DEVELOPING A NEW ARCGIS TOOL TO QUANTIFY BUILDING-CONTENT VULNERABILITY FROM STORM-SURGE INUNDATION

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Motivation

Natural hazards occur and recur, impacting humans and infrastructure.
Motivation

It is critical to assess potential damage on the human environment prior to a natural hazard.
Problem Statement

The greatest potential for loss of life related to a hurricane is from the storm surge.

Source(s): www.katrinadestruction.com
Objective

develop a new method of quantifying flood-damage risk to vulnerable-building contents
Background

Storm Surge: *Damage*

Source(s): www.katrinadestruction.com
Background

Storm Surge: *Modeling*

SLOSH Model

**Sea, Lake and Overland Surges from Hurricanes** is a computerized model to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes.

Source(s): www.nhc.noaa.gov, Jelesnianski et al. 1992
Background

Storm Surge: *Damage Assessment*

Damage to Building’s Structure

Contents

Source(s): www.katrinadestruction.com
Background

Storm Surge: Damage to Building Contents

Damage to building content increases with flood water depth inside the building.
Methodology

Study Area: *Town of Groton*

Population ~ 40,000, Population density ~ 490 people/km$^2$
Methodology

General Work Flow

LIDAR data

RTN-GPS data

DEM

SLOSH model

Surge heights

Flooding scenarios

Damage assessment tool

Estimate damage
Methodology: Damage Assessment Tool

Hypothetical-damage function

\[
D = \left\lfloor S_n(d) \right\rfloor + 1 - e^{-5\text{Mod}[S_n(d),1]}
\]

\[S_n(d) = \text{Min}(d / m, n)\]

- **D**: normalized damage (unitless, \(0 < D < 1\))
- **d**: flood-water depth inside the building (meters)
- **m**: meters per story
- **n**: number of floors in the building (stories)
- **\lfloor \cdot \rfloor**: floor operator
Methodology: Damage Assessment Tool

Hypothetical damage function

Depth-Damage Curve: Single story

Flood depth

Flood Depth (m)
Methodology: Damage Assessment Tool

Hypothetical damage function

Depth-Damage curve: Multistory building

![Diagram of Multistory Building with Flood Depth and Damage Levels](image-url)
Methodology: Damage Assessment Tool

Damage assessment algorithm: simplified version

- Non-ground LIDAR
- Flood raster
- Not-Flooded
- Flooded
- Foot-print

DEM
Methodology: Damage Assessment Tool

Programming with Python

Python IDLE 2.5.1 was used to code the damage assessment-algorithm script.

A new ArcGIS 9.3 tool was developed to automate the entire process.
Results & Discussion

Damage Assessment Tool

User interface of the damage assessment tool
Results & Discussion

Estimated damage: 27 flooding scenarios in detail

<table>
<thead>
<tr>
<th>Surge height (ft)</th>
<th>Total no. of damaged buildings</th>
<th>Estimated Damage (Nominal Damage - ND)</th>
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</tr>
</tbody>
</table>
Results & Discussion

3-D Damage visualization

4 ft (1.5 m) surge scenario
Results & Discussion

3-D Damage visualization

10 ft (3 m) surge scenario
Results & Discussion

3-D Damage visualization

16 ft (5 m) surge scenario
Results & Discussion

Estimated damage

Estimated damages were expressed as nominal damage (0 - 1)

Damage would be more meaningful if expressed in US dollars

building layer did not contain any attributes indicating either structure values or property values
Results & Discussion

Damage Assessment Tool

The ArcGIS tool is not limited to assessing flood damages posed by storm surges. Therefore, this tool can be used in other flood damage assessments as well by assuming a still water model.
Results & Discussion

Damage function

It would have been desirable to validate the damage function using actual damage data.

Following variables should have been included into the damage function:

- Flood-water velocity (we assumed a still-water model for flooding)
- Construction material of buildings