

# Analyzing Flood Risk Zones in Harris County, Texas

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## **Background:**

Harris County is the third most populous county in the United States and includes more than 4 million residents of Houston. It is also only 50 miles from the Gulf of Mexico. On paper, the mix of so many people and proximity to the coast is a breeding ground for some of the biggest problems. Harris County has a history of flooding, and the flooding over recent years has gotten worse and worse.

In August 2017, Hurricane Harvey hit the Gulf Coast and caused widespread destruction to the city. This historic flood included extreme rainfall, catastrophic flooding, and losses above \$125 billion. The estimated rainfall from Hurricane Harvey was over 60 inches across Texas, with over 35 inches falling across Harris County in a four-day span as it crept across the state.

This flooding during this storm was possibly heightened by the increasing amount of urbanization and an increase in the population of the city. The county has seen a nearly 10% increase in population since 2010. With a growing population comes increased infrastructure to support the growing city. An average of 40% of the city is impervious surfaces.

Impervious cover is defined as any human-made surface that does not absorb rainfall, like cement roads, parking lots, business offices, and homes. In a city already prone to devastating flooding, high rates of impervious cover will only increase damage due to flooding

## **2 Problem:**

This study will try to find some reasons that may increase the potential for flooding in Harris County, Texas. In this project, I will explore a possible relationship between elevation and high impervious cover for flood zones in Harris County, as well as the hazards for those increasing factors. Additionally, by using the existing Harris County floodplain shown in Figure 1, the predefined risk of flooding will be compared with those factors.

factors. By understanding how impervious cover, elevation, and floodplain data are related, we can be better prepared for any future flooding. I expect to find that high percentages of impervious cover will be related to higher flood risk, lower elevation, and being closer to water sources. A relationship between impervious cover and flooding has been studied previously by the USGS, who concluded that it increases the severity of flooding in areas with higher impervious cover.

Cover percentages decreased as the amount of potential infiltration decreased. The FEMA Flood maps, and Harris County impervious cover data were utilized as well as the ArcMap and ArcGIS software to analyze this data.

### **3 Methods:**

To understand flood risk in Harris County a three-part analysis was performed using data on impervious cover, elevation, and floodplain. The impervious data came from the City of Houston (Figure 3), the elevation data from the National Elevation Dataset (Figure 2), and the floodplain data from FEMA (Figure 1). Figure 4 displays final analysis and looks at a relationship between impervious cover and flood zones.

Comparisons between impervious cover, elevation, and floodplain will provide how these factors correlate with each other, as well as the most highly susceptible flood-risk areas of Harris County.

### **4 Data Collection:**

Harris County Boundary Shapefile:

<https://hub.arcgis.com/datasets/HarrisCounty::hcad-harris-county-boundary>

Source: HCAD GIS data set

Projection: NAD 1983 State Plane Texas South Central FIPS 4204 Feet

Harris County Impervious Cover data:

<https://www.h-gac.com/land-use-and-land-cover-data>

Source: City of Houston; SIMMER project

Projection: NAD 1983 State Plane Texas South Central FIPS 4204 Feet

National Elevation Dataset (NED):

<https://data.tnris.org/collection?c=e0ead9bd-0c01-4716-97e9-808ec330afd2&geo=-96.37660956318744,28.987439486172647,-94.58389897188562,30.714047019565243#4.54/31.43/-100>

Source: Texas National Elevation Dataset

Projection: NAD 1983 UTM Zone 15N

Harris County Floodplain Data:

<https://h-gac.sharefile.com/share/view/s3afeac2a3314e4bb>

Source: FEMA 2015 Floodplain

Projection: NAD 1983 State Plane Texas South Central FIPS 4204 Feet

## **5. Data Preprocessing:**

In an empty ArcMap document, a topographic basemap layer was added. The downloaded Harris county shapefile was then added to the map. The shapefile was originally in WGS84 format. projection however, it was later reprojected to the NAD 1983 State Plane Texas South Central FIPS. 4204 feet, to match the projections from the other files used.

The basemap was then clipped to extend to the boundary of the Harris County shapefile (Data). Frame Properties → Data Frame Tab → Clip to shape → select shape → outline of features "county.shp."

## **6 Data Processing: Impervious Cover**

Impervious data coverage was downloaded from ArcGIS online to the local geodatabase. The file was clipped (Toolbox → Analysis Tools → Extract → Clip → Input Features: Impervious Cover.shp → Output Features: County Boundary.shp). The symbology of the data was then changed to a natural break's method (Layer Properties → Symbology → Quantities → Classification, Classify → Method: Natural Breaks → Classes: 3). The natural breaks of the Classes were then divided into three different groups: low, medium, and high percentage coverage..

"Impervious Coverage Levels Based on Natural Breaks in Percent Impervious Cover" can be best articulated by the following writing in the passage format. Impervious cover levels are classified into three classes based on natural breaks in the distribution of percentage of impervious cover. The Low impervious cover level corresponds to a range from 0% to 38%, while the Medium impervious cover level goes from 38% to 58%. Lastly, the High impervious cover level includes values between 58% and 92%.

## **6 Data Processing: FEMA Floodplain**

The FEMA floodplain data extended beyond the boundaries of Harris County; the file was then clipped by (Toolbox → Analysis Tools → Extract → Clip → Input Features: FEMA floodplain.shp → Output Features: County Boundary (.shp)). The resulting map demonstrated the floodplain data held within. the border of Harris County, which was represented by one color. The symbolism was altered to be represented by the flood zones, as shown in Table 2. Values for A, AE, and AO were collapsed into one category because they all represented the same zone, but are divided by several measurement forms

Description of floodplain types according to FEMA 2015 In prose, the table can be stated as: Floodplain types are categorized based on the criteria developed by FEMA in 2015. The FLD\_ZONE X is described as areas that lie outside of the 100-year floodplain. The zones A, AE, and AO are described as areas that are within the 100-year floodplain. Lastly, the VE zone refers to areas that are within the 100-year floodplain but involve coastal hazards.

## **6 Data Processing: Elevation**

The elevation dataset was downloaded from the National Elevation Data web site. The files were displayed as individual raster tiles. All six tiles were downloaded to ensure the coverage of the edge of Harris County. The six tiles were loaded into an empty ArcMap document and then stitched together into a new layer file using the Mosaic to Raster tool in the Data Management toolbox (Toolbox → Data Management Tools → Raster → Mosaic to New Raster). The new raster was added to the map document as a second layer and then clipped to match the base Harris County boundary shapefile Data Management Tools → Raster → Raster Processing → Clip).

## **6 Data Processing: Impervious Surface and Floodplain**

A blank map document was created, and both the impervious cover shapefile and floodplain Shapefiles were imported. To analyze their relationship, it is essential that both be transformed into Raster files can be created using the Feature to Raster tool, by selecting Impervious Cover for input.shp Floodplain .shp → Field: percentIMP, FLD\_ZONE → Output Raster: imp\_raster, flood\_raster). Both files are now raster files, and can be manipulated and reclassified by ranking. The ranks given to each property below are shown. The reclassify tool was used to change the values of the new rankings, (Spatial Analyst Tools → Reclassify → Input Raster: Impervious %, Flood Zone → Reclass Field: percentIMP; FLD\_ZONE → Reclassification: values in . A new layer will be added to the map TOC along with the ranking values that were just created.

### **Impervious Cover Rankings**

Impervious cover values are ranked based on their coverage percentages. **Low impervious cover (0% - 38%)** is assigned a **rank of 1**, while **Medium impervious cover (38% - 58%)** is ranked as **2**, and **High impervious cover (58% - 92%)** is given a **rank of 3**.

### **Flood Zone Rankings**

Flood zones are ranked based on the likelihood of flooding. **Zone X**, which is outside the 100-year floodplain, is ranked as **1**. The zones **A, AE, and AO**, located within the 100-year floodplain, are assigned a **ranking of 2**. Lastly, **Zone VE**, representing areas within the 100-year floodplain with coastal hazards, is given a **ranking of 3**.

Finally, to evaluate the probability of flooding related to the floodplain and impervious surfaces cover percentage, the two reclassified rasters will be input in the raster calculator tool, (Spatial Analyst Tools → Raster Calculator → "flood\_reclass" + "imp\_reclass"). The calculation will result in a new layer being added to the map Table of Contents (TOC). The symbology was updated to follow a gradient display, light green is associated with lower rankings and dark blue is associated with higher Rankings. To be able to have a number value in the resulting data, another field was added to the attribute table; area in square miles. To do this, the attribute table of the new raster Calculation file was opened. (Table Options → Add Field → Name: Area Type: Long Integer). After generating the new field, the field calculator can be used (Field Calculator → Area = Cell). The formula for Size squared times Count will be the area for each ranking, which is then enumerated.

The table titled "Raster calculation of area of each final ranking" can be described in passage form as follows:

The raster calculation provides the area in square feet for each final ranking. The area for **ranking 2** is **9,731,083,499 square feet**, while **ranking 3** covers an area of **10,701,160,360 square feet**. For **ranking 4**, the area is **5,199,005,670 square feet**, and **ranking 5** has an area of **560,825,684.5 square feet**.

## 7. Results and Conclusion

As can be seen in the tables above, after computing the rankings, the lower figures are coupled with Flood Zone X and low impervious surfaces. The central part of the county is composed of having a higher percentage of impervious cover (Figure 3), and this pattern is again seen as shown in Figure 4. The rank that covered the most ground was rank 3 (Table 5); this can be explained by low. Impervious cover and flood zone X are outside the 100-year flood zone. This is shown in Figure 4 as a light. green color, this is primarily in the suburbs of Harris county. High impervious cover, likelihood Flooding and low infiltration go hand in hand with urbanization and, therefore, are focused. in the central downtown core of the city. While rank 5 (Table 5) is the smallest area of Many are worried about those risks in the county as it is densely populated. In analyzing the floodplain in Harris County and its impervious cover, my The data supports the hypothesis outlined in Section 2. Figure 4 displays the rankings of impervious cover and risks of different flood zones. By cross-referencing Figures 3 & 4, it becomes clear Both follow the same trend, therefore substantiating the statement that high impervious cover

Corresponds to increased risk for flooding. They show that the population trends in Harris County are increasing over time. That means the impervious cover is probably going to keep on growing, as are the risks that come with it. associated with lower infiltration rates. The

elevation pertinent to Harris County is displayed in Figure 2. According to the legend, The elevation of the county ranges between -7 meters and 98 meters above sea level. This variation is of great importance for creating floodplain maps because these areas are also associated with higher risk of flooding.

A comparison of Figures 1 and 2 reveals that the flood areas A, AE, AH, and AO are zones. within the 100 year floodplain, follow the watercourses as well as the lower elevation areas. This Correlation helps in the making of flood plain maps and hazard mitigation. The city of Houston has taken steps to mitigate the impact of increased

urbanization and impervious cover through the construction of new water-drainage systems. Flood damage Structural measures after the disastrous consequences of Hurricane Harvey include channel improvements, storm water retention, and levee implementation. Bayous are one of Houston's natural water drainage systems. The most common solution at present is channel modification. The city is now currently re-engineering these water drainage systems to be more efficient especially during catastrophic storms by widening or deepening the channels, building them with materials Not only concrete removal but also the woody vegetation removal is essential. Stormwater basins and levees are more Planning might be challenging due to the low space in the city; however, it might be beneficial for low-density areas. infiltration and water drainage systems.

Figure 1: FEMA Floodzones for Harris County

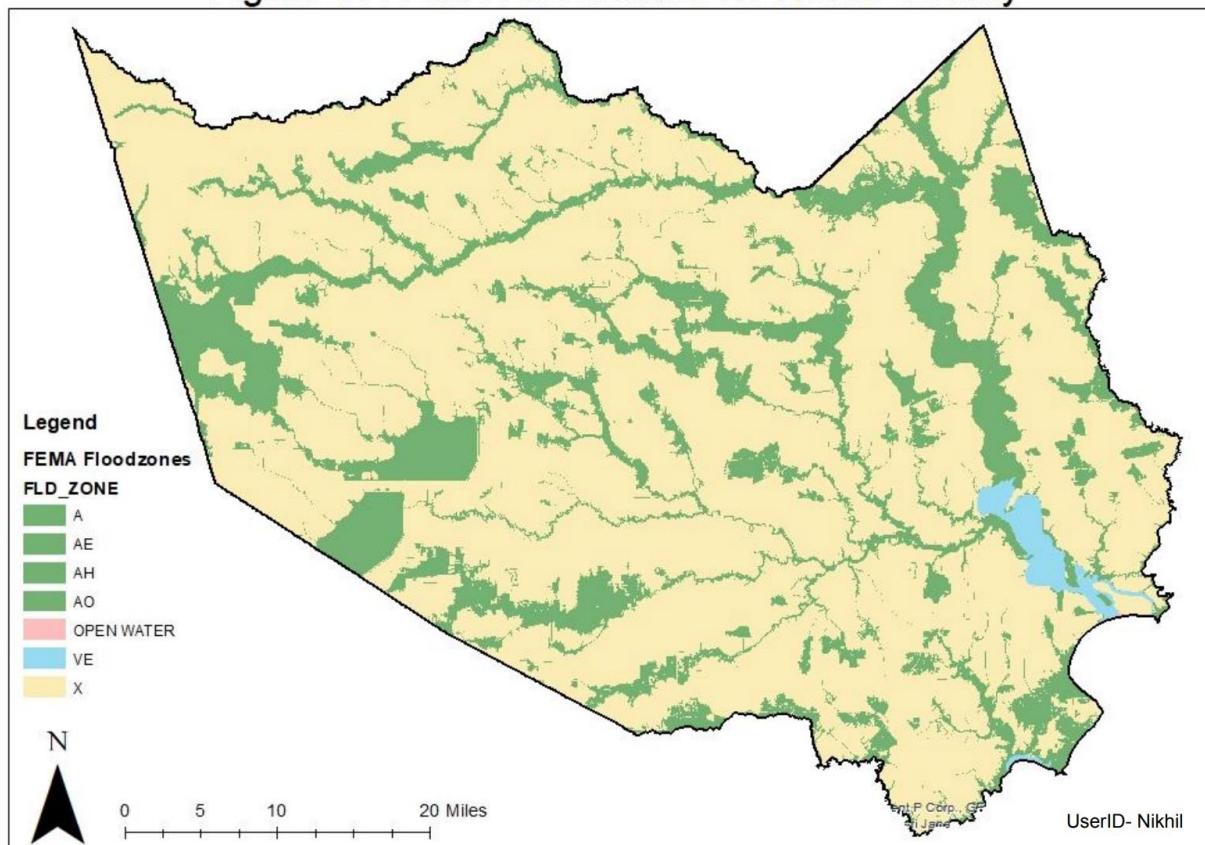


Figure 2: Elevation Map for Harris County

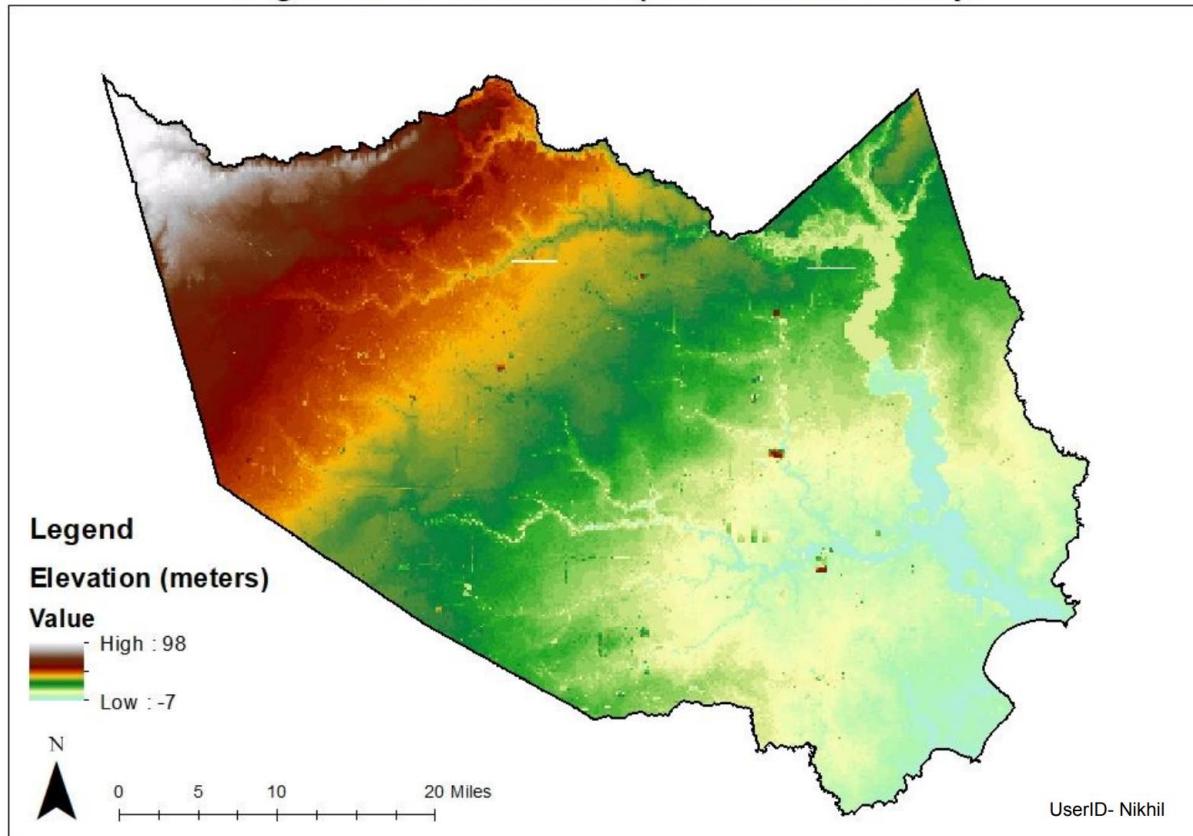


Figure 3: Impervious Cover in Harris County

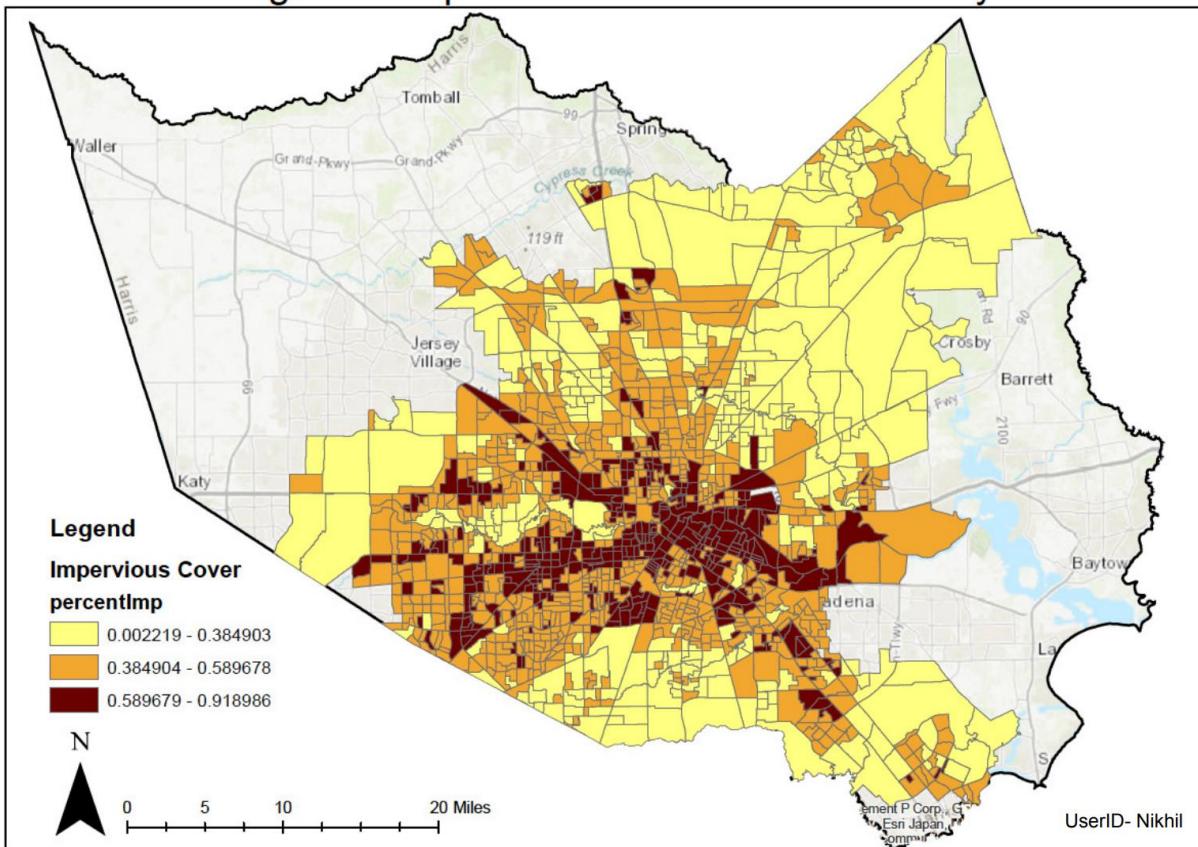


Figure 4: Flood Zone and Impervious Cover

