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User Perspectives on the Implementation of Geographic Information Systems (GIS) in Emergency Management Organizations: A Case Study

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USER PERSPECTIVES ON THE IMPLEMENTATION OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN EMERGENCY MANAGEMENT ORGANIZATIONS: A CASE STUDY

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ABSTRACT

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Recent natural and technological disasters have highlighted the need for a regional approach to emergency management. Technological advancements have the potential to increase both the efficiency and effectiveness of emergency planning, response, and recovery, while also supporting a regional approach. However, a number of factors suppress the diffusion of technologies, including varying access to resources and expertise. The purpose of this study is to identify end-user perspectives of barriers that exist associated with the implementation of GIS within emergency management. Comparative analysis of Lauderdale, Shelby, and Tipton Counties in Tennessee and Crittenden County in Arkansas forms the basis of this effort. Data were collected from surveys, interviews, After Action Reports, and participant observations within the context of a regional GIS development project. Results reveal perceived benefits and limitations of utilizing GIS in the complex practice of emergency management and lead to recommendations for addressing perceived and actual barriers to implementation.

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CHAPTER 1

INTRODUCTION

The field of emergency management is continually evolving. Just as the overarching focus has shifted from one type of hazard to another over the years, so have the various approaches that are employed in an attempt to deal with disasters (McEntire 2004; McEntire, Fuller, Johnson, & Weber 2004). The events of the last decade, including the terrorist attacks of September 11, 2001 and the hurricane season of 2005, have highlighted the weaknesses and challenges that still pervade the field. Despite efforts to prepare for and mitigate risk to human life and property, studies show that the frequency and scope of disasters are increasing, often exceeding the ability of local governments to respond to them (Burby 2006). The reality of terrorism as a major threat to homeland security, the potential for catastrophic natural disasters that cross political jurisdictions, and the failures of the existing system that were made apparent during Hurricane Katrina have led researchers and practitioners to favor a more regional approach to emergency management (Burby 2006; McEntire 2004; Gerber & Robinson 2009).

Technological developments, such as improvements in early warning systems, communication equipment, and information management systems, have significantly contributed to the field of emergency management. GIS is well established as a useful tool to provide decision support for emergency planners, managers, and first responders (Cova 1999; Cutter 2003; Johnson 2000; Mondschein 1994). However, most of the existing literature on the subject of GIS in emergency management merely examines the innumerable applications of the technology to the field and does not address the barriers to the integration of the technology in practice. The purpose of this study is to identify the barriers that inhibit the implementation of GIS within emergency management organizations according to the perspective of the individuals involved in emergency operations. The research takes place within the context of the Memphis/Shelby County Urban Area Security Initiative (UASI) Working Group's efforts to develop, populate, and disseminate a comprehensive GIS database and web access tools to its member governments and organizations. Although the conclusions arising from this study are specific to the experiences of the members of the Memphis/Shelby County UASI Working Group, it is reasonable to expect similar attitudes and perceptions in emergency management organizations across the country. This thesis reviews the existing literature and the background of the Memphis/Shelby County UASI GIS project, the approach and methodology including data collection techniques are presented, followed by data analysis and results. Finally, a discussion with recommendations for practitioners aspiring to integrate GIS into their own emergency operations concludes the work.

CHAPTER 2

BACKGROUND

This section presents a review of literature relevant to the use of GIS in the field of emergency management and reviews the circumstances that spurred the development of a comprehensive GIS project in Memphis/Shelby County, Tennessee and surrounding counties.

2.1 Literature Review

The role of GIS in emergency management

In order to lessen or cope with the impacts of disasters, the comprehensive planning approach to emergency management that has been adopted by local, state, and federal government encompasses four interrelated phases: mitigation, preparedness, response, and recovery. Each of these phases has specific objectives, but the functions of each phase often overlap with the others, constituting a continuous process. The existing literature on the topic establishes the unique applications of GIS in each of the four phases (Cova 1999; Cutter 2003; Mileti 1999).

Mitigation refers to measures, often regulatory, that can be taken to reduce the impact of emergencies or disasters. According to Mileti (1999), some of the tools that can be used to mitigate the negative consequences of disasters include "land-use planning, building codes, insurance, engineering, and warnings" (p. 155). GIS has been applied to land-use planning for many years and allows users to combine current land-use data with information about the physical characteristics of the environment, such as base flood elevations, stormwater runoff resulting from impervious surfaces, or erosion patterns

(Berke, Godschalk, Kaiser, and Rodriguez 2006). Planners can then make more informed decisions regarding how to assign a given parcel's allowed use. Maintaining a spatial database within a GIS is a useful method for code enforcement and engineering offices; the spatial database would allow for the efficient storage of pertinent information about a building's physical structure while the reporting functions in the software would allow them to streamline the organization of building inspections, issue building permits, and monitor compliance. As evidenced by its everyday use in weather forecasting, GIS has become an important tool for predicting dangerous weather patterns as well as communicating warnings to various audiences. According to the Federal Emergency Management Agency (FEMA), "each dollar spent on mitigation saves society an average of four dollars" ("Mitigation," n.d.). Clearly, GIS technology has important implications for this aspect of emergency management.

Preparedness refers to actions taken to prepare for an emergency or disaster. This can include developing plans outlining the actions that a family, business, or emergency management agency should take after an event occurs, as well as maintaining a store of essential items, such as food, clothing, and first aid, in the event that emergency responders are unable to immediately assist individuals (Cova 1999; Cutter 2003; Mondschein 1994). Perhaps one of the most important functions of GIS in this phase of emergency management is the ability to model response plans so that emergency managers and first responders can gain a better understanding of the actions that might or might not work during a real event response. Training is an essential part of this phase (Johnson 2000). It is crucial that GIS become integrated with training and exercise programs so that users are comfortable operating the software under the intense pressure that is characteristic of actual emergencies and disasters and so that non-users become familiar with the types of questions that can be answered using their GIS. Preparedness also includes having procedures for response and mutual aid agreements in place ahead of an emergency or disaster. A GIS database can aid in tracking these agreements as well as the resources that are available for immediate aid (Cova 1999).

Emergency response is defined as the actions taken during and immediately following an event with the primary goals including rescuing, recovering, and providing assistance to victims (Baird 2010; Waugh 2000). According to Cova (1999), "[t]he tremendous demand for timely, accurate answers to geographical queries makes this GIS application area unique...[t]he primary benefits of GIS in this phase lie in spatial information integration and dissemination" (p. 850). Readily available and highly accurate data are extremely important; lack of these can result in loss of property and, more importantly, life. Some examples of GIS applications in this phase include hazardous material spill and plume modeling, coordinating police, fire, rescue, and evacuation operations, as well as communicating risk and incident information to the public (Cova 1999; Cutter 2003; Johnson 2000; Mondschein 1994). Ultimately, the application of GIS in this phase is limited only by the number and types of spatial questions asked by response officials against the data that is available (Waldron, Hill, & Nations 2011).

Recovery consists of the short- and long-term actions taken to return a place to pre-disaster circumstances. According to Johnson (2000), some of the short-term goals include "restor[ing] vital services and systems" such as electricity and water as well as providing temporary shelter to victims. Integrating GIS and its map products into this phase allows officials to prioritize recovery efforts based on damage reports as well as monitor progress and coordinate public assistance. Long-term recovery involves restoring the affected community to normal conditions. This includes the restoration of homes, commercial buildings, schools, and streets, and managing the return of evacuees. As in short-term recovery, GIS allows officials to prioritize and monitor progress, as well as develop sophisticated loss assessments for cost projections and financial assistance (Baird 2010; Johnson 2000).

The implementation of GIS in practice

Most of the literature related to the thesis topic describes examples of the applications of GIS technology in the field of emergency management. Existing research establishes that human and organizational characteristics have a significant effect on the adoption of technological innovations, including GIS, in practice (Innes & Simpson 1993; Nedovic-Budic & Godschalk 1996; Sussman 1996; Ventura 1995). Interestingly, some even argue that social and organizational factors affect the adoption of technology in practice to an even greater degree than the technical aspects of implementation in government organizations. The role and implementation of GIS within governmental planning organizations has been studied extensively over the years. Innes and Simpson (1993) discuss the value of the technology in the practice of city planning and identify potential barriers to implementation by building upon Rogers' (1983) previous work on the diffusion of technological innovations across many different kinds of organizational environments. They conclude that GIS applied to the field of planning typically violate all five of Rogers' principles for success in innovation: simplicity, observable benefits, relative advantage of implementation versus the cost of implementation, the ability to implement the technology incrementally, and compatibility with organizational culture (p. 3-4). The authors identify that barriers to implementation include a lack of visible, objectively measurable benefits, the large monetary investment required, and, ultimately, fundamental changes in the operation of the organization. The reality of these issues as perceived barriers is reinforced by Nedovic-Budic and Godschalk's (1996) findings in their study of four county government agencies. Respondents to surveys, including GIS users, non-users, and indirect users, identified relative advantage, computer experience, and exposure to the technology as determining factors in decisions to implement GIS. Brown (1996) asserts that major impediments to GIS in local government organizations fall into categories consisting of technological, organizational, and financial limitations. In a survey of perceived barriers to GIS integration in eighty-eight local government agencies across the United States, she finds that "[f]ifty-three percent [of respondents] regarded organizational hurdles as especially challenging: those factors relating to conflict, apathy, planning, staffing, goal agreement, leadership, and personnel commitment" (p. 200). In contrast, only seven percent of respondents indicated that technological issues were a barrier to GIS implementation. She also concludes that measurable outcomes are slow to appear in early stages of GIS initiation, development, and implementation but increase over time as agencies transition into an operational phase. Other studies indicate that the beginning stages of implementation are limited to the basic applications of the technology, such as querying data and displaying information; the more complex tasks of spatial modeling, analysis, and prediction are slower to develop and limited by organizational and institutional factors (Campbell and Masser 1995; Masser 1998; Ventura 1995).

A more recent study by Göçmen and Ventura (2010) suggests that while GIS have become increasingly commonplace in the field of planning, the significance of the barriers faced by agencies has evolved: "[d]uring the last decade, awareness of GIS increased, access to geospatial data and trained staff improved, and costs fell, but, as [the] study shows, planning departments still face many barriers to GIS use" (p. 180). The authors' survey of planners in the State of Wisconsin revealed that a lack of training, frequent updates to software and technology capabilities, and data creation, sharing, and management issues are the primary barriers to the use of GIS in planning agencies.

As mentioned above, existing research on GIS in the field of emergency management focuses on specific applications of the technology in practice rather than on the actual and perceived barriers to implementation. Although lessons from studies examining the implementation of GIS in other governmental agencies are certainly useful, it is critical to distinguish the nature of emergency management agencies from other governmental functions. Emergency management organizations are tasked with the fundamental responsibility of governments to protect human lives and property from man-made or natural disasters. This places unique demands on emergency management personnel and may potentially result in perceptions on the use of GIS technology that differ significantly from those organizations with less urgent responsibilities.

The research presented here draws on previous studies that examine the integration of GIS into other government organizations and reveals the absence of research that focuses specifically on the adoption of GIS within emergency management organizations. Recognition of the emergency management mission as an essential function of government, coupled with a proper understanding of the contributions that decision support systems, like GIS, can make to the capabilities of emergency managers and first responders, supports a research focus not only on the continued development of GIS software and products for emergency management applications, but also on understanding the factors that may promote underutilization of the technology in practice.

2.2 Research Setting

The UASI grant program was developed by FEMA to "address the unique planning, organization, equipment, training, and exercise needs of high-threat, high-density urban areas" by supporting preparedness and response agencies in metropolitan areas, often crossing county and state boundaries ("Homeland Security Grant Program" n.d.). Given the current state of the economy, however, the UASI program, in addition to other Department of Homeland Security (DHS) grant programs, has been targeted for deep reductions in funding by the federal government. The program has also been criticized at the national level due to its lack of objective evidence demonstrating effectiveness.

The Memphis/Shelby County UASI includes the counties of Shelby, Lauderdale, Tipton, and Fayette in Tennessee, Desoto County, Mississippi, and Crittenden County, Arkansas, as well as numerous preparedness and response organizations and stakeholders in the region. The UASI is diverse in many respects with a range of characteristics (urban vs rural; population total and density; variable income levels) which interact and combine to define the resources and tasks available in emergency management. Despite diversity, the region shares exposure, risk and vulnerability characteristics which motivates and necessitates regional coordination and cooperation. To advance its mission and the core priority of regional information sharing, the group voted to prioritize, fund and sustain the development of a geographic information database that is tailored to the needs of emergency managers and first responders. Prior to 2011, GIS had been used only sporadically in the emergency environment and had not played a major role in official emergency planning, response, or recovery activities within the emergency management agencies in most member counties. The utility of the technology was demonstrated to emergency personnel and UASI members during Shelby County's response to the flooding of the Mississippi River in late April and May 2011, illustrated in Figure 1, an event caused by heavy precipitation and snow melt in the Mississippi River watershed (Waldron, Hill, & Nations 2011). The event resulted in flooding over an extended period of time in all counties of the Memphis/Shelby County UASI group as well as federal disaster declarations in Shelby and Fayette Counties in Tennessee (DR-1974), Desoto County in Mississippi (DR-1972), and Crittenden County in Arkansas (DR-1975) ("Disaster Declarations for 2011"). In Shelby County, the slow onset of the event allowed for proactive planning and response. The presence of University of Memphis partners in the Emergency Operations Center (EOC) during pre-planning for the event ultimately resulted in a working relationship that enabled the visualization of predicted flood extents and depths of the Mississippi River and its tributaries using GIS. This enabled emergency support personnel in the EOC to make well- informed decisions and effectively communicate risk to the public (Waldron, Hill, & Nations 2011).

Figure 1. Photos of flood waters in Shelby County, Tennessee, May 2011. (A) Aerial view looking North along the Mississippi River and Downtown Memphis. (B) Aerial view of Mud Island River Park. Photo credit of Memphis Police Department.

The study also briefly references a more isolated flood event that occurred in May 2010. GIS was not heavily used during the May 2010 event for two primary reasons: first, induced by flash flooding, this particular event occurred much more rapidly compared to the 2011 event, and, second, responders did not have the advantage of GIS resources, expertise, and skills during this event which were made available by the partnership with the University of Memphis during the 2011 event. The 2010 flood was spatially restricted primarily to one municipality in Shelby County while the 2011 event was a region-wide event and characterized by slow onset and slow retreat of flood waters. In addition to the traditional GIS database that allows visualization, manipulation, and analyses of data within a GIS software environment (requiring an advanced understanding of the technology), a core component of the UASI GIS project is a secure, web-based spatial information portal that provides an intuitive, dynamic platform through which non-GIS users can access and query data and perform simple spatial analyses. The development of the regional GIS database provides users with a common operating platform and also ensures all users are accessing the same data with the goal of reducing misinformation (Waldron, Hill, & Nations 2011). While seen by UASI members as primarily supporting response needs, the system was developed and is ideally implemented in all phases of emergency management. The Memphis/Shelby County UASI no longer receives federal funding; however, the regional group continues to meet monthly to plan, exercise, train, and share resources as a region. Defunding has required creative solutions to hosting and maintaining the data accuracy and functional advancements. The study population is limited to individuals in Shelby, Lauderdale, and Tipton Counties in Tennessee and Crittenden County in Arkansas, as illustrated in

Figure 2, who participated in official response and recovery efforts during the 2011 flood event. As discussed previously, Shelby County emergency management personnel utilized GIS heavily during the event. Emergency management personnel in Tipton County were also supported by a GIS technician. However, Lauderdale and Crittenden Counties received little or no on-site GIS support throughout the event. Some GIS support was provided remotely to Lauderdale County via the Tennessee Emergency Management Agency (TEMA).

The selection of these study areas allows the researcher to examine end-user perceptions of GIS in counties with varying capacities to respond to events and differing experiences with the use of GIS in practice. These counties also provide a full range of resources as well as GIS expertise and experience. Select demographic characteristics of study counties are presented in Table 1. Shelby County, containing the City of Memphis and six other municipalities, is the population center of the Memphis/Shelby County UASI region with over 900,000 residents. Emergency operations in Shelby County are handled by a full-time director and staff through the Office of Preparedness. The county's EOC is supported by a number of ancillary agencies from municipal and county governments as well as non-governmental organizations, giving it access to a wide range of equipment and human resources. The emergency management agencies in Tipton, Lauderdale, and Crittenden Counties have smaller staffs, part-time in some cases, and more limited access to ancillary resources. UASI members share resources and expertise as a common practice.

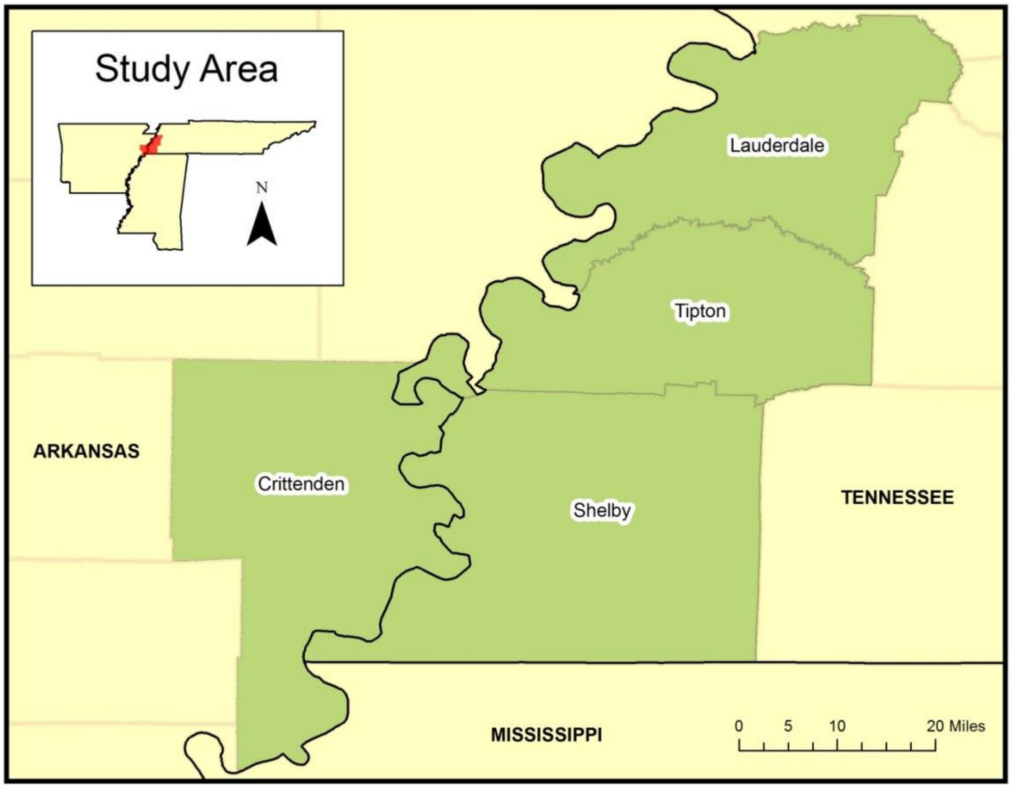

Figure 2. Study area

Table 1. Select demographic characteristics of study counties

Characteristic	Crittenden County	Lauderdale County	Shelby County	Tipton County
Population, 2010	50,902	27,815	927,644	61,081
Persons per household, 2008-2012	2.69	2.54	2.66	2.81
Median household income, 2008-2012	$36,521	$32,987	$46,251	$51,847
Per capita income past 12 months (2012 dollars), 2008-2012	$19,548	$16,328	$25,465	$22,410

2.3 Research Questions

In order to better understand the integration of GIS technology within emergency management organizations, the following research questions will guide the study:

1. What are the perceived benefits and limitations of GIS technology among emergency management personnel?
2. Do the perceived benefits and limitations match the capability of GIS technology?
3. Are perceptions different among counties that have been directly exposed to the technology in practice versus those that have not?

The use of GIS as a tool in the field of emergency management is well-established in theory. However, studies also suggest that there are obstacles to the implementation of any technology in practice. Given the fact that developing a GIS is a significant investment of time, money, and resources, this research helps to identify obstacles relating to the utilization of this tool in response to and recovery from an actual emergency or disaster event.

CHAPTER 3

DATA AND METHODS

The research questions are assessed by studying the case of counties that have recently experienced the significant flood event that took place in May 2011 in the Mid-South region along the Mississippi River. The following section details the methodological approach and the data collection techniques that are employed to address the research questions.

Quantitative data alone limit the ability to fully explore the complex nature of human perceptions (Creswell 2003). Because individuals' perspectives form the basis of this research, this study utilizes a mixed methods approach supported by both quantitative and qualitative data where multiple data collection methods are employed sequentially. This study employs a non-probability, purposive sampling technique. The sample population was adapted from emergency support contact lists provided by each county's emergency management agency. Other individuals in the sample were referred to the researcher by study participants or UASI members. ESFs are not equally represented among the sample population. Some respondents, particularly those from rural counties, identify with multiple ESFs. Participants were active members of the emergency response community and are professionally affiliated with agencies that staff county emergency operations centers during the study time period.

Perception data are collected in part by means of a survey instrument distributed to the sample population via US Postal Service between May 2013 and September 2013. The survey instrument is designed to gauge practitioners' perspectives on the benefits and limitations of GIS in practice, particularly focusing on how the technology can or cannot contribute to the mission of the EOC as a whole, as well as the role of the technology in supporting the objectives of each respondent's emergency support function (ESF). The roles of each ESF are outlined in Table 2. A four-point Likert scale is used to identify the concerns, criticisms, and major organizational barriers to the implementation of GIS in the EOC and in respondents' own ESF(s). The four-point scale is used in lieu of a five-point scale so that respondents must identify with either the positive or negative end of the scale. Neutral response options are provided when respondents feel they "don't know" the answer to the question or that the question is "not applicable." The use of the Likert Scale as well as the wording of questions in surveys on human perception typically present the need for some subjective interpretation of the meaning of responses on behalf of the researcher, though in this case interviews can be relied on as well. The first two questions on the survey ask participants to compare the effectiveness of four response/recovery activities (situational awareness, information sharing, distribution of personnel, and management and allocation of resources) between the flood event of May 2011 and the flood event of May 2010. The purpose here is to allow participants to consider the difference in response and recovery activities during an event that did not heavily incorporate GIS into operations (May 2010 flood) versus an event that did (May 2011 flood). However, not all respondents were involved in the management of both events. Also, memories, and thus perceptions, could have been influenced by the passage of time between the events and the time that data were collected. The third question asks respondents to rate how GIS has improved or could improve situational awareness, information sharing, distribution of personnel, and management and allocation of resources during response and recovery. Questions four and five prompt participants to rate the degree to which certain factors, shown in Table 3, inhibit the use of GIS within their ESF and EOC, respectively. These organizational and technical factors are adapted from previous studies on the implementation of GIS in planning agencies and other governmental organizations (Innes & Simpson 1993; Nedovic-Budic & Godschalk 1996; Sussman 1996; Ventura 1995). Participants also have the option to include and rate their own factors which are not built into the survey.

Quantitative data gathered through the distribution of surveys are used to evaluate the research question "what are the perceived benefits and limitations of GIS technology within and among emergency support functions?" at multiple levels of analysis. The range/variance of perspectives within each ESF are established by comparing survey responses at the individual level. Further, survey results are used to determine and examine the differences and similarities in perspectives across ESFs for each EOC. Similarly, the third research question "are perceptions different among counties that have been directly exposed to the technology in practice versus those that have not?" is evaluated by comparing patterns in survey responses between EOCs at the county level.

Table 2. Emergency support functions and their roles

ESF #	ESF Name	Responsibilities
1	Transportation	Transportation networking
2	Communications	Communications systems and warning systems
3	Infrastructure	Building inspection and condemnation Route clearance and bridge inspection Debris removal Water and wastewater systems
4	Firefighting	Firefighting
5	Information and Planning	Disaster intelligence Damage assessment Public information and awareness Warnings and protective action guidelines
6	Human Services	Shelter and mass care operations Disaster victim services
7	Resource Management	Logistics and resource management Vehicle allocation Staging areas
8	Public Health and Crisis Intervention Support	Emergency medical services, public health, and pandemics
9	Search and Rescue	Search and rescue
10	Environmental Response	Hazardous materials and radiological materials
11	Food	Agriculture and natural food resources
12	Energy	Energy (petroleum, electrical, natural gas, etc.)
13	Law Enforcement	Traffic control, security and crime control, evacuation/movement Terrorism Correctional institutions and jails
14	Donations and Volunteers	Donations and volunteers
15	Recovery	Assistance programs, recovery, and reconstruction
16	Animal Housing and Care Services	Animal housing and care, livestock, and animal disease management

Source: “Tennessee Emergency Management Plan” (n.d.)

Table 3. Classification of factors potentially limiting the integration of GIS

Organizational	Applicability of GIS to ESF/EOC Support of Colleagues within ESF/EOC Support of Administrators within ESF/EOC
Technical	Lack of Standard Operating Procedures Availability of Data Accuracy of Data Poor Visual Representation of Data (design, symbols, labels, etc.) Inadequate or Outdated Hardware/Software Inadequate or Outdated Supporting Equipment (GPS, projectors, printers, etc.) Lack of Technical Training

The qualitative component of the study is comprised of semi-structured individual interviews with a selection of survey respondents, content analysis of After Action Reports, optional survey comments, and observations based on experience with Memphis/Shelby County UASI members as a participant-observer through the GIS project development and implementation. The individuals invited to participate in interviews were selected by the researcher from survey respondents to provide an even representation of ESFs. Emergency management directors from the study counties were also interviewed. The content and agenda of individual interviews are informed by survey findings and in most cases are tailored according to the emergency support responsibilities of the interviewee. These interviews replace intended focus group discussions; these discussions could not be implemented due to the schedules of survey respondents. Interview data are used to validate the results of surveys, clarify observations and explore the findings in more detail. After Action Reports within the context of emergency management include EOC participant discussions and are intended to evaluate the performance of the organization as well as to identify areas that need improvement.

The UASI GIS project introduced in Chapter 2 provided unmatched insight into the opportunities and challenges individuals and agencies face when implementing GIS into agency, local and regional emergency management and decision making environments. Specifically, the investigator participated in monthly UASI working group meetings; GIS and Information Sharing subcommittee meetings (quarterly to bi-annually); and served as liaison for data creation, collection, and training for three of the six UASI counties. The interaction with professionals in these settings/roles provided an appreciation for the context of technology, data-driven decision making, and challenges in adopting a new approach in incident management. While anecdotal, this data source cannot be underestimated though would not be easily replicated. Qualitative data obtained from the methods described above are categorized into major themes based on content analysis.

Out of a total of eighty-one surveys that were distributed, thirty-five were returned, yielding a response rate of 43.2%. Table 4 shows the breakdown of responses by county. The number of surveys sent to and received from Shelby County was considerably higher compared to other study counties and could skew results; however, this accurately reflects the nature of emergency management and ESF staffing and highlights the reality of disparity in access to human resources across the study counties.

Table 4. Response rate summarized by jurisdiction

Jurisdiction	Surveys Distributed	Surveys Received	Response Rate
Lauderdale	3	0	0.0%
Shelby	54	20	24.1%
Tipton	10	3	30.0%
Crittenden	11	11	100.0%
State of TN	3	1	33.3%
Total:	**81**	**35**	**43.2%**

CHAPTER 4

FINDINGS

Given the relatively small sample size for survey responses, descriptive statistics are relied on to reveal patterns in responses that address each research question. The low survey response rate could have been influenced by the researcher's previous involvement with the UASI group. As seen in Table 5, survey responses indicate an overall perception of improvement to all four response and recovery activities listed on the survey during the 2011 event. Sixty-nine percent of respondents rated situational awareness during the flood of 2011 as "excellent," an increase of twenty percent from the previous year's event. When examined at the county level, eighty-five and one-hundred percent of respondents from Shelby and Tipton Counties, respectively, regard situational awareness during the 2011 event as "excellent." In Crittenden County, only thirty-six percent rated the same. However, a greater number of individuals from Crittenden County responded that they "don't know" the effectiveness of situational awareness during that event. Fewer individuals surveyed from Crittenden County were present during response and recovery to the event and GIS was not used during the event. A vast majority (80%) of respondents perceive that GIS could greatly improve situational awareness and information sharing capabilities, but that percentage dropped considerably when asked about the applicability of the technology to the more complex tasks of distributing personnel (54%) and managing resources (60%).

Table 5. Comparison of May 2010 and May 2011 response and recovery activities (important elements in bold)

What is your opinion on the effectiveness of the following activities during response and recovery to the **May 2010** Flood:

	Poor			Excellent	Don't Know	NA	No Answer	Total
Situational awareness	0%	6%	**23%**	**49%**	11%	9%	3%	100%
Information sharing	0%	3%	**37%**	**37%**	11%	9%	3%	100%
Distribution of personnel	0%	0%	**37%**	**26%**	20%	14%	3%	100%
Management of resources	0%	6%	**34%**	**26%**	17%	14%	3%	100%

What is your opinion on the effectiveness of the following activities during response and recovery to the **May 2011** Flood:

	Poor			Excellent	Don't Know	NA	No Answer	Total
Situational awareness	0%	0%	**11%**	**69%**	11%	6%	3%	100%
Information sharing	0%	0%	**31%**	**49%**	11%	6%	3%	100%
Distribution of personnel	0%	0%	**20%**	**46%**	20%	11%	3%	100%
Management of resources	0%	0%	**29%**	**40%**	17%	11%	3%	100%

This pattern is also reflected when examining data at the county level with respondents from both Shelby and Crittenden Counties reporting that they "don't know" how GIS has or could improve these two operations activities.

When asked to rate how limiting certain organizational and technical factors are to the integration of GIS within ESF workflows, respondents overall indicate that the most limiting factors include the perceived availability and accuracy of data, inadequate supporting hardware, software, and equipment, and a lack of technical training. Organizational elements are perceived as the least limiting factors. Results are similar when the same factors are assessed as potential limitations at the EOC level:

organizational factors are regarded as the least limiting factors by a majority of participants while a lack of technical training is viewed as the most limiting factor.

Responses are also analyzed at the ESF level where the ESF is represented by four or more respondents (note that some respondents identify with more than one ESF). A total of five individuals indicated involvement with ESF 4 Firefighting. Respondents among this group indicate improvements in situational awareness, information sharing, and management of resources during response and recovery from the 2011 event. Eighty percent of respondents believe GIS has or could greatly improve situational awareness, information sharing, and the management of resources while a lower percentage (60%) perceive the same degree of improvement for the distribution of personnel. All respondents believe that GIS is applicable to the roles and responsibilities of the Firefighting ESF. Interestingly, forty percent report the support of administrators as a somewhat limiting factor. Twenty percent indicate that the availability of data is a greatly limiting factor.

Four individuals identified with ESF 5 Information and Planning. Improvement in all activities is reported except for information sharing, which remained the same between the two events. A majority of respondents feel GIS either has greatly improved or has the potential to greatly improve each of the response/recovery activities. However, compared to other ESFs, a larger percentage of respondents from this ESF report that they don’t know how GIS has or could improve situational awareness (25%), information sharing (25%), distribution of personnel (50%), or management of resources (50%). Participants report that there are no factors which greatly limit the use of GIS in their ESF.

Participants staffing ESF 8 Public Health and Crisis Intervention Support (n = 6) report improvement in all response/recovery activities between the 2010 and 2011 events, particularly in the management of resources. One hundred percent believe GIS has or could greatly improve situational awareness and information sharing. However, only thirty-three percent feel the same about improvements to the distribution of personnel and the management of resources. As highlighted in Table 6, participants in this group report more limitations than any other.

ESF 13 Law Enforcement is the most well represented ESF in the study sample with a total of 8 participants identifying with this ESF. The trend in improvements between the 2010 flood event and the 2011 flood event continues in this group. A majority of respondents indicate that GIS has or could greatly improve all response/recovery activities included in the survey. None of the organizational or technical factors surveyed are perceived as greatly limiting to the use of GIS in practice. A majority of respondents indicate that the visual representation of data is not a challenge. However, results show a wider variance in the *degree* to which all other technical factors inhibit implementation. Survey results are also classified and reported by county. In Crittenden County, a larger percentage of respondents are unable to compare response and recovery between the 2010 and 2011 flood events due to absence during one or both events. Perceptions on the effectiveness of the activities during those events do not vary greatly. Consistent with other results, a majority of respondents perceive GIS to be an improvement to situational awareness and information sharing, but the percentage dropped for the more complex tasks of distributing personnel and managing resources.

Table 6. Users' perspectives on factors limiting the use of GIS within ESF 8 Public Health and Crisis Intervention Support (important elements in bold)

Organizational/Technical Factors	Does Not Limit Use			Greatly Limits Use	Don't Know	NA
Applicability of GIS to ESF	50.0%	0.0%	16.7%	0.0%	0.0%	33.3%
Support of Colleagues within ESF	33.3%	50.0%	0.0%	0.0%	0.0%	16.7%
Support of Administrators within ESF	50.0%	16.7%	16.7%	0.0%	0.0%	16.7%
Lack of Standard Operating Procedures	16.7%	50.0%	0.0%	16.7%	0.0%	16.7%
Availability of Data	0.0%	16.7%	**16.7%**	**50.0%**	0.0%	16.7%
Accuracy of Data	16.7%	0.0%	**33.3%**	**16.7%**	**16.7%**	16.7%
Poor Visual Representation of Data (design, symbols, labels, etc.)	16.7%	33.3%	**16.7%**	**16.7%**	0.0%	16.7%
Inadequate or Outdated Hardware/Software	16.7%	0.0%	**16.7%**	**33.3%**	**16.7%**	16.7%
Inadequate or Outdated Supporting Equipment (GPS, projectors, printers, etc.)	0.0%	0.0%	**50.0%**	**16.7%**	**16.7%**	16.7%
Lack of Technical Training	0.0%	16.7%	**33.3%**	**33.3%**	0.0%	16.7%

Out of eleven people surveyed, 27.3% reported a lack of technical training as a greatly limiting factor. Compared to other counties, participants in this county also perceived organizational factors to be greater limitations to the use of the technology in practice. Many more participants also responded that they don’t know whether the factors listed on the survey are limiting or not.

Three out of ten people involved in emergency operations in Tipton County responded to the survey. Perceptions on the comparison of the two flood events remained consistent, with the surprising exception that respondents indicated poorer information sharing during the 2011 flood. All participants perceive that GIS has or could greatly improve situational awareness and information sharing in the emergency management setting, and, matching the overall trend, a smaller percentage feel the same about the more complex tasks of distributing personnel and managing resources using GIS. All of the respondents from this county report that there are no organizational or technical limitations to the use of GIS in practice.

Personnel that were surveyed from Shelby County reported increases in the effectiveness of all activities between 2010 and 2011. A majority of participants perceive that GIS has or could greatly improve situational awareness and information sharing in the emergency management setting, and, though still a majority, a smaller percentage feel the same about the more complex tasks of distributing personnel and managing resources using GIS. Survey results indicate strong organizational support for the use of GIS in practice and view the technical aspects of implementation as more limiting. A lack of training is reported as the biggest limitation to implementation (note that training sessions have taken place for this county since data collection but had occurred for other counties prior to data collection).

After Action Reports were not available for Crittenden and Lauderdale Counties. Although Tipton County held an After Action Review, a formal report was not available. Content analysis of Shelby County's After Action Report for the 2011 flood (Bach 2012) reveals how highly emergency support personnel regarded the use of GIS in this event, and perhaps more importantly, the consequence of the analytical power behind the technology resulting from community partnerships. The report calls attention to the significance of "coordinated capabilities," or the abilities created by the network of relationships between organizations. The advanced predictive modeling of flood extents and depths that made response and recovery so successful in this case would not have been possible without the expertise made available through the relationship between the Shelby County Office of Preparedness and the Center for Partnerships in GIS at the University of Memphis. Partnerships offer support in the form of expertise, insights, experience, and resources that, as demonstrated in this case, can prove invaluable in the emergency management setting. Major themes emerging from interviews include concerns over the long-term sustainability of the project and the ability to replicate the successful use of the technology in another event, expansion of the existing system to build on its ability to meet the needs of emergency management organizations, the applicability of the technology not only to the needs of the EOC but also to individual agencies, and the need for expanded training opportunities. Individuals interviewed overwhelmingly agree that the technology is presently underutilized in emergency management operations.

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

Research question 1: *What are the perceived benefits and limitations of GIS technology among emergency management personnel?*

Perceived benefits and limitations among personnel vary with experience and ESF role. Survey results and individual interviews reveal that a majority of emergency management personnel recognize the contribution that GIS can make to their ability to visualize an event and share and communicate information among and between ESFs, administrators, and field-based responders. Several interviewees even go so far as to say they can't envision going forward in the emergency management field without the tool. Most of the survey respondents were either directly involved with the successful response to the flood of 2011 using GIS or are familiar with the critical role played by the technology in planning for and responding to the event due to their involvement with the UASI working group. Interestingly, the data show that organizational support for the implementation of GIS within the overall survey population may not be as limiting a factor as it has been in previous studies that focused on other types of organizations. However, that may be expected considering the context of this study. The integration of GIS into emergency operations has been a goal in at least a developmental or planning context in several counties in the Memphis/Shelby County region for several years preceding the flood event of 2011. It became a higher priority in some counties following the real-life demonstration of its applicability to enhanced decision-making. Also, while access has increased over time, the evolution of the technology itself demands more computing power for hardware and software and advanced expertise to match advanced capabilities.

GIS, and other technologies supporting decision-making, are applied more frequently in some fields related to emergency management than others. Individuals staffing the fire services and law enforcement emergency support functions, for example, may be more familiar with the applications of GIS to their roles within the EOC than individuals staffing the Human Services, Donations and Volunteers, or Animal Housing and Care Services. Many interviewees, especially representing fire, law enforcement, and public health agencies, praised the use of GIS during the 2011 event as transformative to the way they conduct response and recovery activities. They also spoke of their efforts to extend the use of the system beyond an EOC activation to integrate it into planning activities within their organization. Ultimately integration into business-as-usual operations may alleviate several concerns raised as familiarity and proficiency with the tools is built and as thinking spatially becomes habit. It is recommended that future implementation projects attempt to leverage this element of system function. The emergency environment is highly reactive in nature. Because of the urgency of the environment, emergency management personnel tend to trust what they know works. Developing trust in the technology is a major barrier to the implementation of the technology in practice.

These cases support the idea that a GIS commissioned and endorsed by a formal collection of agencies across a region provide recognized benefits not only to the regional organization as a whole or the counties represented, but also to the individual agencies that participate in its development. Several individuals expressed that they would like to see the current system expanded to build the capacity to use the technology in the field (damage assessments for example). They reported frustration with the functionality of the web interface across different devices (laptops, tablets, mobile phones) and device platforms (Apple, Android, etc.); if users are able to access the system using their existing resources it would greatly enhance their ability to utilize the technology in the field. One individual remarked that one of the biggest challenges to the use of GIS in the field of emergency management is the fact that there is no prototype for development. Although some federal agencies and private companies have developed GIS data models, these have been criticized for lacking information needed at the local level. Involving stakeholders from the earliest stages in the development process is critical to establishing buy-in and long-term cooperation.

The number of years spent working within the field of emergency management has little impact on individuals' ideas on the potential for GIS to contribute to decision-making. Emergency management personnel are more likely to investigate the potential of the technology when they have been exposed to its successful use in practice. When comparing survey responses by age, the only clear pattern that emerges across all age groups is a trend showing differences in perceptions based on the complexity of the function. More individuals recognize the application of the simpler functions of the technology (situational awareness and information sharing) than the more complex functions (resource allocation). One-hundred percent of individuals in the youngest age group (20-29 years) and the oldest age group (60-69 years) perceive that GIS has the potential to greatly improve situational awareness, information sharing, the distribution of personnel and the management of resources. More variation in the *degree* for improvement of these activities appears in the remaining age groups (30-39 years, 40-49 years, and 50-59 years).

Research question 2: *Do the perceived benefits and limitations match the capability of GIS technology?*

The answer to this question is found to depend on the analysis capability, where a distinction between advanced spatial analyses becomes relevant. Although a majority of the overall study population also recognize that GIS has or has the potential to improve the management and distribution of personnel and resources, the decline in the percentage of participants that feel the technology could greatly improve (as opposed to somewhat improve, slightly improve, or does not improve) those functions indicates a gap in the recognition of GIS tools for more complex tasks. It is important to note that some respondents may have been assessing the question based on their own ability to interact with GIS data and analytical functions rather than the overall applicability of the technology to the responsibilities of the EOC as a whole. For example, when asked about this disparity in an interview, one participant mentioned that he understands how the technology could be applied during an emergency, but felt he did not have the expertise or skill required to manage those tasks through the interactive UASI GIS portal. As a result, he felt that those tasks would be better conducted by the GIS technicians on staff. Several other interviewees indicated that they perceive among many of their colleagues a lack of understanding of the application of the technology to the specific responsibilities of their ESF. This is supported by professional observations during the training element of the UASI GIS project and in subsequent attempts to employ the technology in planning for small-scale events in some of the study counties. Although users in this case had participated in at least one scenario-based GIS training event, it is evident from challenges in navigating the web interface without consulting developers that time to practice training concepts was not available as this group of users is frequently overtasked. Consequently, the author recommends incorporating a training component utilizing a variety of approaches with an emphasis on linking training to experience and to on-going activities rather than keeping GIS training as separate which would reinforce the separation in practice. When implementing a system like the UASI GIS, users should first be introduced to the data and basic functions available through the user-friendly interface, but training cannot stop there. Use of the GIS must be purposefully integrated into other training opportunities, such as seminars and workshops, but especially in table-top and full-scale exercises and drills. Other training events should be designed in collaboration with and for potential users in each ESF that address the applications of the technology to the specific roles and responsibilities of each ESF. Emergency support personnel should be, at the very least, generally aware of how the data that are available, especially those data that are easily accessed by non-technical users through a guided interface, can be applied to the most basic operations of their ESF; thus, ESF-specific training and identification of skill and knowledge gaps is essential. Having an emergency support staff that can perform simple tasks using the intuitive interface potentially frees up the dedicated GIS support staff for more complex functions. The technology is presently not being used to its full potential in practice. Individuals recognize the applicability of the basic functions of the technology to practice, but the same is not true for the more complex functions.

Research question 3: *Are perceptions different among counties that have been directly exposed to the technology in practice versus those that have not?* Perceptions on the use of GIS vary based on successful experience with the technology in practice. Crittenden and Lauderdale Counties are rural counties that at the time lack the resources and capacity to independently initiate and sustain the development of a GIS. In these counties, primary support for participation in the development of the regional GIS came from the emergency managers. Crittenden County received no GIS support during the flood event and Lauderdale County received only some remote support; thus, neither of these counties has had a practical experience with the technology that is comparable to the kind experienced by Shelby or Tipton Counties. Shelby and Tipton Counties have the advantage of skill, expertise, and experience. Both counties staff GIS technicians and analysts, often distributed across multiple agencies and jurisdictions. Shelby County had the added support of partners from the University of Memphis who were able to contribute advanced analytical capabilities of hydrological modeling. Crittenden County respondents, more than any other county, indicated the greatest absence of organizational support for the technology. Other perceptions on critical barriers according to participants in Crittenden County include the availability and accuracy of data and a lack of standard operating procedures and technical training. In addition to a lack of experience with the technology, other explanations for these responses could include the fragmented nature of the emergency management agency. Crittenden County employs only a part-time emergency management coordinator and the EOC is staffed in large part by volunteers. Only two individuals out of the eleven surveyed in Crittenden County have interacted with the UASI GIS portal, attended a training session, or are active participants in monthly UASI member meetings. It is likely that most of the survey respondents in Crittenden County are not even aware of what data the system contains or the methods used to obtain them, resulting in their perceptions of data availability, data accuracy, and data representation as barriers to use. No survey responses were received by invited participants in Lauderdale County, but professional experience and interview data lead to the same conclusions. It also seems that Lauderdale County faces more resistance from county administrators. In both Crittenden and Lauderdale Counties, the individuals involved with the researcher in coordinating data collection from county organizations seem more supportive of its use as a regular part of emergency management workflows than their peers. Interviewees also expressed a concern that it would likely be difficult to convince some members of the emergency management community in their counties of the value added by the system. When prompted, they associate this with generational differences; some members of the community believe the current system of managing emergencies is entirely adequate and that changing the way things are done creates opportunities for error and places extra demands on personnel due to the necessity of training to develop skills.

Tipton County has a dedicated GIS professional who serves the needs of all county agencies. The use of GIS in emergency management is clearly well-established here. Interestingly, survey respondents indicate that there are no perceived barriers to the implementation of GIS in practice. Tipton County, perhaps more than any other study county, has managed to integrate GIS into standard operational workflows. One individual interviewed from Tipton County acknowledged that the presence of the county GIS staff reinforced users' confidence in the long-term viability and accuracy of data.

Shelby County participants report strong organizational and administrative support for the technology. When asked about perceptions regarding the availability and accuracy of data, some Shelby County individuals indicated concern over the long-term sustainability of the project. The time-sensitivity of some of the data that were collected, along with disappearing sources for funding, lead some to believe that data may become quickly outdated. Agencies in Shelby County that contribute data are also much larger than their rural counterparts and have many more resources and assets to maintain in the system. Most agencies do not have the resources to devote maintenance of the data to a single employee, so responsibility for this aspect of project longevity must be absorbed by existing personnel who are likely already overtasked. If users of the system discover they are working with old data, they say, trust in the system is going to falter. For many agencies, participation in the UASI GIS project highlighted the fact that critical information about resources and assets often exist in individuals' minds and are not explicitly or formally accounted for. The greatest limiting factor according to Shelby County respondents is a lack of technical training. As mentioned above, users understand quite well the broader implications of the technology, but are less comfortable interacting with the technology themselves. One potential challenge revealed in Shelby County is the size and diversity of experience across agencies and a related challenge is the reliance on University of Memphis partners. While partnerships with community organizations for advanced expertise are certainly needed for advanced capabilities, an over-reliance on outside individuals for basic support has the potential to seriously undermine the need for emergency support personnel to learn how to interact with the platform. On the other hand, rural counties will be limited in the types of complex analyses they can conduct in the absence of these important partnerships. Developing working relationships and increasing the capacity for advanced analysis, especially in non-emergency times, while also balancing their dependence on those relationships should be a priority among urban and rural counties alike.

CHAPTER 6

CONCLUSION

This study assesses users' perceptions on the implementation of GIS within the practice of emergency management in four counties in West Tennessee and Arkansas. In contrast to studies on the use of GIS in other government organizations, the study finds that, overall, organizational factors, are not perceived to be the most limiting factors to implementation. According to participants, issues such as the availability and accuracy of data, inadequate software, hardware, and supporting equipment, and a lack of technical training are perceived to be most limiting. Quantitative and qualitative data indicate a gap in individuals' perceptions of the capability of GIS in practice. A major potential barrier to effective implementation includes individuals' inability to match data with questions specific to the role/responsibility of the ESF.

The UASI GIS project afforded member governments and organizations the opportunity to develop a locally and regionally defined GIS for use in emergency management. In particular, this project offered a powerful tool to governments who would otherwise not have the resources to develop, populate, and implement a GIS on their own. In the author's experience, organizational and leadership support at the county level are vital factors in the successful development and integration of GIS in emergency management operations. At the county level, perceptions on organizational versus technical barriers are more varied. Counties with more experience with the technology in practice generally report more organizational support with technical aspects presenting impediments. Recommendations to address the perceived barriers include fostering support among county leadership and agency administrators, forming solid plans to insure the maintenance of data, and fostering experiential training programs that address the needs of the EOC as a whole as well as the applications of the technology to the various individual ESFs.

The emergency management environment is one that demands reliable data and information. GIS has the potential to meet that demand but developers and trainers need to address users' trust in the data and confidence in performing analyses. Without trust and confidence, the capabilities of GIS will remain under-utilized in this area where GIS is well suited to support decision-making.

A number of future research opportunities arise from the findings of this study. Ideally, the sample size should be increased to get a more adequate representation of the population and to allow statistical analyses to be applied to test the significance of findings. Similar studies on users' perspectives could be conducted on other emergency management agencies across the country to compare to the findings of this work and to build a more solid understanding of the role of organizational context in the implementation of GIS. While the investigator's prior involvement with the UASI group provided distinct advantages in this study, future studies may benefit from an outside researcher. The UASI GIS project used as context in this case study is still in the early stages of implementation. Conducting the same or similar study when the system is being used operationally could provide important insights on perceptions have changed over time and how the issues revealed here have or have not been addressed.

GIS supports powerful spatial analysis and can provide a robust decision making tool for agencies, counties and regions that manage, plan for and respond to incidents. The utility as a regional tool in this case is found to extend beyond supporting technical data analysis but to be especially helpful in counties which have limited technical and data driven support.

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APPENDIX A

SURVEY INSTRUMENT

Purpose: The purpose of this survey is to assess the use of geographic information systems (GIS) within the field of emergency management from a variety of end-user perspectives. Your participation will allow the researcher to explore the benefits and limitations of GIS according to the users within the emergency management organization.

Confidentiality: Your responses will remain confidential. Responses will be tracked through the use of an identification code, which will be kept secure at all times and accessed only by the research team. Responses will not be associated with names in the reporting of results.

Instructions: Please consider each question carefully and answer from the perspective of the multiple roles you play as a professional within the emergency management agency. If you feel like you do not know the answer to a question or that it does not apply to you, please mark N/A. Space for additional comments is provided at the end of the survey.

Name: ______________________________

Emergency Support Function: ______________________________

Agency/Organization: ______________________________

Age: ______________ **Sex:** ______________________________

How many years have you served in your current position? ______________

How many years have you served in the field of emergency management? __________

1. What is your opinion on the effectiveness of the following activities during response to and recovery from the **May 2010** flood event:	Poor			Excellent	Don't Know	N/A
a. Situational awareness	1	2	3	4	5	6
b. Information sharing	1	2	3	4	5	6
c. Distribution of personnel	1	2	3	4	5	6
d. Management and allocation of resources	1	2	3	4	5	6

Comments: ____

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2. What is your opinion on the effectiveness of the following activities during response to and recovery from the **May 2011** flood event:	Poor			Excellent	Don't Know	N/A
a. Situational awareness	1	2	3	4	5	6
b. Information sharing	1	2	3	4	5	6
c. Distribution of personnel	1	2	3	4	5	6
d. Management and allocation of resources	1	2	3	4	5	6

Comments: ____

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3. What is your opinion on how the use of GIS **has improved**, or **could improve**, the effectiveness of the following activities during response and recovery:	Not improve			Greatly improve	Don't Know	N/A
a. Situational awareness	1	2	3	4	5	6
b. Information sharing	1	2	3	4	5	6
c. Distribution of personnel	1	2	3	4	5	6
d. Management and allocation of resources	1	2	3	4	5	6

Comments: ____

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4. Rate the following factors based on how they limit the use of GIS within your **Emergency Support Function (ESF)**:	Does not limit use			Greatly limits use	Don't Know	N/A
a. GIS is not applicable to the roles and responsibilities of my ESF	1	2	3	4	5	6
b. Support of colleagues (within ESF)	1	2	3	4	5	6
c. Support of administrators	1	2	3	4	5	6
d. Lack of standard operating procedures	1	2	3	4	5	6
e. Availability of data	1	2	3	4	5	6
f. Accuracy of data	1	2	3	4	5	6
g. Poor visual representation of data (symbols, labels, etc.)	1	2	3	4	5	6
h. Inadequate or outdated hardware/software	1	2	3	4	5	6
i. Inadequate or outdated support equipment (GPS, projectors, printers, etc.)	1	2	3	4	5	6
j. Lack of technical training	1	2	3	4	5	6

Comments: ____

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5. Rate the following factors based on how they limit the use of GIS within your **Emergency Operations Center (EOC)**:	Does not limit use			Greatly limits use	Don't Know	N/A
a. GIS is not applicable to the roles and responsibilities of my EOC	1	2	3	4	5	6
b. Support of colleagues (within EOC)	1	2	3	4	5	6
c. Support of administrators	1	2	3	4	5	6
d. Lack of standard operating procedures	1	2	3	4	5	6
e. Availability of data	1	2	3	4	5	6
f. Accuracy of data	1	2	3	4	5	6
g. Poor visual representation of data (symbols, labels, etc.)	1	2	3	4	5	6
h. Inadequate or outdated hardware/software	1	2	3	4	5	6
i. Inadequate or outdated support equipment (GPS, projectors, printers, etc.)	1	2	3	4	5	6
j. Lack of technical training	1	2	3	4	5	6

Comments: ____

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Thank you for your participation in this study. If you have additional comments, please provide them in this space.

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL

From: Beverly Jacobik (bjacobik) on behalf of Institutional Review Board

Sent: Tuesday, October 08, 2013 9:46 AM

To: Lauren Elizabeth Goddard (lgoddard)

Subject: IRB Approval2659

Hello,

The University of Memphis Institutional Review Board, FWA00006815, has reviewed and approved your submission in accordance with all applicable statuses and regulations as well as ethical principles.

PI NAME: Lauren Goddard

CO-PI:

PROJECT TITLE: End-user Perspectives of Geographic Information Systems (GIS) within Emergency Management Organizations: A Case Study of two West Tennessee Counties

FACULTY ADVISOR NAME (if applicable): Arleen Hill

IRB ID: #2659

APPROVAL DATE: 10/8/2013

EXPIRATION DATE: 10/7/2014

LEVEL OF REVIEW: Exempt

Please Note: Modifications do not extend the expiration of the original approval

Approval of this project is given with the following obligations:

1. If this IRB approval has an expiration date, an approved renewal must be in effect to continue the project prior to that date. If approval is not obtained, the human consent form(s) and recruiting material(s) are no longer valid and any research activities involving human subjects must stop.

2. When the project is finished or terminated, a completion form must be completed and sent to the board.

3. No change may be made in the approved protocol without prior board approval, whether the approved protocol was reviewed at the Exempt, Exedited or Full Board level.

4. Exempt approval are considered to have no expiration date and no further review is necessary unless the protocol needs modification.

Approval of this project is given with the following special obligations:

Thank you,

Ronnie Priest, PhD

Institutional Review Board Chair

The University of Memphis.

Note: Review outcomes will be communicated to the email address on file. This email should be considered an official communication from the UM IRB. Consent Forms are no longer being stamped as well. Please contact the IRB at IRB@memphis.edu if a letter on IRB letterhead is required.