMAGE LEVELS AND RELIEF EFFORTS IN PUERTO RICO AFTER HURRICANE MARIA

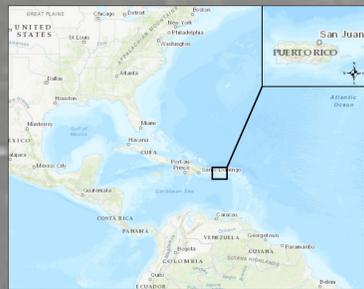


Figure 1. Spatial Location of Puerto Rico



Figure 2. Path of Hurricane Maria over Puerto Rico
National Hurricane Center, <http://www.nhc.noaa.gov/>

INCREASED HURRICANE INTENSITY

Scientists estimate an increase of global temperature of about 1.7 degrees Fahrenheit (1.1 degrees Celsius) since 1880, as a result of anthropogenic greenhouse gases. This increase in temperature has notably impacted the oceans, causing an increase of 0.13 degrees Fahrenheit every 10 years¹. Temperature change not only disrupts marine environments and organisms but has devastating impacts on storms.

Tropical cyclones, known as hurricanes, are formed by vaporizing water at the ocean's surface around the equator. Rising ocean temperatures as a result of climate change increases rate of water vaporization and thus leads to more frequent and more intense storms².

Hurricane Maria crossed over mainland Puerto Rico as a category 4 hurricane (defined by sustain wind speeds from 130 – 156 mph³) just two weeks after Hurricane Irma hit the island, destroying infrastructure and leaving the entire island without power⁴. Assessing the impact of these hurricanes is important in developing interventions to improve resiliency, both in Puerto Rico and all at-risk areas.

This research project examines the impacts of Hurricane Maria on Puerto Rico, with a focus on damages to wind, hospitals, and structures as a result of landslides. This analysis can be used to assess the efficacy of the response areas in relation to the highest impact zones.

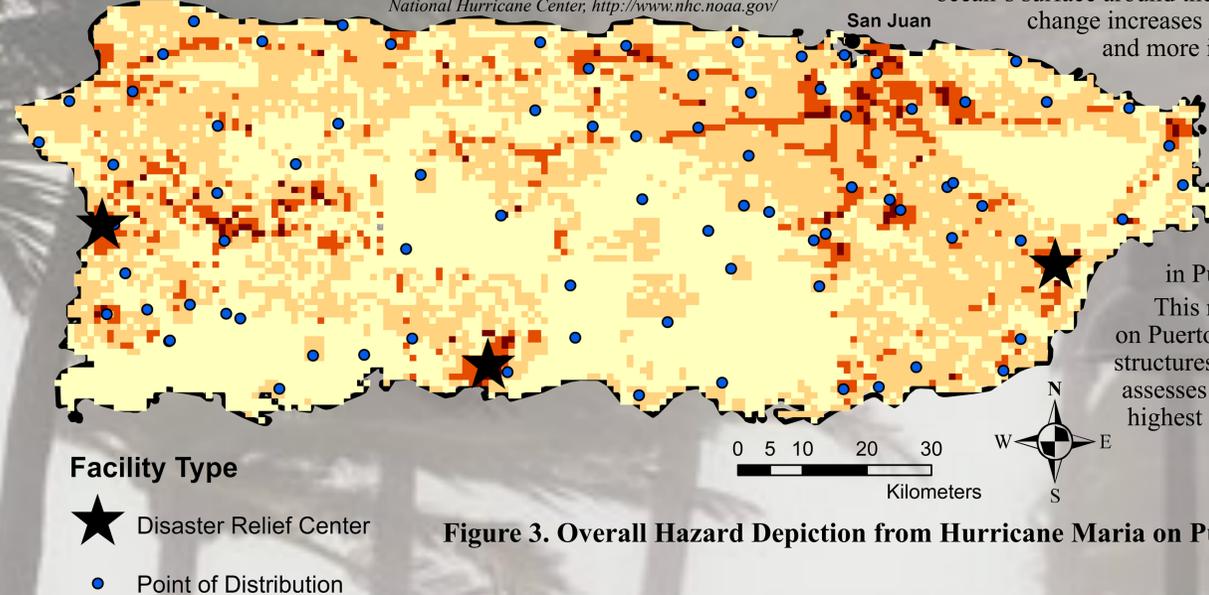


Figure 3. Overall Hazard Depiction from Hurricane Maria on Puerto Rico

METHODOLOGY

Damage Factors: Hurricane damage was assessed using five factors, each assigned different hazard value based on relative risk. Damage factors were clipped to mainland Puerto Rico and analyzed for spatial impacts. Each factor was converted to a raster for hazard reclassification and risk analysis. Reclassification of hazard values are located below.

Analysis: Raster algebra was used to obtain an overall hazard map.

DAMAGE FACTOR	BUFFER	DAMAGE ASSESSMENT	HAZARD VALUE
Hospital Status	2000 meter radius	Generator Degraded	2
		Closed	3
Wind Damage	0	Affected	2
	0	Destroyed	3
Electrical Lines	7 meters	None	1
Power Damage	100 meters	Affected	3
		Destroyed	4
Landslide Damage	0	Slope of Geography	1 – 2.5

Data Sources: FEMA, USGS, HIFLD, Tufts Geodata, ArcGIS online
Background Image: Chip Somodevilla, <https://ionline.sapo.pt/579942>

RESULTS AND CONCLUSIONS

Specific damages (Figures 4-7) were generally concentrated around the path of the hurricane, which is seen in Figure 2, although landslide occurrence was isolated to the western region of the island (Figure 7). Hospital closure and generator degradation was heavily concentrated around San Juan (Figure 6), which is likely an indicator of population size rather than volume of damages, as a large number of hospitals are located near San Juan to meet the needs of the population. The most significant source of damage was wind. As seen in Figure 4, the magnitude and area of damages caused by wind spans most of the island. Wind damages put electrical lines most at risk (impacts are modeled in Figure 5), as lines run mostly above ground. Loss of electricity due to destruction of electrical lines significantly impacts conditions for health and safety for long periods after the disaster. Damages to electrical lines are difficult to resolve and require extensive infrastructure repair, compared to other relief efforts such as delivering food and water.

The overall hazard map (Figure 3) shows pockets of high damage in the upper northeast area, the center southern area, and the western area. Several pockets of damaged areas are underserved by disaster relief centers. Specifically, the region in the northeast corner lacks a close disaster relief center. This is especially concerning since San Juan, the largest city and capital of Puerto Rico, is nearby. Points of distribution are generally evenly distributed around the island and appropriately located around areas of high damage, much more than the disaster relief centers.

This analysis serves to highlight the magnitude of damage inflicted on Puerto Rico due to Hurricane Maria and the lack of adequate relief centers in the midst of the damage. The U.S. federal government has the responsibility to do more to improve the conditions in Puerto Rico, both now and in future disasters.

HURRICANE DAMAGES

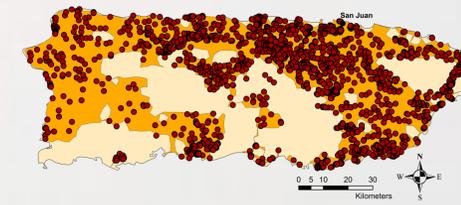


Figure 4. Hurricane Maria Wind Damages

Figure 4 details the damages due to wind on Mainland Puerto Rico due to Hurricane Maria. The damages are classified into destroyed and affected. Damages are most heavily concentrated in the mid-northeast region, which follows the general trend of the path of the hurricane over the mainland.

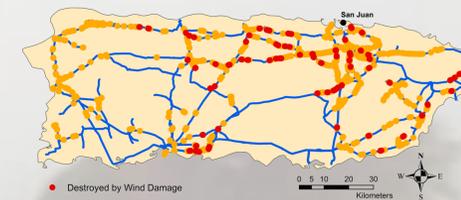


Figure 5. Hurricane Maria Power Line Damages

Figure 5 indicates areas that were destroyed or affected by wind and also crosses over paths of electrical lines. This provides context to the power outage following Hurricane Maria, which left the entire island without electricity. Most affected areas are concentrated in the mid-northeast region.

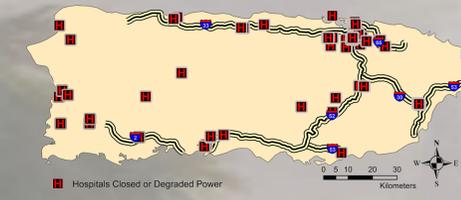


Figure 6. Hurricane Maria Hospital Impacts

Figure 6 identifies the location of hospitals that closed or lost generator power following Hurricane Maria. A significant amount of hospitals affected, especially in the northeast corner, near San Juan. Hospital closures indicate a serious health risk for citizens of Puerto Rico.

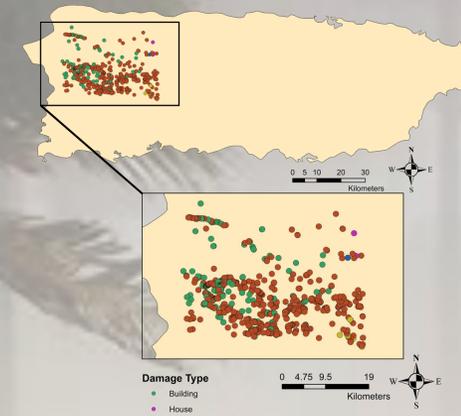


Figure 7. Hurricane Maria Landslide Occurrences

Figure 7 indicates the location of damages due to landslides following Hurricane Maria, which are concentrated on the northwestern region of the island. Damages affected different structures, most significantly roads and buildings. Landslide damages minimally impacted reservoirs, houses, and other structures.

Landslide damage level is influenced by the slope of the geography at the location of the incident. In my analysis, I defined hazard levels based on the slope at the location of the landslide.

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Cartographer, Hannah Zafar

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Projection: NAD_1983_StatePlane_Puerto_Rico_Virgin_Islands_FIPS_5201

Tufts