Data Analysis Report

Resilient Housing Study

TEXAS GENERAL LAND OFFICE

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INTRODUCTION

OVERVIEW OF THE RESILIENT HOUSING STUDY

The Texas General Land Office – Community Development and Revitalization (GLO-CDR) is taking a leading approach to state management of Federal Emergency Management Agency (FEMA) dollars and the expansive, long-term vision for what U.S. Department of Housing and Urban Development (HUD) Community Development Block Grant – Disaster Recovery (CDBG-DR) funds can accomplish. By providing resilient homes to impacted families, resiliency is improved at both the household and community levels, while also protecting the public investment in homes constructed or repaired under CDBG-DR-funded housing programs.

As part of this effort, the GLO-CDR is conducting the Resilient Housing Study (the Study), a multi-faceted community and housing resilience assessment of CDBG-DR housing programs implemented in the State of Texas and across peer states since Hurricane Ike in 2008. This evaluation of the full scope of housing programs is conducted through assessments of construction standards and processes, cost-effectiveness, economic and social impacts, among others. The goal of the Study is to generate a comprehensive understanding of the resilience of post-disaster housing programs in order to improve upon and highlight best practices for use in future programs. This effort will ultimately support the State of Texas' long-term vision of promoting increased resilience across the State and nationwide.

OVERVIEW OF DATA ANALYSIS REPORT

An integral part of the Study, the Data Analysis Report provides an assessment of how GLO-CDR programs have supported long-term community and housing resiliency. This assessment is completed by assessing resilience impacts through three complementary analyses of GLO-CDR CDBG-DR housing programs since Hurricane Ike in 2008:

- **Spatial Analysis**: A geospatial assessment of how GLO-CDR housing program resilience has evolved across disasters under different construction standards and codes.
- **Loss Avoidance Study**: A quantitative assessment of losses avoided in Texas due to adopting I-Codes to determine the cost savings of adopting resilient housing codes and standards.
- **Cost-Benefit Analysis**: An evaluation of the cost-effectiveness of building approaches utilized across GLO-CDR housing programs to support long-term community resiliency. The Cost-Benefit Analysis is developed with data pulled from the results developed in the Spatial Analysis and the Loss Avoidance Study.

The results of the Data Analysis Report are presented as a series of key takeaways, goals, objectives and recommendations to improve cost-effectiveness and resilience in GLO-CDR implementation of future allocations of CBDG-DR funds, located in the **Conclusion** section.

PURPOSE

The purpose of the Data Analysis Report is to provide a series of assessments that will help guide policy makers and post-disaster housing program leaders in prioritizing more resilient and cost-effective codes and standards across Texas. Reviewing GLO-CDR post-disaster housing programs can help highlight the ways future housing construction can prioritize resilience measures. The results gathered and presented in this report serve to demonstrate the benefits and importance of employing resilient codes and standards not just within post-disaster housing programs, but in general housing construction across Texas.

In order to carry forward the purpose of the Data Analysis Report, the Study team has highlighted a series of priorities, which were influenced by takeaways noted by representatives engaged in the outreach process (see **Outreach Key Takeaways** below). These priorities are as follows:

- Understanding the relationship between cost-effectiveness and resilience;
- Analyzing the cost-effectiveness of past and current GLO-CDR post-disaster housing solutions; and
- Identifying ways of improving cost-effectiveness and resilience in GLO-CDR implementation of future allocations of CBDG-DR funds (e.g., improving codes, increasing stakeholder coordination).

These priorities guide not only the analyses developed as part of the Data Analysis Report but also the concluding policy recommendations (see **CDBG-DR Policy Recommendations**).

OUTREACH KEY TAKEAWAYS

As part of the Study, the Team completed a series of interviews with representatives involved in the development and implementation of post-disaster housing construction across the United States, including federal, private and non-governmental entity (NGO) officials. The outreach process conducted as part of the Study highlighted the following key takeaways related to post-disaster cost-effectiveness and resilience of post-disaster housing construction:

Table 1: Outreach Key Takeaways

Comprehensive Definition of Resilience	• In addition to social and hazard resilience, it is critical to incorporate resilience on a maintenance level as maintenance and upgrade costs critically affect long term housing sustainability. • The impact of insurance and education on community resilience needs to be considered.
Balance between Cost-Effectiveness and other Factors	• It is important to utilize cost-effective strategies for increasing resilience so resilient homes remain affordable. • The construction of more resilient and better designed homes may lead to higher property taxes for the beneficiaries, which can ultimately be detrimental to the long-term sustainability of the housing solutions (e.g., increasing the likelihood of displacement).
Cost-Related Barriers to Increased Resilience	• Homeowner association gridlocks, city requirements, local ordinances, elevation imperfections, increasing costs, time, and labor are barriers to increasing resilience. • It is often more expensive to rebuild in rural areas than urban areas because building materials and contractor and labor costs are higher, but the units sell for less because of the lower property values in rural areas.
Stakeholder Coordination	• Coordination of resilient construction practices across builders and the real estate industry (i.e., realtors and appraisers need to evolve their practice to value resilient construction) can help increase cost effectiveness and affordability. • Coordination with designers and engineers can help ensure designs are cost-effective and easy to build. This is especially critical when considering the untrained labor that often needs to be used in post-disaster construction (e.g., volunteers, or other available labor). • Coordination with local stakeholders can help streamline the construction process and reduce the need for changing and/or updating construction. • Coordination across all stakeholders can be a barrier to increasing resilience and cost-effectiveness, since stakeholders have different interests and definitions of resilience and cost-effectiveness.
Production Process	• Construction resilience is dependent on the supply chain of availability of high-quality materials that can increase resiliency, such as exterior housing materials used to protect against wildfires.

	• Cost-effectiveness and resilience are affected by the production process of post-disaster homes, which requires companies to scale up quickly to respond to the need. In a tight construction market it is difficult to scale up without compromising quality.
Codes	• Standardization and clarity of codes and specifications would significantly increase housing affordability. • Coordination with local codes and ordinances can help streamline the construction process and reduce the need for changing and/or updating construction. • Cost of increasing resilience is affected by the labor required for states and communities to adopt standards and for customization to meet local needs and requirements.

SCOPE

The analyses included in this report utilize a broad range of sources. These range from geospatial databases of GLO-CDR post-Ike CDBG-DR programs and census data for the Spatial Analysis, to construction specifications, building codes, and financial databases for the Cost-Benefit Analysis. These datasets are complemented by qualitative and anecdotal information captured though outreach. Although the Study team strived to build these analyses from a comprehensive pool of data, the data used in this report is not all-inclusive.

The priorities of the analysis (e.g., the prioritization of relevance to Texas post-Ike housing programs) and lack of available data resulted in a series of data gaps and exclusions. Refer to **Appendix C: Data Scope Inventory** for a full list of the data sets utilized in the Data Analysis Report, as wells as key gaps and exclusions. Additionally, aggregated data, analyzed data, and other data sets not provided by GLO-CDR will be provided in a digital folder that can be accessed through **Appendix E: Data Analysis Report Annex.**

METHODOLOGY

OVERVIEW

The Data Analysis Report was developed through the three analyses defined in the introduction. Each of the three analyses included in the Data Analysis Report result in independent conclusions and data sets regarding the resilience of GLO-CDR housing programs. Additionally, results from the Spatial Analysis and the Loss Avoidance Study are utilized to build out the Cost-Benefit Analysis (see **Figure 1**).

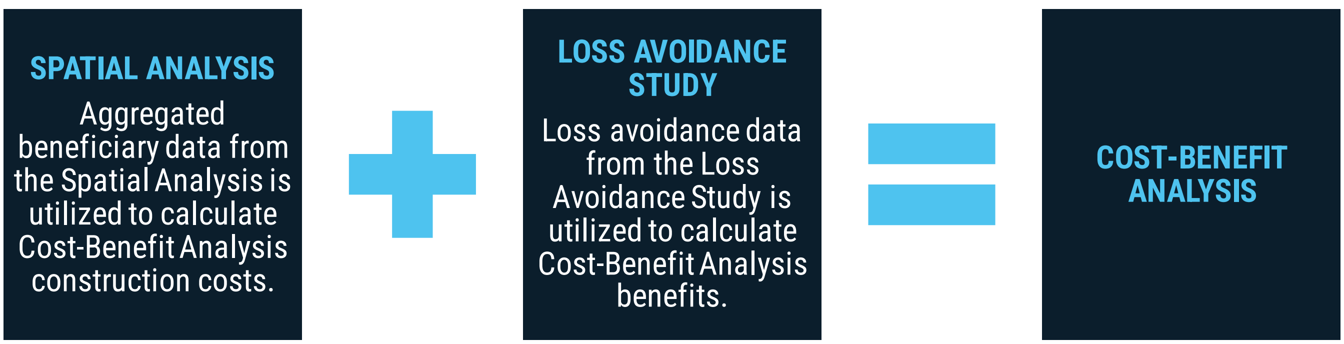

Figure 1: Relationship of Data Analysis Report Analyses

The Study team then pulled a series of key takeaways from these three analyses to highlight the more relevant and useful observations developed therein. In an effort to better frame these key takeaways, the Study team further contextualized these data-driven takeaways with additional factors and/or information relevant but not qualitatively assessed in the Study (e.g., factors that might affect potential skews, inconsistencies, or biases in the results). These observations are summarized in the **Key Takeaways** section at the end of this report.

SPATIAL ANALYSIS

The Spatial Analysis is a geographic and socioeconomic impact assessment of CDBG-DR funded programs and activities across the State of Texas. This analysis was conducted using Geographic Information Systems (GIS) capabilities, for the purpose of analyzing a geospatially accurate dataset of CDBG-DR beneficiaries. The goal of the Spatial Analysis is to draw correlations between CDBG-DR funds and the geospatial location of beneficiaries.

CDBG-DR funds and the geospatial location of beneficiaries were assessed across the following variables for a comparative analysis:

- Disasters;
- Counties;
- GLO-CDR programs (see **Appendix C: Data Scope Inventory** for full list of programs included in this analysis);
- Activities;
- Physical characteristics (i.e., National Flood Risk Index [NFRI], soil type, and elevation);
- Socio-economic demographics (i.e., Social Vulnerability Index [SVI] and poverty rates); and
- Repetitive loss properties.

For a step-by-step breakdown of the process, refer to the following subsections.

Step 1: Data Collection

The data collected for the Spatial Analysis resulted in the following framework:

- **CDBG-DR allocation data**: CDBG-DR allocations mapped to specific beneficiary or subrecipient locations, disasters, programs, and activities. This data is sourced from GLO-CDR program documentation.
- **Supplemental geographic and socioeconomic data**: This data is used for comparative analysis against GLO-CDR program documentation, and consists of relevant datasets sourced from federal, state, and local sources. Supplemental data used for the Spatial Analysis includes data as outlined in **Table 2**.

Table 2: Supplemental Geographic and Socio-Economic Data

Associated Comparative Analysis	Data Topic	Data Source	Description of Data
Physical Characteristics of Region	Flood Risk	FEMA National Risk Index	A geospatial map illustrating FEMA's NFRI at the county level
	Soil Type	United Stated of America Soil Survey Geographic Database (USA SSURGO) - Soil Hydrologic Group	A geospatial map illustrating soil type as grouped by USA SSURGO (See

Associated Comparative Analysis	Data Topic	Data Source	Description of Data
			Appendix B: Definitions for groupings)
	Elevation	U.S. Geological Survey's (USGS) National Elevation Dataset	A geospatial dataset that contains geospatially accurate elevation level information in meters
Socio-Economic Demographics	Social Vulnerability	Centers for Disease Control and Prevention (CDC) SVI	A geospatial map illustrating vulnerable populations, based on SVI.
	Poverty Levels	United States Census Bureau American Community Survey (ACS)	A geospatial map illustrating poverty levels by county.

To view the full datasets used throughout this report, see **Appendix D: Data Analysis Report Resources** and **Appendix E: Data Analysis Report Annex**.

The primary data used in the Spatial Analysis is the CDBG-DR allocation data. The Study team collected CDBG-DR allocation data in several rounds to resolve data gaps identified throughout the data collection process. Additionally, supplemental geographic and socioeconomic data was used for a comparative analysis against the primary data (i.e., CDBG-DR allocation data). The Study team collected supplemental geographic and socioeconomic data deemed to be relevant, reliable, and as up to date as possible.

Step 2: Data Cataloging and Aggregation

As the CDBG-DR allocation data was collected in the form of disparate documents and workbooks, all GLO-CDR program documentation was first catalogued. All GLO-CDR program documentation was inventoried by the Study team for relevancy and completeness. If determined complete (i.e., no major data gaps, most up to date as possible) and relevant to the Spatial Analysis, data was aggregated into two datasets:

- **CDBG-DR beneficiary data:** The primary dataset in the Spatial Analysis. This dataset consists of information pertaining to CDBG-DR funding that went to beneficiaries (i.e., homeowners who received direct CDBG-DR funds). Each line items contains the following information:
    - Beneficiary address (i.e., exact address);

  - CDBG-DR allocation amount;
  - The disaster that impacted the beneficiary;
  - The program that funded the allocation; and
  - The activity performed with the allocation (e.g., reconstruction, rehabilitation, demolition).
- **CDBG-DR subrecipient data:** This supplemental dataset provides additional context to the Spatial Analysis. This dataset consists of information pertaining to CDBG-DR funding that went to subrecipients (e.g., Harris County, Lower Rio Grande Valley Council). Each line items contains the following information:
  - Subrecipient location information (i.e., city or county);
  - CDBG-DR allocation amount;
  - The disaster that impacted the beneficiary;
  - The program that funded the allocation; and
  - The activity performed with the allocation (e.g., reconstruction, rehabilitation, demolition).

Step 3: Data Cleaning and Transformation

Prior to transforming the CDBG-DR beneficiary data into a geospatial dataset, standard data cleaning measures were utilized to control inaccurate and incomplete data, as follows:

- **Inaccuracy controls:** Inaccurate line items were identified and removed. Inaccurate line items consisted of duplicate data entries and data entries connected to irregular addresses (i.e., P.O. Boxes, Rural Routes Boxes). In the case of duplicate data, the most recent data was deferred to, while line items represented by containing irregular addresses were removed from the dataset.
- **Incompleteness controls:** Data gaps were identified and resolved. During the data aggregation process, most of the data gaps were resolved (i.e., missing program, activity, or allocation data), but some data gaps remained unresolved. Line items containing unresolved data gaps (e.g., funding allocation and location data, with missing disaster and program data) were removed from the master dataset used for Spatial Analysis.

Once cleaned, the CDBG-DR beneficiary data was transformed into a geospatial dataset. Using GIS capabilities, each line item of the dataset was attributed with longitude and latitude coordinates. Using these coordinates, an additional round of data cleaning was performed to remove any duplicate line items that were originally missed in the first round of data cleaning. Repetitive loss properties were identified at this time and pulled out to later analyze for significance.

Step 4: Comparative Analyses

After collecting, cataloging, aggregating, cleaning, and geospatially transforming primary data into one dataset (i.e., the geospatially accurate CDBG-DR beneficiary dataset), the additional supplemental data was utilized to analyze CDBG-DR funds from geographic and socioeconomic perspectives. The purpose of this step of the Spatial Analysis was to provide context to the primary data and draw correlations regarding geographical and socioeconomic trends.

Comparison Across Disasters

The Study team identified insights regarding CDBG-DR beneficiary funding allocations through the following process:

1) Aggregating funding allocations by disaster;
2) Conducting a geospatial analysis of where disasters occurred;
3) Layering geospatial CDBG-DR allocation data with supplemental socioeconomic and geographic data; and
4) Capturing insights about the impacts of disasters, regarding population demographics and physical characteristics of the regions.

Comparison Across Counties

CDBG-DR allocations were assessed at the county level to identify funding trends across the state. The Study team identified insights about CDBG-DR beneficiary funding allocations through the following process:

1) Aggregating funding allocations at the county level;
2) Identifying CDBG-DR allocation funding ranges at the county level;
3) Producing a funding heat map (see **Map 2**) that illustrates funding allocations across counties; and
4) Collect additional insights about the number of beneficiaries within counties who received CDBG-DR funding.

Comparison Across Programs Implemented

The Study team identified insights about CDBG-DR beneficiary funding allocations across programs through the following process:

1) Aggregating funding allocations by CDBG-DR program; and
2) Conducting a geospatial analysis of where CDBG-DR programs were implemented.

Comparison Across Program Activities

The Study team identified insights about CDBG-DR beneficiary funding allocations across activities through the following process:

1) Aggregating funding allocations by CDBG-DR activity; and
2) Conducting a geospatial analysis of where CDBG-DR activities were implemented.

Comparison Across Physical Characteristics in the Region

The Study team identified insights about CDBG-DR beneficiary funding allocations across physical characteristics, by integrating the supplemental data listed in **Table 2**: Supplemental Geographic and Socio-Economic Data.

NATIONAL FLOOD RISK INDEX

The geolocation of funded projects and their proximity to flood risk was illustrated through the following process:

1) Layering NFRI data on the geospatially accurate CDBG-DR beneficiary dataset, produce a map; and
2) Aggregating project data by NFRI score to extract funding insights.

SOIL TYPE

The geolocation of funded projects in relation to soil type was illustrated through the following processes:

1) Layering USA SSURGO data on the geospatially accurate CDBG-DR beneficiary dataset, to produce a map; and
2) Aggregating project data by soil group to extract funding insights.

ELEVATION

The geolocation of funded projects in relation to elevation levels was illustrated through the following processes:

1) Layering USGS elevation data on the geospatially accurate CDBG-DR beneficiary dataset, to produce a dataset; and
2) Aggregating project data by elevation level in meters compared to sea level, to extract funding insights.

Comparison Across Socio-Economic Characteristics

The Study team identified insights about CDBG-DR beneficiary funding allocations across socio-economic characteristics, by integrating the supplemental data listed in **Table 2**.

SOCIAL VULNERABILITY INDEX

The CDC SVI utilizes 16 U.S. census variables to assist officials in identifying communities that may need support before, during, or after disasters. SVI values are calculated from zero to one. Higher values indicate increased social vulnerability within the specified community. The geolocation of funded projects in relation to vulnerable communities at the county level, was illustrated through the following processes:

1) Layering 2018 CDC SVI data on the geospatially accurate CDBG-DR beneficiary dataset, to produce a map; and
2) Aggregating project data by SVI score to extract funding insights.

POVERTY RATE

Poverty rates are calculated by the U.S. Census Bureau by comparing a family's total income with the current poverty threshold. A low poverty rate calculation number indicates a high level of poverty. The geolocation of funded projects in relation to poverty rates at the county level was illustrated through the following processes:

1) Layering 2020 ACS poverty rate data on the geospatially accurate CDBG-DR beneficiary dataset, to produce a map; and
2) Aggregating project data by poverty rate to extract funding insights.

Comparison Across Repetitive Loss Properties

CDBG-DR beneficiaries identified as recipients of funding across multiple disasters were stored in a geospatially accurate repetitive loss dataset. Insights about CDBG-DR beneficiaries who experienced repetitive loss were extracted through the following processes:

1) Layering the repetitive loss beneficiary dataset with NFRI data to produce a map showing proximity between repetitive loss properties and flood risk;
2) Layering the repetitive loss beneficiary dataset with USA SSURGO data to produce a map showing proximity between repetitive loss properties and soil type;
3) Layering the repetitive loss beneficiary dataset with CDC SVI data to produce a map showing correlations between repetitive loss properties and vulnerable communities; and

4) Layering the repetitive loss beneficiary dataset with ACS poverty rate data to produce a map showing correlations between repetitive loss properties and poverty rates.

LOSS AVOIDANCE STUDY

The Study team conducted the Loss Avoidance Study to determine if adopting resilient housing codes and standards results in savings for CDBG-DR housing programs in the State of Texas. The results of the Loss Avoidance Study will inform recommendations to the GLO-CDR which can be implemented in future allocations of CDBG-DR funds. The avoided losses are calculated using data from FEMA's *Building Codes Save*[1] nationwide study on the losses avoided from adopting hazard-resistant building codes, such as those in the I-Codes. This report analyzed flood, hurricane wind, and seismic hazard construction specifications across the United States. The Study team did not include seismic data in this report as it was not considered applicable to the State of Texas.

BUILDING CODES SAVE

FEMA conducted a comprehensive nationwide study by evaluating buildings constructed prior to the first iteration of the I-Codes (pre-2006) to 2018 and compared the estimated losses from pre-I-Code construction to estimated losses built to the actual I-Code at the time of construction. The calculated AAAL is used throughout the study.

The result of these calculations is the Average Annual Avoided Losses (AAAL) by county in the State of Texas. The AAAL is a calculation of the avoided loss from adopting I-Codes as it relates to flood and wind resilient construction specifications for CDBG-DR funded housing programs. The AAAL results are the baseline for the Cost-Benefit Analysis.

The Study team developed a comprehensive tiered adjustment of the AAAL results. This was used to conduct the Loss Avoidance Analysis through a series of comparative analyses. These results are compared across the following:

- Counties;
- I-Code edition year;
- Flood, wind, and general resilience codes; and

[1] Building Codes Save: A Nationwide Study – Losses Avoided as a Result of Adopting Hazard-Resistant Building Codes, November 2020

- Counties with disaster declarations.

For a step-by-step breakdown of the process, refer to the following subsections.

Step 1: Develop Tiered Adjustments

The Study team developed a tiered adjustment of AAAL values (referred to throughout this document as AAALs) to account for earlier I-Code edition years and create a comprehensive picture of the effectiveness of I-Code edition across GLO-CDR housing programs. The I-Codes are cataloged for each year (2006, 2009, 2012, and 2015)[2] , then each code section was compared chronologically to identify key differences.

To determine the tiered adjustment of each I-Code edition year, the Study team completed the following steps:

1) Determined the total flood, wind, and general resilience building codes in the I-Code catalog;
2) Assigned a score (0, 1, 3, 5) to each I-Code that reflects the relative importance of each code change to improve flood and wind resilience;
3) Determined the total quantity of each assigned score; and
4) Approximated the distribution of the AAAL data for all Texas counties.

The tiered adjustment results shown in **Table 3** represent the total number of relevant I-Codes (e.g., flood, wind) in that particular year divided by the total number of relevant I-Codes updates across all years.

Table 3: AAAL Adjustment

I-Code edition Year	Number of Relevant Codes	Adjustment (%)
	Flood	
2006	249	20
2009	303	44
2012	325	70
2015	367	100
	Wind	
2006	207	21

[2] The 2018 I-Codes were cataloged but excluded from this analysis as the State of Texas had not implemented these codes in any of their housing programs.

I-Code edition Year	Number of Relevant Codes	Adjustment (%)
2009	240	46
2012	239	70
2015	284	100

Step 2: Develop General Resilience Tiered Adjustments

In addition to analyzing the avoided losses of flood and wind resilient I-Codes, the Study team totaled the number of resilient flood, wind, and other I-Codes into a final comprehensive category: general resilience. Other I-Codes are those related to room size requirements, energy efficiency, fire safety, insulation, utilities, and other construction specifications not specifically tied to flood or wind resilience. While the focus of the Study is flood and wind resilience in CDBG-DR funded housing programs, the general resilience category was created as the grand total of all I-Codes to calculate the losses avoided across all construction specifications. Similar to the flood and wind I-Codes, the general resilience code savings are adjusted based on the 2015 I-Code edition to previous editions. The tiered adjustment results displayed in **Table 4** represent the total number of I-Codes (i.e., flood, wind, other) divided by the total number of I-Codes and I-Code updates across all years.

Table 4: General Resilience AAAL Adjustment

I-Code Edition Year	Number of Relevant Codes	Adjustment (%)
2006	630	21
2009	721	45
2012	749	71
2015	856	100

Step 3: Comparative Analyses

Comparison Across Counties

The Study team observed several counties in Texas were calculated as having little or no AAAL. To conduct a well-rounded analysis, the Study removed counties that presented a total AAAL of $1.00 or less. This elimination removed a total of 160 counties from the Loss Avoidance Study. The full list of eliminated counties may be found in **Appendix F: Counties Eliminated from the Loss Avoidance Study**. In the FEMA *Building Codes Save* report, the reasoning behind these low values for some counties in Texas can be attributed to gaps in their data collection process. Some areas of the country (e.g., rural areas) did not have sufficient building permit or building code information for inclusion in the national study.[3]

For the 94 counties that had AAAL's above $1.00, the Study team compared counties against each other to determine where savings from adopting the I-Codes are highest and lowest in the State of Texas. In the analysis, the Study team pulled the top five highest and five lowest AAAL's as a sample within this document utilizing the general resilience AAAL. The full results of each analysis for all counties are located within their respective appendices. This approach is utilized in each subsequent analysis.

Comparison Across I-Code Edition Years

The Study team compared AAAL's across the 2006 and 2012 I-Code edition years to determine a negative or positive trend of avoided losses across counties. The programs and disasters analyzed within the Study utilized either the 2006 or 2012 I-Code edition. While the State of Texas did not adopt or utilize the 2009 or 2015 I-Codes, these values were contextually analyzed to estimate the savings under these I-Code editions.

Comparison Across Flood and Wind Codes

The Study team compared the losses avoided by I-Code edition year between resilient flood and wind codes. First, the Study team compared values by county and I-Code edition year between flood and wind to determine where savings were greater under flood and wind specific building codes. Additionally, a comparison of the total savings of adopting resilient flood and wind building codes was conducted for the entire State of Texas.

Since the general resilience code category is a total of flood, wind, and general I-Codes, an analysis between counties was completed in a preceding section of this Data Analysis Report.

Comparison Across Disasters

The Study team compiled a list of Texas' 254 counties and the corresponding disaster declarations analyzed within this Study. **Appendix G: Texas Counties and Corresponding Disaster Declarations** lists each Texas county with its corresponding disaster declaration. This list was compared against the 2015 I-Code AAAL savings for general resilience codes to determine if avoided losses correlate with the number of disaster

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[3] FEMA *Building Codes Save.* https://www.fema.gov/sites/default/files/2020-11/fema_building-codes-save_study.pdf

declarations in a county. **Table 5** displays the list of disasters assessed with their corresponding I-Codes and disaster declaration numbers.

Table 5: Disasters and I-Code Edition in Effect

Disaster Declaration	I-Code Edition in Effect	Description
Hurricane Ike and Dolly		
1791	2006	This funding encompasses Individual Assistance and Public Assistance as a result of Hurricane Ike in September 2008.
3294	2006	Additional Individual Assistance and Public Assistance funding to Texas counties that were damaged by Hurricane Ike.
1780	2006	This funding encompasses Individual Assistance and Public Assistance as a result of Hurricane Dolly in July 2008.
2011 Bastrop Wildfires		
2958	2006	This funding encompasses Individual Assistance and Public Assistance to Bastrop County as a result of the 2011 Bastrop Wildfires.
2015 and 2016 Disasters		
4223	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms, tornadoes, straight-line winds, and flooding in May 2015.
4245	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms, tornadoes, straight-line winds, and flooding in October 2015.
4269	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms and flooding in April 2016.
4272	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms and flooding in May 2016.
4266	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms, tornadoes, and flooding in March 2016.
4255	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms, tornadoes, straight-line winds, and flooding in December 2015 and January 2016.

Disaster Declaration	I-Code Edition in Effect	Description
Hurricane Harvey		
4332	2012	This funding encompasses Individual Assistance and Public Assistance as a result of Hurricane Harvey in August 2017.
2018 and 2019 Disasters		
4337	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms and flooding in June 2018.
4416	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms and flooding from September to November 2018.
4454	2012	This funding encompasses Individual Assistance and Public Assistance as a result of severe storms and flooding in June 2019.

COST-BENEFIT ANALYSIS

The Cost-Benefit Analysis was conducted after the Loss Avoidance Study to evaluate the cost-effectiveness of CDBG-DR housing programs and how different building approaches that support long-term community resiliency contribute to the cost-effectiveness of these programs. The cost-effectiveness of these approaches was determined through the development of a benefit-cost ratio (BCR). To develop the BCR, the Study team employed a three-step process outlined in the proceeding sections. These results are compared across the following:

- County; and
- I-Code edition year.

Step 1: Benefits Calculation

The AAAL data from the Loss Avoidance Study is utilized as the base data set for calculating the benefits. The Study team determined the benefits of adopting the I-Codes by weighing social benefits of resilient housing units and the FEMA Discount Rate for federally funded housing projects. The Study team used the following quantifiable indicators of resilience:

- **Social benefits:** These account for protecting residents in a community from harm as a direct result of resilient housing projects. Utilizing FEMA social benefit standards, these values are calculated for each county having an AAAL of at least $1.00 by multiplying average household size and avoided mental stress

($2,443/person), then adding the avoided lost productivity of individual working residents (assumed one worker per household at $8,736/person).

- **Project useful life:** The project useful life indicates the anticipated duration of the life cycle cost. The Study team used 30 years as the project useful life, which is the FEMA Standard value for most residential retrofit projects.
- **FEMA discount rate:** In their BCR tool, FEMA currently requires a discount rate of 7% when converting AAAL's to present value benefits over the anticipated life of a project (30 years). The Study team utilized a present value coefficient (PVC) tool to show the impact of the discount rate for project useful lifetimes.

To calculate the benefits, the Study team utilized four equations. First, the Study team calculated the PVC. The PVC is utilized to determine the present value of the annualized benefits and costs. As shown in **Equation 1**, the PVC is a product of the estimated useful life of the project and the discount rate used to account for the time value of money. Where "PVC" equals the Present Value Coefficient, "r" equals the FEMA discount rate of 7.00% and "T" is the project useful life of 30 years. The result of the PVC calculation is 12.41.

Equation 1: Present Value Coefficient (PVC) Formula

$$PVC = \left[\frac{1 - (1 + r)^{-T}}{r} \right]$$

When calculating the economic benefits, the Study team utilized the AAAL's and multiplied them by the PVC for each county as displayed in **Equation 2**.

Equation 2: Present Value of Resilient Housing Economic Benefits

Economic Benefits = AAAL x PVC = AAAL x (12.41)

To calculate the social benefits as displayed in **Equation 3**, the FEMA standard values for social benefits at $2,443/person for avoided mental stress and anxiety of individual housing residents and $8,736/person for avoided lost productivity of individual working residents were used across all counties. For each county, the average number of persons per household is integrated based on the most recent U.S. Census data. A value of one worker per household is employed as it is the FEMA default value for the average number of working residents per household.

Equation 3: Present Value of Resilient Housing Social Benefits

Social Benefits = ($2,443 x Average Number of Occupants) + ($8,736 x 1)

To calculate the total benefits for all counties, the Study team added the economic benefits and social benefits together to determine the total benefits as displayed in **Equation 4.**

Utilizing the PVC value, the Study team employed **Equation 4** to calculate the project benefits.

Equation 4: Project Benefits Formula

Total BENEFITS = Economic Benefits + Social Benefits

Once the total benefits by building was calculated, the Study team multiplied the total benefits per building by the number of buildings that received assistance from GLO-CDR CDBG-DR housing programs.

Step 2: Costs Calculation

Construction cost data was sourced from aggregated beneficiary data provided by GLO-CDR. Beneficiary data was aggregated into total construction costs across all GLO-CDR programs for each county in Texas. This data was available for 58 counties, listed in **Appendix H: Texas Counties Included in the Benefit-Cost Ratio Calculation**. Once the aggregated beneficiary data by county was pulled, the Study team expanded these cost calculations by adding an Annual Operation & Maintenance (O&M) Cost[4] and multiplying it by the PVC, as displayed in **Equation 5**. The O&M calculation is used to adjust the construction costs for anticipated maintenance costs over the life of the project.

Equation 5: Expanded Cost Calculation Formula

Total Construction Costs = Aggregated Construction Costs + (Aggregated Construction Costs * 1% O&M) * PVC)

AAAL data from the Loss Avoidance Study reflects the difference in losses avoided from building to the current I-Codes versus original pre-code building construction. In other words, the Total Benefits identified in this methodology are resilience differential benefits (i.e., the increased benefit of building to resilient codes over

[4] The O&M cost calculation is a component of FEMA's Benefit-Cost Analysis to fully estimate the project's overall investment costs in comparison to project benefits.

the baseline rebuilding benefits). Therefore, in order to provide a direct comparison of project benefits to project costs, the Total Construction Cost needs to be the "resilience differential" cost (i.e., the increased cost of resilient measures over the baseline rebuilding cost), as opposed to the entire project costs of the resilience measures.

The Study team determined that the best approach to calculate the resilience differential cost was to adjust the Total Construction Costs from aggregated beneficiary data across all GLO-CDR programs for individual buildings by the estimated percentage of cost needed to build an existing pre-code residence to current I-Codes. Since this percentage can vary based on whether the upgrade is done as part of the new construction as opposed to retrofitting, the Study team decided to use different resilience differential costs for reconstruction (i.e., rebuilding a structure on the same site) projects and rehabilitation (i.e., retrofitting a structure for elevation above the flood or storm shutters) projects.

To identify these reconstruction costs and rehabilitation costs, the Study team looked at a range of sources. The National Multifamily Housing Council (NMHC) and the National Association of Homebuilders (NAHB) recently published a joint study[5] that suggested that increased regulations by local governments accounted for 40.6% of multi-family development costs, and changes to building codes accounted for 11.1% of new housing costs. However, these findings are inconsistent with those of other studies, which show lower percentages for reconstruction. For example, a recent University of Alabama study[6] indicates that the additional construction cost of building to the Institute for Business and Home Safety (IBHS) FORTIFIED Standard for Multifamily Construction that exceeds current building codes is only within the range of 0.29% to 1.43%. The University of Alabama study is consistent with the 2019 report by the National Institute of Building Sciences (NIBS)[7] that was supported by FEMA and the ICC, which states that adding hazard-resistant building features averages less than 2% of total construction. However, given that these percentages are based on the additional cost of new construction (i.e., reconstruction) as opposed to retrofitting a structure for elevation above the flood or storm shutters (i.e., rehabilitation), the Study team conservatively assumed the resilience differential costs used in

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[5] *The 2022 NMHC-NAHB Cost of Regulations Report can be downloaded from the NMHC website:* https://www.nmhc.org/globalassets/research--insight/research-reports/cost-of-regulations/2022-nahb-nmhc-cost-of-regulations-report.pdf

[6] *The 2022 Alabama FORTIFIED Multifamily Value Study can be downloaded from the University of Alabama website:* https://alabama.app.box.com/s/4w8bahzwqgettjzayw9zo9989h9k95wm

[7] *The 2019 NIBS Report Natural Hazard Mitigation Saves can be downloaded from the NIBS website:* https://www.nibs.org/files/pdfs/NIBS_MMC_MitigationSaves_2019.pdf

the BCR to be 1.5% of the Total Construction Costs for reconstruction projects and 10% of the Total Construction Costs for rehabilitation projects. This is shown in **Equation 6**, which established total costs based on weighted average resilience differential cost.

Equation 6: Resilience Differential Cost Formula

$$\textit{Total COSTS} = \textit{Weighted Average Resilience Differential Cost} = \frac{[\Sigma(\text{Total Reconstruction Costs} \times 1.5\%) + \Sigma(\text{Total Rehabilitation Costs} \times 10\%)]}{[\Sigma(\text{Reconstruction Projects}) + \Sigma(\text{Rehabilitation Projects})]}$$

Step 3: Benefit-Cost Ratio Calculation

To calculate the BCR, the Study team divided the calculated benefits over the calculated costs by county and I-Code edition year as displayed in **Equation** . The BCR informed the Study team on the cost-effectiveness of GLO-CDR housing programs and activities.

Equation 7: BCR Formula

$$BCR = \frac{BENEFITS}{COSTS}$$

For a project to be cost-effective and eligible for funding, most federal agencies, including FEMA, require the BCR to be 1.0 or greater, meaning the benefits of project outweigh its costs. When the Study team calculated the BCR across the counties, some counties presented with a much higher or much lower BCR than other counties. This variance in BCR calculations can be attributed to counties whose calculated benefits outweigh calculated costs or vice versa. For example, Cameron County has a calculated BCR of 29.53 as their calculated benefits per building equaled $148,428 and calculated average differential construction costs per building equaled $5,027. Milam County received this high BCR score because they only received CDBG-DR funding for one project across all programs. Comparatively, Madison County received a BCR of 1.78 due to their lower average benefits of $14,842 and higher differential average costs of $8,336.

Step 4: Comparative Analyses

Comparison Across Counties

The Study team compared the BCR across the 58 counties that received CDBG-DR allocations to determine where BCR values were highest and lowest in the State of Texas. In the analysis, the Study team pulled a sample of the five counties with the highest BCR and the five counties with the lowest BCR. The full results of each analysis for all counties are in **Appendix E: Data Analysis Report Annex.** This approach is utilized in each subsequent analysis.

Comparison Across I-Code Edition Years

Utilizing the aggregated beneficiary data and AAAL tiered adjustment ratios, the Study team compared the BCR values by county against each I-Code edition year (i.e., 2006, 2009, 2012, and 2015). Beneficiary data was only available for Hurricane Ike, Hurricane Dolly, and Hurricane Harvey. Beneficiary data was unavailable for the 2011 Bastrop Wildfires, the 2015 and 2016 Disasters, the 2018 Floods, and 2019 Disasters. This analysis shows the trend of BCR values across counties from each I-Code edition year to measure the cost-effectiveness of programs under each disaster.

SPATIAL ANALYSIS

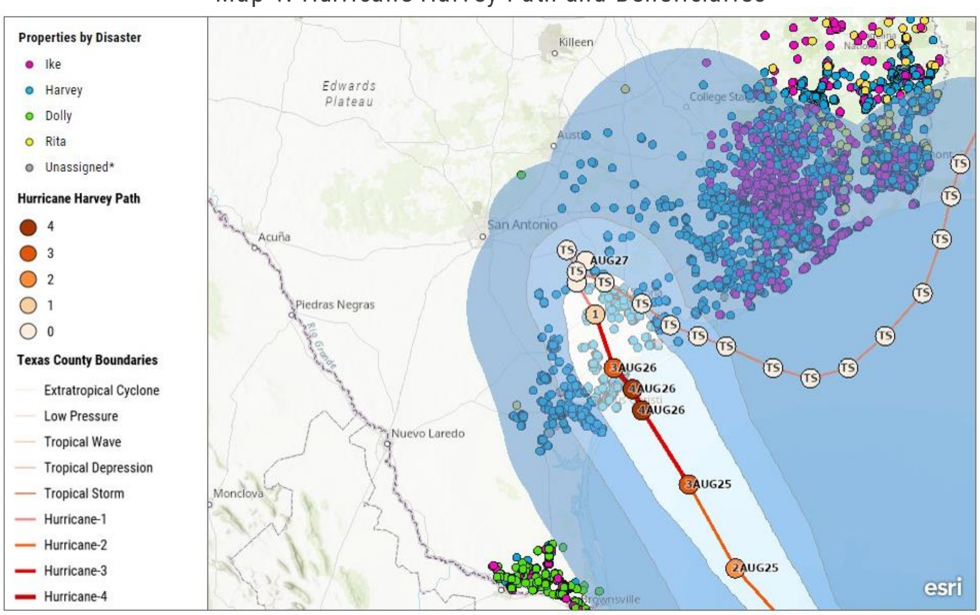
The Spatial Analysis summarizes the geolocation of CDBG-DR funded projects across Texas. Comparative analyses were conducted across the following:

- Disasters;
- Counties;
- Programs implemented;
- Program activities;
- Physical characteristics in the region (i.e., NFRI, soil type, and elevation);
- Socio-economic characteristics (i.e., SVI and poverty rate); and
- Repetitive loss properties.

COMPARISON ACROSS DISASTERS

The results of the Comparison Across Disasters are summarized in **Map 1** and **Table 6**, which display the total number of allocations by disaster.

Map 1: Hurricane Harvey Path and Beneficiaries



* GLO-CDR program documentation did not identify the specific disaster(s) (i.e., Ike, Harvey, Dolly, Rita) for which this property was a beneficiary.

Table 6: CDBG-DR Funding by Disaster

Disaster	Number of Projects	Total Allocation ($)	Average Project Amount ($)
Harvey	9,916	1,625,126,993	163,889
Ike	10,547	1,164,618,687	110,421
Dolly	907	96,328,167	106,205
Rita	515	34,190,346	66,389
Unassigned[8]	383	98,269,153	256,577

Analyzing the results summarized in **Map 1** and **Table 6**, the following key takeaways were identified:

- Most Hurricane Harvey beneficiaries received assistance within the path of the storm; and
- Hurricanes Ike and Harvey received the largest allocations of CDBG-DR funding compared to Hurricanes Dolly and Rita.

COMPARISON ACROSS COUNTIES

The results of the Comparison Across Counties are summarized in **Map 2**, which displays CDBG-DR allocations across all programs and disasters, and **Table 7,** which displays CDBG-DR allocations for the five counties with the highest CDBG-DR allocations and the five counties with the lowest allocations. The full dataset of allocations by county is provided in **Appendix I: CDBG-DR Allocations Across Counties**.

Map 2: CDBG-DR Allocations by County

[8] GLO-CDR program documentation did not identify the specific disaster(s) (i.e., Ike, Harvey, Dolly, Rita) for which these properties were beneficiaries.

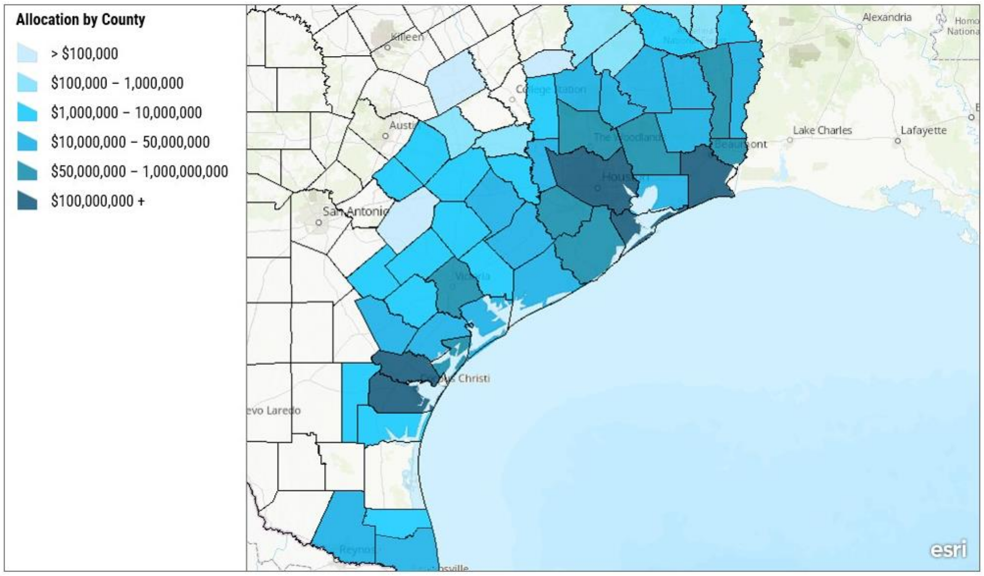


Table 7: CDBG-DR Allocations by County

County	Number of Housing Projects	Total County Allocation ($)	Average Allocation per Project ($)
Counties with Highest CDBG-DR Allocations			
Galveston	4,978	714,088,582	143,448
Jefferson	4,860	588,792,925	121,150
Nueces	846	183,229,981	216,583
Harris	1,738	165,487,705	95,217
San Patricio	626	129,942,748	207,576
Counties with Lowest CDBG-DR Allocations			
Shelby	1	65,000	65,000
Hemphill	1	56,752	56,752
Hill	1	43,051	43,051
Milam	1	37,786	37,786
Gonzales	1	18,235	18,235

Analyzing the results summarized in **Map 2** and **Table 7**, the following key takeaways were identified:

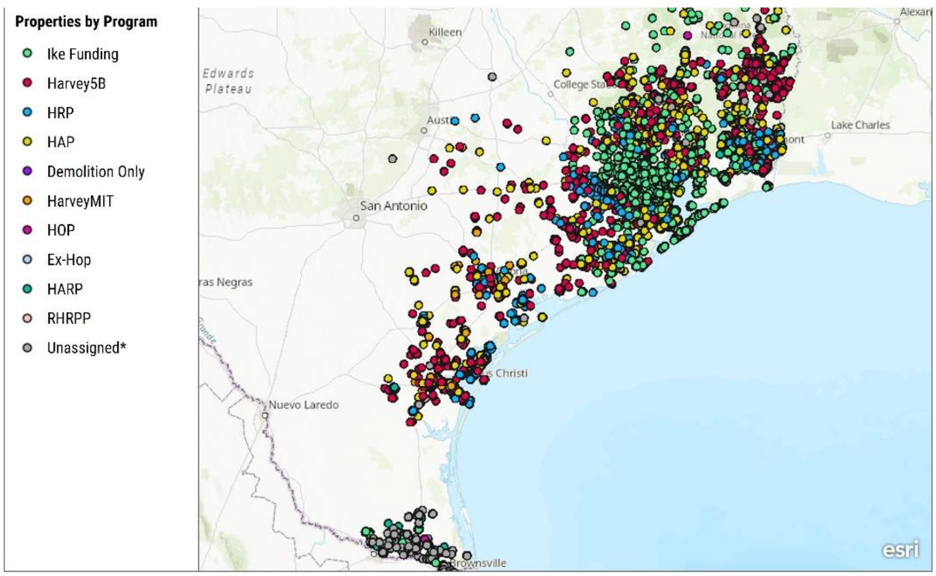
- Galveston County received the highest allocations across all disasters; and

- Counties that received the highest allocations are located along the coast of the Gulf of Mexico.

COMPARISON ACROSS PROGRAMS IMPLEMENTED

The results of the Comparison Across Programs Implemented are summarized in **Map 3**, which displays the geolocation of implemented programs, and **Table 8**, which displays the total allocations by housing program.

Map 3: CDBG-DR Allocations by Program



* GLO-CDR program documentation did not identify the specific program(s) for which this property was a beneficiary.

Table 8: CDBG-DR Funding by Program

Program	Number of Projects	Total Allocation ($)	Average Allocation per Project ($)
Harvey5B	4,241	1,038,414,070	244,851
HAP (Housing Assistance Program)	2,762	403,950,978	146,253
HarveyMIT	443	117,423,650	265,064
HRP	2,913	84,028,702	28,846
HOP	254	34,993,150	137,768
HARP	52	13,807,072	265,520
Ex-HOP	57	7,878,031	138,211

Program	Number of Projects	Total Allocation ($)	Average Allocation per Project ($)
Demolition Only	499	5,953,188	11,930
RHRPP	39	5,190,389	133,086
Rita - Round I	18	1,502,999	83,499
Down Payment Assistance Only	30	1,156,500	38,550
Ike Funding	9,823	1,127,954,482	114,827
Harvey	1	240,277	240,277
Acquisition Only	2	171,864	85,932
Unassigned[9]	1,134	175,867,989	155,086

Analyzing the results summarized in **Map 3** and **Table 8**, the following key takeaways were identified:

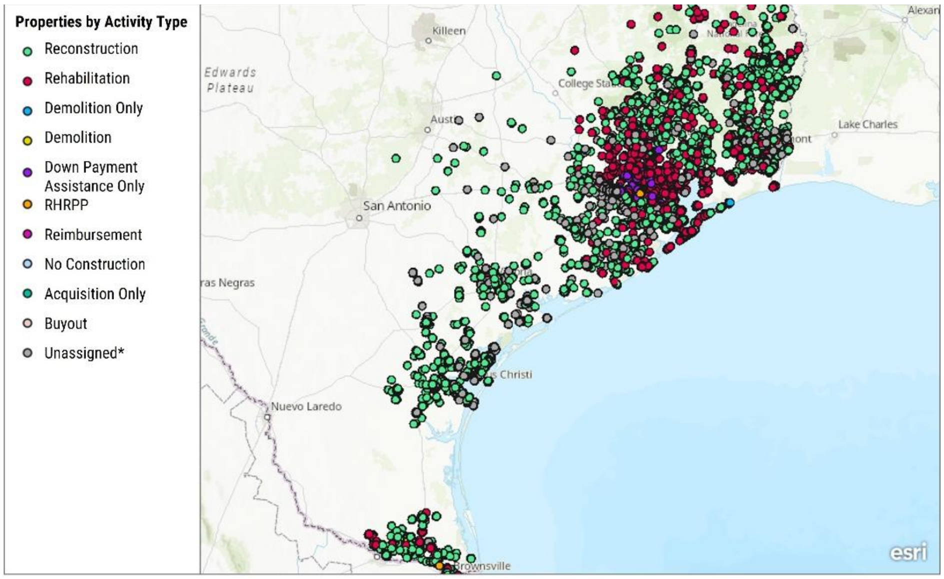
- Ike Funding and Harvey 5B are the largest program allocations compared to other implemented programs; and
- Most implemented programs are located around the Houston area.

COMPARISON ACROSS PROGRAM ACTIVITIES

The results of the Comparison Across Program Activities are summarized in **Map 4**, which displays the geolocation of program activities, and **Table 9,** which displays the total allocations for each activity type across all GLO-CDR housing programs.

[9] GLO-CDR program documentation did not identify the program(s) for which these properties were beneficiaries.

Map 4: CDBG-DR Funding by Activity



* GLO-CDR program documentation did not identify the specific activity type(s) for which this property was a beneficiary.

Table 9: CBDG-DR Funding by Activity Type

Activity	Number of Projects	Value ($)	Average Value per Project ($)
Reconstruction	9,268	1,871,446,095	201,925
Rehabilitation	7,323	859,867,341	117,420
Down Payment Assistance Only	283	10,108,500	35,719
Demolition Only	668	6,973,944	10,440
Demolition	499	5,953,188	11,930
RHRPP	40	5,396,113	134,902
No Construction	30	1,156,500	38,550
Buyout	2	171,864	85,932
Acquisition Only	2	171,864	85,932
Reimbursement	40	5,194,139	129,853

Activity	Number of Projects	Value ($)	Average Value per Project ($)
Unassigned[10]	4,113	252,093,795	61,291

Analyzing the results summarized in **Map 4** and **Table 9**, the following key takeaways were identified:

- The largest allocations went to reconstruction and rehabilitation housing projects across all programs;
- Rehabilitation program activities are focused around the Houston area; and
- Many projects did not have an attributed activity type, which is the third largest grouping of allocated funds.

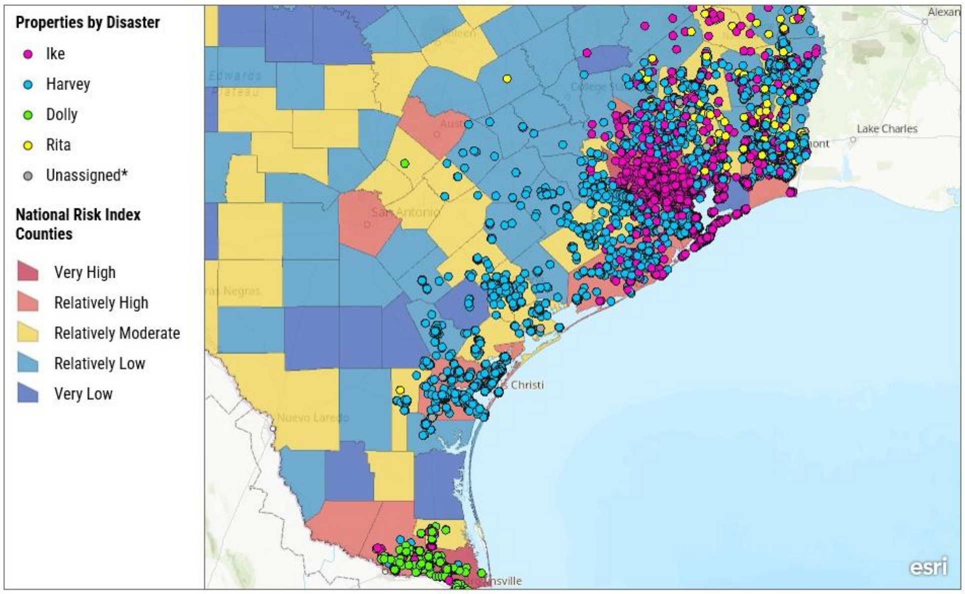
COMPARISON ACROSS PHYSICAL CHARACTERISTICS IN THE REGION

National Flood Risk Index

The results of the Comparison Across National Flood Risk Index score are summarized in **Map 5**, which displays the geolocation of funded projects and their proximity to flood risk, and **Table 10,** which displays the total allocations across different flood risk indicators.

[10] GLO-CDR program documentation did not identify the specific activity type(s) for which these properties were beneficiaries.

Map 5: CDBG-DR Funding and NFRI



* GLO-CDR program documentation did not identify the specific disaster(s) (i.e., Ike, Harvey, Dolly, Rita) for which this property was a beneficiary.

Table 10: CDBG-DR Funding by NFRI Score

NFRI Score	Number of Projects	Total Allocations ($)	Average Allocations per Project ($)
0-5	1,375	0	0
5-10	3	863,541	287,847
10-15	26	5,265,720	202,527
15-20	1,104	153,775,913	139,289
20-25	4,143	560,096,960	135,191
25-30	4,104	520,168,975	126,746
30-35	3,560	497,103,101	139,635
35-40	3,567	526,896,186	147,714
40-45	1,508	213,817,041	141,788
45-50	2,290	298,300,015	130,262
50-55	322	48,176,937	149,617

NFRI Score	Number of Projects	Total Allocations ($)	Average Allocations per Project ($)
55-60	266	39,284,314	147,685

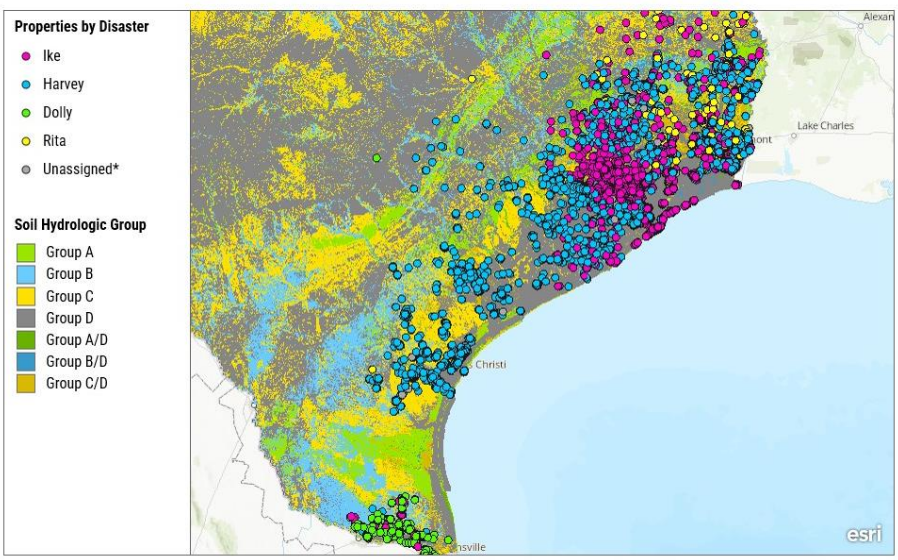
Analyzing the results summarized in **Map 5** and **Table 10**, the following key takeaways were identified:

- The geolocation of funded projects are concentrated in areas with high flood risk; and
- A larger number of projects and allocations are implemented in areas with a high flood risk.

Soil Type

The results of the Comparison Across Soil Types are summarized in **Map 6**, which displays the geolocation of implemented projects compared to soil types and **Table 11,** which displays total allocations across different soil types.

Map 6: CDBG-DR Funding and Soil Type



* GLO-CDR program documentation did not identify the specific disaster(s) (i.e., Ike, Harvey, Dolly, Rita) for which this property was a beneficiary.

Table 11: CDBG-DR Funding by Soil Type

Soil Type	Description	Number of Projects	Total Allocated ($)
Group A	Soils that consist of deep, well drained sands or gravelly sands with high infiltration and low runoff rates.	1,028	176,004,430
Group C	Soils with a layer that impedes the downward movement of water or fine textured soils and a slow rate of infiltration.	2,272	398,881,160
Group D	Soils with a very slow infiltration rate and high runoff potential. This group is composed of clays that have a high shrink-swell potential, soils with a high-water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.	13,178	1,697,846,562
Group B	Soils that consist of deep well drained soils with a moderately fine to moderately coarse texture and a moderate rate of infiltration and runoff.	3,200	470,477,549
Group C/D	Soils that naturally have a very slow infiltration rate due to a high-water table but will have a slow rate of infiltration if drained.	1,986	222,607,154
Group B/D	Soils that naturally have a very slow infiltration rate due to a high-water table but will have a moderate rate of infiltration and runoff if drained.	562	46,397,422
Group A/D	Soils that naturally have a very slow infiltration rate due to a high-water table but will have high infiltration and low runoff rates if drained.	42	6,319,067

Analyzing the results summarized in **Map 6** and **Table 11**, the following key takeaway was identified:

- Most CDBG-DR allocations have been focused on properties with soil type Group D: soils with a very slow infiltration rate and high runoff potential.

Elevation

The results of the Comparison Across Elevations are summarized in **Table 12,** which displays the total allocations by elevation.

Table 12: CDBG-DR Funding by Elevation

Elevation (Meters)	Number of Projects	Total Allocation ($)	Average Allocation by Project ($)
At or below sea level	3	274,907	91,635
0.03-5	8,492	1,157,908,382	136,352
5-10	4,733	595,783,804	125,878
10-15	2,051	282,940,323	137,952
15-20	1,339	188,322,588	140,644
20-25	1,236	196,921,998	159,322
25-30	1,166	130,088,186	111,567
30-35	814	79,086,473	97,157
35-40	186	24,510,996	131,779
40-45	135	17,385,635	128,782
45-50	191	32,322,878	169,229
50-55	163	27,586,499	169,242
55-60	107	20,712,419	193,574
60-65	150	26,131,484	174,209
65-70	111	19,995,779	180,142
70-75	148	27,396,415	185,110
75-80	133	24,168,986	181,721
80-85	117	20,641,599	176,423
85-90	98	17,340,496	176,943
90-95	83	14,410,000	173,614
95-100	78	15,010,119	192,437
100-105	64	11,372,869	177,701

Elevation (Meters)	Number of Projects	Total Allocation ($)	Average Allocation by Project ($)
105-110	41	7,764,282	189,372
110-115	41	6,186,877	150,899
115-120	37	6,510,262	175,953
120-125	26	4,404,684	169,410
125-1000	29	4,812,194	165,937
Unknown Elevation	496	58,542,198	118,028

Analyzing the results summarized in **Table 12**, the following key takeaway was identified:

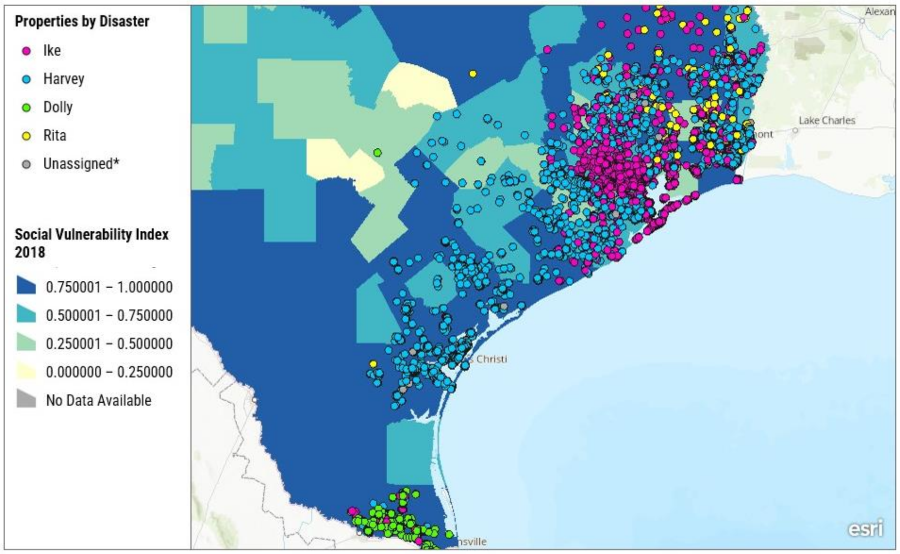
- The majority of CDBG-DR housing program allocations are located in low lying areas less than five meters above sea level.

COMPARISON ACROSS SOCIO-ECONOMIC CHARACTERISTICS

Social Vulnerability Index

The results of the comparison across SVI score are summarized in **Map 7**, which displays the geolocation of implemented projects against SVI score, and **Table 13**, which displays the total allocations across SVI scores.

Map 7: CDBG-DR Funding and SVI



* GLO-CDR program documentation did not identify the specific disaster(s) (i.e., Ike, Harvey, Dolly, Rita) for which this property was a beneficiary.

Table 13: CDBG-DR Funding by SVI Score

SVI Score	Number of Projects	Total Allocated ($)	Average Allocation per Project ($)
0-0.05	1,446	5151,951	3,562
0.05-0.1	161	7314,023	45,428
0.1-0.15	217	13,202,059	60,838
0.15-0.2	248	17,123,887	69,047
0.2-0.25	205	17,343,742	84,603
0.25-0.3	367	34,167,054	93,098
0.3-0.35	540	45,608,467	84,460
0.35-0.4	419	50,718,512	121,046
0.4-0.45	395	48,349,289	122,403
0.45-0.5	705	87,252,031	123,761
0.5-0.55	885	77,365,313	87,418
0.55-0.6	635	101,800,048	160,315

SVI Score	Number of Projects	Total Allocated ($)	Average Allocation per Project ($)
0.6-0.65	1,099	152,360,793	138,635
0.65-0.7	1,546	227,958,787	147,450
0.7-0.75	1,560	230,716,623	147,895
0.75-0.8	2,261	311,638,610	137,832
0.8-0.85	1,638	252,816,671	154,344
0.85-0.9	2,753	377,248,341	137,031
0.9-0.95	2,395	353,208,343	147,477
0.95-1	2,793	459,587,124	164,549

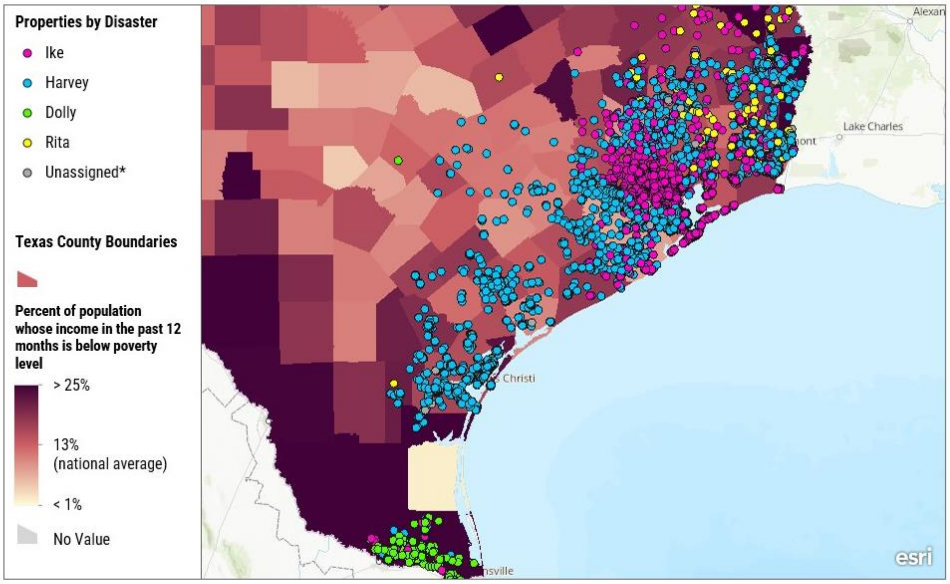
Analyzing the results summarized in **Map 7** and **Table 13**, the following key takeaway was identified:

- The majority of CDBG-DR allocations were focused in areas of high social vulnerability.

Poverty Rate

The results of the comparison across poverty rates are summarized in **Map 8**, which displays the geolocation of implemented projects against poverty rates, and **Table 14,** which displays the total allocations across poverty rates.

Map 8: CDBG-DR Funding and Poverty Rate



* GLO-CDR program documentation did not identify the specific disaster(s) (i.e., Ike, Harvey, Dolly, Rita) for which this property was a beneficiary.

Table 14: CDBG-DR Funding by Poverty Rate

Poverty Rate	Number of Projects	Total Allocated ($)	Average Allocation per Project ($)
0-0.025	1,237	60,816,679	49,164
0.025-0.05	2,777	336,642,204	121,225
0.05-0.075	4,811	702,010,732	145,917
0.075-0.1	5,750	797,394,803	138,677
0.1-0.125	3,436	472,348,891	137,470
0.125-0.15	2,248	311,388,608	138,518
0.15-0.175	1,470	217,602,109	148,028
0.175-0.2	196	21,433,879	109,356
0.2-0.225	73	8,227,353	112,703
0.225-0.25	35	3,667,659	104,790
0.25-0.275	38	4,819,744	126,835
0.275-0.3	140	19,944,840	142,463

Poverty Rate	Number of Projects	Total Allocated ($)	Average Allocation per Project ($)
0.3-0.325	16	1,983,636	123,977
0.325-0.35	39	1,360,985	34,897
0.35-0.375	0	0	0
0.375-0.4	0	0	0
0.4-0.425	0	0	0
0.425-0.45	1	45,000	45,000
0.45-0.475	1	33,656	33,656

Analyzing the results summarized in **Map 8** and **Table 14**, the following key takeaway was identified:

- The majority of CDBG-DR allocations are focused in high poverty rate areas.

COMPARISON ACROSS REPETITIVE LOSS PROPERTIES

The results of the Analysis of Repetitive Loss Properties are summarized in **Map 9**, which displays the geolocation of repetitive loss properties, and **Table 15**, which displays the total CDBG-DR funding for the identified repetitive loss properties along with breakdowns of the repetitive loss properties along the other comparative analysis included in the Spatial Analysis. For a full list of the comparative analyses refer to the **Spatial Analysis** section.

The full dataset and list of additional maps of repetitive loss properties is located in **Appendix E: Data Analysis Report Annex** (i.e., Maps 10-15).

Map 9: Repetitive Loss Properties

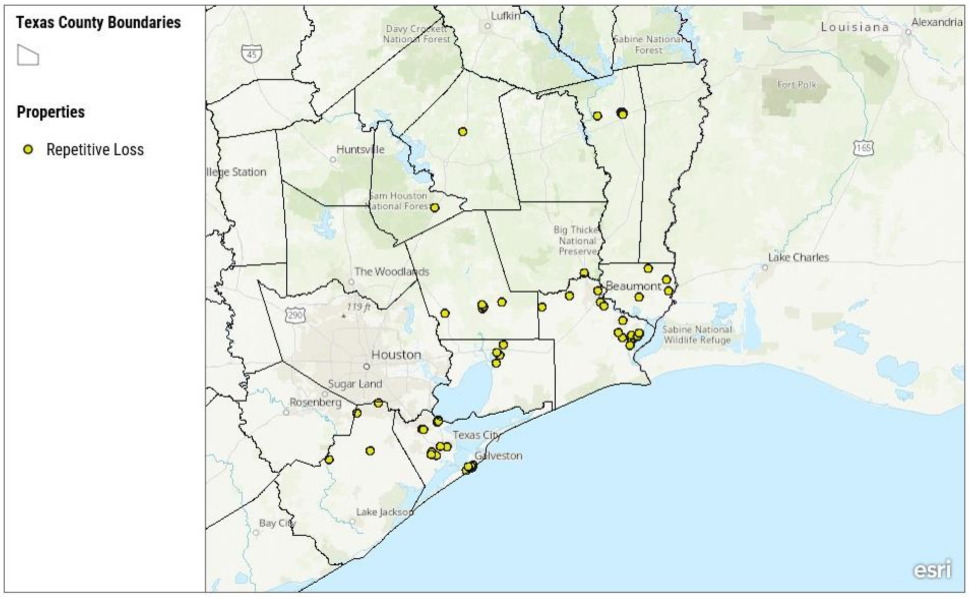


Table 15: Analysis of Repetitive Loss Properties

Category	Number of Repetitive Loss Properties	Total Allocation for Repetitive Loss Properties ($)
Total	130	14,204,576
Comparison Across Disaster		
Harvey	57	7,391,035
Ike	51	5,111,278
Rita	19	1,079,238
Comparison Across County		
Ames	1	58,097
Anahuac	6	482,495
Bacliff	6	571,323
Beaumont	8	901,284
Dayton	2	353,542
Dickinson	4	904,411

Category	Number of Repetitive Loss Properties	Total Allocation for Repetitive Loss Properties ($)
Galveston	19	2,115,169
Hankamer	2	354,462
Hitchcock	6	1,030,042
Jasper	12	1,058,091
Liberty	7	450,823
Livingston	2	39,961
Lumberton	2	132,945
Nederland	2	285,582
Nome	2	107,386
Orange	8	891,334
Pearland	2	97,092
Port Arthur	26	3,137,186
Rosharon	6	632,745
Shepherd	2	304,338
Texas City	5	296,260
Comparison Across Programs Implemented		
HRP	10	173,354
Ike Funding	49	4,952,443
Harvey5B	17	3,656,399
HAP	46	3,817,228
Harvey MIT	2	524,285
Demolition Only	1	4,920
HARP	1	299,006
Ex-HOP	1	153,915

Category	Number of Repetitive Loss Properties	Total Allocation for Repetitive Loss Properties ($)
Unassigned[11]	3	623,023
Comparison Across Program Activities		
Reconstruction	58	8,853,679
Rehabilitation	52	4,652,272
Demolition	2	9,840
Unassigned[12]	18	688,783
Comparison Across Physical Characteristics in the Region – National Flood Risk Index		
20-25	24	2,911,829
25-30	34	3,629,328
30-35	20	2,129,040
35-40	22	2,332,804
40-45	7	552,419
45-50	13	1,228,350
50-55	4	455,157
Comparison Across Physical Characteristics in the Region – Soil Type		
Group D	81	9,157,783
Group A	10	868,365
Group C/D	14	1,651,812
Group C	4	371,485
Group B	19	2,115,169
Group B/D	2	39,961
Comparison Across Physical Characteristics in the Region – Elevation		
0.03-5	74	8,838,200

[11] GLO-CDR program documentation did not identify the specific program(s) for which these properties were beneficiaries.
[12] GLO-CDR program documentation did not identify the specific activity type(s) for which these properties were beneficiaries.

Category	Number of Repetitive Loss Properties	Total Allocation for Repetitive Loss Properties ($)
5-10	18	2,152,087
10-15	10	543,649
15-20	2	111,535
20-25	10	1,156,712
25-30	0	0
30-35	0	0
35-40	0	0
40-45	0	0
45-50	4	331,874
50-55	0	0
55-60	0	0
60-65	0	0
65-70	0	0
70-75	2	267,749
75-80	2	39,961
80-85	0	0
85-90	6	542,437
90-95	0	0
95-100	0	0
100-105	2	220,367
Comparison Across Socio-Economic Characteristics – Social Vulnerability Index		
0.2-0.25	4	540,646
0.25-0.3	2	115,500
0.3-0.35	4	209,302
0.35-0.4	2	393,109
0.4-0.45	4	232,862

Category	Number of Repetitive Loss Properties	Total Allocation for Repetitive Loss Properties ($)
0.45-0.5	8	1,214,569
0.5-0.55	8	789,361
0.55-0.6	6	742,921
0.6-0.65	15	1,437,450
0.65-0.7	10	1,316,412
0.7-0.75	4	465,077
0.75-0.8	6	922,637
0.8-0.85	10	750,629
0.85-0.9	20	1,902,404
0.9-0.95	21	2,206,044
Comparison Across Socio-Economic Characteristics – Poverty Rate		
0-0.025	6	513,170
0.025-0.05	19	1,804,066
0.05-0.075	27	3,423,442
0.075-0.1	22	2,035,669
0.1-0.125	30	3,368,185
0.125-0.15	10	1,131,930
0.15-0.175	16	1,672,586

Analyzing the results summarized in **Map 9**, **Table 15**, and subsequent maps in **Appendix E: Data Analysis Report Annex**, the following key takeaways were identified:

- Hurricane Harvey had the greatest number of repetitive loss properties, followed closely by Hurricane Ike;
- Port Arthur County had the largest number of repetitive loss properties;
- Repetitive loss properties are funded most by Ike Funding and the HAP;
- Repetitive loss properties are identified the most through reconstruction and rehabilitation program activities;
- Repetitive loss properties are in high flood risk areas;

- Most repetitive loss properties are in soil type Group D: soils with a very slow infiltration rate and high runoff potential;
- Most repetitive loss properties are in low lying areas;
- Most allocated funds for repetitive loss properties are present in high SVI score areas; and
- Repetitive loss properties are in high poverty rate areas.

LOSS AVOIDANCE STUDY

The Loss Avoidance Study summarizes the calculated losses avoided across Texas from implementing I-Codes. Comparative analyses were conducted across the following:

- Counties;
- I-Code edition years;
- Flood and wind hazards; and
- Disasters.

COMPARISON ACROSS COUNTIES

The results of the Comparison Across Counties are summarized in **Table 16,** which displays savings for the five counties with the highest savings and the five counties with the lowest savings. The full dataset of savings by county is located in **Appendix E: Data Analysis Report Annex**.

Table 16: Top Five Highest and Lowest General Resilience AAAL

County	General Resilience AAAL ($)	2020 Census Population	County	General Resilience AAAL ($)	2020 Census Population
Counties with Highest Savings			**Counties with Lowest Savings***		
Harris	42,738	4,731,145	**DeWitt**	1	19,824
Galveston	11,698	350,682	**Brooks**	1	7,076
Brazoria	6,284	372,031	**Grimes**	1	29,268
Fort Bend	5,206	822,779	**Val Verde**	1	47,586
Dallas	4,936	2,613,539	**Rusk**	1	52,214

**Counties with the lowest savings are those that present a total general resilience AAAL value of $1.00 or more.*

Analyzing the results summarized in **Table 16**, the following key takeaway was identified:

- Counties with a higher population presented higher savings compared to counties with a lower population.

COMPARISON ACROSS I-CODE EDITION YEARS

The results of the Comparison Across I-Code edition Years are summarized in **Table 17**, which displays the savings for five counties with the highest savings and the five counties with the lowest savings for the 2006 and 2012 I-Code edition. The full dataset of savings by county is located in **Appendix E: Data Analysis Report Annex.**

Table 17: General Resilience AAAL Comparison (2006 vs. 2012)

County	2006 General Resilience AAAL ($)	2012 General Resilience AAAL ($)	Difference ($)
Counties with Highest Savings			
Harris	9,103	30,344	+ 21,241
Galveston	2,491	8,305	+ 5,814
Brazoria	1,338	4,461	+ 3,123
Fort Bend	1,051	3,504	+ 2,453
Dallas	514	1,714	+ 1,200
Counties with Lowest Savings*			
DeWitt	0	0	+ 0.58
Brooks	0	0	+ 0.57
Grimes	0	0	+ 0.56
Val Verde	0	0	+ 0.58
Rusk	0	0	+ 0.57

**Counties with the lowest savings are those that present a total general resilience AAAL value of $1.00 or more*

Additionally, the Study team calculated the percent increase of avoided losses on a statewide basis across I-Code edition years:

- From 2006 to 2009, there was a 187.19% increase in avoided losses;
- From 2009 to 2012, there was a 142.79% increase in avoided losses; and
- From 2012 to 2015, there was a 185.40% increase in avoided losses.

Analyzing the results in **Table 17** and the percent increase of avoided losses by I-Code edition, the following key takeaways were identified:

- The value of avoided losses increased with each new edition of I-Codes;
- The 2009 I-Code edition produced the highest increase in avoided losses; and
- The 2012 I-Code edition produced the lowest increase in avoided losses.

COMPARISON ACROSS FLOOD AND WIND HAZARDS

The results of the Comparison Across Flood and Wind Hazards under the 2006 and 2012 I-Codes are summarized **Table 18,** which displays savings for the five counties with the highest general resilience savings and the five counties with the lowest general resilience savings. The full dataset of savings by county and hazard is located in **Appendix E: Data Analysis Report Annex.**

Table 18: 2006 AAAL Comparison Between Flood and Wind Hazards

County	2006 Flood AAAL ($)	2012 Flood AAAL ($)	2006 Wind AAAL ($)	2012 Wind AAAL ($)	Hazard with Highest Avoided Losses
Counties with Highest General Resilience Savings					
Harris	5,401	19,025	3,361	11,140	Flood
Galveston	865	3,047	1,573	5,216	Wind
Brazoria	1,257	4,430	0	0	Flood
Fort Bend	769	2,708	291	964	Flood
Dallas	987	3,479	0	0	Flood
Counties with General Resilience Lowest Savings*					
DeWitt	0	1	0	0	Flood
Brooks	0	0	0	1	Wind
Grimes	0	0	0	0	Wind
Val Verde	0	1	0	0	Flood
Rusk	0	1	0	0	Flood

**Counties with the lowest savings are those that present a total general resilience AAAL value of $1.00 or more*

Analyzing the results summarized in **Table 18**, the following key takeaways were identified:

- 85% of counties experienced higher avoided losses from adopting resilient flood codes, with the remaining 15% of counties experiencing higher avoided losses from adopting resilient wind codes across all I-Code edition years; and
- Based on the full dataset in **Appendix E: Data Analysis Report Annex**, the counties that are identified as benefiting more from resilient wind codes than resilient flood codes are Aransas, Bee, Brooks, Calhoun, Galveston, Grimes, Kleberg, Lavaca, San Patricio, Starr, Willacy, and Wilson County.

COMPARISON ACROSS DISASTERS

The results of the Comparison Across Disasters are summarized in **Table 19,** which displays savings for the five counties with the highest savings and the five counties with the lowest savings. The full dataset of savings by county can be found in **Appendix E: Data Analysis Report Annex** and the full dataset of counties and corresponding disasters can be found in **Appendix G: Texas Counties and Corresponding Disaster Declarations**.

Table 19: 2015 I-Code AAAL Comparison against Disaster Declarations

County	Number of Disaster Declarations	2015 General Resilience AAAL ($)
Counties with Highest General Resilience Savings		
Harris	3	42,738
Galveston	2	11,698
Brazoria	3	6,284
Fort Bend	3	5,206
Dallas	1	4,936
Counties with Lowest General Resilience Savings*		
DeWitt	1	1
Brooks	1	1
Grimes	4	1
Val Verde	2	1
Rusk	1	1

**Counties with the lowest savings are those that present a total general resilience AAAL value of $1.00 or more*

Additionally, the results from the Analysis of Losses Avoided by Disaster are summarized in **Table 20**, which displays the total 2015 general resilience AAAL for all counties, grouped by the number of disaster declarations counties have experienced (i.e., one through five).

Table 20: Disaster Declarations and Total Sum of General Resilience AAAL

Number of Disaster Declarations	Number of Counties	Total 2015 General Resilience AAAL ($)	Average 2015 General Resilience AAAL ($)
5	1	0	0
4	5	372	74
3	21	57,368	2,731
2	45	20,429	454
1	89	7,604	85
0	93	5,792	62

Analyzing the results summarized in **Table 19** and **Table 20,** the following key takeaways were identified:

- Counties with a higher number of disaster declarations (i.e., having experienced four or five disasters) tend toward lower avoided losses compared to counties that have experienced two or three disasters;
- Counties with no disaster declarations still benefit from adoption of resilient I-Codes; and
- Walker, Jasper, and Madison Counties had the highest number of disaster declarations but presented with a total avoided loss of less than $1.

COST-BENEFIT ANALYSIS

The Cost-Benefit Analysis summarizes the calculated BCR of GLO-CDR CDBG-DR housing programs across Texas. Using these BCRs, comparative analyses were conducted across the following:

- Counties; and
- I-Code edition years.

COMPARISON ACROSS COUNTIES

The results of the Comparison Across Counties are summarized in **Table 21** which displays savings for the five counties with the highest calculated BCR and the five counties with the lowest calculated BCR. The full dataset of BCR calculations by county is located in **Appendix E: Data Analysis Report Annex**.

Table 21: BCR by County

County	BCR	County	BCR
Counties with Highest BCR		Counties with Lowest BCR*	
Cameron	29.53	**Madison**	1.78
Milam	23.60	**Angelia**	2.01
Hill	21.12	**Houston**	2.03
Shelby	14.03	**Nacogdoches**	2.16
Fort Bend	11.65	**Orange**	2.19

** Counties with the lowest savings are those that present a BCR less than 1.00*

Analyzing the analysis results summarized in **Table 21**, the following key takeaways were identified:

- Based on the full dataset in **Appendix E: Data Analysis Report Annex,** all counties except Gonzalez County have a cost-effective BCR greater than 1.00 (Gonzalez County has no BCR due to a lack of reconstruction or rehabilitation projects);
- The average BCR across all 58 counties is 5.77; and
- Utilizing a standard deviation calculation based on the average BCR, it is observed that there is little variability in BCR values amongst counties.

COMPARISON ACROSS I-CODE EDITION YEARS

The results of the Comparison Across I-Code Edition Years are summarized in **Table 22,** which displays savings for the five counties with the highest calculated BCR and the five counties with the lowest calculated BCR. The full dataset of BCR calculations by county is located in **Appendix E: Data Analysis Report Annex**.

Table 22: BCR by I-Code Edition Year

County	2006 I-Code BCR	2009 I-Code BCR	2012 I-Code BCR	2015 I-Code BCR
Counties with Highest BCR				
Cameron	8.95	15.33	21.95	29.53
Milam	23.60	23.60	23.60	23.60
Hill	21.12	21.12	12.12	21.12
Shelby	14.03	14.03	14.03	14.03
Fort Bend	4.19	6.50	8.90	11.65
Counties with Lowest BCR*				
Madison	1.78	1.78	1.78	1.78
Angelina	1.84	1.89	1.95	2.01
Houston	2.03	2.03	2.03	2.03
Nacadoches	2.15	2.16	2.16	2.16
Orange	2.18	2.18	2.19	2.19

Analyzing the analysis results summarized in **Table 22**, the following key takeaways were identified:

- The majority of counties calculated BCR increases with each I-Code edition from 2006 to 2015. This translates to an average increase of 29% in the calculated BCR from 2006 to 2015; and
- Based on the full dataset in **Appendix E: Data Analysis Report Annex**, Caldwell, Goliad, Grimes, Hemphill, Hidalgo, Hill, Houston, Jasper, Karnes, Lavaca, Lee, Madison, Marion, Milam, Refugio, Sabine, San Augustine, San Jacinto, Shelby, Trinity and Walker Counties saw no increase in the calculated BCR from 2006 to 2015.

CONCLUSION

The Data Analysis Report captures key takeaways, recommendations for future allocations of CBDG-DR funds, and next steps acquired through three separate, yet interconnected analyses:

- **Spatial Analysis**: A geospatial assessment of how GLO-CDR housing program resilience has evolved across disasters under different construction standards and codes.
- **Loss Avoidance Study**: A quantitative assessment of losses avoided in Texas due to adopting I-Codes to determine the cost savings of adopting resilient housing codes and standards.
- **Cost-Benefit Analysis**: An evaluation of the cost-effectiveness of building approaches utilized across GLO-CDR housing programs to support long-term community resiliency. The Cost-Benefit Analysis pulls from the results developed in the Spatial Analysis and the Loss Avoidance Study.

The following subsections provide an overview of the key takeaways that have been gathered from these analyses, recommendations for future allocations of CDBG-DR funds based on observations from the Study team, and next steps for the Study.

KEY TAKEAWAYS

The following subsections provide an overview of the key takeaways that are gathered through the Spatial Analysis, Loss Avoidance Study, and Cost-Benefit Analysis. The Study team made an effort to contextualize and frame the key takeaways in a manner that understands that these data observations are not siloed, but rather part of a bigger picture to ensure future CDBG-DR allocations are resilient and cost-effective.

Spatial Analysis

Key takeaways gathered from the Spatial Analysis include the following:

- **Physical characteristics:** Areas with a high flood risk and low elevation have the largest number of projects implemented. Most CDBG-DR allocations were focused on properties with soil type Group D, or soils with a very slow infiltration rate and high runoff potential. This key takeaway indicates the possibility that housing built in areas with these physical characteristics is (1) the most likely to be impacted by disasters, and (2) high-priority areas for CDBG-DR funds. This is likely due to the impact of flood and wind events in areas with these types of physical characteristics.
- **Socio-economic Characteristics:** The majority of CDBG-DR allocations were focused in high socially vulnerable populated areas and high poverty areas. This is likely guided by HUD regulation for allocation of

CDBG-DR funds, which prioritizes low-to-moderate income populations and most-impacted and distressed communities, which can be correlated to areas with high poverty rates and high social vulnerability. Taking this into account, this takeaway could still indicate the possibility that areas with high social vulnerability and high poverty rates were impacted the most by the disasters, and therefore in the greatest need of assistance.

- **Repetitive loss properties:** There are a total of 130 repetitive loss properties identified in this Study. The data shows an increase in repetitive loss since Ike in 2010, which may be due to a variety of contextual factors. These include but are not limited to a lack of comprehensive data used in this Study, the limited scope of the Study (i.e., the fact that the Study only looks at programs post-Ike), as well as site-specific factors that would influence the repeated impact of disasters on certain units (e.g., repetitive loss properties identified and located in high flood risk areas and in low elevation locations). These repetitive loss properties were first damaged by Hurricane Ike in 2008, then again by Hurricane Harvey in 2018. Repetitive loss properties were largely funded by the Ike Funding and HAP programs, both of which implemented reconstruction and rehabilitation activities. Taking into account all these factors, this takeaway highlights the importance of promoting more resilient long-term solutions for housing in high-risk areas (e.g., relocation and new construction options).
- **Geolocation of implemented projects:** The majority of CBDG-DR housing program allocations are clustered in Texas counties on the coast of the Gulf of Mexico, with Galveston County receiving the highest program allocations across all disasters. As expected, this key takeaway indicates that the coastline is a high-priority area for resilient housing investments, potentially due to the proximity of coastline counties to major wind and flood events. Climate change predictions from various agencies including a recent report by the Virginia Institute for Marine Science (VIMS)[13] indicate that the Gulf of Mexico coastline will see an increase in sea levels and more frequent and intense storms that will increase the risk of flood and wind hazards, and therefore may require an increase in resilient and cost-effective housing construction.
- **Geolocation of implemented program activities:** Of the types of CDBG-DR activities funded, construction partners performed reconstruction the most often, and the highest amount of CDBG-DR funding across all programs was dedicated to reconstruction The largest number of reconstruction housing projects are implemented in Harris County. These observations indicate the possibilities that (1) decision-makers allocating CDBG-DR funds prioritized reconstruction, and (2) reconstruction activities were the most beneficial for increasing housing resiliency. This may be due to (1) programmatic regulations in place

[13] *The 2018 report, "Anthropocene Sea Level Change: History of Recent Trends Observed in the U.S. East, Gulf, and West Coast Regions", can be downloaded from the VIMS website:* https://www.vims.edu/research/products/slrc/index.php

favoring reconstruction, and (2) the scale of disaster impacts resulted in a greater need for reconstruction, as opposed to other CDBG-DR funded activities.

Loss Avoidance Study

Key takeaways gathered from the Loss Avoidance Study include the following:

- **I-Codes adoption:** On average, each new edition of I-Codes saw a 186% increase in the value of avoided losses, except for 2009 to 2012 which experienced a 143% increase in avoided losses. This increase in resilience is consistent with the expectation that implementation of updated I-Code editions improves resilience. This increase may also reflect an increase in the availability and affordability of cost-effective resilient construction standards, thus resulting in more avoided losses.
- **Flood and ind hazards:** Implemented resilient flood hazard codes resulted in a higher value of avoided losses compared to implemented resilient wind hazard codes. Of these, 15% of counties assessed within the Study benefited more from adopting resilient wind codes over resilient flood codes. The counties that were identified as benefiting more from resilient wind codes than resilient flood codes are Aransas, Bee, Brooks, Calhoun, Galveston, Grimes, Kleberg, Lavaca, San Patricio, Starr, Willacy, and Wilson Counties. This key takeaway points to the possibility that flood hazard resilience measures are more cost-effective than wind hazard resilience measures. These numbers could be impacted by the fact that the majority of disasters analyzed within this study are flood-related; therefore CDBG-DR allocations largely went to flood retrofits that are more extensive (i.e., encompass more aspects of a home) and costly than resilient wind retrofits.
- **Total avoided losses**: Counties with a higher population presented higher savings (i.e., more resilient and less likely to incur significant damage) compared to counties with a lower population. This takeaway can be indicative of a greater need for CDBG-DR allocations in higher density populations. This may be due to different economic and resilient construction standard factors for rural versus urban communities (e.g., outreach representatives noted the higher cost of construction and lack of builders in rural areas).

Cost-Benefit Analysis

Key takeaways gathered from the Cost-Benefit Analysis include the following:

- **BCR:** The average BCR across all 58 counties included in the Cost-Benefit Analysis is 5.77, indicating that (1) the calculated social and economic benefits exceed CDBG-DR funding allocations, and (2) based on the cost-effectiveness methodology outlined in this report, the benefits of implementing resilient housing standards outweigh the differential cost of resilient housing funded through CDBG-DR housing program. This result is consistent with previous studies on the cost-effectiveness of hazard mitigation and resilience projects. However, it is important to recognize that the application of the FEMA methodology to the available does not address specific hazard risks or consider a comprehensive set of all potential benefits for individual building, and therefore provides only a partial picture of the overall impacts. Taking this into consideration, it is important to continue developing and employing a more detailed methodology for assessing the cost-effectiveness of hazard resilient housing solutions.

- **I-Codes adoption:** The BCR calculated for the majority of counties has increased an average of 29% with each I-Code edition from 2006 to 2015. Corresponding with findings from the Loss Avoidance Analysis, this could be due to an increase in availability and affordability of more cost-effective resilient construction solutions. This increase highlights the importance of promoting higher resilience standards through the implementation and regulation of updated I-Code editions.

CDBG-DR POLICY RECOMMENDATIONS

Based on the key takeaways gathered in this Data Analysis Report and other observations gathered through these analyses, the Study team has generated the following policy recommendations for the GLO-CDR to consider for future CDBG-DR housing program allocations:

- Expand and improve resilience standard;
- Improve data collection;
- Increase stakeholder coordination; and
- Implement the latest edition of the I-Codes.

Recommendation 1: Expand and Improve Resilience Standard

One of the key conclusions the Study team drew from the analyses conducted as part of the Data Analysis Report is that employing a more comprehensive and rigorous definition of resilience can lead to higher resilience impacts for CDBG-DR housing programs. Results from the analyses revealed higher CDBG-DR allocations to high-risk areas over time (i.e., Hurricane Ike received 39% of the total allocations across all disasters, where Hurricane Harvey received 54% of the total allocations across all disasters). In other words, high risk areas received increasing funds with each disaster allocation and experienced linear increases in repetitive loss over time. Consistently, program allocations went towards reconstruction and rehabilitation program activities across all disasters. Projects were concentrated in areas with high flood risk and low-lying areas less than five meters above sea level. From Hurricane Ike in 2008 to Hurricane Harvey in 2017, the number of repetitive loss properties across GLO-CDR CDBG-DR housing programs increased.

Through stakeholder outreach, several state and local representatives from across Texas pointed out that a resilience definition should integrate an understanding of the resilience impact of housing maintenance and upgrading. Some representatives highlighted that maintenance and upgrade costs over the long-term life of the project can be a hinderance to low-to-moderate income households, thus limiting their ability to increase their own resilience and housing sustainability.

These findings indicate that HUD's standard of resilience, which is the standard to which CDBG-DR post-disaster housing programs across the nation, including Texas, are held to, is not strong enough to result in resilient housing programs in the State of Texas. The GLO-CDR should expand its definition of resilience beyond minimum HUD standards, such as incorporating FEMA resilience concepts, in order to increase the overall resilience of its housing programs and to reduce repetitive loss in future programs.

Recommendation 2: Improve Data Collection

The Data Analysis Report has also highlighted the importance of improved data collection techniques and standards as beneficial for (1) measuring resilience in past housing programs and (2) compiling lessons learned to increase the resilience and cost-effectiveness of future CDBG-DR allocations. As displayed in **Appendix C: Data Scope Inventory**, there are several data gaps within the overall data available on past GLO-CDR CDBG-DR housing programs, due to the recent digitalization of program data. Due to this, a comprehensive analysis across all components of past programs was significantly reduced, highlighting the importance of ensuring future housing programs maintain high data management standards. Improved data management policies and procedures can lead to improved controls during program implementation. Moreover, as shown in the Study, data collection provides the opportunity for future studies to analyze these programs more comprehensively. This will ultimately result in the development of more accurate and effective approaches to improving overall program resilience in the future. The GLO-CDR should expand upon HUD minimum data collection standards as a tool to effectively measure the overall resilience and cost-effectiveness of projects to improve future CDBG-DR allocations.

Recommendation 3: Increase Stakeholder Coordination

Increasing CDBG-DR stakeholder coordination during program implementation can lead to consistent data collection, a standardized definition of resilience, and a shared understanding of resilient housing priorities in the State of Texas. During the stakeholder outreach process conducted as part of the Study, several state and local representatives pointed out that a lack of coordination across stakeholders involved in program implementation can be a barrier to increasing resilience and cost-effectiveness due to competing interests. Additionally, representatives placed an emphasis on increasing coordination and shared understanding amongst all key construction stakeholders, such as real estate professionals, builders, engineers, and designers.

Findings from the Data Analysis Report point to a potential for improved stakeholder coordination that otherwise can result in inconsistent data collection processes and definitions of resilience. Increasing the coordination among stakeholders can lead to better data management, and therefore lead to increased resilient and cost-effective housing programs in Texas.

Recommendation 4: Implement the Latest Edition of the I-Codes

Finally, in order to increase cost-effectiveness and reduce repetitive losses, future CDBG-DR programs should prioritize the implementation of the latest edition of the I-Codes. In the latest CDBG-DR housing program, the State of Texas employed the 2012 I-Codes even though there were other, more recent editions (i.e., 2015, 2018, and 2021). Representatives in the stakeholder outreach process stated that the standardization and clarity of codes and specifications would increase the affordability of homes, and therefore the resilience of homes.

Results from the Data Analysis Report prove that with each new edition of the I-Codes, the value of avoided losses increases, increasing the BCR over time. This key takeaway is that implementing standardized resilient housing codes and standards increases the resilience, avoided losses, and cost-effectiveness of housing projects. For future CDBG-DR allocations, the GLO-CDR should implement the latest resilient I-Codes to increase the resilience and cost-effectiveness of implemented programs and activities.

NEXT STEPS

The Data Analysis Report will feed into the following documents what will be developed as part of the Study:

- Research and Inventory Development Summary #2;
- Community Educational Outreach Plan;
- StoryMap; and
- Comprehensive Resilient Housing Study Report.

Research and Inventory Development Summary #2

The Study team will build upon the data collected for the Research and Inventory Development Summary #1 through the stakeholder outreach that will be conducted as part of Phase 2 as well as further data collection and analysis within the Data Analysis Report. This will build out the Research and Inventory Development Summary #2.

Community Educational Outreach Plan

Building upon the stakeholder outreach conducted in Phase 2, the Study team will develop a Community Educational Outreach Plan to support the socialization of resilient home maintenance and mitigation strategies based on key takeaways from the Data Analysis Report, Research and Inventory Development Summary #1, and Research and Inventory Development Summary #2. The Community Educational Outreach Plan will include a vision, methodology, and materials to support outreach. This will include the development of a StoryMap (see below) to aid in this educational outreach strategy.

StoryMap

The Study team will build upon the results of the Spatial Analysis in this Data Analysis Report and the Research and Inventory Development Summaries to develop an ArcGIS StoryMap as part of Phase 3. The StoryMap will be a public facing web map that will integrate maps, legends, text, and photos as an educational and informative tool to stakeholders and the public on resilient housing initiatives in the State of Texas.

Comprehensive Resilient Housing Study Report

Upon completion and approval of the Data Analysis Report, Research and Inventory Development Summary #1, Research and Inventory Development Summary #2, and the Community Educational Outreach Plan, the Study team will develop a comprehensive report that summarizes and aggregates the materials and deliverables completed over the course of the Study. The Comprehensive Resilient Housing Study Report will consist of an executive summary, overviews of each deliverable, including key takeaways, recommendations, and strategies for operational implementation.

APPENDICES

APPENDIX A: ACRONYMS

Acronym	Definition
AAAL	Average Annual Avoided Losses
ACS	American Community Survey
ARP	Affordable Rental Program
BCR	Benefit-Cost Ratio
CDBG-DR	Community Development Block Grant - Disaster Relief
CDC	Center for Disease Control
Ex-HOP	ex-Homeowner Opportunity Program
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
GLO-CDR	Texas General Land Office - Community Development and Revitalization
HAP	Housing Assistance Program
HARP	Homeowner Assistance and Reimbursement Programs
HOP	Homeowner Opportunity Program
HRP	Housing Reimbursement Program
HUD	U.S. Department of Housing and Urban Development
IBC	International Building Codes
I-Codes	International Code Council Codes (including the International Building Codes and International Residential Codes)
IRC	International Residential Code
NFRI	National Flood Risk Index
NGO's	Non-Governmental Organization
O&M	Annual Operations & Maintenance
PVC	Present Value Coefficient
RHRPP	Rapid Disaster Recovery Housing Program

Acronym	Definition
SVI	Social Vulnerability Index
USA SSURGO	United States of America Soil Survey Geographic Database
USGS	U.S. Geological Survey

APPENDIX B: DEFINITIONS

Term	Definition
Acquisition Only	A GLO-CDR CDBG-DR housing program that allocated funds to acquisition damaged properties.
Annual Operation & Maintenance Cost	A 1% addition to the cost of a project to approximate anticipated operation and maintenance costs over the life of the project.
Average Annual Avoided Losses (AAAL)	The AAAL is a calculation of the avoided loss from adopting I-Codes as it related to flood and wind resilient construction specifications for CDBG-DR funded housing programs.
Average Annual Avoided Losses (AAAL) Tiered Adjustment Ratios	The AAAL Tiered Adjustment Ratios are adjustments to the AAAL's to account for earlier I-Code edition years.
Benefit-Cost Ratio (BCR)	Ratio used in the Cost-Benefit Analysis to calculate the relationship between the relative costs and benefits of a project.
Community Development Block Grant - Disaster Relief (CDBG-DR)	Funds under HUD that are utilized to help cities, counties, and state to recover from Presidentially declared disasters.
Demolition Only	A GLO-CDR CDBG-DR housing program that allocated funds to demolishing damaged properties.
Down Payment Assistance Only	This GLO-CDR CDBG-DR program provided down payment assistance to beneficiaries seeking to purchase new or pre-existing homes post-disaster.
ex-HOP	See HOP.
FEMA Discount Rate	The Discount Rate is a rate set by the U.S. Office of Management and Budget to estimate the net present value of annual project benefits or annualized maintenance cost over the life of a project.
FEMA National Flood Risk Index	An online mapping application created by FEMA that identifies communities' risk to 18 natural hazards.
General Land Office	The Texas General Land Office is the lead state agency for managing the state's Community Development Block Grant - Disaster Recovery grants through the U.S. Department of Housing and Urban Development

Term	Definition
Geographic Information System (GIS)	A software program or system that creates, manages, analyzes, and maps data.
Group A Soils	Soils that consist of deep, well drained sands or gravelly sands with high infiltration and low runoff rates.
Group A/D Soils	Soils that naturally have a very slow infiltration rate due to a high-water table but will have high infiltration and low runoff rates if drained.
Group B soils	Soils that consist of deep well drained soils with a moderately fine to moderately coarse texture and a moderate rate of infiltration and runoff.
Group B/D Soils	Soils that naturally have a very slow infiltration rate due to a high-water table but will have a moderate rate of infiltration and runoff if drained.
Group C Soils	Soils with a layer that impedes the downward movement of water or fine textured soils and a slow rate of infiltration.
Group C/D Soils	Soils that naturally have a very slow infiltration rate due to a high-water table but will have a slow rate of infiltration if drained.
Group D Soils	Soils with a very slow infiltration rate and high runoff potential. This group is composed of clays that have a high shrink-swell potential, soils with a high-water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.
HAP	This GLO-CDR CDBG-DR program assist homeowners affected by disaster to repair and rebuild their homes through rehabilitation and reconstruction activities to improve its resilience, elevate homes above flood level, and temporary relocation assistance.
HARP	This GLO-CDR CDBG-DR program provides funding for reconstruction activities and reimbursement for owner-occupied homes impacted by Hurricane Harvey. The HARP program is a subsidiary of HAP.
Harvey	A GLO-CDR CDBG-DR housing program utilized for Hurricane Harvey damaged housing.
Harvey5B	This GLO-CDR CDBG-DR program provides funding for reconstruction and rehabilitation activities for homes impacted by Hurricane Harvey. Harvey 5B is a sub-category of the HAP program.

Term	Definition
HarveyMIT	This GLO-CDR CDBG-DR program provided reconstruction activity funds to homes impacted by Hurricane Harvey and is a sub-category of the HAP program.
HOP	This GLO-CDR CDBG-DR program allocates funds for rehabilitation or reconstruction activities to existing homes in FEMA-designated 'High Risk' areas or for the relocation of households to a safer and higher opportunity area.
HRP	This GLO-CDR CDBG-DR program provides reimbursement to homeowners for up to $50,000 in out-of-pocket expenses to repair their damaged homes.
I-Codes	The I-Codes is a reference to the International Building and International Residential Codes developed by the International Code Council to increase the resilience of communities from hazards. The I-Codes are typically updated every three to four years.
Individual Assistance	This FEMA program provides financial and direct services to eligible individuals and households who have sustained losses due to a disaster.
Ike Funding	A GLO-CDR CDBG-DR housing program utilized for Hurricane Ike damaged housing.
Local Buyout and Acquisition Program	This program provides funding to local units of government to purchase eligible damaged properties with the intent to reduce risk from future flooding or to reduce risk from future hazards.
Present Value Coefficient (PVC)	A calculation of the useful life of the project and FEMA discount rate to account for the time value of money.
Project Useful Life	Indicates the anticipated duration over which project will maintain its effectiveness.
Public Assistance	This FEMA program provides aid in the aftermath of a major disaster to state and local governments, and to certain non-profits, to assist communities in their recovery efforts.
RHRPP	Similar to the HRP program, the Rapid Housing Recovery Pilot Program provided reimbursements to homeowners for out-of-pocket recovery expenses.
Rita - Round 1	A GLO-CDR CDBG-DR housing program utilized for Hurricane Rita damaged housing.

Term	Definition
Social Vulnerability Index (SVI)	The SVI is a calculation of the relative social vulnerability of a census tract that utilized 14 social factors and groups them into four related themes. These four themes are used to rank the vulnerability of certain populations.

APPENDIX C: DATA SCOPE INVENTORY

The following table summarizes the data utilized in each analysis included in the Data Analysis Plan, as well as data gaps and exclusions therein.

<table>
<tr><th>Data Being Utilized</th><th>Current Data Gaps</th><th>Exclusions</th></tr>
<tr><td colspan="3">Spatial Analysis</td></tr>
<tr><td colspan="3">Subcomponent: CDBG-DR Funding by Activity Type</td></tr>
<tr><td colspan="3">Description: An assessment of how CDBG-DR funding has been distributed for each individual disaster allocation across rehabilitation, reconstruction, and new construction housing programs to clarify the priorities of the GLO-CDR across disasters.</td></tr>
<tr><td>• 2015 Floods HAP, ARP, and HRP
• Harvey HAP (Reconstruction, Rehabilitation), ARP, and HRP
• Ike Acquisition, Demolition, Down Payment Assistance, Reconstruction, and Rehabilitation
• Ike ex-HOP and HOP
• Rita ex-HOP, HOP, HAP, and HRP
• Dolly ex-HOP, HOP, HAP, and HRP</td><td>• 2016 Floods Housing Programs
• 2011 Bastrop Wildfires Housing Programs
• 2018/2019 Floods Housing Programs
• Beneficiary Data under HAP, HRP, HARP, ARP, and RHP by disaster</td><td>• Outdated Contracts
• Lead-Based Paint safety worksheet
• Duplicative data sets for housing programs
• Unconnected housing program data
• Project closeout letters
• Insurance forms
• Drafts of documents</td></tr>
<tr><td colspan="3">Subcomponent: Comparison of Subrecipients and Beneficiaries by Location, Disaster, and Program Activity Types</td></tr>
<tr><td colspan="3">Description: A comparison of the geolocation of subrecipients and beneficiaries for rehabilitation, reconstruction, and new construction housing programs across various disasters impacting Texas.</td></tr>
</table>

Data Being Utilized	Current Data Gaps	Exclusions
• Beneficiary data for the following housing programs: HAP, ex-HOP, HOP, HRP, and Homebuyer Assistance • 2015 Flood Subrecipient data for the following counties: Grimes, Hidalgo, Hays, Jasper, Jim Wells, Newton, Travis, Willacy • 2015 Flood Subrecipient data for the following cities: Austin, Bellaire, Bridgeport, Buda, Buffalo, Christoval, La Marque, Penitas, Raymondville, Clifton, Corpus Christi, Corsicana, Dawson, Freer, Hays, Hubbard, Jewett, Kyle, La Porte, Lyford, Navasota, Normangee, Nueces, Orange Grove, Pasadena, Petronila, Premont, Raymondville, Reno, Rice, Somerville, Travis, Williamson, and Wimberley • 2016 Flood Subrecipient data for the following counties: Austin, Bastrop, Eastland, Grimes, Harris, Hidalgo, Jasper, Lee, Madison, Newton, San Augustine, and San Jacinto • 2016 Flood Subrecipient data for the following cities: Bandera, Brenham, Buffalo, Baytown, Brazoria, Brenham, Brookshire, Buffalo, Clute, Eastland, Elgin, Freeport, Houston, Jacinto City, Kingsville, Newton, Sweeny, Trinity, Zavalla, Clifton, Kleberg, Linden, Navasota, Pasadena, Oak North Ridge, Patton Village, Rosenberg, San Felipe, Sealy, Simonton, Stagecoach, Stephenville, Tomball, Tenaha, Travis, Wallis, Wharton, Willis, Woodloch, and Woodsville	• 2016 Floods Housing Programs by beneficiary and subrecipient • 2011 Bastrop Wildfires Housing Programs by beneficiary and subrecipient • 2018/2019 Floods by beneficiary and subrecipient • Beneficiary Data under HAP, HRP, HARP, ARP, and RHP by disaster • Subrecipient data	• Outdated Contracts • Lead-Based Paint safety worksheet • Duplicative data sets for housing programs • Unconnected housing program data • Project closeout letters • Insurance forms • Drafts of documents

Data Being Utilized	Current Data Gaps	Exclusions
• 2016 Flood Subrecipient data for the following organizations: Deep East Texas COG and Harris County Community Services Department • Bastrop Wildfire Subrecipient data for the City of Bastrop • Hurricane Dolly Subrecipient data for the South East Texas Regional Planning Commission • Hurricane Ike Subrecipient data for the City of Galveston, Galveston County, and the Galveston Housing Authority. • Hurricane Ike and Dolly Subrecipient Data for the following cities: Galveston, Houston, and Liberty • A comprehensive data set of Hurricane Harvey subrecipients by city, county, and organization • Hurricane's Katrina and Rita Subrecipient data for the City of Houston, Harris County, and South East Texas Regional Planning Commission		
Subcomponent: *Repetitive Loss Properties*		
Description: *An analysis of repetitive loss properties of CDBG-DR programs in Texas for programs carried out directly by the State, excluding subrecipient-led programs.*		
• Repetitive loss properties are determined through the spatial analysis of beneficiaries	• Beneficiary Data under HAP, HRP, HARP, ARP, and RHP by disaster	• Outdated Contracts • Lead-Based Paint safety worksheet

Data Being Utilized	Current Data Gaps	Exclusions
		• Duplicative data sets for housing programs • Unconnected housing program data • Project closeout letters • Insurance forms • Drafts of documents
Loss Avoidance Study		
Subcomponent: *Loss Avoidance Study*		
Description: *A detailed and targeted analysis of programs identified through the Spatial Analysis as having a statistically significant impact on reducing repetitive losses.*		
• Policies utilized in programs identified as key to increasing resilience • Types of programs being implemented (buyout, rehab, etc.) • Construction specifications utilized in programs identified as key to increasing resilience • Contextual factors that may have impacted the higher resilience (e.g., location, severity of disaster, social climate at the time, socio-economic status of the impacted region, existing mitigation projects in the region) • Investment caps determined by United States Department of Housing and Urban Development (HUD)	• 2016 Floods Housing Programs by beneficiary • 2011 Bastrop Wildfires Housing Programs by beneficiary • 2018/2019 Floods by beneficiary • Beneficiary Data under HAP, HRP, HARP, ARP, and RHP by disaster	• Outdated Contracts • Lead-Based Paint safety worksheet • Duplicative data sets for housing programs • Unconnected housing program data • Project closeout letters • Insurance forms • Drafts of documents

Data Being Utilized	Current Data Gaps	Exclusions
• Duplication of Benefits as outlined in the Stafford Act • Amount of money spent on repetitive loss properties • Estimated amount of money avoided on properties that would have experienced repetitive loss if it weren't for the resiliency measure implemented.		
Cost-Benefit Analysis		
Subcomponent: *Calculate Benefit-Cost Ratio (BCR)*		
Description: *Cost-effectiveness will be determined by cost data relating to CDBG-DR program construction costs and resiliency benefits according to construction specifications.*		
• Construction specifications mandated by HUD for CDBG-DR housing rehabilitation and reconstruction programs • Construction specifications drawn from the IBC/IRC available at the time of the disaster • Construction specifications for resilient housing drawn from academic and industry best practices • Property values	N/A	N/A

APPENDIX D: DATA ANALYSIS REPORT RESOURCES

Document / Resource Title	Year	Author / Institution
American Community Survey 5-Year Estimates, Poverty Rate	2020	U.S. Census Bureau
Centers for Disease Control Social Vulnerability Index	2020	Centers for Disease Control
FEMA Benefit-Cost Analysis Tool	n/a	Federal Emergency Management Agency
FEMA *Building Codes Save: A Nationwide Study*	2018	Federal Emergency Management Agency
FEMA Disaster Declarations	2007-2019	Federal Emergency Management Agency
FEMA National Risk Index	2021	Federal Emergency Management Agency
U.S. Geological Survey National Elevation Dataset	2018	U.S. Geological Survey
United Stated of America Soil Survey Geographic Database - Soil Hydrologic Group	2022	U.S. Soil Survey

APPENDIX E: DATA ANALYSIS REPORT ANNEX

Document Title / Link
AAAL Tiered Adjustment Calculation.xlsx
BCR Calculation and Analysis.xlsx
Loss Avoidance Study AAAL Data and Analysis.xlsx
Spatial Analysis Data and Analysis.xlsx
Map 1 – Hurricane Harvey Path and Beneficiaries.jpg
Map 2 – CDBG-DR Allocations by County.jpg
Map 3 – CDBG-DR Allocations by Program.jpg
Map 4 – CDBG-DR Funding by Activity.jpg
Map 5 – CDBG-DR Funding and NFRI.jpg
Map 6 – CDBG-DR Funding and Soil Type.jpg
Map 7 – CDBG-DR Funding and SVI.jpg
Map 8 – CDBG-DR Funding and Poverty Rate jpg
Map 9 – Repetitive Loss Properties.jpg
Map 10 – Repetitive Loss Properties by Programs Implemented.jpg
Map 11 – Repetitive Loss Properties by Program Activities.jpg
Map 12 – Repetitive Loss Properties by National Flood Risk Index.jpg
Map 13 – Repetitive Loss Properties by Soil Type.jpg
Map 14 – Repetitive Loss Properties by Social Vulnerability Index.jpg
Map 15 – Repetitive Loss Properties by Poverty Rate.jpg

APPENDIX F: COUNTIES ELIMINATED FROM THE LOSS AVOIDANCE STUDY

Counties Eliminated from the Loss Avoidance Study				
Anderson	Culberson	Haskell	Madison	San Augustine
Andrews	Dallam	Hemphill	Marion	San Jacinto
Archer	Dawson	Hill	Martin	San Saba
Armstrong	Deaf Smith	Hockley	Mason	Schleicher
Atascosa	Delta	Hopkins	McCulloch	Scurry
Bailey	Dickens	Houston	McMullen	Shackelford
Bandera	Dimmit	Howard	Menard	Shelby
Baylor	Donley	Hudspeth	Milam	Sherman
Blanco	Duval	Hutchinson	Mills	Somervell
Borden	Eastland	Irion	Mitchell	Stephens
Bosque	Edwards	Jack	Montague	Sterling
Brewster	El Paso	Jasper**	Moore	Stonewall
Briscoe	Erath	Jeff Davis	Morris	Sutton
Burleson	Falls	Jim Hogg	Motley	Swisher
Callahan	Fannin	Jones	Nolan	Terrell
Camp	Fisher	Karnes	Ochiltree	Terry
Carson	Floyd	Kendall	Oldham	Throckmorton
Cass	Foard	Kenedy	Palo Pinto	Titus
Castro	Franklin	Kent	Panola	Trinity
Cherokee	Freestone	Kimble	Parmer	Upshur
Childress	Frio	King	Pecos	Upton
Clay	Gaines	Kinney	Presidio	Uvalde
Cochran	Garza	Knox	Rains	Walker
Coke	Glasscock	La Salle	Reagan	Ward

Counties Eliminated from the Loss Avoidance Study				
Coleman	Goliad	Lamar	Real	Wheeler
Collingsworth	Gonzales	Lamb	Red River	Wilbarger
Comanche	Gray	Lampasas	Reeves	Winkler
Concho	Hall	Lee	Refugio	Wood
Cottle	Hamilton	Limestone	Roberts	Yoakum
Crane	Hansford	Lipscomb	Robertson	Young
Crockett	Hardeman	Loving	Runnels	Zapata
Crosby	Hartley	Lynn	Sabine	Zavala

APPENDIX G: TEXAS COUNTIES AND CORRESPONDING DISASTER DECLARATIONS

Texas County Disaster Declarations

County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Anderson									2
Andrews									0
Angelina									2
Aransas									2
Archer									1
Armstrong									0
Atascosa									0
Austin									2
Bailey									1
Bandera									1
Bastrop									3
Baylor									1
Bee									1
Bell									0
Bexar									0
Blanco									0
Borden									1
Bosque									2
Bowie									1
Brazoria									3

Texas County Disaster Declarations

County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Brazos									2
Brewster									0
Briscoe									0
Brooks									1
Brown									2
Burleson									3
Burnet									1
Caldwell									3
Calhoun									2
Callahan									2
Cameron									2
Camp									0
Carson									0
Cass									2
Castro									1
Chambers									2
Cherokee									2
Childress									1
Clay									0
Cochran									1
Coke									0
Coleman									1
Collin									0

Texas County Disaster Declarations									
County	Ike	Dolly	2011 Fires	2015 Floods	2016 Floods	Harvey	2018 Floods	2019 Floods	Total
	DR 1791, 3294	DR 1780	DR 2958	DR 4223, 4245	DR 4269, 4272, 4266, 4255	DR 4332	DR 4377	DR 4416, 4454	
Collingsworth									1
Colorado									2
Comal									2
Comanche									2
Concho									0
Cooke									0
Coryell									2
Cottle									1
Crane									0
Crockett									0
Crosby									1
Culberson									0
Dallam									0
Dallas									1
Dawson									0
Deaf Smith									1
Delta									1
Denton									0
DeWitt									1
Dickens									1
Dimmit									1
Donley									1
Duval									0

Texas County Disaster Declarations									
County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Eastland									1
Ector									0
Edwards									1
El Paso									0
Ellis									1
Erath									1
Falls									1
Fannin									1
Fayette									2
Fisher									1
Floyd									1
Foard									1
Fort Bend									3
Franklin									2
Freestone									0
Frio									0
Gaines									0
Galveston									2
Garza									0
Gillespie									0
Glasscock									0
Goliad									1
Gonzales									1

Texas County Disaster Declarations

County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Gray									0
Grayson									0
Gregg									2
Grimes									4
Guadalupe									2
Hale									0
Hall									1
Hamilton									0
Hansford									0
Hardeman									1
Hardin									3
Harris									3
Harrison									2
Hartley									0
Haskell									2
Hays									1
Hemphill									0
Henderson									1
Hidalgo									3
Hill									2
Hockley									1
Hood									1
Hopkins									2

Texas County Disaster Declarations									
County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Houston									3
Howard									0
Hudspeth									0
Hunt									0
Hutchinson									0
Irion									0
Jack									0
Jackson									1
Jasper**									4
Jeff Davis									0
Jefferson									2
Jim Hogg									1
Jim Wells									2
Johnson									0
Jones									2
Karnes									0
Kaufman									1
Kendall									0
Kenedy**									1
Kent									1
Kerr									0
Kimble									1
King									1

Texas County Disaster Declarations									
County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Kinney									1
Kleberg									1
Knox									2
La Salle									0
Lamar									1
Lamb									1
Lampasas									0
Lavaca									1
Lee									2
Leon									2
Liberty									4
Limestone									0
Lipscomb									0
Live Oak									0
Llano									1
Loving									0
Lubbock									1
Lynn									0
Madison									4
Marion									2
Martin									0
Mason									1
Matagorda									2

Texas County Disaster Declarations									
County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Maverick									0
McCulloch									1
McLennan									0
McMullen									0
Medina									0
Menard									1
Midland									0
Milam									3
Mills									0
Mitchell									0
Montague									0
Montgomery									3
Moore									0
Morris									1
Motley									1
Nacogdoches									1
Navarro									2
Newton									4
Nolan									2
Nueces									2
Ochiltree									0
Oldham									0
Orange									3

Texas County Disaster Declarations

County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Palo Pinto									1
Panola									1
Parker									1
Parmer									1
Pecos									0
Polk									3
Potter									0
Presidio									0
Rains									1
Randall									0
Reagan									0
Real									1
Red River									1
Reeves									0
Refugio									1
Roberts									0
Robertson									1
Rockwall									1
Runnels									0
Rusk									1
Sabine									3
San Augustine									3
San Jacinto									3

Texas County Disaster Declarations

County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
San Patricio									2
San Saba									1
Schleicher									1
Scurry									1
Shackelford									1
Shelby									2
Sherman									0
Smith									2
Somervell									1
Starr									1
Stephens									1
Sterling									0
Stonewall									1
Sutton									1
Swisher									0
Tarrant									0
Taylor									0
Terrell									0
Terry									1
Throckmorton									2
Titus									1
Tom Green									0
Travis									2

Texas County Disaster Declarations									
County	Ike DR 1791, 3294	Dolly DR 1780	2011 Fires DR 2958	2015 Floods DR 4223, 4245	2016 Floods DR 4269, 4272, 4266, 4255	Harvey DR 4332	2018 Floods DR 4377	2019 Floods DR 4416, 4454	Total
Trinity									2
Tyler									3
Upshur									3
Upton									0
Uvalde									1
Val Verde									2
Van Zandt									1
Victoria									1
Walker									5
Waller									3
Ward									0
Washington									3
Webb									0
Wharton									3
Wheeler									1
Wichita									0
Wilbarger									1
Willacy									2
Williamson									0
Wilson									1
Winkler									0
Wise									0
Wood									1

Texas County Disaster Declarations									
County	Ike	Dolly	2011 Fires	2015 Floods	2016 Floods	Harvey	2018 Floods	2019 Floods	Total
	DR 1791, 3294	DR 1780	DR 2958	DR 4223, 4245	DR 4269, 4272, 4266, 4255	DR 4332	DR 4377	DR 4416, 4454	
Yoakum									0
Young									0
Zapata									0
Zavala									0

APPENDIX H: TEXAS COUNTIES INCLUDED IN THE BENEFIT-COST RATIO CALCULATION

Counties Included in the Benefit-Cost Ratio Calculation				
Angelina	Fayette	Houston	Matagorda	San Patricio
Aransas	Fort Bend	Jackson	Milam	Shelby
Austin	Galveston	Jasper	Montgomery	Trinity
Bastrop	Goliad	Jefferson	Nacogdoches	Tyler
Bee	Gonzales	Jim Wells	Newton	Victoria
Brazoria	Gregg	Karnes	Nueces	Walker
Caldwell	Grimes	Kleberg	Orange	Waller
Calhoun	Hardin	Lavaca	Polk	Washington
Cameron	Harris	Lee	Refugio	Wharton
Chambers	Hemphill	Liberty	Sabine	Willacy
Colorado	Hidalgo	Madison	San Augustine	
DeWitt	Hill	Marion	San Jacinto	

APPENDIX I: CDBG-DR ALLOCATIONS ACROSS COUNTIES

County	Instances	Value ($)	Average / Incident ($)
Angelina	22	1,875,487	85,249
Aransas	408	71,133,838	174,347
Austin	23	4,844,481	210,629
Bastrop	12	1,960,326	163,360
Bee	67	13,815,014	206,194
Brazoria	628	91,033,682	144,958
Caldwell	7	1,399,457	199,922
Calhoun	163	33,542,271	205,780
Cameron	586	64,604,341	110,246
Chambers	478	46,788,295	97,883
Colorado	48	11,163,335	232,569
DeWitt	29	6,174,478	212,913
Fayette	7	1,144,298	163,471
Fort Bend	1,226	57,452,936	46,862
Galveston	4,978	714,088,582	143,448
Goliad	8	1,670,654	208,831
Gonzales	1	18,235	18,235
GREGG	4	332,860	83,215
Grimes	10	1,985,283	198,528
Hardin	387	39,597,673	102,319
Harris	1,738	165,487,705	95,217
Hemphill	1	56,752	56,752
HIDALGO	426	45,578,211	106,991
Hill	1	43,051	43,051
Houston	3	191,811	63,937

County	Instances	Value ($)	Average / Incident ($)
Jackson	26	5,550,950	213,498
Jasper	554	105,867,129	191,095
Jefferson	4,860	588,792,925	121,150
Jim Wells	32	7,516,215	234,881
Karnes	21	4,672,342	222,492
Kleberg	16	3,573,586	223,349
Lavaca	16	3,514,670	219,666
Lee	6	920,553	153,425.
Liberty	632	89,723,095	141,966
Madison	1	74,162	74,162
Marion	1	298,992	298,992
Matagorda	187	39,207,355	209,665
Milam	1	37,786	37,786
Montgomery	369	53,471,437	144,909
Nacogdoches	13	942,494	72,499
Newton	151	26,333,376	174,393
Nueces	846	183,229,981	216,583
Orange	894	95,293,295	106,592
Polk	204	34,969,537	171,419
Refugio	168	32,307,364	192,305
Sabine	25	3,184,243	127,369
San Augustine	7	902,931	128,990
San Jacinto	86	15,735,119	182,966
San Patricio	626	129,942,748	207,576
Shelby	1	65,000.	65,000
Trinity	10	497,987	49,798
Tyler	185	31,132,087	168,281

County	Instances	Value ($)	Average / Incident ($)
Victoria	507	96,665,892	190,662
Walker	88	14,362,737	163,212
Waller	58	12,369,565	213,268
Washington	2	258,191	129,095
Wharton	171	33,142,582	193,816
Willacy	242	27,835,414	115,022
Unknown / Unassigned	1	133,685	133,685