Environmental Injustice and Natural Disasters

A Case Study of Hurricane Harvey and Harris County, Texas

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ABSTRACT

While the impacts of natural disasters are heavily covered following major events, the underlying social and economic inequities that often make populations more vulnerable to these events are often overlooked. Following an environmental justice framework, this project examines 1) whether certain socioeconomic and racial groups tend to live closer to toxic sites in Harris County, Texas, and 2) whether Hurricane Harvey exacerbated existing inequities or placed new populations at risk of environmental hazard. Using geographic information systems (GIS), Census block groups in Harris County were analyzed based on six socioeconomic variables: race (Black, White, Hispanic/Latino), income, health insurance status, and education. Statistical surfaces for each variable were produced using areal interpolation of block group centroids and toxic sites (impacted and all) were mapped onto these surfaces to assess how socio-demographic character changed with distance from the grouping of toxic sites. Finally, hazardous facility hotspots for all sites and only "impacted" sites were identified using a cluster analysis and compared with the sociodemographic surfaces to identify high-risk areas before and after the hurricane.

The results show that, in most cases, socioeconomic status (SES) decreases with proximity to hazardous facilities in Harris County. However, the impact of Hurricane Harvey on this phenomenon is less clear. Overall, the results suggest that the hurricane had a more equal distribution of harm across all demographic groups. In addition, this study provides disaster relief organizations with areas within Harris County where populations face increased environmental risk before and after severe flooding events. Further studies should incorporate more accurate flood damage data and other information regarding amount and toxicity of toxic release into similar analyses to more precisely analyze environmental injustice and the impact of severe flooding events.

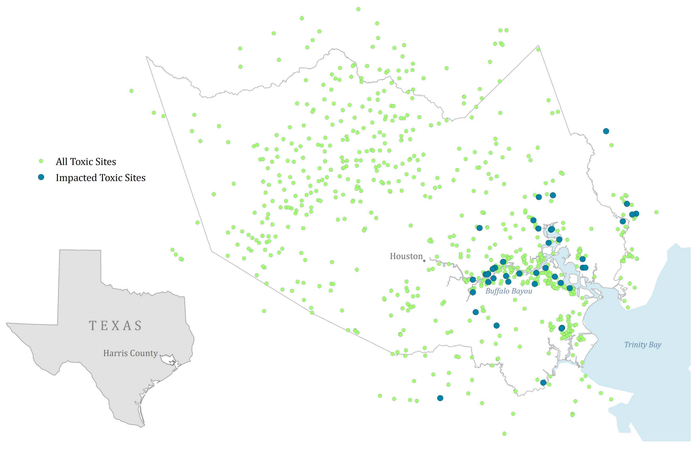

Figure 1: This map shows all toxic sites within 10km of Harris County, TX. Sites with known incidents following Hurricane Harvey are highlighted in blue.
Sources: Natural Earth, Sierra Club, Texas Natural Resources Information System

INTRODUCTION

Natural disasters affect populations to vastly different degrees depending on not only physical factors like poor housing infrastructure, but also social, economic, and political forces that can place certain populations at higher risk and impose additional barriers to recovery (Maantay and Maroko, 2014). Environmental injustice, occurring when certain populations are disproportionately burdened with environmental hazards, is one phenomenon that contributes to this social vulnerability (Fisher et al, 2006). Issues of environmental injustice are inherently spatial, and GIS is one the best tools researchers have to analyze the impact and scale of these inequities and to identify high-risk areas.

This project focuses on Harris County, Texas, which is the site of a large concentration of toxic sites (Fig. 1), including chemical plants, refineries, Superfund sites, and fossil fuel operations, many of which suffered damage during Hurricane Harvey. There has been reports of chemical spills and releases of toxic compounds that are harmful to water and air quality. While Houston's toxic sites were having adverse effects on the health of nearby residents long before the hurricane, spills, releases, and flooding after the hurricane will cause even more contact with these materials. To assess the impact of Hurricane Harvey on toxic sites and the populations surrounding them, a baseline for exposure and inequity is important. This project will compare the demographic trends around 1) all toxic sites, and 2) only toxic sites with known incidents following the hurricane. This will inform whether certain populations experience disproportionate exposure to toxic releases, and whether the hurricane worsened this inequity. In addition, based on the demographic characteristics, high-risk areas will be identified that will show where further flood and toxic management should be focused. I hypothesize that 1) low-SES populations in Harris County are more likely to live closer to toxic sites, and 2) Hurricane Harvey disproportionately impacted these populations.

METHODOLOGY

The methodology for this study involved modifying the traditional environmental justice workflow. Instead of using demographic data aggregated in areal units for my analysis, I created statistical surfaces based on areal unit centroids, a method inspired by Mennis (2002) to overcome the modifiable areal unit problem (MAUP). The MAUP is the fact that data (such as ACS or Census data) aggregated into different scales or boundaries will affect the results of spatial analysis. Using interpolation from areal unit centroids to generate statistical surfaces is a simple technique to overcome this issue, although it makes assumptions and is not perfect (Mennis, 2002).

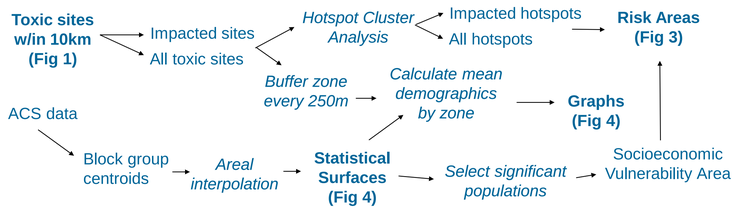

Figure 2: GIS Workflow. Spatial analysis steps are *italicized* and results displayed in maps are in **bold**.

RESULTS

- **Socioeconomic status decreases with proximity to hazardous facilities**
  - As proximity to a toxic site decreases, four characteristics change significantly: median household income decreases (Fig. 4d), percent Hispanic/Latino increases (4c), percent of the population without health insurance increases (4e), and percent White decreases (4a). Percent of population with only a high school education and percent African-American only show minimal decrease.

- **Demographic trends around impacted sites suggest a more equal distribution of harm from Hurricane Harvey than I had anticipated**
  - The trends for White (4a) and African-American (4b) populations were inverted and income did not have as clear of a positive relationship, suggesting that socioeconomic status was not a general predictor of populations living near impacted sites. Hispanic/Latino and uninsured populations still tended to live near impacted sites (5c and 5e), while education trends stayed relatively constant before and after – although populations near impacted sites overall were less educated.

- **High-risk areas are concentrated around the Buffalo Bayou after Hurricane Harvey**
  - My analysis of socioeconomic vulnerability areas and toxic hotspots before and after Harvey shows that the main areas of risk are located in the Northern and Southeastern portions of the county (Fig. 3). After Harvey, the main risk areas surround the Buffalo Bayou, which leads into Houston. This area had a large concentration of impacted toxic sites (2) and has significant low-SES populations (4a-f)

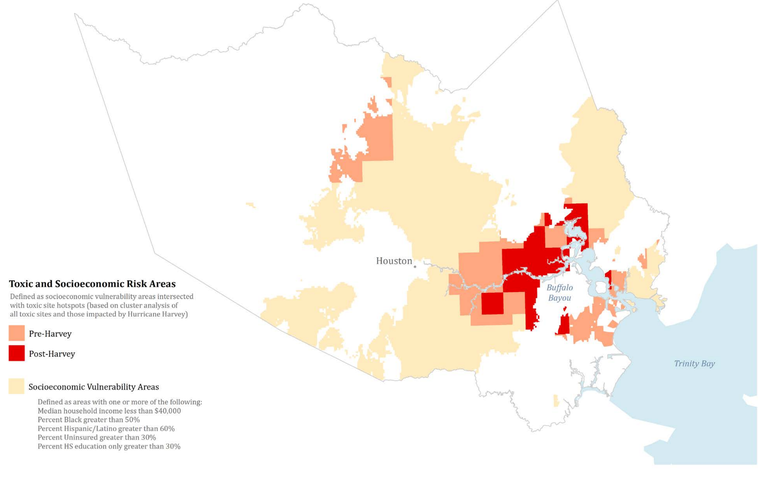

Figure 3: This map shows the areas in Harris County that were identified as high-risk before and after Hurricane Harvey. The light yellow shows Socioeconomic Vulnerability Areas, which are areas with one or more marker of low socioeconomic status. The darker areas show the intersections between these areas and hotspots identified by a cluster analysis as being significant toxic locations.
Sources: Texas Natural Resources Information System, Sierra Club, US Census Bureau

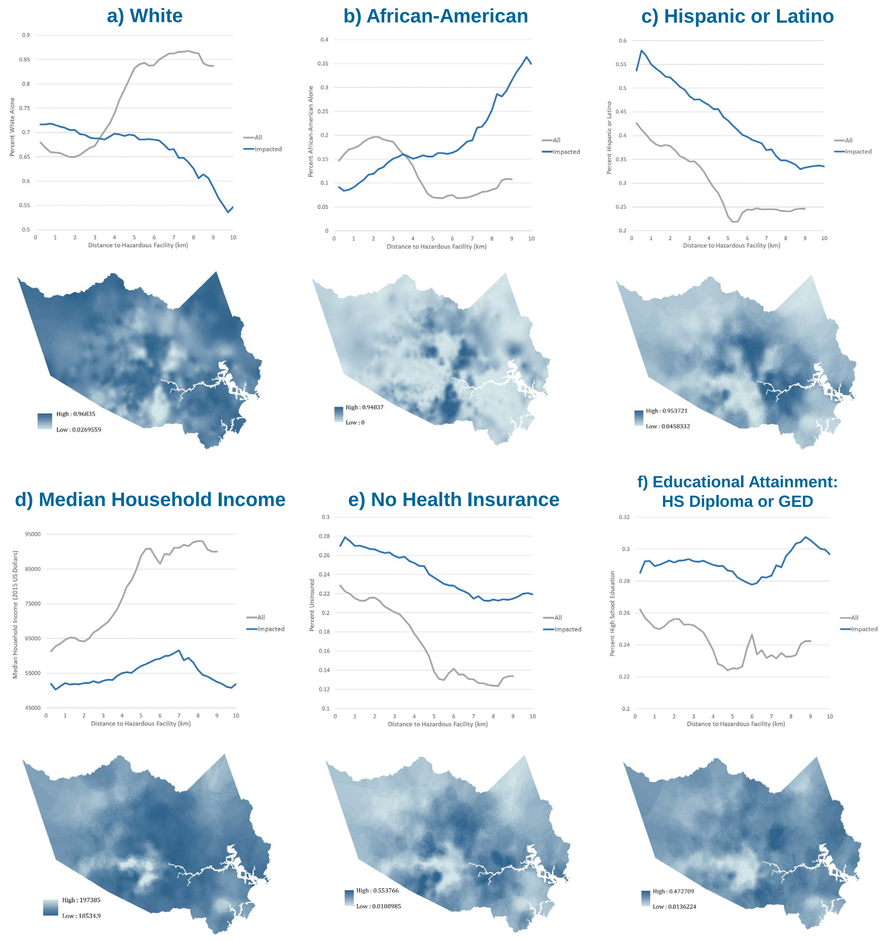

Figure 4: These graphs show the relationship between distance to hazardous facilities and other characteristics, which are displayed by statistical surfaces in each corresponding map. Each graph shows the relationship between the demographic indicator before the hurricane with all toxic sites within 10km of Harris County, and after the hurricane only with impacted sites.
Sources: Texas Natural Resources Information System, US Census Bureau, Sierra Club

CONCLUSIONS

These results provide evidence of environmental injustice in Harris County before Hurricane Harvey and suggest that the hurricane impacted populations across the socioeconomic spectrum. Although, since this study uses impacted toxic sites as a proxy for hurricane damage, this cannot be generalized to the overall situation post-Harvey. However, it is clear that the areas where toxic sites were damaged, surrounding the Buffalo Bayou outside Houston, had populations with a wide range of socioeconomic backgrounds. This differs from the results with all toxic sites in Harris County, which suggests that the impact of the hurricane on toxic sites was more equally distributed across backgrounds.

In terms of future management, this study provides disaster relief organizations with general areas within Harris County where vulnerable populations face increased environmental risk from toxic sites before and after future severe flooding events. Areas where toxic sites and socioeconomic vulnerability intersect should be a priority for future flood management projects.

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