Floodplain Management and Risk Communication: An Iowa Silver Jackets Pilot

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Pilot Purpose

- To assemble a central database that merges various agency’s info into a central location to identify current and future flood risk.
Pilot Focus Area: IA-Cedar

- **Watershed Description**
  - 12,620 mi² (~8 million Acres)
  - 15,700 mi stream segment length
  - Historic Landuse: Tall Grass Prairie intermixed with wetlands and bottomland hardwood forests
  - Current Landuse: Mixed-Use basin. Primarily Row Crop and Livestock Agriculture along with 3 Major Growing Urban Centers
  - Basin Population ~ 1 million
Introduction/Background

- The state of Iowa has delegated most ordinance decisions to the local units of government.
- The only mandatory state ordinance is the floodplain ordinance.
- Main Issues:
  - Structures are increasing within the FEMA defined FP boundary.
  - Landuse and Climate changes are expanding the inundation area, increasing flood risk on existing structures.
Goal

- Provide State and Local Organizations Zoning and Technical Information in a Meaningful Way to Encourage Actions that Lower Current and Future Flood Risk in the IA-Cedar Basin.
Objectives

- **Primary objective:** Compile flood risk related data and information into a database for better understanding of flood risk in the Iowa-Cedar Watershed.
- **Secondary objective:** Quantify current and future flood risk.
- **Tertiary Objective:** Identify how to lower flood risk by community adoption of various floodplain management measures (CRS).
Primary Objective: Database Fields

- **Demographic**
  - ▶ FIP and CID
  - ▶ Contact Info
  - ▶ Location and Population
  - ▶ NFIP Status?

- **Proactive Planning**
  - ▶ Adopted Hazard Mitigation Plan?
  - ▶ Adopted Comp Plan?
  - ▶ Future LU Map?

- **Regulatory**
  - ▶ Adopted a Zoning Ordinance?
  - ▶ Adopted Subdivision Ordinance?
  - ▶ Adopted Storm Water Management Regulations?
  - ▶ Adopted Sensitive Areas Ordinance?
Database Statistics

▪ Demographic
  ► Communities = 270
  ► FEMA Recognized = 181
  ► NFIP Participating = 151

▪ Proactive Planning
  ► Adopted Higher Stnds then NFIP State Minimum = 7
  ► Developed Hazard Mitigation Plans = 17
  ► Developed Comprehensive Plan = 88
  ► Future LU Plan Map = 47

▪ Regulatory
  ► Adopted Zoning Ordinance = 128
  ► Adopted Subdivision Ordinance = 104
  ► Adopted SW Management Ordinance = 56
  ► Adopted Sensitive Areas Ordinance = 80

▪ Unable to Contact = 69
Secondary Objective: Quantify Risks

- **Current Risk**
  - How to Identify the FP: FIRM or NO FIRM
    - If FIRM use HAZUS (FEMA)
    - No FIRM use Landform method (NRCS)
    - How do they compare?
  - Current Structures and Landuse

- **Future Risk**
  - Future Structures???
  - Future Landuse???
  - Climate Change???
Landform Method vs FIRM

Method Area Comparisons

Legend:
- DFIRM FEMA FIG 10 yr. Floodplain Extent
  - Area: 2057.5 Acres / 827.9 sq. mi.
- DFIRM FEMA FIG 50 yr. Floodplain Extent
  - Area: 2544 Acres / 1015.8 sq. mi.
- SSURGO Landform Floodplain Extent
  - Area: 3282.3 Acres / 1317.9 sq. mi.

Iowa-Cedar Watershed
- Iowa-Cedar Watershed Boundary
- SSURGO Floodplain Extent
- City Limits

Miles

BUILDING STRONG®
Indian Creek Example

- FIRM is available - Run HAZUS to identify current flood risk by census block
- What is the per capita flood risk?
- How is the flood risk changing based on their future landuse plans? Climate Change?
- What actions can we take now that will help?
Current Landuse Indian Creek

Land Use Proportion for Floodplain Area of Indian Creek Watershed

- Developed: 22%
- Forest/Shrubland: 15%
- Grassland/Herbaceous: 8%
- Pasture/Hay: 11%
- Row Crops: 37%
- Wetland: 7%
- Water: 0.01%

Land Use Proportion for Upland Area of Indian Creek Watershed

- Developed: 26%
- Forest/Shrubland: 6%
- Grassland/Herbaceous: 3%
- Pasture/Hay: 6%
- Row Crops: 59%
- Wetland: 0.1%
- Water: 0.01%
Worth a Closer Look?

<table>
<thead>
<tr>
<th>Community Name</th>
<th>HAZUS Census Blocks Affected</th>
<th>HAZUS Total Structural Loss</th>
<th>HAZUS Total Population of Affected Blocks</th>
<th>Total Community Population</th>
<th>HAZUS Structural Loss Per Capita (In Affected Blocks)</th>
<th>HAZUS Structural Loss Per Capita (Entire Community)</th>
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</thead>
<tbody>
<tr>
<td>CITY OF ALBURNETT</td>
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<tr>
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<td>$10,779</td>
<td>$514</td>
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</tbody>
</table>

Notes:
Structural Loss refers to a combination of building and building content damage. This damage was assessed through HAZUS 2.1 using default inventories, valuation parameters and replacement values. Model inputs are as follows: NED 10m elevation grid & 10m Depth grid derived from FEMA cross section & 100yr flood water surface elevations.

**Total Structural Loss** is an aggregation of census block structural losses that are within the boundaries of each town.

**Structural Loss Per Capita (In Affected Blocks)** is the total structural loss divided by the population of only the blocks that experienced flood damages.

**Structural Loss Per Capita (Entire Community)** is the total structural loss divided by the entire population of the community.

Method notes:
HAZUS provides area weighted damage estimates based on the depth of flooding within a given census block. The methodology assumes an even distribution of structures throughout each block. This may lead to generalized results. For more information refer to the HAZUS 2.1 Technical Manual, available online through FEMA.
Acceptable Flood Risk?

- Risk = Probability * Consequence
- Stakeholder’s were asked
  - Appropriate LU’s?: Flood Resilient Structures, Agriculture (minus CAFO’s), Parks, Natural Habitat
  - Future Landuse Plan Acceptable???
    - Are you willing to accept consequences assuming the probability stays constant?
    - How about if the probability changes too?
Potential
Future
Landuse
Indian Creek
Landuse Change Indian Creek

National Land Use Cover: Indian Creek Watershed National Land Use Cover 2006 and Proposed Linn County Modified Future Land Use

*Agricultural areas were assumed to all be converted to row crop based on high recent market prices.
Acceptable Future Landuse Plan in Indian Creek?

Land Use Proportion for Floodplain Area of Indian Creek Watershed

- Row Crops: 37%
- Pasture/Hay: 11%
- Grassland/Herbaceous: 8%
- Forest/Shrubland: 15%
- Wetland: 7%
- Developed: 22%
- Water: 0.01%

Proposed Future Land Use for Floodplain Area of Indian Creek Watershed

- Row Crops: 39%
- Pasture/Hay: 2%
- Grassland/Herbaceous: 4%
- Forest/Shrubland: 12%
- Developed: 40%
- Wetland: 3%
- Water: 0.01%
Moderately Frequent Event – Same Precipitation, Different Land Use
(26-28 August 2009)

100% Impervious Watershed

Future Build Out (2020)

Current Land Use

Historical Land Use (1980)

Unofficial model results for illustrative purposes only
Moderately Frequent Event – Same Land Use, Different Precipitation
(26-28 August 2009)

Current land use, potential future 25-year storm

Current land use, current 25-year storm

Unofficial model results for illustrative purposes only
Moderately Frequent Event – Different Land Use, Different Precipitation
(26-28 August 2009)

Flow (cfs)

100% impervious watershed, current 25-year storm

2020 land use with potential future 25-year storm

Current land use with potential future 25-year storm

2020 land use with current 25-year storm

Current land use with current 25-year storm

Unofficial model results for illustrative purposes only
2009 Flood

Unofficial model results for illustrative purposes only
2009 Flood
Climate Change Scenario

Unofficial model results for illustrative purposes only
2009 Flood
100% Impervious Watershed Scenario

Unofficial model results for illustrative purposes only
Tertiary Objective: FP Actions to Lower Flood Risk (CRS)

- New CRS Manual under review at OMB
- Preservation of FP Open Space + Restoration of Critical FP Areas
- Outreach and Education
- Warning Systems
- Structural and Non-Structural Measures???
Urban Risk
Informed Decision Making and Communication

- Given what you learned about hydrologic modification is this development acceptable currently? Future?
- Who bears the cost associated with this decision (Fed/State Gov’t/taxpayers? Local Gov’t? Residents? Downstream Resources?)
- Probability is full of Uncertainty… Are stakeholders willing to realize the potential consequence?
Rural Risk
Informed Decision Making and Communication

• Look for Low Hanging Fruit: Wetland Reconnection provides benefits for:
  • Habitat and Wildlife
  • Water Quality
  • Recreation
  • Water Quantity???
  • Urban Assets (Roads and Downstream Residences)
Conclusions

- Few communities have developed a full suite of ordinances to manage their current and future development/flood risk.
- Agencies may need to consider a two-pronged approach to focus attention on smaller communities while working to lower the highest total flood risk in larger communities.
- HAZUS and other GIS-based tools may be effective in rapidly identifying and/or estimating economic losses associated with FP structures.
Floodplain Management and Risk Communication: An Iowa Silver Jackets Pilot

Technical Details

Michael Dougherty
Potential Technical Methods

- 3 different methods for delineating the floodplain extent and estimating economic losses.
  - Detailed Hydrologic analysis and Detailed Economic Valuation
  - FEMA-FIRM map floodplain delineation and HAZUS Economic Valuation
  - NRCS landform methods floodplain delineation and Area-Weighted Average Economic Valuation.
Detailed Hydrologic Analysis, Detailed Economic Valuation

**Pros**

- Highly accurate hydrologic analysis based on standard USACE H&H modeling methods
- Highly accurate economic valuation of loss based on standard USACE structure inventory methods

**Cons**

- Extremely expensive
- Extremely time consuming
- Methods do not cost-effectively scale to regional level
DFIRM Flood Extents

**Pros**
- National Dataset (NFHL)
- De facto standard
- Hydrologically based return interval (100, 500 year)
- Covers all high-population areas
- Planned national coverage

**Cons**
- Not complete for the entire US, or Iowa-Cedar watershed
- Large areas based on older studies where hydrology may have changed
NRCS, SSURGO Landform

The SSURGO Landform field records the landform class of the soil map unit. The following landform classes were identified as representing floodplains:

- Flood plain
- Alluvial fans
- Stream terrace
- Terrace
- Water
- Pits, sand, and gravel
# SSURGO Floodplain

## Pros
- National Dataset
- Covers Iowa-Cedar watershed

## Cons
- Flood extent much larger than 500 year return interval
- Not consistently attributed nationwide
- Contains many upland soil map units
- Cannot be used to depths for input into HAZUS
FEMA HAZUS-MH

FEMA’s Methodology for Estimating Potential Losses from Disasters  www.fema.gov/hazus

- Hazards-United States (Hazus) is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes.
- Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters.
- It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods.
- Permits the use of 3 tiers of input data detail to allow progressively more refined loss estimates.
Test HAZUS on Cedar Rapids

To determine the accuracy of HAZUS estimates, we decided to compare HAZUS results with the detailed Cedar Rapids Economic analysis.

Can HAZUS match the Cedar Rapids Economic Study?

- The red line indicates where all of the data points should fall if prediction was perfect.
- All points fall to the upper left of the 1:1 line indicating that the rapid HAZUS approach is consistently underestimating the more detailed standard economic loss analysis.
Can HAZUS match the Cedar Rapids Economic Study?

- However, the rapid HAZUS analysis was able to predict 37% of the variation in the more detailed Cedar Rapids economic loss estimate.
- Efforts to improve this method should focus on identifying the sources of the remaining 60% of error residuals.
- Estimates for Economic Reaches 4B, 5C, 3 were especially low.
How does DFIRM 500 yr or SSURGO match the Cedar Rapids Economic Study?

- The blue line represents the DFIRM 500 yr floodplain, HAZUS depreciated loss.
- The green line represents the SSURGO floodplain, HAZUS total loss (no depths).
- The red line (black reaches) indicates perfect prediction.
- DFIRM/HAZUS depreciated loss underestimates.
- SSURGO/HAZUS total loss greatly overestimates.
How does DFIRM 500 yr Floodplain with HAZUS match the Cedar Rapids Economic Study?

- The blue line represents the DFIRM 500 yr floodplain, HAZUS depreciated loss.
- The outliers are economic reaches being underestimated (4B, 5C, 3, 2D, and 4A).
- These suffer from "industrial error" which can be addressed through user defined significant structures in HAZUS.
- Addressing this source of underestimation would dramatically improve this simple model.

Adjusted R-squared: 0.45
F-statistic: 11.64 on 1 and 12 DF
p-value: 0.005163
n = 13
y = 4.708 x
S.E.: 1.38
Industrial Error: 4B, Quaker Oats/Pepsi
HAZUS Significant Structures

- HAZUS allows user input of significant structures and their values.
- Significant structures could be identified across a large watershed using cost effective air photo interpretation.
- Cost-effective economic valuation techniques could be used to rapidly value these significant structures.
Remaining Sources of Error

User defined significant structures only helps remove the “Industrial Error” in those economic reaches dominated by industry.

Other techniques will need to be identified to cost-effectively improve the estimation of residential and commercial land use classes.

These other cost-effective techniques will likely involve using local experts to adjust the valuation tables to more closely represent regional conditions.
HAZUS on Iowa-Cedar

- HAZUS is storage intensive.
- Large study areas need to be broken into subsets (4-5 counties max.), unless MS SQL Server is used.
- Computation time per subset is reasonable (2-3 hours total).
Q: Wait, I thought HAZUS underestimated flood loss?
A: Why not use the “Heat Map” approach?

• Although you may be underestimating the actual $ amount of flood loss, the analysis largely identifies the relative amount of flood loss risk.
• Binning the $ amount of loss into 3 coarse levels communicates risk while avoiding $ valuation errors.
What about areas where DFIRMs don’t exist yet?

SSURGO was explored as a potential data source of floodplain extents, but several problems were identified.

- Because it is not hydrologically based, it cannot be used to generate depth grids as input into HAZUS.
- Therefore, only TOTAL structure and content loss could be calculated.
- Represents a measure of maximum values potentially at risk.
Conclusions

HAZUS Flood analysis using FEMA DFIRM floodplains provides a cost-effective initial estimate of flood loss risk. Can be refined.

Total loss index using SSURGO floodplain extents provides a cost-effective crude measure of flood risk where detailed flood extents have not been developed. Malformed index – use with caution.
Lessons Learned from Pilot
Lessons Learned

- Some small communities stated that they are promoting development in the floodplain or near the river in their communities.
- FIRM is not available for all counties in IA-Cedar Basin (yet)
- In absence of FIRM, SSURGO data may identify areas of highest flood risk using total loss but not representative of actual depreciated loss.
Lessons Learned (cont)

- Per Capita losses may be highest in smaller communities.
- Communities are likely to have increasing flood risk based on future landuse plans.
- Communities are likely to have increasing flood risk based on Climate Changes.
- CRS measures may provide major benefits in lowering current and especially future flood risk.
Lessons Learned (cont)

- Modification of HAZUS Economic data tables to account for underestimated structures (such as industrial complexes) and regional assumptions may bring HAZUS loss estimates much closer to traditional Corps method at Cedar Rapids.

- A modified HAZUS may be a useful tool for rapid estimation of flood risk for Federal, state and local governments.
Questions ???

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