

# Disaster Decision Support Tool (DDST): AN ADDITIONAL STEP TOWARDS COMMUNITY RESILIENCE

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# Contents

	Page
1. Introduction .....	3
2. Important Concepts .....	4
Disaster: .....	4
Catastrophe: .....	4
Hazard: .....	4
Risk: .....	4
Social Vulnerability .....	4
Resilience.....	5
3. Brief Introduction to Geographic Information Systems .....	6
3a. What is a GIS? .....	6
3b. GIS and Emergency Management .....	6
3c. Social Vulnerability: Understanding Population Characteristics Preceding Disasters .....	7
3d. Social Vulnerability Assessment for Puerto Rico, 1990-2000 .....	8
Figure 1: Social Vulnerability in Mayagüez 1990.....	10
Figure 2: Social Vulnerability in Mayagüez 2000.....	10
4. Disaster Decision Support Tool (DDST) .....	11
5. Web Browser Requirements .....	13
6. Obtaining Access to the DDST.....	14
7. Geographic Information Currently Available .....	14
7a. Vector Layers .....	14
7b. Raster Layers .....	15
8. How to start using the DDST? .....	16
9. DDST Features .....	16
9a. Managing the left pane .....	16
Opening/Expanding or Closing/Collapsing Tabs .....	16
Selecting a layer or multiple layers .....	17
9b. The Navigation Toolbar .....	18
Zoom In and Zoom Out.....	18
Pan.....	18
Identify .....	19
Results.....	20
Measure .....	20
Magnifier.....	21
Printing a Map .....	21
10. Summary.....	22
11. How to Contact Us .....	22
12. Referenced Publications .....	23



## **1. Introduction**

The *Disaster Research Center* (DRC) at the University of Delaware (UD), with funding from the National Science Foundation (NSF) and the University of Puerto Rico-Mayagüez Sea Grant College Program (UPRSGCP), and in collaboration with the Center for Applied Social Research (CISA-UPRM), the Center for Collaborative Adaptive Sensing of the Atmosphere (CASA), the University of Delaware Research and Data Management Services (RDMS), and the Center for Coastal Hazards (CCH-UPRM) are pilot testing a Geographic Information Systems (GIS) based mapping tool.

**The Puerto Rico Disaster Decision Support Tool (DDST)** is an Internet-based scalable mapping server for disaster planners, responders, and related officials at the municipal, emergency management, and state level. DDST offers access to a variety of geo-referenced information for all municipalities in Puerto Rico. The purpose of this manual is to provide an overview of the general capabilities of the DDST as a way to facilitate the use of the tool.

One of the goals of the DDST is to provide end-users with accurate and easy to access geographic information at no cost. Consequently, we use a number of governmental data sources, as well as data generated through our research and the research of investigators at research centers affiliated with this project. Given that this is a pilot tool that is currently under development, as is also the case for the computer-based systems, the tool is not 100% reliable and a failure in any part of the system is possible. Therefore, we cannot assume any liability or responsibility for any personal, property or any other type of damage directly or indirectly related to the use of or reliance on the mapping tool. Further, we cannot guarantee its accuracy and/or availability at any time, including but not limited to, in a real emergency. Moreover, we do not assume any responsibility for any delays in processing mapping requests. While we have attempted to provide the most reliable and up-to-date data and information, it may contain incorrect or dated information. Therefore, the user acknowledges that the online internet tool is part of an ongoing research project, and, as such, the data provided is subject to revisions and modifications. If you have any questions, comments, recommendations or would like to publish additional data, we would like to hear from you. Please contact Jenniffer Santos-Hernández at (302) 831- 6618, Monday-Friday, 9AM-4PM EST; or by email at [jsantos@udel.edu](mailto:jsantos@udel.edu).

## **2. Important Concepts**

**Disaster:** Disasters are not natural events but result from the exposure of vulnerable populations to hazards (Rodríguez, 2002). They are “processes/events involving the combination of a potentially destructive agent(s) from the natural, modified, and/or constructed environment and a population in a socially and economically produced condition of vulnerability, resulting in a perceived disruption of the customary relative satisfaction of individual and social needs for physical survival, social order, and meaning” (Oliver-Smith, 1998).

**Catastrophe:** According to the National Response Plan, a catastrophe is a natural or man made incident (including terrorism), that results in an extraordinary number of casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, and national morale and/or government functions. Incidents are considered catastrophes when their impacts extend over a prolonged period of time, the required resources exceed the capacity of authorities at all levels, multiple economic sectors are affected, and government functions are challenged (see also Quarantelli, 2006).

**Hazard:** Extreme events in the environment. They are “extreme, low probability meteorological or geological phenomena that have the potential to cause disasters when they strike human collectives” (Mileti, 1999:22).

**Risk:** Risk is the potential for harm or the potential exposure of a population, infrastructure, resources and other assets to a hazard. Risks often emerge as a result of inadequate or unplanned development.

**Social Vulnerability:** “the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard, an extreme natural event, or process” (Wisner, et al., 2004:11). Social vulnerability also focuses on the differential and relative impact of disasters to different

members of our society. While we can all share the same risk, social vulnerability may vary according to a number of demographic and socio-economic factors. To fully understand the complexity of social vulnerability, we must examine population and environmental characteristics and conditions before and after the impact of the hazard event in order to improve our understanding of the causes and consequences of disasters.

**Resilience:** “the capacity to cope with unanticipated danger after they have become manifest, learning to bounce back” (Wildavsky, 1991:77).

### **3. Brief Introduction to Geographic Information Systems**

#### **3a. What is a GIS?**

Geographic information Systems (GIS) keep track of the “what” happens and “where” it happens. While geographic information systems were previously done on paper, today they are computer-based allowing the storage, management, and presentation of large amounts of diverse information in a single platform. The value of GIS lies in its capability to use modern technology to accumulate, analyze, and graphically display extensive amounts of data and maps. In addition to their current popularity in the automobile industry, a wide range of devices have been developed to access geographic information when and where it is needed, such as handhelds and cell phones, among many others. There are also a number of software and extensions that facilitate the dissemination of geographic information. For example, one of the greatest advancements in Geographic Information Sciences are web-based GIS tools as they provide easy access at a relatively low cost to multiple users who share responsibility for a particular area.

#### **3b. GIS and Emergency Management**

The use of computer-based GIS is a somewhat recent phenomenon in emergency management but one that has become increasingly important, particularly after Hurricane Hugo (Cutter, et al., 2007). Throughout all the phases of emergency management, access to information is vital. GIS can assist in planning, mitigation, preparedness, response, and recovery from disasters. Moreover, it allows us to examine and generate a clearer understanding of how disasters impact vulnerable populations. In *Confronting Catastrophe: A GIS Handbook (2002)*, Greene highlights the value of geographic information systems in assisting the emergency management community. The use of GIS in emergency management provides the capacity to identify and assess the risk and to better understand the composition of the management area or of the area under study. Demographic and socio-economic characteristics significantly impact the disaster experiences and outcomes for different groups; through

the use of GIS we can explore these relationships. Geographic Information Systems are very valuable tools and methods that can assist and facilitate the analysis of the intersection or convergence of exposure to different hazards and of the characteristics of a group in a specific location.

Given that emergency management was initially constituted as a Civil Defense agency during the Cold War, it was primarily a responsive type of organization and did not necessarily focus on preparedness or mitigation. As the field of emergency management continues to move away from response and towards management, geographic information systems provide a unique opportunity for strengthening and better informing governmental and non-governmental efforts aimed at disaster mitigation and preparedness. Emergency management is different from emergency response as the former requires the identification, coordination, mitigation, and assessment of vulnerabilities and risks and the creation of mechanisms to cope with disasters (Waugh, 2007). Incorporating the use of GIS can facilitate emergency management responsibilities and outcomes. GIS tools are very powerful tools that can enhance our understanding regarding the intersection of a hazard and a population with specific demographic and socio-economic characteristics and needs. The use of geographic information systems (GIS) allows us to map, visualize, and examine changes throughout time in the characteristics of the population in the areas or jurisdictions under study. Furthermore, as the next section highlights, the use of GIS also provides an opportunity to examine the geographic distribution and social characteristics of the population and their risk to different hazards.

### **3c. Social Vulnerability: Understanding Population Characteristics Preceding Disasters**

The commitment, training, and expertise of emergency managers at all levels is not enough to successfully plan, mitigate, prepare for, cope with, respond to, and recover from disasters; although important, these factors cannot reduce social vulnerability.

The social vulnerability framework was incorporated into the study of disasters in the early 1980s. Social vulnerability is often defined as “the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard, an extreme natural event, or process” (Wisner, et al., 2004). Social vulnerability specifically refers to the relative or differential impact that disasters have on different members of our society.

Enarson (2007) stresses that it is very important that emergency managers pay careful attention to the living conditions, needs, and resources of population groups at high risk. Current disaster management policies are consonant with those recommendations. The *Disaster Mitigation Act of 2000*, points out that **all jurisdictions are required** to perform hazard assessments as the underlying basis for state and local hazard mitigation plans. More specifically, the *2006-07 Standard on Disaster/Emergency Management and Business Continuity Programs* of the *National Response Plan* now require that emergency officials review the history, frequency, and severity of potential hazards; assess the vulnerability of their communities; identify steps for hazard mitigation; and allocate resources to reduce losses based on risk and vulnerability assessments.

### **3d. Social Vulnerability Assessment for Puerto Rico, 1990-2000**

The Disaster Decision Support Tool presents the findings of the social vulnerability index generated by Santos (2007) for coastal municipalities in Puerto Rico. The use of GIS allowed us to map, visualize, and examine changes in social vulnerability from 1990 to 2000. The social vulnerability assessment uses geo-referenced census data and the U.S. Census Topologically Integrated Geographic Encoding and Referencing System (TIGER/line files) to construct an additive index at the block group level and explore the prevalence of indicators related to disaster vulnerability.

The social vulnerability index for coastal municipalities in Puerto Rico provides a composite score that examines eleven variables or indicators: population density, population living below poverty level, housing tenure, education, children under 18 years of age, female-headed households with children, unemployment, elderly

population (65 years and over), vehicle tenure, and land phone tenure. The social vulnerability score for each block group ranges from a low of 11 to a high of 55. In the vulnerability layer included in the DDST, red represents block groups with high vulnerability scores and green represents a low vulnerability score. The social vulnerability score for each block group was generated through recoding and aggregating the value of each of the abovementioned characteristics for all block groups in coastal municipalities. For each indicator, the percentage of population with a particular characteristic was recoded into five categories (e.g., 0-19.99% = 1, 20-39.99% = 2, 40.00-59.99% = 3, 60.00-79.99% = 4, and 80.00-100 = 5). The score of each of the eleven variables was then added; the result of this mathematical process is what we identify as the *social vulnerability score (SV)*.

Overall findings of the social vulnerability assessment suggest that while the population residing in areas susceptible to storm surge-related flooding increased by about 12%, from 1990 to 2000, there was a slight reduction in social vulnerability during this same time period (see Figure 1). This may be a result of the observed decline in the scores of most vulnerability indicators from 1990 to 2000. Furthermore, high vulnerability is characteristic of areas with lack of employment opportunities and consequently high unemployment rates; thus, despite the decline in the score of most vulnerability indicators, such as poverty and low education, they remain quite high, particularly in comparison to the United States. Consequently, this research suggests the need to develop emergency preparedness and response plans that are geared towards the needs of a demographically and socio-economically changing population with relatively high levels of vulnerability. For example, as a consequence of changes in the age structure of the population in the Western region of Puerto Rico, it is imperative that we plan ahead and prepare to meet the needs of an increasingly elderly population group as well as those with disabilities and chronic illnesses, especially focusing on disaster preparedness and response, including evacuation and sheltering. It is necessary to develop effective evacuation strategies that acknowledge the physical and mental health needs of those that may require to be evacuated. Programs, such as the NOAA Tsunami Ready Initiative, can serve to enhance disaster awareness, preparedness and response.

Figure 1: Social Vulnerability in Mayagüez 1990



Figure 2: Social Vulnerability in Mayagüez 2000



#### 4. Disaster Decision Support Tool (DDST)

In preparing and responding to disasters, it is indispensable that we identify the characteristics of the population residing in at-risk areas (*National Research Council Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk*, 2007). During emergencies and in the aftermath of disasters, a clear understanding of the population composition and its distribution in the impacted areas provides responders with the capacity to attend, manage and to channel aid more easily and effectively, particularly to the population groups with the greatest needs. Access to a GIS application containing demographic and socio-economic data, as well as geo-referenced data on the risk to different hazards and the physical features and the infrastructure of a region allows emergency officials and a wide range of decision makers to better visualize the potential impacts of a particular event (e.g. urban flood, storm surge flood, accident, landslides, among others). Easy access to a geographic information system allows emergency decision-makers to identify the location and visualize the convergence of a number of factors that would otherwise be assessed independently. Moreover, GIS is also a very powerful tool that can and should be used for disaster mitigation and preparedness initiatives.

It is noteworthy that emergency managers at all levels and other decision makers often lack geo-coded data for their jurisdictions. The National Research Council (NRC) Committee on the *Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk* (2007) presents some of the challenges regarding the availability and accessibility of such data, including the limited availability of data, frequent or continuous population movements that take place among residents of a specific geographic area, and the aggregate scale of the data available in most Western countries. For example, Census data provides information about the population in their area or residence. However, as we all know, residents are constantly moving from one geographic area to the next. The current data does take into account the dynamic nature of population movements and, thus, challenge our ability to estimate populations at risk at a particular point in time. Moreover, visualizing demographic and socio-economic data is not always an easy task for emergency managers when they lack

thematic maps. As the report suggests, the ideal solution for better estimates would be a population registry instead of aggregate census data. However, the costs of population registries are significantly higher and they are only available in a few European countries.

To advance the use of GIS in emergency management an online decision support tool is being developed that combines demographic, socio-economic, physical, and infrastructure data in a single platform. The Disaster Decision Support Tool is the product of two major research projects. The first project, *“Population Composition, Geographic Distribution, and Natural Hazards: Vulnerability in the Coastal Regions of Puerto Rico,”* funded by the University of Puerto Rico Sea Grant College Program, focused on generating geographical maps, in both paper and GIS formats, of the coastal areas of Puerto Rico that include detailed demographic and socioeconomic data of the resident population. This research project was aimed at developing a better understanding regarding the demographic and socio-economic factors that contribute to vulnerability, perception of risk, disaster mitigation, and preparedness among communities in the Island’s coastal regions. As discussed in the previous section, a social vulnerability index for population in all coastal municipalities was generated. Using the 1990 and 2000 Census data, we were able to generate a social vulnerability index for this segment of the population. During this process, storm surge paper maps for Puerto Rico, provided by the United States Army Corps of Engineers (USACE) and the Puerto Rico Planning Board (*Junta de Planificación de Puerto Rico*), were digitized. Further, computer-based GIS maps were developed integrating coastal flooding due to storm surge and tsunamis, 1990 and 2000 census data on Population and Housing characteristics, built infrastructure, and satellite and aerial imagery for the island of Puerto Rico. This project was a collaborative effort between the University of Puerto Rico-Mayagüez and the University of Delaware<sup>1</sup>. The second project is part of a larger

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<sup>1</sup>Researchers for this UPR-Sea Grant program funded proposal included Havidán Rodríguez (PI) at the Disaster Research Center (DRC), Walter Díaz (CO-PI), Center for Applied Social Research Aurelio Mercado (CO-PI), Physical Oceanography Laboratory, and Jenniffer Santos-Hernández, doctoral student in sociology and lead graduate research assistant at the Disaster Research Center.

research effort by the Engineering Research Center (ERC) for Collaborative Adaptive Sensing of the Atmosphere (CASA) funded by the National Science Foundation<sup>2</sup> (NSF).

The Disaster Decision Support Tool, developed at the Disaster Research Center (DRC) and available online (<http://www.udel.edu/DRC/DDST>), is a mapping tool which uses a web browser to enable the user to place a service request to a mapping server located at the University of Delaware. This request is processed by the hosting server, and a map image, with the information requested, is delivered to the end-user. As part of the CASA project, we are exploring the capability of the Disaster Decision Support Tool to display real time radar data generated in the Puerto Rico Student-Led Testbed.

## **5. Web Browser Requirements**

The *Disaster Decision Support Tool* can be accessed using most web browsers, such as Netscape Navigator 8.1, Netscape Communicator 7, Mozilla Firefox 1, Internet Explorer 6, or Opera 9.

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<sup>2</sup>This work was partially supported by the Engineering Research Center's Program of the National Science Foundation under NSF award number 0313747. This tool is part of the research generated in the Puerto Rico Student-Led Testbed. The primary social science researchers in this project include Havidán Rodríguez, Walter Diaz, Jenniffer Santos-Hernández, and William Donner.

## 6. Obtaining Access to the DDST

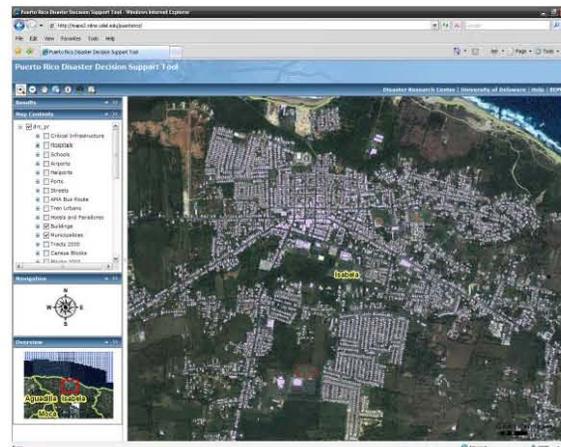
The Disaster Decision Support Tool is an open access tool available to any end-user. However, in the future, there may be the need to provide password protected access to the system. If this were to be the case, end-users would be able to obtain a username and a password, once the user provides the requested information, to gain access to the system.

## 7. Geographic Information Currently Available

The DDST uses a number of governmental data sources and data generated through the aforementioned research projects, including research of investigators at the partner research centers. The online mapping tool integrates vector and raster data layers in a single platform.

**7a. Vector Layers** are layers that present a discrete object. Vector layers are points that indicate a specific location or connected points that form a polygon (e.g., polygon delineating an area exposed to flooding). Geo-referenced databases are associated with all layers (vector and raster). Some of the vector layers included in the DDST are:

- Roads
- Bridges
- Hydrography
- Building Footprints
- Neighborhoods
- Coastal Barriers
- Airports
- Ports
- Bus Routes
- Train Routes
- Public Schools
- Hospitals
- Storm Flooding
- Tsunami Line
- Tsunami Areas
- Storm Surge Flood Prone Areas
- Hurricane Tracks



- Social Vulnerability Assessment, 1990 and 2000
- Demographic and Socioeconomic data at the municipal, barrio, tract, block and group levels where available, including
  - Children under the age of 18
  - Elderly (65 years and older)
  - Female-Headed Households
  - Population Living in Poverty
  - Population with Low Levels of Education
  - Population with Disabilities
  - Population Unemployed
  - Households without a vehicle
  - Households without phone service
  - Renter-occupied households
  - Households receiving financial assistance
- Others

**7b. Raster Layers** presents a continuous field. In a raster layer, data is represented in cells, pixels or squares that are usually part of a bigger field or collection of cells. Some of the raster layers included in the DDST are:

- Digital Elevation Models
- Hill shade
- Aerial Imagery
- IKONOS
- Others

*If you would like to publish additional data or to update the data currently published in the DDST, please contact us by email at [jsantos@udel.edu](mailto:jsantos@udel.edu).*

## 8. How to start using the DDST?

This manual has been provided to guide you through the basic functions and capabilities of the online mapping tool. First, using your web browser access the following URL:



<http://www.udel.edu/DRC/DDST>

After reading the user's agreement, you should proceed to launch the mapping tool by following the hyperlink located in the bottom of the webpage that reads:

[Click Here to Launch the DDST Online](#)

Figure 1.1 Puerto Rico Disaster Decision Support Tool Homepage

## 9. DDST Features

### 9a. Managing the left pane

The left pane has a number of features.

**Opening/Expanding or Closing/Collapsing Tabs:** You can open and close or expand and collapse the information tabs on the left pane by clicking on the triangle located on the right end of each tab (see figure 1.3).

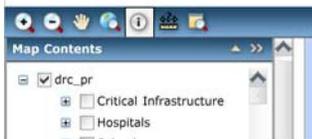


Figure 1.3 Managing Tabs

Tabs can also be taken inside and outside of the left pane by clicking on the double arrows that are located at the very end of each tab.

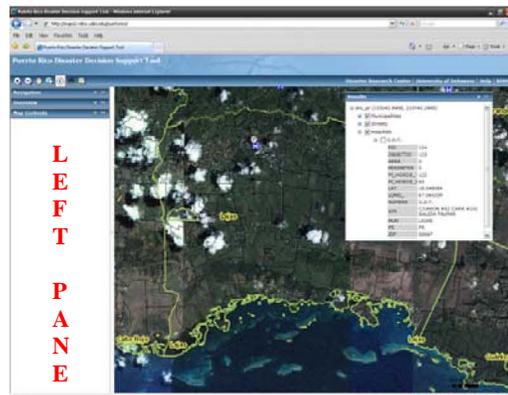


Figure 1.2 Overview of the left pane

## Selecting a layer or multiple layers

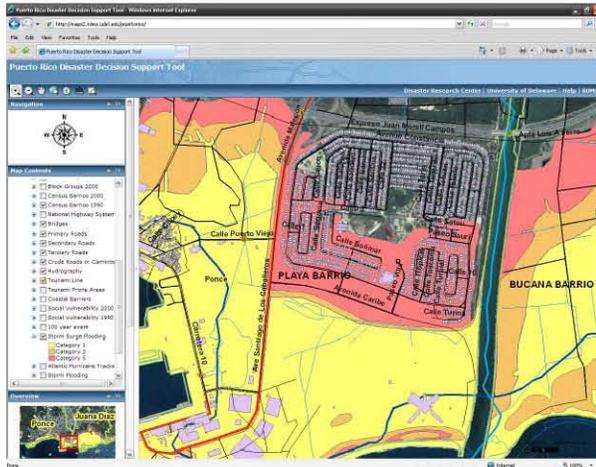


Figure 1.4 Navigating through the Map Contents

The left pane can also be completely hidden or collapsed by clicking its right border. This allows you have a larger area for map viewing (see the sample image illustrating the left pane collapsed in the Results section).

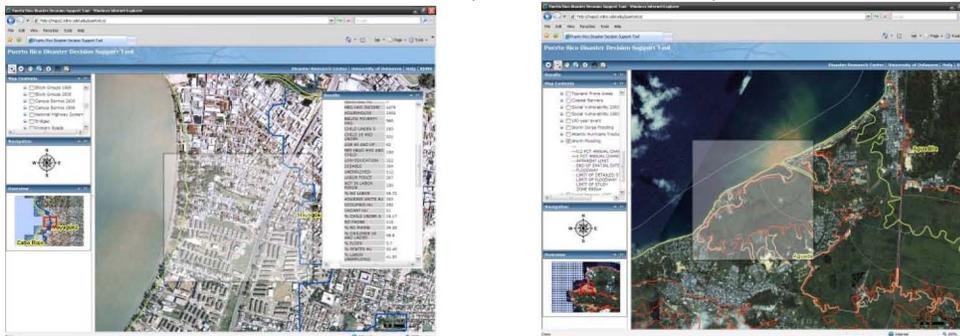
As noted earlier, a number of layers and their associated geo-referenced databases

are available in the DDST. The list of layers can be seen in the 'Map Contents' tab located in the left pane. First, you will have to expand the list by clicking on the plus (+) sign located before the only map contents menu that is available called 'drc\_pr'. The plus sign (+) becomes a minus sign (-) and the Map Contents Menu is expanded. By clicking on the plus sign (+) located before each layer, the symbols are displayed. It is very important that you understand how to collapse and expand the tabs, menus, and sub-menus as this process is also used to expand the information that is generated by submitting a request using the 'Identify' feature. The information received when submitting a request will show in the 'Results' tab located on the left pane. As with all other tabs, you can remove this tab from the left pane and you can also resize the tab window.

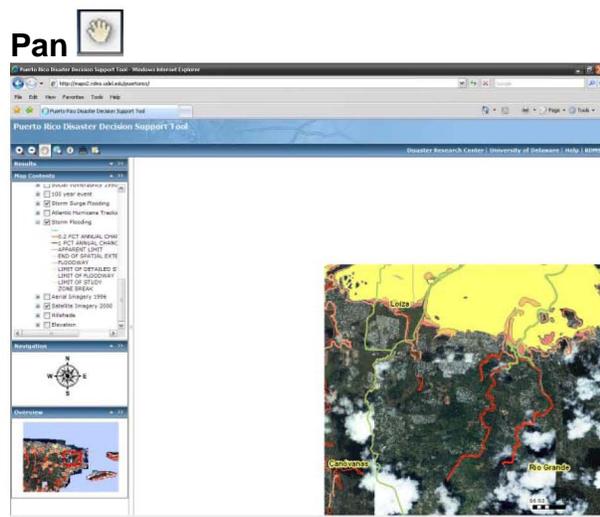
## 9b. The Navigation Toolbar

The Navigation Toolbar contains the functions offered by the mapping tool, including zoom in, zoom out, pan, full extent, identify, measure, magnifier. You can also print a map using the print function of your web browser. This section provides a brief description of the functions in the navigation toolbar.

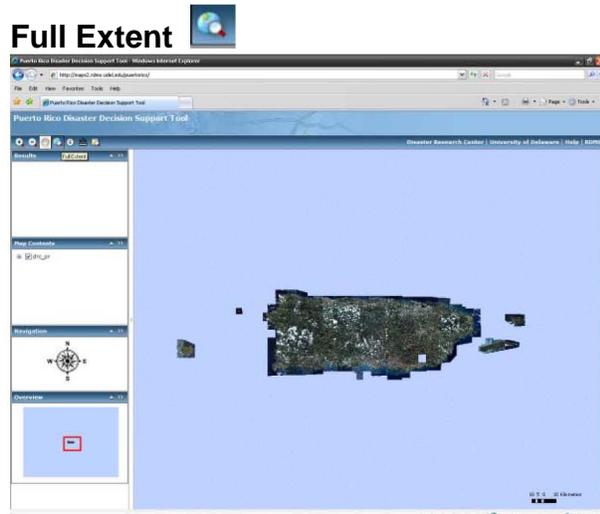
### Zoom In and Zoom Out (Shift + + or Shift + - )



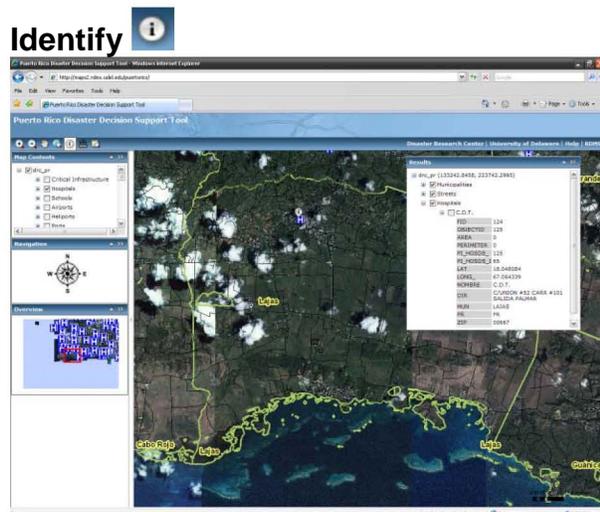
The *Zoom In* and *Zoom Out* functions allow you to make a specific area closer or farther. There are three main ways to use the Zoom In and Out functions. First, you select from the navigation toolbar the function that you want to use. Once you select the function you can “left click” into or out of a geographic area, you can drag your mouse and draw a square to select a specific area, or you can use the mouse scroll wheel (if available) to make the map appear closer or farther.



The *Pan* function works as a “virtual hand” allowing you to grab the map and move it around the viewer.

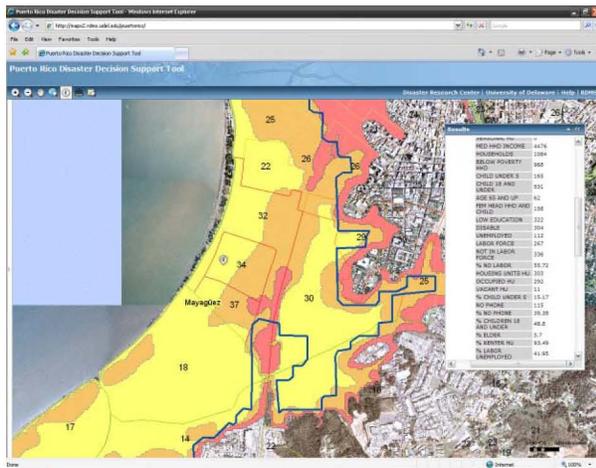


The *full extent function* completely “zooms out” the map on the viewer. You should only use this function if you want to zoom completely out of the map you are viewing. This feature does not refresh or re-launch the tool. To re-launch the tool, you should use the ‘Refresh’ function of your web-browser.



The *Identify function* places a request on the mapping server for information about a specific geographic area; this information will be displayed in the results tab, located in the left pane. The information displayed is the one corresponding to the layers that you have selected. If you need a particular database, you need to activate that layer by clicking in the checkbox located before the name of the desired layer.

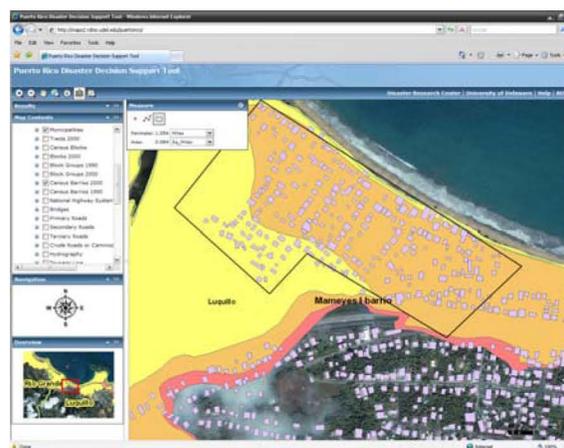
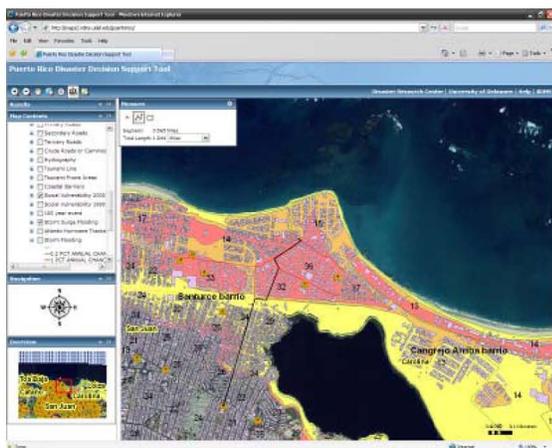
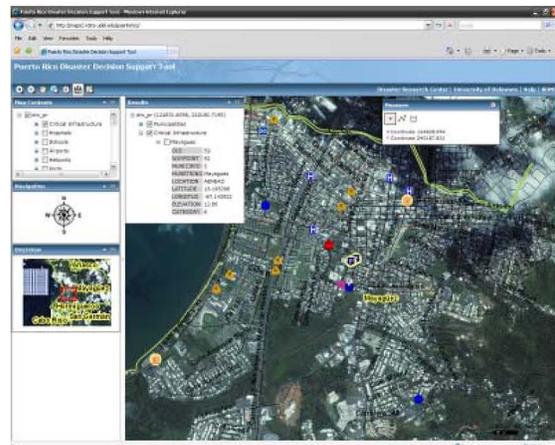
## Results



The *Results* of your request or query are displayed in the results tab. You can also hide the left pane to expand the viewer area. To do so, you need to click on the right border of the left pane. When viewing the results, collapsing the left pane allows for an expanded view of the area under examination.

## Measure

The *Measure function* has the capability to identify the coordinates of a specific location, to measure distances (e.g., trajectories, routes), and to measure the perimeter of a specific area (e.g., exposed area, affected area). The illustrations that appear here show the different capabilities of the *Measure function*.





The *Magnifier* function allows you to take a closer look (up to 10x) at a specific area. To select an area, the magnifier window should be moved to the desired area.



To adjust the distance, you can select from the drop down menu located on the bottom left corner of the magnifier window, how much you would like magnify the selected area.

## Printing a Map

You can print a map by using the print function of your web browser.

## 10. Summary

Throughout all the phases of an emergency or disaster (e.g., mitigation, preparedness, response, recovery, and reconstruction), access to information is vital. Geographic Information Systems can serve as a critical and vital tool that enables the emergency management community to plan, mitigate, prepare, respond, and recover from disasters. The Puerto Rico Disaster Decision Support Tool (DDST) is an internet-based tool for disaster planners, responders, and related officials at the municipal, regional, and state level. The tool offers its users access to a variety of geo-referenced information and data for their areas of jurisdiction. During emergencies and in the aftermath of disasters, a clear understanding of the composition of the population as well as its distribution in the affected area provides responders with the capacity to prepare for and respond to the disaster situation. If used appropriately, the DDST will also allow first responders to channel aid more efficiently and effectively to the population groups with the greatest needs.

As described above, the *DDST* has minimal computer requirements and can be accessed using most web browsers. This manual is provided as a guide for end-user's use of the basic functions and capabilities of the online mapping tool.

## 11. How to Contact Us

To receive additional information regarding the Disaster Decision Support Tool or if you have any questions, comments, suggestions, or are interested in adding relevant data related to your agency, please contact Jenniffer Santos-Hernández at [jsantos@udel.edu](mailto:jsantos@udel.edu) or by calling the Disaster Research Center (302)831-6618. You may also contact Havidán Rodríguez or Walter Díaz by email at [havidan@udel.edu](mailto:havidan@udel.edu) and [wdiaz@uprm.edu](mailto:wdiaz@uprm.edu).

## 12. Referenced Publications

- Cutter, S.; Emrich, T., Adams, B., et al. 2007. *New Information technologies in emergency management*, In Waugh, W., Tierney, K. (eds) Emergency Management: Principles and Practice for Local Government, Second Edition. Washington, DC: ICMA Press.
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# Notes

