A GEOSPATIAL FRAMEWORK FOR ALLOCATING DISASTER RECOVERY CENTERS

Heidi Hurst
Applied Mathematics
Harvard College 2016

INTRODUCTION

Disaster Recovery Centers (DRCs) provide important services for individuals in impacted counties. For those who survive tornados, hurricanes, floods, or other disasters, these pop-up shops provide information about Federal Emergency Management Agency (FEMA) programs, access to resources from volunteer organizations and other agencies, and a source of hope. FEMA opens between 200 and 600 DRCs per year, depending on the number of Individual Assistance disaster declarations. From 2008 to 2013, 1,674 DRCs were opened, providing service to 1,050,629 visitors.[1]

Location choice is vital in ensuring that DRCs are accessible to the target population and meet the goals of the coordinated disaster response. Infrastructure damage or lack of access to transportation may prevent survivors from reaching facilities within a reasonable amount of time, hindering effective recovery. Geographic information about damaged local road networks and the distribution of vulnerable populations must be taken into account when selecting location choice to maximize both DRC impact and overall recovery potential.

Despite the clear importance of these geographic considerations, comparatively few resources have been dedicated to developing a rigorous methodology for determining DRC location. This research creates a baseline methodology for analyzing populations served by one or more DRCs. This spatial analysis is an important first step towards developing a rigorous, data-driven process for selecting DRC locations.

RESEARCH QUESTION

My project addressed the following question:

How can FEMA leverage spatial analysis to evaluate DRC locations? Specifically, (1) how many people can reach a DRC and (2) what are their vulnerabilities?

DATA SOURCES

This analysis relied on a combination of Federal, Agency, commercial, and public data. The script relies on the following five data sources:

(1) Current disaster shapefile indicating the designation of each county (frequently updated)

(2) DRC locations from FEMA's REST service (frequently updated)

(3) A link to state Social Vulnerability Index (SVI) data on the tract level[2] (static)

(4) Road network data[3] (static)

(5) Landscan population estimates[4] (static)

---

[1] Response to FEMAStat Memorandum dated December 30, 2013 (Action Item #1)

[2] Center for Disease Control, http://svi.cdc.gov/

[3] Homeland Security Infrastructure Program

[4] conus-night approximations

METHODOLOGY

This project was scripted in Python 2.7 for use with ArcMap Desktop 10.2.2. The convenient integration of these two technologies allows for efficient execution and consistent replication, which allows analysts to reduce turn around time and increase responsiveness to survivors.

The methodology consists of four steps:

(1) Determine catchment areas of DRCs using the Network Analyst extension.

These areas, also called service areas or drive time areas, show areas in which a person could likely drive to a DRC in a specified amount of time (e.g. 20 minutes). Crucially, ESRI's Network Analyst tool allows damaged infrastructure to be included as "impedances," allowing this analysis to account for driving delays due to collapsed bridges, inundated roads, or other "off limits" roads. This analysis can be re-run as new information about infrastructure damage becomes available, providing a more accurate impression of survivor ability to access DRCs.

(2) Categorize population characteristics in affected counties using raster reclassification.

This analysis used the Social Vulnerability Index (SVI) to categorize populations as high, medium, or low vulnerability. This metric, based on several American Community Survey variables, takes social factors into account to predict the resiliency and community-wide ability to prevent suffering and financial loss.[5] (Note that this index is not available for tribal nations or territories.)

(3) Analyze populations served by DRCs using Zonal Statistics.

Catchment areas and population characteristics are combined as rasters and then converted to polygons. Next, these polygons are combined with LandScan data using Zonal Statistics and Python's NumPy manipulations. This gives population estimates with more granularity than American Community Survey or Census data, allowing a thorough breakdown of vulnerability and drive time for all people in a given county or disaster area.

(4) Visualize results in ArcGIS, Excel, PowerPoint, or other media for use by analysts and decision makers.

The results of this analysis can be visualized as shapefiles in ArcGIS. Additionally, the data can be visualized as useful pie charts, bar graphs, etc depending on the audience. The versatility of this approach ensures that these insights can be communicated regardless of GIS or map proficiency, while still retaining the analytic heft of geospatial analysis.

Although these steps can be completed without using Python, the first three can easily be combined into one cohesive code. This allows for more efficient analysis as well as standardization of products, allowing any GIS specialist to rapidly run a rigorous analysis for any scenario in real time.

APPLICATIONS AND CONCLUSION

There are many applications of this research to the DRC program, to field services, and to FEMA Recovery Directorate's efforts more broadly.

This research has the potential to help drive decisions about where to allocate DRCs. Before opening facilities, state and federal officials could analyze what populations would be served and

---

[5] For more information on the derivation and use of SVI, see Flanagan, Barry E.; Gregory, Edward W.; Hallisey, Elaine J.; Heitgerd, Janet L.; and Lewis, Brian (2011) "A Social Vulnerability Index for Disaster Management," *Journal of Homeland Security and Emergency Management*: Vol. 8: Iss. 1, Article 3. http://svi.cdc.gov/Documents/DataA%20Social%20Vulnerability%20Index%20for%20Disaster%20Management.pdf

assess whether proposed DRC locations meet their goals. This process allows for comparison of potential locations, providing firm analytic footing to prevent inefficient, politically motivated, or otherwise suboptimal DRC locations.

This research also supports the operations of individual DRCs. By obtaining detailed information on the population served by a given facility, DRC Managers will have a better idea of what resources are needed at a specific location.

In addition, this research enables data-driven collaboration between the DRC workgroup and the Disaster Survivor Assistance (DSA) teams. Identifying high vulnerability populations far from DRC catchment areas can serve as one way to identify locations for DSA teams to visit. This prevents duplication of efforts and ensures easier and more comprehensive access to resources.

Ultimately, the goal of this tool is to better serve survivors of any disaster. By taking full advantage of Python scripting for ArcGIS, FEMA can decrease response time and optimize use of resources, helping survivors and communities recover and thrive.

For more information, source code, and an example for Texas Disaster 4223, see
https://www.dropbox.com/sh/enb6cnitirjupjq/AAC3Xl9syV7GIe7qYeSJGWmNa?dl=0

ACKNOWLEDGEMENTS

With special thanks to the DRC Group; Mick Brierley, Anna Krzystyniak-Sobiewska, David Warren, Greg Edgar, and Michelle Bonifas in Recovery GIS; Carter Hawley; Chris Vaughan for data access; Tim Allen, statistical wizard; Chris Smith; fellow intern Kennedy Akwuba; my mentor Julia Moline; and my (very patient) supervisor Carlos Davila.

This project was funded and made possible through the DHS HS-STEM Summer Internship Program administered by Oak Ridge Associated Universities.