Using GIS for Hazard Mitigation
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THE ROLE OF GIS IN HAZARD MITIGATION
Hazard Mitigation Assistance (HMA) programs provide funding for eligible activities that are consistent with the National Mitigation Framework’s Long-Term Vulnerability Reduction capability. HMA programs reduce community vulnerability to disasters and their effects, promote individual and community safety and resilience, and promote community vitality after an incident. Furthermore, HMA programs reduce response and recovery resource requirements in the wake of a disaster or incident, which results in a safer community that is less reliant on external financial assistance.

General program requirements must be met to receive funding under the three HMA programs: Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation, and Flood Mitigation Assistance. To meet minimum requirements for eligibility, project applications, or subapplications, must demonstrate that projects are:

- Eligible activities
- Cost-effective
- Technically feasible
- Compliant with Environmental Planning and Historic Preservation (EHP) requirements

Further, the Applicant and subapplicant must be in conformance with the hazard mitigation plan requirement.

Among the principle components of a subapplication are the Scope of Work (SOW), budget, and schedule. Depending on the mitigation activity, complexity of the SOW, and environmental considerations, visually depicting key data elements in a manner that will facilitate the FEMA review and approval process may be advantageous.

A Geographic Information System (GIS) is a tool that can provide a visual depiction of complex information. GIS can display, store, and analyze data, and store and display results of any analysis performed.

This visual depiction of data can help improve decision-making transparency and communication by enhancing project scoping and project development. For example, with a base map for a landslide or stormwater management project, an Applicant or subapplicant can use GIS to overlay data such as:

- Location of the proposed project
- Location of the area impacted
- Affected population
- Vulnerability to flood risk
- Flood zone/risk profile
- Areas impacted by archeological or historical resources
- Potential EHP impacts (e.g., biological)
- Before and after data to depict the impact of the mitigation activity

Additionally, GIS produces maps that can help communities organize their resources (e.g., community response and prioritization of mitigation activities based on vulnerability assessments through improved information) to develop effective mitigation strategies. Often, this mitigation strategy is developed through the mitigation planning effort, which would benefit from the use of information that is visually displayed in GIS.

GIS databases can include property boundary information, infrastructure information, demographics, and property statistics. Multiple GIS datasets can be used to streamline the application process and assist in the decision-making process (see Table 1). FEMA uses GIS in many forums, including Joint Field Offices, Preliminary Damage Assessments, Individual Assistance housing inspections, and other Federal Agency Programs.

**TABLE 1: GIS Datasets Useful in HMA Applications**

<table>
<thead>
<tr>
<th>Parcel data</th>
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<tbody>
<tr>
<td>Pre-event imagery</td>
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<tr>
<td>Post-event imagery</td>
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<tr>
<td>Damage assessments</td>
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<tr>
<td>Census population data</td>
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<tr>
<td>Elevation (Digital Elevation Models)</td>
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<td>Floodplain mapping</td>
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GIS USES IN IDENTIFYING MITIGATION AREAS
The following examples from Oregon and North Carolina illustrate some of the ways that GIS can be used to identify potential hazard mitigation project areas. GIS helps answer questions such as where, how much, and how many, and can display the answers visually in tables, maps, and reports.

2.1. Oregon 4258-DR

Oregon received a Presidential Major Disaster Declaration (4258-DR) for 14 counties along Oregon’s coast after a devastating storm hit in late December 2015. HMGP funds were used in Lane County where a deadly landslide disrupted a public water supply and electricity to many homes. Figure 1 displays several illustrations of the event using GIS-developed maps, which could be used to determine the location and type of future mitigation projects.
The map in Figure 2 was created using a U.S. Census data shapefile. It provides a visual snapshot of all the counties that were designated for 4258-DR-OR. It also visually identifies how much and which parts of the state were affected by the storm.

A very valuable aspect of GIS data is the attributes table, which lists important information about each area it geographically represents. Attribute tables contain pertinent information and users can edit or add data, and calculations can easily be completed within the table (similar to the functionality in Microsoft Excel).

Some of the information contained in attribute tables include:
- Addresses
- Names of property owners
- Tax information
- Population and housing totals
- Area of land or water
- Road names
- County, state, or town names
- FIP numbers
- Zip codes

Figure 3 shows the total population of each county designated for 4258-DR-OR. GIS statistical tools were used to sum the population of all of the counties; 2,634,767 people were affected by this storm (2010 U.S. Census). The total population of Oregon is 5,012,881, so approximately 52.5 percent of the state’s population was affected by this storm.
Google Earth and the U.S. Department of Agriculture (USDA) are good sources for high-resolution images. Recent aerial images were available from the USDA for the disaster-affected areas of Oregon. Images downloaded from these services could be designated for HMA project applications for better context.

The image in Figure 4 was created using an image from Google Earth and adding a road layer in GIS. This image shows the location of a home that was destroyed (red dot) and the surrounding topography before the landslide occurred. It also shows additional properties that could be at risk from a future landslide.

Figure 5 is another Google image with a more detailed look at the home that was destroyed and the home next to it that was severely damaged.
Google Earth can be used to create elevation profiles, which are helpful in determining potential landslide areas. Figure 6 shows the hillslope that failed behind the residence at 6055 Santa Road. The elevation profile is shown in pink in the box below the image. The elevation was 193 feet where the failure began and the elevation of the home was 40 feet. The slope was approximately 150 feet higher in elevation than the residence. By measuring the linear distance (yellow line in Figure 7), the user can determine the approximate grade of the slope.

**FIGURE 6: ELEVATION PROFILE OF 6055 SANTA RD**

**FIGURE 7: ELEVATION PROFILE OF 6055 SANTA RD WITH LINEAR DISTANCE**
2.2. North Carolina 4019-DR

North Carolina received a Presidential Major Disaster Declaration (4019-DR) for 38 counties along North Carolina’s eastern coast that were severely affected by Hurricane Irene in late August 2011.

Figure 8 shows the 38 counties designated in 4019-DR-NC and was created using 2010 U.S. Census data. The area designated for the disaster is 20,154.8 square miles. The area of all of North Carolina is 49,521 square miles, so approximately 40.7 percent of North Carolina was designated for 4019-DR-NC.

Figure 9 shows the population of the counties affected by 4019-DR-NC. It was created using 2010 U.S. Census data. The total population of North Carolina is 12,830,881 people; approximately 17 percent of the population was affected by Hurricane Irene.
One of the North Carolina counties that suffered the most damage from Hurricane Irene was Pamlico County. One HMGP project funded in Pamlico County was for six acquisition and demolition projects. The locations and addresses of the acquired residences are shown in Figure 10.

Pamlico County’s low elevation and proximity to the coast makes it vulnerable to hurricanes, severe storms, and flooding. Knowing where the population is located within the county helps in better understanding the risk for the county. Having a better understanding of risk helps in determining where mitigation projects and response and recovery resources are likely to be needed.

The map in Figure 10 was created using a mixture of USDA and U.S. Census data. It shows the population of Pamlico County based on 2010 U.S. Census data. Knowing whether heavily populated areas shown on this map are at risk of flooding based on their elevation is helpful for prioritizing proposed mitigation projects.

Figures 11 and 12 were created using elevation data from the USDA Natural Resources Conservation Service and the U.S. Census Bureau. Figure 11 shows elevations and the locations of residences acquired with HMGP grant funds. Figure 12 shows elevations and the number of households per Census block. Elevation is shown as meters above or below sea level. The acquired homes were in areas with an elevation at or below sea level.
Figures 13 and 14 show two close-ups (larger-scale maps) of one area where residences were acquired. The USDA National Agriculture Imagery Program aerial images were taken in 2014.

GIS layers showing land use can be compared to aerial images to highlight areas of land use or land cover change over time, which can be helpful in determining areas potentially at risk.
2.3. Conclusion

This document has explored ways that GIS can be and has been utilized to aid in hazard mitigation and recovery efforts. With creativity, and a little training and experience, the possibilities are almost endless and a product can be created to meet almost any need.

Resources to acquire GIS data:

USDA Geospatial Data Gateway: https://gdg.sc.egov.usda.gov/

U.S. Census Bureau Topologically Integrated Geographic Encoding and Referencing: https://www.census.gov/geo/maps-data/data/tiger.html


Google Earth: https://www.google.com/earth/

Wundermap: https://www.wunderground.com/wundermap/

FIGURE 14: BEFORE- AND AFTER-EVENT ACQUISITION AND DEMOLITION FOR 15576 AND 15703 N.C. 304 HWY