Analysis of County Hazard Vulnerability Assessments for Flood Risk in Illinois

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THESIS

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LIST OF ABBREVIATIONS

BRACE	Building Resilience Against Climate Effects
CDC	Centers for Disease Control
FEMA	Federal Emergency Management Agency
FS	Flood Score
GIS	Geographic Information Systems
HVA	Hazard Vulnerability Assessment
IDPH	Illinois Department of Health
IEMA	Illinois Emergency Management Agency
IPCC	Intergovernmental Panel on Climate Change
NFIP	National Flood Insurance Program
NHRMG	Natural Hazards Research and Mitigation Group
NOAA	National Oceanic and Atmospheric Administration
PHEP	Public Health Emergency Preparedness
SIUC	Southern Illinois University at Carbondale
SoVi®	Social Vulnerability Index
THIRA	Threat and Hazard Identification and Risk Assessment

SUMMARY

Flooding is a hazard that has been around for a long time, and in the United State it is the

natural hazard that occurs most frequently (Watson and Adams, 2011). It also has caused the most

property damage and death within the United States as far as hazards go (Brody et al. 2011). Flooding is

a hazard that communities must continue to prepare for and adapt to. As part of this preparedness,

communities must learn to assess the risks of the hazards that may affect them. This study looked at

how this is done by the public health sector in Illinois.

Out of the 102 counties in Illinois, some form of hazard vulnerability assessment (HVA) was

gathered from the Illinois Department of Public Health (IDPH) for 94 of those counties. Within this group

of 94, there were only 77 counties that had quantifiable data that could either be used to calculate risk

(56 counties) or that already had risk values determined (21 counties). Amongst these counties it was

found that flooding was the second-most frequently identified risk right behind tornadoes with a

representation of 91% (70 counties) of the counties. However, it was also determined that of the 77

counties with quantifiable flood risk data flooding was only ranked in the top two risks for 26% (20

counties) of the counties. For calculated risk, only 47 of the 56 counties had a flood risk value and of

these counties only 7 (15%) were assessed to be in the top quartile of perceived risk.

To assess the flood risk based on geospatial data methods, a state flood hazard assessment

completed in 2013 with the Federal Emergency Management Agency's (FEMA) Hazus-MH software by

the Natural Hazards Research and Mitigation Group (NHRMG) at Southern Illinois University at

Carbondale (SIUC) was used as a foundation to acquire flood risk values. Minor adjustments to the

created flood-score values were made to only look at the same 47 counties as the HVA analysis. After

SUMMARY (continued)

this adjustment it was found that using the geospatial analysis 3 (6%) counties of the 47 were assessed to be in the top quartile of risk.

A comparison between risk values of the two forms of flood vulnerability analysis was completed. The HVA analysis was viewed as the more subjective method, whereas the Hazus-MH based assessment was viewed as the more objective and data driven method. This comparison revealed that out of the 47 counties 40% (19 counties) were placed in comparable risk quartiles between the two methods. In addition, when using the Hazus-MH method as the more objective and standard method it was found that 28% (13) of the counties from the HVA analysis assessed an overestimate of the flood risks and 32% (15) of the counties in the HVA analysis assessed an underestimate of the flood risk.

Beyond these findings specific to the assessment of flood risk there was also an awareness of a large lack of standardization within the health departments and the way that the HVAs are implemented. It is in part due to this lack of set standards and methods that more data could not be compiled for all the counties and their flood risk. This was also a source of difficulty when it came to trying to compare the HVA analysis to the GIS assessment, because the level of data used within each assessment was not always clearly noted.

I. BACKGROUND

A.   **Public Health Impacts of Flooding**

Of all natural disasters, floods occur more frequently than any other. Some researchers have even stated that floods make up one-third of all geophysical hazards worldwide (Adhikari et al., 2010). In addition, in a 2011 review of US flood data, Brody et al. concluded that throughout the nation, "More property is lost and more people die from flood events than from tornados, earthquakes, and wildfires combined "(Brody et al., 2011). According to the International Flood Network, during the period from 1995 to 2004, 20% of all natural disaster fatalities were connected to flood events. The International Flood Network also claims that these events caused economic flood damages equivalent to $16 billion (US), which was 33% of the total incurred costs by natural disasters worldwide (Adhikari et al., 2010). A 2004 strategic review of flood health and climate change by Few and colleagues cites that according to the International Federation of Red Cross and Red Crescent Societies globally an average 140 million people per year were affected by flood disasters between 1993 and 2003, more than all the other disasters combined (Few et al., 2004). This included not only fatalities, but also those who had property damage, those whose mental health had been affected by the disaster, those who were impacted in other economic ways, those who have been displaced, and those who sustained injuries in relation to the flooding. In the same review of current epidemiological flood research, Few et al. claimed that since the 1900s flood disasters have led to 6.8 million deaths and 1.3 million reported injuries worldwide (Few et al., 2004).

The impacts of floods are not only felt during the event, but also after the event during recovery. In 2012, Alderman and colleagues completed a systematic review of current global literature looking at flooding and its impacts on human health. This study found that in the first year after the flood event, mortality rates increased by up to 50%, with a particular increased risk of outbreaks of hepatitis E, gastrointestinal disease, and leptospirosis in vulnerable populations (Alderman et al., 2012). Psychological distress was also found to be caused by flood events and to have the ability to intensify physical illnesses. The most common cause of flood-related mortality identified in this study was drowning, which in one specific instance accounted for 40% of all flood-related deaths in Louisiana in the two months after Hurricane Katrina (Alderman et al., 2012).

There is still little to be known about trends in flood-related injuries and long-term health effects, in part due to poor systems for flood surveillance (Adhikari et al., 2010; Ahern et al., 2005). However, this problem is also partially due to the wide onset timeframe of various health conditions linked to flooding, as well as the lack of recognition that some health problems are flood-related. Some injuries, for instance, occur during the flooding as individuals try to assist others out of flooded areas, and other injuries don't occur until residents return to the disaster site to clean-up (Ahern et al., 2005). Yet both injuries are due to the flooding event. In the few surveillance studies that have been done some common documented flood-related injuries are sprains/strains, lacerations, and abrasions/contusions (CDC #1, 1993; CDC #2, 1993).

Beyond the morbidity and mortality impacts, floods have been known to have negative impacts on health system infrastructures and delivery systems, by way of making these key facilities inaccessible to many. Additionally, flooding or power outages have contaminated water supplies at hospitals and other health facilities (Powell et al., 2012; Redlener and Reilly, 2012; Abramson and Redlener, 2012).

When flooding causes parts of the health system to become inoperable this puts extra pressure on other facilities and systems, and sometimes on systems that were already stressed for resources prior to the flood. An example involved the community-based primary health care system during the 1993 Midwest flood in the United States. The flood caused an increase in the frequency of patient visits and increased the number of new patients, both of which stressed the system and began to cause a decrease in the ability of the system to support all of these needs (Axelrod et al., 1994). In 2012 many New York area hospitals were affected by Hurricane Sandy. New York University Langone Medical Center had to do a mid-storm evacuation of 300 patients due to a power outage; and Bellevue Hospital, another facility in the area, evacuated 700 patients the day after the storm. With all these evacuees other hospitals had to be prepared for surge capacity as the patients were moved (Redlener and Reilly, 2012; Ofri, 2012). These incidents were similar to health infrastructure and evacuation problems that occurred in New Orleans in 2005 due to Hurricane Katrina (Powell et al., 2012; Gray and Hebert, 2007).

To assess the threat level to human health and healthcare systems, a variety of factors play a role, including flood characteristics, human population and systems vulnerability, and the adaptive capacity of human populations and systems (Ahern et al., 2005; Few, 2013). The next section will look more at the different types of flooding and the ways that they occur.

B.   **Definition(s) of Flooding**

According to the National Flood Insurance Program (NFIP) *flooding* is defined as "a general and temporary condition in which the surface of normally dry land is partially or completely inundated. Two properties in the area or two or more acres must be affected."(Watson and Adams, 2011). Within the general definition of flooding there are a variety of flood types that Watson and Adams outline in their

book, *Design for Flooding*, as the following: coastal flooding, riverine flooding, alluvial flooding, and

shallow flooding. Coastal flooding occurs on the coastlines and results from any combination of ocean

storms, tides, storm surges, and other precipitation events. Riverine flooding occurs inland when the

land is overwhelmed by an extreme amount of precipitation that is more than the watershed base

capacity can handle. Alluvial flooding, the third type of flooding described, occurs when mud flows and

flash flooding are possibilities in the desert and mountainous areas. Flash flooding as mentioned in the

previous definition is when there is a rapid increase in water levels, normally within six hours of the

beginning of a heavy precipitation event ("Flash Flood", 2014). The final type of flooding Watson and

Adams mention is a type that occurs when water depths are one to three feet outside of a defined

channel, known as shallow flooding. This last type of flooding involves ponding of water in flat areas,

when sheet flow occurs (water spreading across flat area), and can result in urban drainage problems.

C.   **Historical Aspects of Flooding in Illinois**

With nearly 15% of the total land area in the state being subject to flooding, Illinois has one of

the largest inland water systems in the United States and is familiar with the dangers of flooding (State

of Illinois, 2013). Since 1957, Illinois has had 39 FEMA disaster declarations involving flooding, with every

county receiving a declaration at least once (State of Illinois, 2013; "Disaster Declarations for Illinois,"

2013). Figure 1 shows a map of all of the Illinois counties and how many flooding disaster declarations

each county has had, for a total of 460 declarations of individual counties between January 1981 and

May 2013 (State of Illinois, 2013). According to the National Climatic Data Center of NOAA, flood loss

expenses in Illinois surpassed $5.5 billion between 1993 and 2012 (State of Illinois, 2013). Flooding in

the spring of 2013, which was declared a major disaster and affected many counties, has raised

prominence of the issue in Chicago. In October 2013, Rahm Emmanuel, the mayor of Chicago,

announced that as a continued effort to deal with basement and street flooding the city would allocate

$50 million for upgrades and improvements to the city's water and sewer infrastructure (Mayor's Press

Office, 2013). A flood assessment completed by the NHRMG at SIUC determined that throughout the

state approximately 250,000 buildings are located in floodplains. According to the *2013 Illinois Natural*

Hazard Mitigation Plan, based on state history, capability assessments, and hazard identification

surveys, flooding is one of the greatest threats to the state of Illinois. Other hazards identified are ice

storms, tornadoes, and severe winter storms (State of Illinois, 2013).
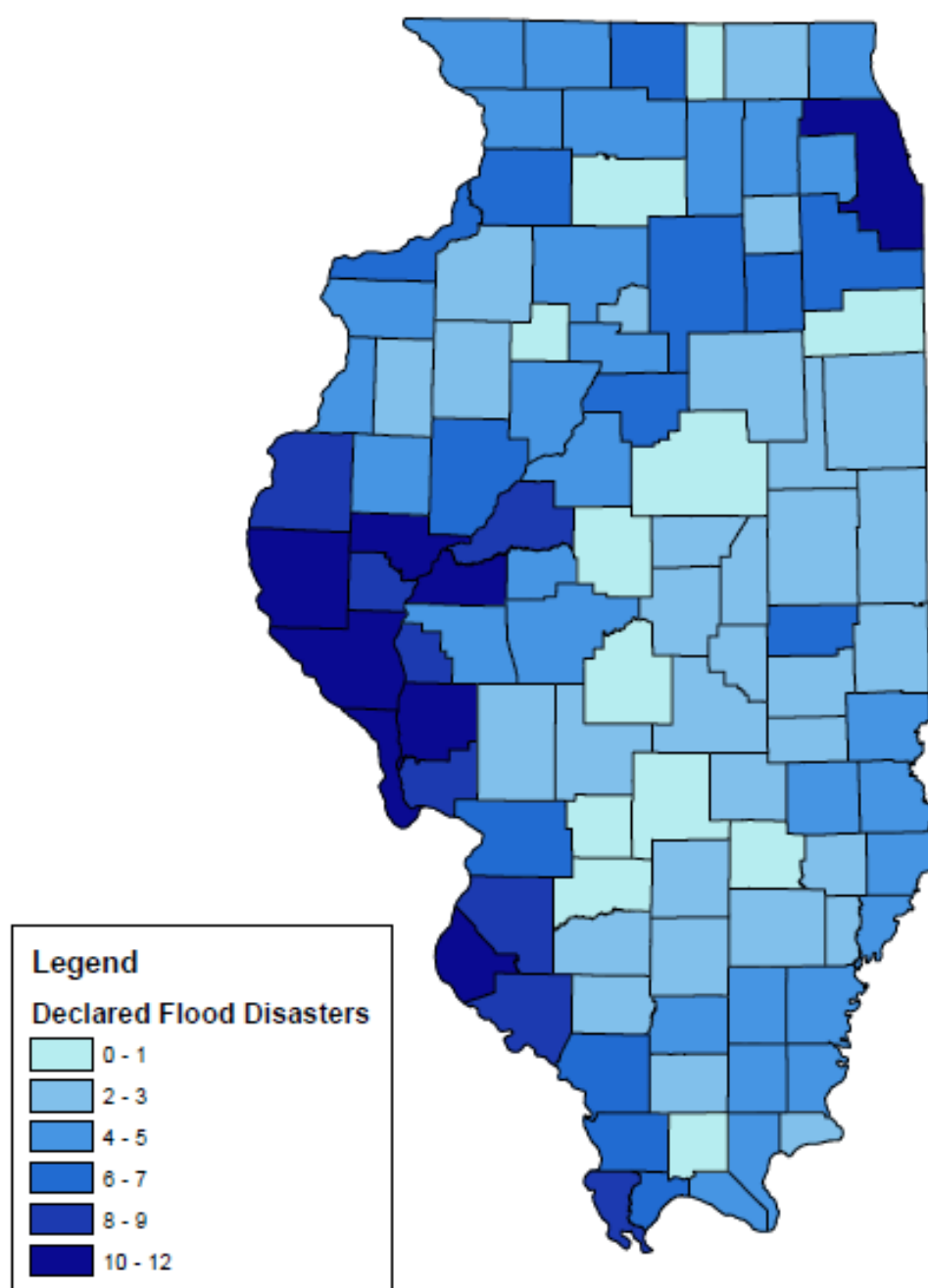
Figure 1. Federal flood disaster declarations by Illinois counties, 1981 to 2013.

D.   **Flooding and Climate Change**

    1.   **Climate change—A brief overview**

In recent decades, research has been done on environmental conditions that cause extreme weather events. One of the main factors that extreme weather events are being attributed to is climate change and global warming. By definition according to the Intergovernmental Panel on Climate Change (IPCC),

> Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC, 2013).

The main anthropogenic factor that is leading to the change in atmospheric composition is carbon dioxide emissions; as emissions increase, it has been shown that this exacerbates a greenhouse effect in the atmosphere and causes global warming (IPCC, 2013; IPCC, 2014). In turn, this warming changes atmospheric conditions and weather patterns and has been shown to account in part for greater increases in severity and frequency of certain extreme weather events, such as heat waves, droughts, tornadoes, and floods, to name a few (IPCC, 2014). These events then have major impacts on ecosystems, food production and distribution, and other parts of the livelihood and health of the communities in which they occur.

In the United States, unprecedented events such as Hurricanes Katrina and Sandy in recent years have severely impacted large metropolitan areas and caused much loss and injury both in terms of life and in the physical/economic realm. In the Midwest, there has been a large increase in heavy precipitation events with a 37% increase observed in the amount of precipitation that falls during heavy

precipitation events from the time period between 1958 and 2012 (National Climate Assessment 3, 2013).

2. **Climate change and its relation to flooding**

More frequent heavy precipitation events are occurring because as temperatures rise the air is warmed and able to contain more water vapor than the cooler air. Then during storm events this extra moisture falls out of the air in the form of heavier rainfalls (National Climate Assessment 3, 2013). In looking toward the future of Illinois and the Midwest it is projected that the severity and frequency of extreme weather events will increase (National Climate Assessment 3, 2013; NCADAC 2013 Draft, 2013). In particular, with the temperatures predicted to continue warming it is predicted that flooding events due to heavy precipitation will continue to rise (National Climate Assessment 3, 2013).

E. **Preparedness Assessment for Flooding**

1. **Emergency management preparedness**

Since flooding is a common hazard there have been many ways in which communities are preparing, and trying to protect people from and reduce the impacts of the hazard. In general this is done through preparedness measures that include protection, mitigation, and adaptation focuses. According to Smith, these three focuses can be broken down into the following general definitions: (Smith, 2013)

- Protection: Taking structural measures to prevent damage by creating new structures or reinforcing existing ones to stand up to the physical stresses of the hazard.

- Mitigation[1]: This is normally an attempt to reduce the loss burden to those who become

  impacted by that hazard, through disaster aid/relief and insurance.

- Adaptation: The aim of this measure is to help promote the change of human behaviors

  surrounding hazards. Examples of this include preparedness-planning, forecasts and warning

  systems, land-use planning, and education.

These are all ways in which people respond to identified risks in a community, but before that, a

community must be made aware or become knowledgeable about the particular hazards that pose a

risk to them. To do this, a hazard analysis or risk assessment is needed, which is a method in which many

location-specific factors are taken into account. As a result, localities can identify hazards to which they

are most vulnerable. Factors normally considered include the prior history of emergencies caused by the

hazard, climate variables, socioeconomic demographics, and the potential severity to the different

aspects of the area. There are a variety of ways in which these assessments are done, though no "gold

standard" exists. Methods can range from being quite subjective by being based almost completely on

risk perception of individuals or a set of individuals, to more objective methods in which the assessment

is more quantitative and scientific (Smith, 2013).

Within the United States much of the hazard risk assessments are supported by FEMA. The

mission of FEMA is "to support our citizens and first responders to ensure that as a nation we work

together to build, sustain, and improve our capability to prepare for, protect against, respond to,

recover from, and mitigate all hazards." ("About the Agency," 2014). As part of this and in response to

the impacts of natural disasters in 2000, the United States passed the Disaster Mitigation Act of 2000,

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[1] It is important to note that in the emergency management sector mitigation also means doing what can be done to prepare for and alleviate the impacts of a disaster. However, when mitigation is used in relation to climate change it means reduction of the amount of gas emissions. The term "adaptation" is used in relation to climate change in the sense that the management sector uses "mitigation."

which amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988. The

Mitigation Act was a step toward more emphasis on the importance of planning for disasters prior to

their occurrence (American Planning Association, 2006). One of the main intentions of the Act was to

require and assist states and localities in creating hazard mitigation plans as a way to prepare for

potential hazardous events. The creation of an approved plan that outlines precautions and actions for

identified hazards was set as a prerequisite for any type of hazard/disaster funding (Office of the Federal

Register, 2012, Parts 201 and 206). In Illinois, the Illinois Emergency Management Agency (IEMA) is the

organization that oversees the state's hazard mitigation planning. Within this role the agency created a

state natural hazard mitigation plan in 2010 and came out with an update in 2013. In addition, the state

has also helped manage and implement the local hazard mitigation planning process for the counties, by

providing them funding and resources.

2. **Public health preparedness**

The discussion up to this point has been about the emergency management sector and

their hazard preparedness techniques, but now we will transition to highlighting preparedness within

the public health realm. While efforts were becoming more proactive in the emergency management

and planning sector in response to hazardous natural events in the past 15 years, the public health

realm has been moving into a more active role in emergency preparedness as well. In 1999, the first

Public Health Emergency Preparedness Cooperative Agreement (PHEP) Grants were awarded to all 50

states with a focus on bioterrorism through the Centers for Disease Control (CDC). However, after 9/11

and Hurricane Katrina, the importance of public health in all hazards was becoming evident. As a result,

the PHEP funding focus shifted from bioterrorism to an "all hazards" approach, with the added

awareness that climate change is projected to cause a greater frequency and an increased severity of

natural hazards. The CDC expresses the importance of the PHEP program with the following language:

> The Public Health Emergency Preparedness (PHEP) cooperative agreement is a critical source of funding for state, local, tribal, and territorial public health departments. Since 2002, the PHEP cooperative agreement has provided nearly $9 billion to public health departments across the nation to upgrade their ability to effectively respond to a range of public health threats, including infectious diseases, natural disasters, and biological, chemical, nuclear, and radiological events. Preparedness activities funded by the PHEP cooperative agreement are targeted specifically for the development of emergency-ready public health departments that are flexible and adaptable. (CDC, 2013 #1.)

The current 2012–2017 PHEP funding cycle encourages the use of national standards created by

the CDC in a 2011 guidance document titled "Public Health Preparedness Capabilities: National

Standards for State and Local Planning." This document was based on preparedness documents from

both the Departments of Homeland Security and Health and Human Services, and was created to assist

local health departments in meeting PHEP funding requirements. Within this document 15 capabilities

are identified, one of which is community preparedness. This capability highlights the importance of

HVAs, and the significance they play in providing local health departments with a better understanding

of their locality's vulnerabilities and risks (CDC, 2013 #2).

The HVA is seen as a key component in the public health emergency preparedness process, and

is beginning to be identified as such in the risk management process in a variety of realms. Within the

FEMA framework and the hazard mitigation process an HVA is identified as the initial step (American

Planning Association, 2006). In addition, in 2012 and 2013 FEMA published the first and second edition

of the Threat and Hazard Identification and Risk Assessment Guide (THIRA). This guide was created to

assist communities with threat and hazard identification by outlining a standard process to do this based

on capabilities from the National Preparedness Goal, which came out of Presidential Policy Directive 8

(Homeland Security, 2013). The National Preparedness Goal was one of the documents that was a key

reference for the creation of the "Public Health Preparedness Capabilities: National Standards for State and Local Planning," that was mentioned previously.

3. **Flooding preparedness in Illinois**

According to IEMA's website, in Illinois the planning process must include organizing resources, assessing risks, developing a mitigation plan, and implementing and monitoring the plan and emergency management ("Mitigation Planning," 2013). In general, the HVA is how states and localities are to begin emergency preparedness by first assessing their vulnerabilities to potential hazards, which includes flooding and other natural extreme weather events that may be driven in part by climate change. In Illinois, HVAs are part of the mitigation plans being completed by the county emergency management offices as part of the risk assessment step. With HVAs being outlined in the "Public Health Preparedness Capabilities," the IDPH has recently begun to encourage their local health departments to create HVAs as well. Since both sectors are being asked to complete HVAs there has been collaboration in some of the counties, but this is not the norm.

With many different sectors completing the HVAs or similar documents, a variety of methods have been created. One method that seems to be gaining some ground within the public health realm is a spreadsheet-based tool put forward by Kaiser Permanente in 2001 to assist hospitals with the HVAs they were required by The Joint Commission to do after 9/11 as a way to be more disaster-ready (Campbell et al., 2011). The initial audience was hospitals, but it has now expanded to a variety of public health entities including local health departments as more and more of them are required to do HVAs through the PHEPs grant program and the "Public Health Preparedness Capabilities: National Standards for State and Local Planning" document. This tool that Kaiser created breaks risk into the two main variables of probability and severity, with the product of these two equating to risk. The probability is

simple, with just one value on a scale from 0–3 being chosen based on the likelihood of a particular event occurring, with three being the greatest likelihood. It is the severity variable that Kaiser has made a bit more detailed, by first breaking severity down into the two subcategories of magnitude and mitigation. In this case magnitude is looking at the level of impact of the event being assessed and in particular in the following three different focus areas: human impact, business impact, and property impact. Each of these areas once again utilizes a scale of 0–3 with three signifying the greatest impact. As for the mitigation subcategory, its focus is based on an assessment of the preparedness and response abilities of the entity completing the assessment. The three focus areas that require scores in this subcategory are: preparedness, internal response, and external response. Once again the scale for scoring is 0–3, with three representing the lowest level of mitigation readiness. When an organization completes scoring all of the severity categories, they are supposed to obtain the sum of the mitigation and magnitude categories and then add these two categories together to get a severity score that can be multiplied by the probability to obtain a risk value.

Though there have been a couple of studies done on HVAs within the hospital setting in the last few years, to the best of our knowledge there has been little research done on HVAs conducted by local health departments and other local agencies as they try to assess hazard risks for their jurisdictions (Campbell et al., 2011; Fares et al., 2014). The research outlined in this paper will begin to do some of this work. Researchers at the University of Illinois at Chicago's School of Public Health received a CDC "Building Resilience Against Climate Effects" (BRACE) grant in partnership with IDPH. As part of this grant project, one of the goals is to determine the current level of preparedness for climate impacts within the state. This study will help meet this goal by collating data from the current HVAs that IDPH has on record for the counties and assessing the perceptions of hazards throughout the state. In particular, this study will assess the current perceptions of flood risk throughout Illinois based on these

HVAs and compare it to a flood risk assessment that used geospatial technology. The geospatial

assessment was part of a recent state flood vulnerability assessment that was completed as part of the

2013 state mitigation planning process using Hazus-MH, a geographical information systems (GIS)

hazard software package created by FEMA. This work has the potential to impact public health

preparedness planning in Illinois if opportunities for improving the HVA process can be identified.

II. RESEARCH QUESTIONS

A.   **Primary: Assessed Risk versus Observed/Projected Risk**

How do flood risks in HVAs done by Illinois local health departments compare to observed flood

risk determined using Hazus-MH, a geospatial hazard software created by FEMA?

B.   **Secondary Questions**

1.   Based on HVAs, what percentages of Illinois counties identify flooding as a hazard?

2.   Using geospatial data methods, how much of a hazard is flooding in each Illinois

counties?

3.   How well do the HVA and the geospatial analysis results of flooding risk agree with one

another?

4.   If there are discrepancies, how can geospatial vulnerability analysis or other aspects of

the HVA process improve the accuracy of HVAs?

III. METHODS

A.   **Hazard Vulnerability Assessment Compilation**

     1.   **Hazard vulnerability assessment collection**

Hazard vulnerability assessments or their equivalent were collected through IDPH with the intention to obtain a better understanding of Illinois counties' current hazard risk assessments in relation to public health. Among the assessments gathered there were a few city/jurisdictional assessments that were not used for this study since the focus was on counties. Due to the lack of a standard method for HVA completion there was a diverse range of HVA formats. In response to this challenge, the variety of formats were reviewed and a common standardized form was created to facilitate the diversity of HVAs. This standardized form also provided uniformity to the data, which allowed for easier analysis.

     2.   **Standardized format for compilation**

First, to create a master HVA dataset ("aggregated document"), a list of all the different identified hazards within the counties was created. This process led to a finalized list of the following hazards: drought, severe thunderstorms, tornado, flooding, flash flooding, extreme heat, extreme cold, blizzard, ice storm, vectorborne illnesses, waterborne illnesses, water system failure, power outage, extreme temperatures, winter storm, and heat weather (a combination of drought and extreme heat). Next, all the ways that probability, risk, and severity were broken up within the documents and calculated were assessed to determine which to keep in aggregate document. To err on the side of not losing any data, many categories were carried over, some of which were not identified by many counties. The standardized format that was decided on for this study was one similar to the Kaiser

Permanente model mentioned earlier, but instead of three magnitude elements there were six. The following three magnitude variables were added to the format: community impact, health department impact, and healthcare services impact. With these additional variables, it meant that there was a total of nine possible variables to go into calculating the severity score, which was the sum of these variables. Once the standardized format was chosen, a rubric for a scoring system was needed. For this scoring system each variable was scaled on a 0 to 3 scale with 3 representing the greatest concern in that category and the lower the number the more positive the outcome. A sample of the final aggregate document can be found in Figure 2, with the blue column representing probability, the orange columns representing magnitude variables, and the green columns representing the mitigation variables. Within this document, the severity sum is the combination of the orange and green columns. Then the final yellow column shows the calculation of risk, which is the product of the severity score and probability. As mentioned before, each of these elements utilized a scale of 0 to 3, with three being the worst case or lowest level of preparedness. This template was filled out for each of the counties that had quantifiable risks and all of these elements were given scores for every hazard that the counties identified.

PROBABILITY	SEVERITY = MAGNITUDE COMBINED WITH MITIGATION									RISK = PROBABILITY * SEVERITY
	HUMAN IMPACT	HEALTH DEPARTMENT IMPACT	HEALTHCARE SERVICES IMPACT	PROPERTY IMPACT	COMMUNITY IMPACT	BUSINESS IMPACT	PREPAREDNESS	INTERNAL RESPONSE	EXTERNAL RESPONSE	
Likelihood this will occur	Possibility of death or injury	Interuption of services	Percentage of healthcare services likely to be affected under an average occurrence of the hazard	Physical losses and damages	Percentage of community members likely to be affected under an average occurrence of the hazard		Preplanning	Time, effectivness, resources	Community/ Mutual Aid staff and supplies	Relative threat
Known risks, historical data, manufacturer statistics	Fatalities, injuries requiring EMS, injuries requiring outpatient services, injuries requiring emergency room visit.	Impact on Public Health Agency Services: i.e. personnel, equipment loss, laboratory services, internal communications, interagency communications, internal communications.	Interruption of Healthcare Services: Interruption of basic EMS, interruption of outpatient services, interruption of hospital ED services, interruption of critical facilities based on population.	Cost of replacement or repair, cost to set up temporary replacement, cost to recover	Impact on Community Services i.e. water supply contamination, water supply availability, population displacement, public utilities interruption, interruption of transportation.		Status of current plans, frequency of drills, training status, insurance, availability of back up resources for supplies, etc.	Whether type & amount of supplies on hand will meet the need, staff availability, availability of backup systems, survivability of internal resources e. the building structure	Agreements with community agencies/drills, coordination with local & state agencies, coordination with other health care facilities, community resources	
0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0. no impact 1. minimal impact 2.moderate impact 3. severe impact	0-100%

Figure 2. HVA aggregate template and rubric.

3.   **<u>Compilation of previously determined risk data</u>**

The majority of the data that had quantifiable risk data was able to be placed within the previously mentioned template. For some counties, though, their HVAs only listed the risk values for the hazards, so another spreadsheet was created in which only risk values were compiled from these particular counties.

4.   **<u>Risk calculation and standardization</u>**

First, the aggregated document values were standardized due to scaling differences and then used for the calculation of the hazard risk values. To do this, the severity values had to be standardized, because the probabilities were already one variable value represented by a number between 0 and 3, whereas the severity values were the sum of up to nine different variable depending on how many the county used. So, to standardize the severity values, it had to be determined how many of the nine variables were considered for each county and then that value was multiplied by three, the maximum value per variable, to get the maximum possible severity value. The severity sum for each county's hazard then was calculated and divided by the maximum possible severity that gave the standardized severity value. This standardized severity value was then multiplied by the probability to get a standardized risk for that hazard within the county. An example of this process can be found in Figure 3.

> **_Step 1:_** _First Determine How Many of the Nine Severity Variables have Values_
>
> **_Step 2:_** _Calculated Severity Sum (depends on variables used) = Preparedness + Internal Response + External Response+ Human Impact + Health Department Impact +Healthcare Services Impact + Property Impact + Community Impact + Business Impact_
>
> **_Step 3:_** _Standardized Severity Value = (Severity Sum)/(# of Severity Variables Used*3)_
>
> **_Step 4:_** _Calculated Risk = Standardized Severity Value*Probability_

Figure 3. Steps for standardizing and calculating risk values.

5. **Frequency count of all identified hazards**

A frequency count of all the different types of hazards was completed to understand which hazards are most frequently acknowledged as risks among counties. This count included the counties that had calculated quantifiable risks from the aggregate document, and the published quantifiable risk values that were already calculated. Some of the published quantifiable risk values obtained from written documents included a few hazards that were not outlined in the aggregate document.

6. **Flooding risk rank placement by county**

After the frequency count was complete, all of same counties were assessed to determine how many had flooding as one of their top two risks. To accomplish this all of the risk values for each county were ordered by rank and a count was done to figure out how many counties had flooding, or flash flooding if it was the case, within the top two risks identified by that county.

B.   **Geographic Information Systems Methods**

1.   **Literature review for objective method**

A literature review was completed as a way to try and find more objective methods, such as geospatial analysis, to assess flood risk. Through this search the *Illinois Statewide Flood Hazard Assessment* that was completed in 2013 by researchers of the NHRMG at SIUC was discovered (State of Illinois, 2013). This group was contracted by IEMA to perform this vulnerability assessment as part of the state mitigation planning process done to meet part of the Disaster Mitigation Act of 2000 requirements. This county-level assessment used FEMA's Hazus-MH software for GIS.

2.   **Illinois statewide flood hazard assessment**

Due to its transparent methods and recent completion date, it was decided to use the findings from this study for the objective method comparison. The following methods listed are a summary of the steps that were taken in the *Illinois Statewide Flood Hazard Assessment* to determine a flood score (FS), which was later used as a more data-driven standard for comparison to the HVA-compiled risk values. Within this assessment the NHRMG used the Hazus-MH software to create flood-loss estimates based on a 100-year floodplain and on infrastructure data that were default within the software. This level of analysis is known as Level One since there were not too many updates to the program database. These flood-loss data were then used in conjunction with Cutter's Social Vulnerability Index (SoVi®) to calculate an FS or risk value. According to the Hazard Vulnerability Research Institute at the University of South Carolina, the SoVi® "synthesizes 30 socioeconomic variables, which the research literature suggests contribute to reduction in a community's ability to prepare for, respond to, and recover from hazards." ("Social Vulnerability Index for the United States—2006–10"; Cutter, 1996).

Figure 4 shows the exact summary of the mathematical steps used in this SIUC assessment to create the FS, which was the basis for our comparison to HVA data. The first step of this process was to determine flood-loss and flood-exposure estimates within the 100-year floodplains through the use of the Hazus-MH software's Level One analysis. Once these values were determined a flood-loss ratio was calculated to normalize the data and account for the differences in the estimates from rural areas and urban areas. Then, through a weighting procedure, these values were aggregated to determine flood-loss ratios for each county. The calculations used for this step can be seen in equation 1 in Figure 4. After determining the flood-loss ratios the SoVi® values were attached to their respective counties. Then both the SoVi® and flood-loss ratios were converted into an index through the calculation shown in equation 4. From this calculation an FS was created for each county by summing both of the previously mentioned indices. This score was then normalized and converted to a z-score so that counties could be ranked by flood vulnerability relative to other counties. For the sake of this study and the comparison to our standardized HVA data, we did not convert the values to the z-score, as will be described in the next section.

The FVI values were calculated as follows:

1. The flood-exposure ($Flood_{exposure}$) and –loss ($Flood_{loss}$) estimates for the 100-year floodplain were calculated using Hazus-MH (see Flood-Loss Modeling Section above for details).

2. A flood loss ratio ($Loss_{ratio}$) was calculated to normalize flood-loss estimation parameter so that urban jurisdictions with large absolute values of flood exposure could be more easily compared with rural jurisdictions with smaller levels of flood exposure.

$$Loss_{ratio} = \frac{Flood_{loss}}{Flood_{exposure}}$$

(Eq. 1)

3. The SoVI (HVRI, 2012) was assigned to its respective county and jurisdictions.

4. Hazus-MH does not calculate flood exposure and losses at jurisdictional scales. The minimum spatial scale at which Hazus-MH calculates flood exposure and losses is at the census block level. In order to ascribe the exposure and flood estimates to a particular jurisdiction, we used the spatial join too within ArcMap. The join tool summed flood-exposure and -loss estimates from the census blocks that were either fully or partly contained within each jurisdiction's boundaries.

5. In order to account for the overlap of census blocks outside a jurisdictional boundary, a floodplain area weighting factor was calculated and then used to weight the jurisdictional flood-loss ratio. This provided a more realistic estimate of a jurisdiction's flood-loss ratio. The floodplain area weighting factor (FP_{wf}) was calculated by dividing the 100-year floodplain area (FP_{area}) within the jurisdiction by the total area of the jurisdiction (JD_{area}).

$$FP_{wf} = \frac{JD_{area}}{FP_{area}}$$

(Eq. 2)

The floodplain area weighting factor was then multiplied by the jurisdiction's loss ratio to calculate the weighted flood-loss ratio ($WLoss_{Ratio}$).

$$WLoss_{Ratio} = Loss_{Ratio} \times FP_{wf}$$

(Eq. 3)

The county flood-loss ratio, jurisdictional weighted flood-loss ratio, and SoVI scores were combined to create a flood-loss index (FLI) and SoVI at the county and jurisdictional levels. The general indexing formula for FLI and SoVI are as follows. The index (I_i) corresponding to each respective index (FLI and SoVI) indicator for i[th] county or jurisdiction is calculated using the following equation, which normalizes each index value to a range from 0.0 to 1.0:

$$I_i = \frac{I_i - I_{min}}{I_{max} - I_{min}}$$

(Eq. 4)

1. The FLI and SoVI were added together to calculate a flood score (FS) for each county and jurisdiction.

$$FS = FLI \times SoVI$$

(Eq. 5)

2. The FSs were normalized so each county or jurisdiction could be ranked by flood vulnerability relative to other Illinois counties and jurisdictions. The flood score was index (FS_i) was calculated using Equation 4.

3. A z-score (z) for the FS_i for each county or jurisdiction was calculated in order to rigorously qualify their relative flood vulnerability.

$$z = \frac{FS_i - \mu}{\sigma}$$

(Eq. 6)

where:
FS_i is the actual flood score for the ith county or jurisdiction;
μ is the mean of the county or jurisdictional flood scores; and
σ is the standard deviation the flood scores.

The z-score was used to assign the relative flood vulnerability description to each (Table 3).

Table 3—Relative flood vulnerability description for the z or standard score

z – Score Range	Relative Flood Vulnerability Description
5.0 to 1.6	High
1.5 to 0.6	Elevated
0.5 to -0.5	Average
-0.6 to -3.0	Low

Illinois Statewide Flood Assessment 2013- Natural Hazards Research and Mitigation Group (NHRMG) at Southern Illinois University, Carbondale

Figure 4. The mathematical calculation for determining the flood vulnerability score.
(Copied verbatim from *Illinois Statewide Flood Assessment2013* [State of Illinois, 2013].)

C.   **Assessment Comparison**

1.   **Hazard vulnerability assessment data preparation**

The data from the HVA analysis could not be exactly comparable to the FS acquired through the Hazus-MH assessment in part because it was more subjective and many different formats were transformed to create an aggregate document standard. However, quantifiable risks were standardized so that they could be compared amongst each other, and so too were the FSs. So for purposes of a crude comparison, both sets of data were put on a risk scale that could be easily broken down into risk quartiles. This was accomplished by normalizing the calculated HVA risk data for the counties, by following the process in Figure 4, equation 4 within the statewide flood assessment. This transformed all of the HVA values to a 0–1 scale, which were then placed into the four following risk categories modeled off of the categories in the Hazus-MH based study: low (0.00–0.25), average (0.26–0.50), elevated (0.51–0.75), high (0.76–1.00).

2.   **Geographic information systems data preparation**

The SIUC FSs were recalculated following the steps in Figure 4 only using the specific counties that had calculated quantifiable risk values from the HVA analysis. This was done because the standardization steps were originally done relative to all 102 counties and this step was to remove any differences due to variance in total counties. The steps from Figure 4 were carried out to the end of step 8 where the FS index was created before the z-score transformation. These scores were on a scale from 0–1 and thought to be the closest to comparison values that could be obtained, so these were also broken down into the four quartile categories for comparison.

3. **The comparison**

Once both sets of data were converted to the risk quartile categories, a comparison of the HVA county quartiles to the flood assessment county quartiles was completed. This determined if the HVA risk level was an overestimate or underestimate in comparison to the flood assessment level, or if it was comparable. The flood assessment data were used as a standard because it was thought that they were more data-driven than the HVA data.

D. **Reference Maps**

In order to have a better reference for the maps that were created as part of the results, a map was created to depict county names throughout Illinois. In addition to this, Illinois floodplain data from 1986 were obtained from the Illinois Water Survey and used to create a floodplain map for reference and comparison for this study.

IV. RESULTS

A. **Descriptive Statistics and Analysis of Vulnerability Assessment Data**

   1. **General county map for reference**

   Figure 5 is a map of Illinois with the counties titled so that it could be used as a reference in relation to the other maps throughout the results section.

   2. **Hazard vulnerability document types**

   Hazard vulnerability documents were gathered and assessed from IDPH for a total of 94 of the 102 counties in Illinois represented. Figure 6 shows a geographical representation of the 102 counties in Illinois and a color differentiation by county based on the type of document format that was gathered and used in this study for that particular county. It is important to note here that even within these document-type categories there was not just one format, but a myriad of types that had to be analyzed and assessed in an attempt to collect the hazard risk data that was necessary for the study.

Figure 5. Counties in the state of Illinois.

Figure 6. Types of hazard vulnerability documents gathered.

Figure 6 shows that of the 94 counties for which documents were obtained the majority were some form of HVA, normally in the form of a spreadsheet, with 56 counties having this type of document. As for the other types of documents, there were 22 counties with written hazard mitigation plans and 16 counties with some other forms that could not easily be categorized. It is also important to note that there were a few documents gathered that did a hazard vulnerability for more than one county, the two main ones being a document for the southern seven counties by their respective health departments, and a document for the Chicago Metropolitan Statistical Area, which covered many of the counties around Chicago. For some of these counties, not only were they covered in these overarching plans, but they were also covered by an individual document that was collected from IDPH. In cases like this the risk values from the individual document were used over the larger document, but when there was not an individual document the data from the overarching document was used.

3. **Lead organizations for vulnerability documents**

The 94 documents were categorized by the type of organization that took the lead in developing the report. This was determined by identifying an organization within the document that was known to be the lead. On some documents—in particular, the mitigation plans—there were a variety of organizations that helped with the plan, but for these, the organization that submitted the document was used. Figure 7 identifies each county by one of six categories of lead organizations. This breakdown revealed that a major portion of the documents were affiliated with health departments, with a total of 39 documents meeting this category. The other documents were completed by a combination of the following groups, three hospitals, 10 emergency management agencies, 17 planning organizations, and 25 for which a lead organization could not be identified.

4. **Counties by hazard vulnerability assessment data type**

Hazard risk data for each county were compiled in the aggregate spreadsheet that was mentioned in the methods. Of the 94 counties for which documents were available, only 56 contained detailed hazard vulnerability data. However, though they did not have data that would fit into the spreadsheet and allow for risk calculation, hazard risk values already published without the breakdown of variable values were available for 21 counties. This meant that once the spreadsheet data were used to calculate hazard risks, a total of 77 of the 94 counties had risk measures. The other 17 documents were mostly hazard mitigation plans that only described the risks in qualitative ways or gave incomplete values such as probabilities that could not be used to determine risk. The map in Figure 8 shows which counties had which type of risk data.
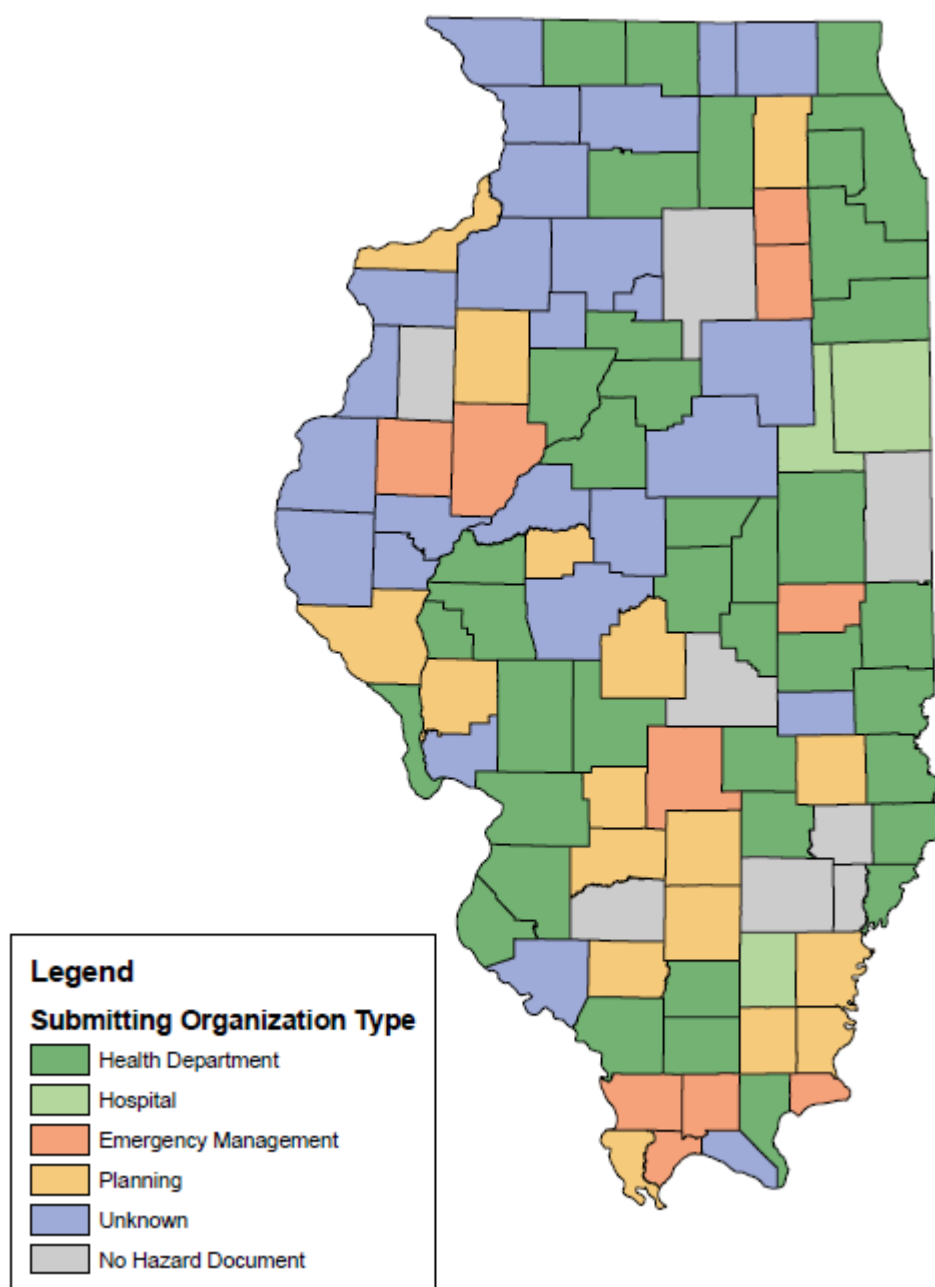
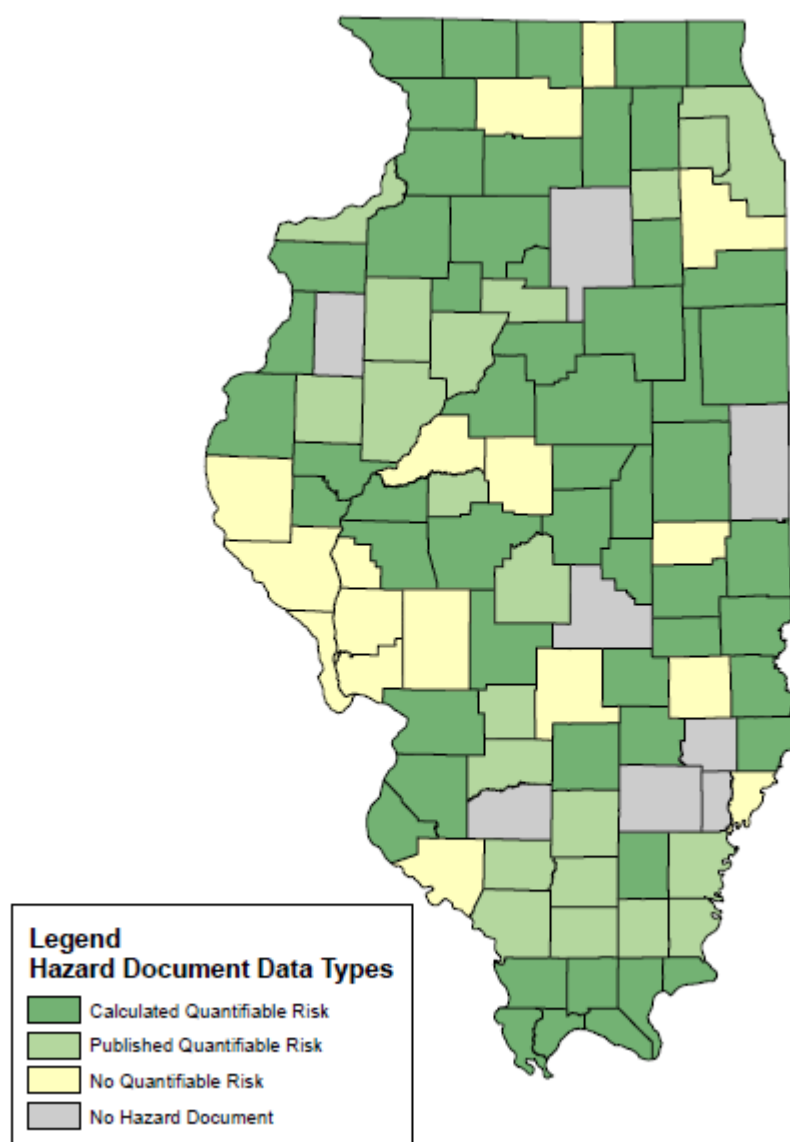Figure 7. Type of organization that submitted hazard document for county.

Figure 8. Gathered hazard document data types by county.

5.   **<u>Flood risk relative to other hazard risks in 77 counties</u>**

An aggregate dataset was compiled containing information about self-assessed

probability (one item), impact (six items), and mitigation (three items) from 56 counties, as well as a

listing of risk by hazards for an additional 21 counties that did not provide more detailed

information. The frequency with which hazards were identified is summarized in Figure 9. Tornado

was the most commonly identified hazard with 74 of the 77 counties recognizing this as a potential

hazard. Counties identified both flooding and flash flooding as a hazard, with some recognizing both

and differentiating between the two and others looking at one or the other, while other counties did

not recognize it as a hazard at all. Of the 77 total counties, flooding was the second most common

hazard identified with 70 (91%) counties recognizing it as a hazard. It should be noted that these 70

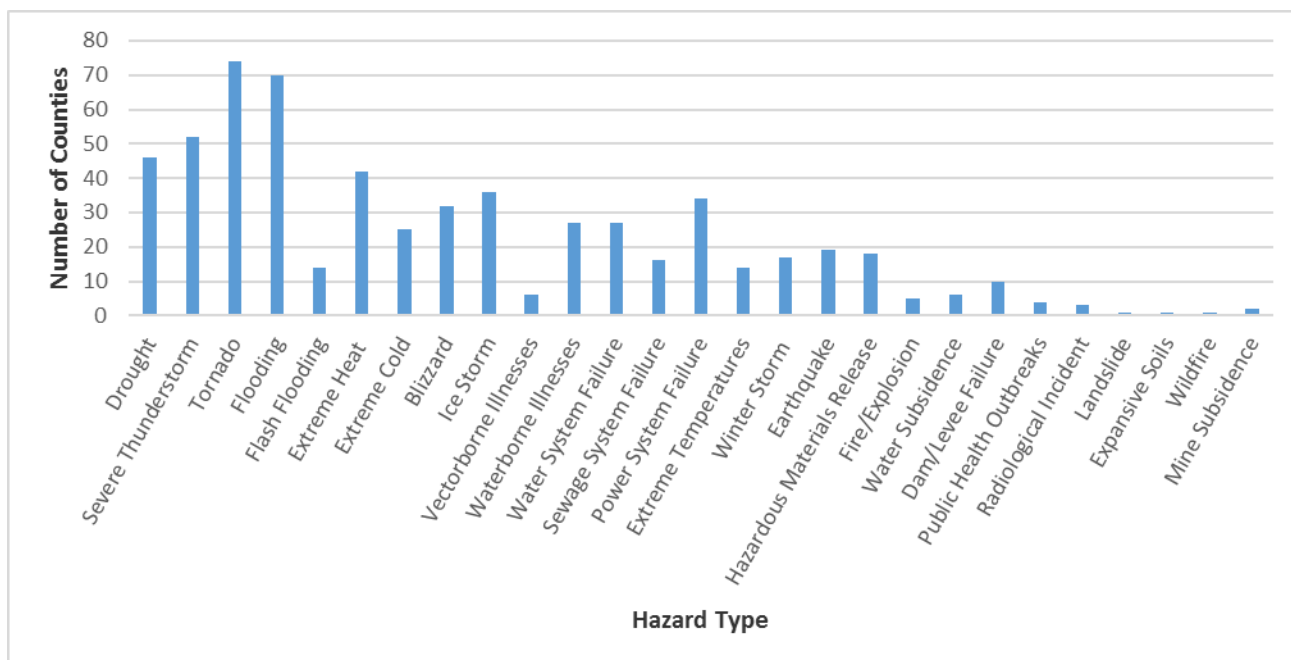counties only accounted for those that specifically identified flooding as a risk, not flash flooding.

Figure 9. Frequency of hazards identified by counties (n=77).

Figure 10. Of counties with quantifiable risk, is flooding ranked as one of the top 2 risks?

Of the 77 counties, flooding was only in the top two risks for 26% (20 counties) of the counties. A map

identifying these counties can be seen in Figure 10.

Beyond this assessment not much could be done with the 21 counties that only had a ranking of

risk for various hazards, rather than a description of the probability, impact, and mitigation elements of

risk. Because each of those rankings were relative to other hazards within that particular county,

comparing perceived flood risk among the 21 counties was not possible.

6.   **Self-Assessed Flood Risk in 56 Counties**

Data on flood risk were transformed from the scale in the documents to the 0–3 scale

within the spreadsheet (see the methods for more details). Only a few counties provided complete

information about the nine variables that could go into the severity score, so a standardized severity

score was created. In other words, if there were a county that provided threes for four of the severity

variables and the rest were missing, then this county may still be found to have a lower score than a

county that gives ones and twos to eight of the variables, which would have a higher overall score

despite the problem not being as significant. The standardization process corrected for the number of

variables for which information was provided. The standardized severity score was then multiplied by

the probabilities to determine the overall risk of each hazard. In general, this took care of all the issues

due to differences in the way that counties had quantified their data. The HVAs from ten counties

(Montgomery, Cass, Champaign, Stephenson, Macon, Pulaski, Johnson, Union, Massac, and Hardin) did

not specify "probability" for flooding or identify flooding as a risk, and as a result risk could not be

determined. However, Montgomery County did have flash flooding assessed as a risk with a probability

value so these values were used instead. Thus, only 47 counties were included in the final flood hazard

assessment calculations for the hazard vulnerability documents.

Standardized flood risk for the 47 counties were then standardized based on the range of their own values to organize the values into scores ranging from 0 to 1 and then they were broken down into quartiles of risk (i.e., 0.0–0.25, 0.26–0.50, 0.51–0.75, and 0.76–1.00). This was done in part so that the risk values could later be compared to the flood hazard risk assessed by the more objective SIUC GIS-based flood hazard assessment. The counties in these four risk quartiles were then placed into one of four categories with the smaller values being "low" risk and moving on up to "average," "elevated," and "high" risk. County frequencies were then assessed for each of the categories and mapped as can be seen in Figure 11. Of the 47 counties the breakdown was the following: there were seven counties with a high risk, 12 with an elevated risk, 10 in the average risk category, and 18 in the low risk category.
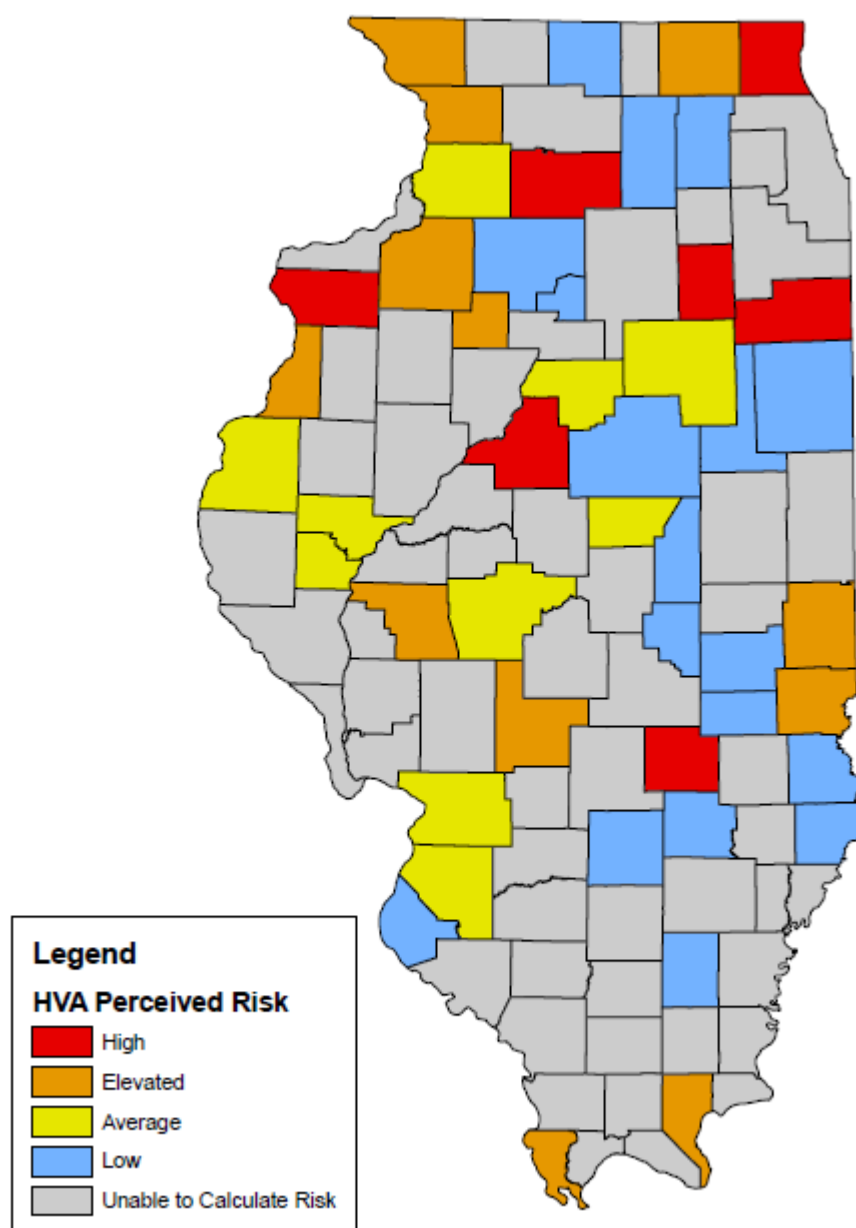
Figure 11. Perceived level of risk to flooding calculated from HVAs.
(Four categories represent quartiles of risk level.)

B.   **Vulnerabilities and Risk from Statewide Flood Hazard Assessment**

1.   **Data sources**

The geospatial analysis of flood risk relied upon historical data, 100-year floodplains, economic loss data, and a social vulnerability index in the methods of the *2013 Illinois State Flood Hazard Assessment* (State of Illinois, 2013). That assessment looked at many different aspects of flooding and the impacts it has had on the state and projected impacts using FEMA's Hazus-MH software for GIS, and developed an FS for each county. Risk categories were defined based on this FS. The SIUC assessment generated an FS for all 102 counties. For our analyses, only FS values for the 47 counties that provided detailed HVA flood data were used. With these values only being a portion of the overall study's counties, the values were re-standardized and normalized following the same methods that were used in the document and listed in the methods above up to the end of step 8 (See Figure 4). This was done so that only the range of values for these particular counties was used in the standardization just like was done with the HVA data. The result of this reworking of the GIS flood assessment data can be viewed in the map in Figure 12, with the same categories and breaks as were used in the HVA assessment.

2.   **Flood score for 47 counties**

Of the 47 counties the following breakdown of risk vulnerability was determined: three counties were identified as high risk, 11 elevated, 24 average, and nine counties were assessed as being low. The next section will show a comparison between the findings of this GIS assessment and the HVA assessment done in this study.
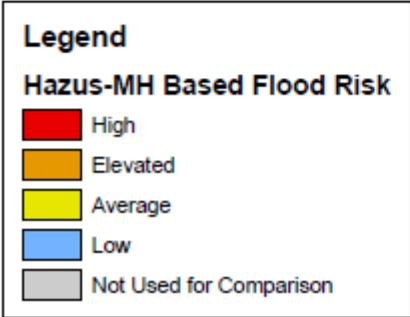
Figure 12. Risk to flooding based on Hazus-MH assessment completed by researchers at SIUC.
(Four categories represent quartiles of risk level.)

C. **Comparison between Assessment Methods**

A comparison between the HVA assessment and GIS assessment was completed and a side-by-side comparison of the results for each can be seen in the Table I. In addition, calculations were done to determine if the HVA-assessed risk was comparable to the GIS risk category, or an under/over-estimate, using the GIS-assessed risk as the standard since it was thought to be developed using a data-driven approach. The outcome of this analysis can be seen in the map in Figure 12. Of the 47 counties, 19 were found to be comparably assessed in both studies, 13 counties were overestimates of risk, and 15 were underestimates.

TABLE I

COMPARISON BETWEEN HVA PERCEIVED FLOOD RISK AND GIS ASSESSED COUNTIES

Risk Category	Number of HVA Assessed Counties	Number of GIS Assessed Counties
High	7	3
Elevated	12	11
Average	10	24
Low	18	9
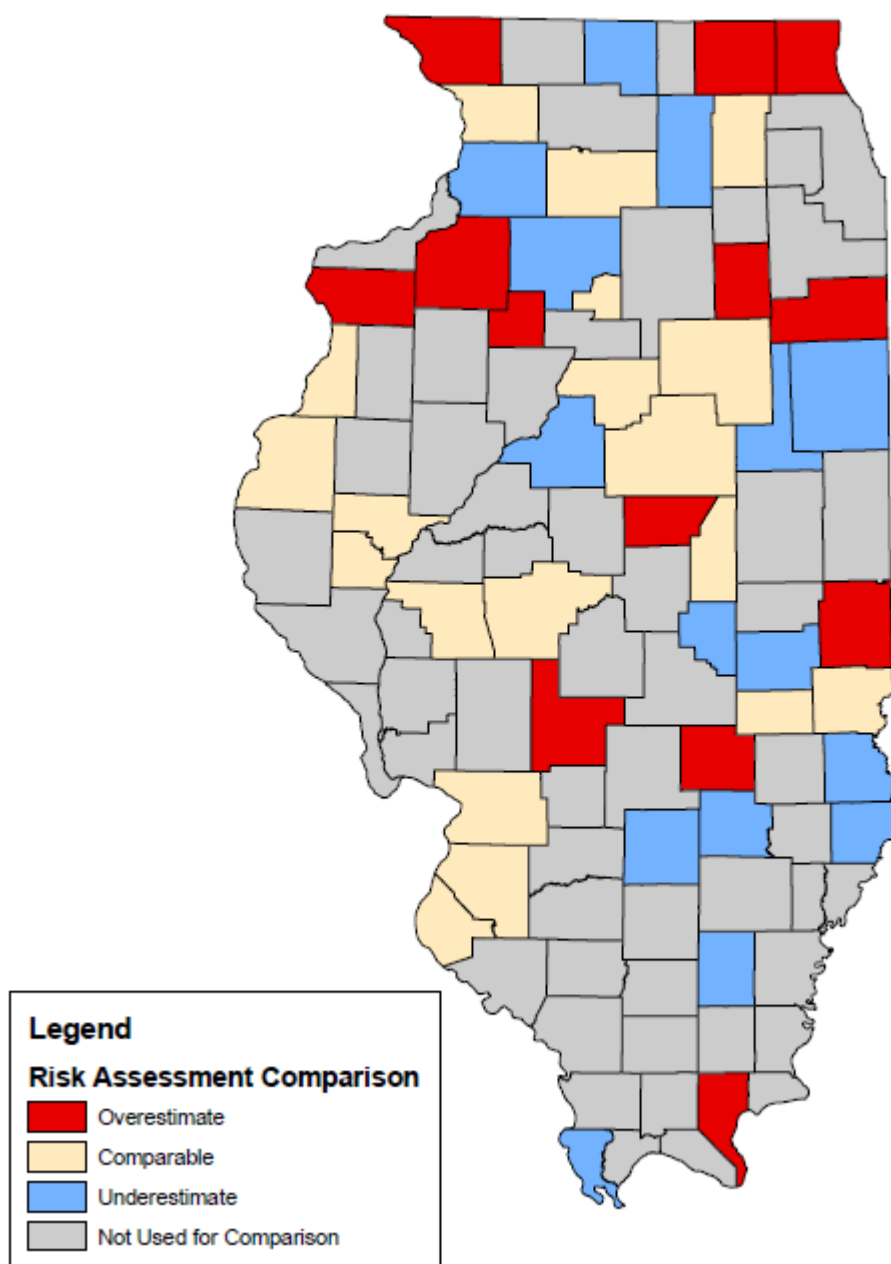
Figure 13. Comparison of HVA perceived risk to Hazus-MH-based assessed risk.
(Comparison done with Hazus-MH risk as standard because more data-driven.)

D.   **<u>Reference Maps</u>**

Figure 14 is provided as a reference to show where the 100-year and 500-year floodplains are located within the state of Illinois. Figure 15 shows the floodplains in relation to the 47 counties that were used in the HVA analysis. The floodplain layer is based on the 1986 floodplains and was created using data from the Illinois Water Survey.

Legend

Floodplain Type (1986)

100 Year

500 Year

Figure 14. Illinois floodplains (1986).
(Data used to create map from Illinois Water Survey.)

Figure 15. Counties used for HVA analysis in relation to floodplains.

V. DISCUSSION

A.   **Summary of Key Findings**

1.   **Hazard vulnerability assessment analysis**

Out of the 102 counties in Illinois, some form of vulnerability assessment was gathered

from IDPH for 94 of those counties (see Figure 6). Within this group of 94, there were only 77 counties

that had quantifiable data that could either be used to calculate risk (56 counties) or that already had
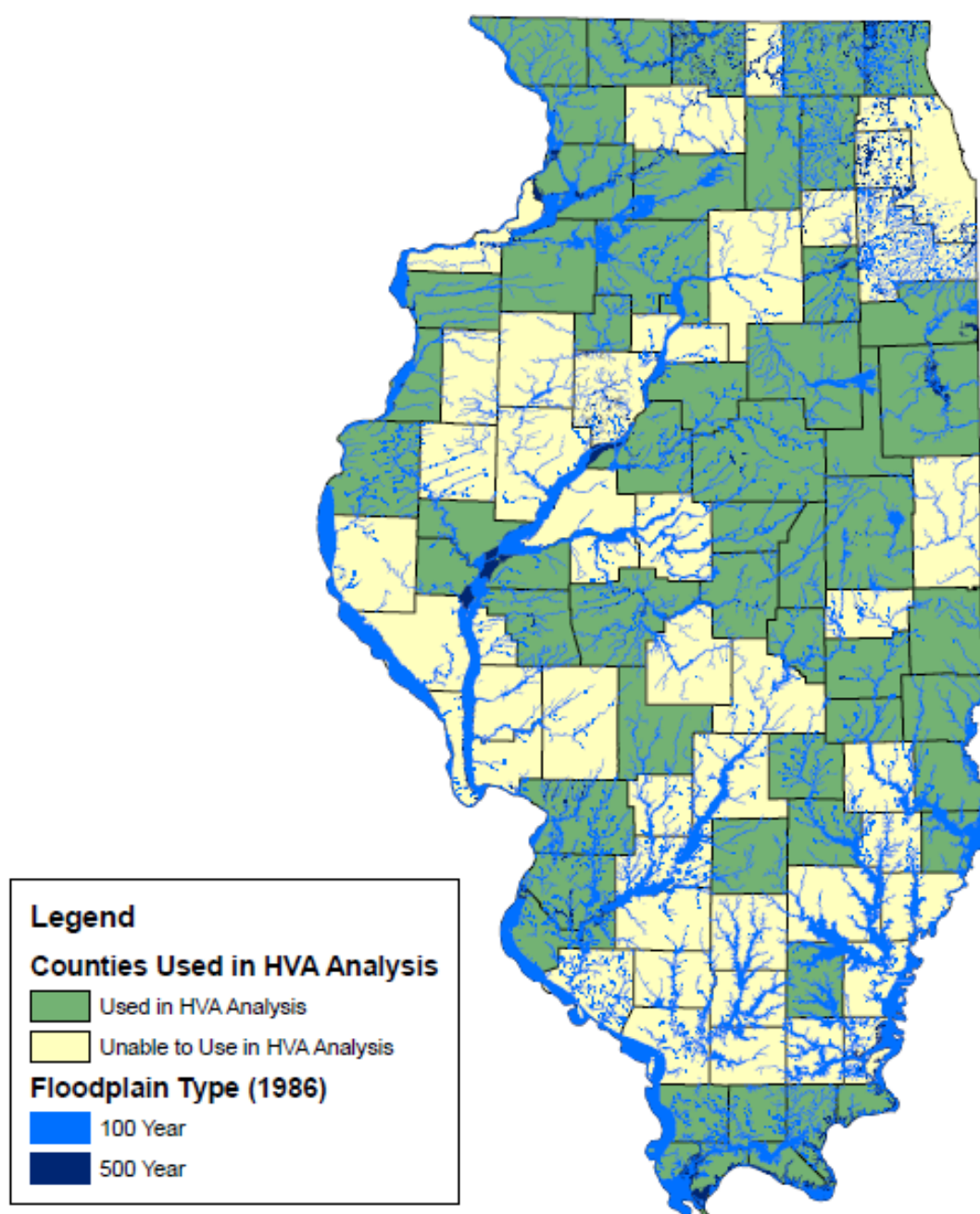
risk values determined (21 counties) (see Figure 8). Amongst these counties it was found that flooding

was the second most frequently identified risk right behind tornadoes with a representation of 91% (70

counties) of the counties (see Figure 9). However, it was also determined that of the 77 counties with

quantifiable flood risk data that flooding was only ranked as being in the top two risks for 26% (20

counties) of the counties (see Figure 10). For calculated risk, only 47 of the 56 counties had a flood risk

value and of these counties only seven (15%) were assessed to be in the top quartile of perceived risk

(see Figure 11). It is also important to note that an observation based off of Figure 15 is that in relation

to the floodplains, many of the counties that were unable to be analyzed have a reasonable amount of

floodplains within them. This can be especially noticed in the western and southern parts of the state.

Knowing this, our study may not be an accurate representation of the counties in the state, but more

HVAs would have to fit a standardized method for this to be possible.

2.   **Hazus-MH-based flood risk analysis**

To assess the flood risk based on geospatial data methods, a state flood hazard

assessment completed in 2013 with FEMA's Hazus-MH software by the NHRMG at SIUC was used as a

foundation to acquire flood risk values. Minor adjustments to the created flood score values were made

to only look at the same 47 counties as the HVA analysis. After this adjustment it was found that using

the geospatial analysis, three (6%) counties of the 47 were assessed to be in the top quartile of risk (see

Figure 12).

3.   **The comparison**

A comparison between risk values of the two forms of flood vulnerability analysis was

completed. The HVA analysis was viewed as the more subjective method, whereas the Hazus-MH-based

assessment was viewed as the more objective and data-driven method. This comparison revealed that

out of the 47 counties, 40% (19 counties) were placed in comparable risk quartiles between the two

methods. In addition, when using the Hazus-MH method as the more objective and standard method it

was found that 28% (13) of the counties from the HVA analysis assessed an overestimate of the flood

risks and 32% (15) of the counties in the HVA analysis assessed an underestimate of the flood risk. These

findings are depicted within the map in Figure 13.

4.   **Other findings**

Beyond these findings specific to the assessment of flood risk there was also an

awareness of a large lack of standardization within the health departments and the way that the HVAs

are implemented. It is in part due to this lack of set standards and methods that more data could not be

compiled for all the counties and their flood risk, despite the fact that it is evident some would have a

risk to flooding based on Figure 15. This was also a source of difficulty when it came to trying to

compare the HVA analysis to the GIS assessment, because the level of data used within each assessment

was not always clearly noted.

B.   **Our Findings in Context**

To our knowledge of the literature, this is the first study that is looking specifically at how local

health departments' HVAs assess their risks to hazards and how they compare to other forms of risk

assessment, specifically in relation to flooding. However, in 2012, research was done that looked at the

diversity of approaches to HVAs amongst the varying disciplines and possible future challenges as more

sustainable, interdisciplinary methods are sought out. One of the main challenges expressed was the

difference in the way that vulnerability is defined amongst the disciplines (Fuchs et al., 2012). After

reviewing the many formats of these HVAs just within the state of Illinois, this sentiment can be echoed

with a lack of definitions and directions being part of the problem of diversity.

In addition to this, within the last few years a couple of studies have looked at how well HVAs in

hospitals have prepared the facilities for disasters, but once again nothing dealing with health

departments (Campbell et al., 2011; Fares et al., 2014). The study completed by Campbell and

colleagues in particular is relevant to this study, because after reviewing HVAs completed at eight

hospitals in southern Maine, they too found the glaring problem to be the lack of standardization. In this

hospital study, it is mentioned that this problem of standardization led to things such as varied scopes of

risk, differing time-frame outlooks as HVAs were completed, subjectivity issues, and a large variance in

the types of resources and expertise utilized in assessment completion (Campbell et al., 2011).

C.   **County Flood Preparedness from a Public Health Stand Point**

1.   **Assessing flood risk in Illinois**

In review of the findings from the HVA analysis, one of the more telling findings was that

91% of the 77 counties with quantifiable risk identified flooding as a hazard for their county (see Figure

9). This seems to say that the health departments are definitely aware of this risk. As they should be considering the number of flood disaster declarations the state has had since 1957, and the fact that every county has had at least one flood declaration within that time (State of Illinois, 2013; "Disaster Declarations for Illinois"). Despite the high identification of flooding being a hazard it was only ranked in the top two greatest risks of 26% of the counties assessed. I feel that this may be due in part to how common flooding has been in the state as mentioned previously, which could have led to a desensitization of the potential severity and danger of this risk.

The results of the comparison of the HVA- and GIS-based risk assessments as seen in Figure 13 and Table I show that only 40% of the risk levels were comparable. This means that 60% of the flood risk levels were over- or under-estimates of the risk as determined by the Hazus-MH-based model. Of particular interest is the 32% of the 47 assessed counties for which the HVA risk value was an underestimate. Granted, this comparison was completed using a crude method due to two completely different data sets and a lack of standardization, but these counties are still noteworthy because according to this study, they are underestimating flood risk, which could lead to a lack of preparedness. So, though it seems that there is an overall awareness of flooding as a potential hazard in the state it appears that at least in some counties more could be done to make sure that risk of flooding is adequately considered.

2. **Improving public health flood risk assessment**

In general, it seems there needs to be a greater awareness of flooding, both its potential and severity, especially since heavy precipitation and severe flooding events are expected to occur more often and with greater intensity in the state due in part to climate change and development. As stated in the National Climate Assessment we have already begun to see a rise in flood-related weather events , with there being a 37% increase in the amount of precipitation that has fallen during heavy precipitation

events from the time period between 1958 and 2012 (National Climate Assessment 3). Also, though

flooding does not seem as dangerous and unpredictable as events like tornadoes, which are identified as

a risk most frequently in the counties assessed (see Figure 9), they are still the leading cause of property

damage and death out of all of the other natural disasters and they occur more frequently (Brody et al.,

2011). So, in addition to all that already goes into the HVA process it would benefit health departments

to begin to consider climate change projections and other data-driven analysis such as GIS within their

assessments. With these additional considerations, health departments should be able to get a better

overall picture of the flood risk in their jurisdiction.

D.   **Improving Overall Hazard Risk Assessments at the County Level**

If IDPH wants to start utilizing the HVAs more and trying to compare hazards among counties it

would be best if there were some standardized format and method for these documents. As evidenced

by this research, it is hard to compile data and assess hazards individually. By the time you get down to

the scale of specific hazards it may only be possible to look at half of the counties in Illinois, which does

not give an accurate picture. It is also noteworthy to highlight that only 47 of the 102 counties were

used for the comparison of HVA-based flood risk to GIS-based flood risk, which is less than 50%. This is

important because, as shown in Figure 9, flooding is identified as a hazard by counties the second most

frequently. As it stands now it is hard to compare the documents, with different scaling and definitions

for hazards, which as mentioned previously has been echoed in a study done by Campbell and

colleagues (Campbell et al., 2011). The most helpful thing would be to create a standardized format and

process. Recommendations that were put forward in the hospital study to accomplish this that may be

beneficial in Illinois are (Campbell et al., 2011):

- Set guidelines and clarifications as to how to complete the HVA

- A set format to be used by all entities

- An encouragement to utilize other experts and resources

Listed below are a few recommendations based on observations from our study.

- Spreadsheet-based method:

  A method such as the Kaiser Permanente HVA would help with standardization, which has been noted as an acceptable standard in other areas (Campbell et al., 2011; Fares et al., 2014). There is an ease to inputting data into a spreadsheet, and it also becomes readily accessible for analysis or querying. If this was a standardized format, a more descriptive rubric would have to be created and attached to it so less scaling issues would come up.

- Questionnaire/survey to large audience:

  A more subjective method based on interviews and surveys, but very detailed in the methods and descriptions was used by the Chicago Metropolitan Statistical Area HVA and could help be part of a standardize format. This method had scenarios to help those who were taking the survey think through what the hazard would look like. This HVA also had the benefit a large number of respondents to the survey, so the average was a lot more informative than if just one or two people filled out this survey (Mier Consulting Group, 2012).

- Data-driven analysis:

  Data-driven analysis using tools like GIS could be beneficial for standardization and to acquire a more detailed risk assessment, as was seen by the statewide flood vulnerability assessment.

With GIS there is a lot of data support in the findings, which can help in educating others in

making different maps and visual aids, and in getting a more confident result based on hard

data. Tools like this can help avoid bias that may be there due to personal experiences with

hazards. An example of data that could be used in this process is floodplain data as shown in

Figures 14 and 15.

- Definitions, training, and education:

To have detailed definitions for the terms and the hazards, and descriptive instructions as to

how to complete the HVAs is a necessity in any standardized method. Training to help health

agencies understand how best to utilize the tool would also be beneficial. Beyond this,

education must continue within the department and the public to teach them about the key

hazards and how best to be prepared.

- More collaboration between emergency management and public health:

Another possibility for assessment improvement is to create multi-sector partnerships between

emergency management and public health in an effort to meet the requirements outlined by

their separate funding sources. As it stands now, they both have to do hazard assessments.

According to the most recent Illinois mitigation plan, as part of the steps forward it is

documented in the plan to assist IDPH in the completion of PHEP-related HVAs (State Mitigation

Plan, 2013). It is also important to note that the flood assessments for Illinois completed by

NHRMG at SIUC were completed for each county and the assessment states that the individual

assessments were provided to each county and are available upon request. As far as flooding is

concerned this would be a good resource to use for the public health vulnerability assessments

and a good place to build some collaboration. The other benefit to cooperation is that it opens

up communication between the state departments and fields that will be necessary when actual

emergencies and hazards occur, because they will both be responding to incidents on some

level. This way they will already be more comfortable with some of the other players at the

table. In addition to these, there may even be some benefit to using the THIRA document from

FEMA as a resource since it has already begun to outline a standard process (Homeland Security,

2013).

E.   **<u>Limitations</u>**

- The lack of standardization amongst the HVAs made it difficult to compile the data and compare

  counties relative to each other. Beyond this, even when methods were different, many of the

  documents did not describe the methods that were used to determine risk. This made it hard to

  tell what resources were used and how subjective or objective the assessment was.

- It was hard to find a way that could comfortably be used to compare the HVA data to the GIS

  data. The difference in assessment type with one being more data driven and purely

  quantitative and the other being more subjective and qualitative, based on perception, did not

  allow for any statistical analysis. Without statistical analysis is was hard to give a strong answer

  as to how the two risk methods compared.

- A future limitation if HVAs move to a form that attempts to include more geospatial data is

  getting access to data and having a person who can spend time analyzing and assessing it.

VI. CONCLUSION

As evidenced by a large number of counties (70 of 77) identifying flooding as a hazard in Illinois, it is recognized as a risk within the state, but not always one of the top two risks within the counties. When it comes to comparing HVAs among other HVAs and against other assessment methods it is difficult to get any solid conclusive findings due to a lack of standardization within the process. From the loose comparison that was accomplished there was a 40% level of similar risk quartiles amongst the counties, so there is still room to improve, but this comparison must also be taken with a grain of salt. If a better comparison is desired or a better analysis of the HVAs, it is suggested that this process become more standardized, with a set format to be used, set guidelines, and possibly a method in which data can easily be entered into an online or computer database. Another aspect that can help with the completion and standardization of these HVAs is to work in cooperation with IEMA and their hazard mitigation process, since it seems that they have worked out some of the problems with standardization and they have other skills that could be helpful in this process.

This study has attempted to show the benefits of GIS analysis, or other data-driven tools, within the HVA. An attempt has also been made to give suggestions based on literature research and observations as to how to better improve flood risk assessment in particular and how to improve the overall process and use of public health HVAs within the state. It should be noted that it is not our belief that objective data-driven analysis is better than subjective analysis, but more so that a combination of these should be used to complement each other. If nobody was brought to the table to help throughout the process of risk assessment, then a planning document would be created, but there would be no mutual ownership. In addition, the preparedness effort would already be weakened due to the lack of communication and resource utilization amongst the sectors, since they were all not brought to the table to do the assessment.

A.   **Potential Significance of Work**

This work has raised an awareness of some gaps and weaknesses within the public health HVA process and can be used to better improve the system in the future so that risks can be more adequately assessed to protect the public and allow for county by county comparison.

B.   **Future Directions**

Possible future directions of this research include doing a complete analysis of all the hazards within the HVAs, working on creating a better outline for how GIS analysis can be tied into the HVA process, taking a more in-depth look at the factors of those counties that were an over- or under-estimate of flood risk, and helping create a better understanding of how to utilize HVA data within the counties and state.

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