EXPLORING THE ROLE OF COMMUNITY CAPACITY AND PLANNING EFFORT IN DISASTER RISK REDUCTION AND ENVIRONMENTAL SUSTAINABILITY: SPATIO-TEMPORAL VULNERABILITY AND RESILIENCY PERSPECTIVES

By

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A dissertation submitted in partial fulfillment of

The requirements for the degree of

Doctor of Philosophy

(Urban and Regional Planning)

at the

UNIVERSITY OF WISCONSIN-MADISON

2015

Date of final oral examination: July 29, 2015

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ABSTRACT

EXPLORING THE ROLE OF COMMUNITY CAPACITY AND PLANNING EFFORT IN DISASTER RISK REDUCTION AND ENVIRONMENTAL SUSTAINABILITY:
SPATIO-TEMPORAL VULNERABILITY AND RESILIENCY PERSPECTIVES

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At the University of Wisconsin-Madison

Using the basic premise that disaster effects are fundamental social processes that require pro-active planning, a conceptual model of disaster losses that involves local exposure, shock, and loss within the context of inherent social system spatial and temporal vulnerability and resilience was formulated. Based upon a review of the extant literature, three theoretical hypotheses were proposed. First, disaster effects will have a negative association with social and economic development metrics; second, the higher the levels of a community's social and economic capacity, the lower the disaster losses; and third, better planning effort, social capital, and social justice in place before a natural disaster will lower disaster losses. This study will focus on examining disaster loss from flooding with respect to local planning effort, and social and economic condition at the county level within the Mississippi River basin in the United States. Data were collected from secondary sources (archival review and existing databases). Mixed analytical methods were used including log-linear model, quantile regression, two-stage least square model, longitudinal data analysis, spatial modeling, and content analysis. Unlike previous research, which has mainly focused on a theoretical approach to disaster resilience, this study adopted an empirical approach based on panel data at the county level from secondary sources. Initial results of spatial modeling suggest that disaster damage has a negative association with community social and economic structure, and that engaged social capital, more equitable distributional characteristics, and local proactive planning in place before a disaster results in lower disaster losses.

ACKNOWLEDGEMENTS

I would like to sincerely thank my advisor, Professor David Marcouiller for his continuous encouragement and warm support during my doctoral program in urban and regional planning at the University of Wisconsin-Madison. In order to discuss my research, job talk, and move my dissertation research forward, we had regular meetings at least once a week. I am also indebted to my wonderful dissertation committee members, Professors Stephen Malpezzi, Vicki Bier, Kenneth Genskow, and Kurt Paulsen for their insightful comments and suggestions on the dissertation draft. I also would like to thank other faculty members. Professors Alfonso Morales and Harvey Jacobs gave me warm encouragement and support in preparing for job talk and job marketing. I am grateful to doctoral students of urban and regional planning. Especially, I would like to thank Todd, Chris, and Wei for giving me a good opportunity to study for the preliminary exam together when I was a first year doctoral student. They also provided great friendship. I wish them continued success in their academic activities. Most importantly, I would like to thank my wife, Myungjin. Without her unconditional love and support, I could not have obtained a PhD degree in the United States. Whenever I felt like a plastic bag, she always gave me encouragement and made delicious food for me to overcome any difficulties. I am deeply indebted to my parents and parents-in-law in South Korea. Thanks to their unconditional love, encouragement, and continuous and sincere prayers, I could study in the United State without any difficulties. In addition, I would like to thank my brother-in-law, Joseph for his exceptional proofreading whenever I have difficulties in writing an English paper. I would like to thank Jack for his excellent English tutoring and comments on my papers. From him, I have learned a lot of American culture and the importance of a positive attitude. I have greatly appreciated God's special love.

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivation of the Study

In an interesting insight, the Intergovernmental Panel on Climate Change (IPCC) (2012, p. 11) noted that

> "Closer integration of disaster risk management and climate change adaptation, along with the incorporation of both into local, sub-national, and international development policies and practices, could provide benefits at all scales."

This passage underscores cross-spatial scale efforts to share and transfer informal and traditional risk management through financial relief, resilience or recovery of livelihoods, and reduction of vulnerability in mitigating disaster losses. In this sense, it is worth addressing a conceptual planning relevant model of disasters caused by climate change, associated with local vulnerability and resiliency. By reviewing the extant knowledge of extreme climate events within the framework of social and community planning relevant to vulnerability and resiliency, this study suggests the role of community capacity and planning effort in disaster risk reduction and environmental sustainability.

The rationale for this research is based on current gaps in the knowledge about vulnerability and resilience to natural disasters and environmental change, especially connected to limited work on spatial and temporal vulnerability and resilience at the community level. These issues formed the scalar focus of this dissertation. This research is also based on the premise that there is insufficient understanding of the interrelationships between resilience and anthropocentric hazards such as socioeconomic change, and a lack of information about the complex interplay between community resilience and different forms of social, economic, and environmental capacity. This research differs from previous studies in two aspects. First, I develop a conceptual framework which provides a theoretical basis for the overall process of disaster vulnerability and resiliency at the community level not specifically described in existing studies. Second, I examine the constructs of disaster vulnerability and resiliency utilizing empirical analyses of longitudinal and spatial data, which complements and extends the conceptual and descriptive approaches found in the extant literature on disaster planning.

Through conceptual models, three central theoretical hypotheses are proposed. First, disaster effects will have a negative association with social and economic development metrics; second, the higher the levels of community social and economic capacity, the lower the disaster loss; and third, better planning effort, social capital, and social justice metrics in place before a natural disaster will lead to lower disaster and environmental change related losses. This approach improves on previous work by incorporating tacit stages of development, social capital, social justice, and distributional elements that speak to social and economic inequity.

In this study I will focus on examining disaster (flooding) losses, planning effort, and social and economic conditions (as community capacity) in local communities within the Mississippi River basin in the United States. A review of the extant knowledge on disaster planning suggests that disaster damage likely has an association with social and economic structure, and that engaged social capital, more equitable distributional characteristics, and local pro-active planning in place before a disaster results in lower disaster losses.

This dissertation is specifically written as four stand-alone, yet closely connected, essays that are in-preparation for submission to publish in peer-review journals. As such, they contain their own abstracts, contents, and literature cited sections. This first chapter provides an overview of the dissertation while the last chapter contains a broad summary of the work and an overall set of limitations and policy implications. While there is some conceptual repetition, I have worked to link each essay into distinct presentations that build upon one another. Further, while I have several manuscripts already published with various mentors, this work remains original to my own unique set of contributions under the guidance of my advisor.

1.2 Spatio-temporal Vulnerability and Resiliency Perspectives

The damages and losses caused by unexpected disaster events have sudden and significant impacts on socio-economic conditions and the environment. One of the critically important issues related to minimizing these losses is the temporal configuration for identifying socio-economic conditions before and after the events. Prior research of natural disaster effects tends not to accurately reflect the spatial and temporal characteristics of socio-economic situations or social systems. Furthermore, the results of previous studies generally lack spatio-temporal changes even though the impacts have changed the social and economic conditions over time such that they are different for the next event. Specifically, they do not consider non-linear phenomena, quality of uncertainty, spatial heterogeneity, randomness, unstable environmental characteristics, and stochastic processes (Kim et al., 2015).

In order to overcome these issues, I developed Chapter 2 as a literature review that culminates in a conceptual and integrated model that inserts spatial and temporal dynamics as a key element within disaster planning. This takes on both planning and decision-making frameworks that act to simultaneously reduce vulnerability elements of a community while promoting resiliency elements. The integrative disaster planning model addresses comprehensive understanding about community vulnerability and resiliency. In line with integrated social and economic spheres, this model encompasses risk assessment and compares hazard and disaster in accordance with disaster management cycles. This conceptual model then leads to a host of empirical applications with ample opportunity for future directions that remain for further research.

1.3 Goals of the Dissertation

The specific aims of this study are developed based on the conceptual framework and preliminary findings.

Aim 1: To identify the shortcomings of the current disaster management paradigm (existing models of planning and governance) as social processes (addressing the underlying social and human causes of natural disasters);

Aim 2: To draw an integrated conceptual and planning relevant model of disaster outcomes along with local vulnerability and resiliency;

Aim 3: To select socio-economic factors and public policies contributing to mitigating disaster losses based on the literature review (emphasizing the contribution to prevention and mitigation by people who bear the effects of disasters);

Aim 4: To assess the role of social and economic condition (i.e., community capacity) and planning effort in mitigating disaster losses by using county-level spatial and longitudinal data and planning and policy documents (stressing the importance of place and context);

Aim 5**:** To apply a qualitative method for evaluating how existing disaster mitigation plans and planning practices are able to create resilient communities;

Aim 6: To elaborate on the explicit links between sustainable development, vulnerability and resilience to natural disaster, and environmental change to understand how a sustainable development planning can increase resiliency and capacity.

In this study, I will address several major gaps in our understanding of disaster risk reduction. Findings from this study will help test the proposed conceptual framework, set directions for future research and practice, and guide the development of a tailored policy for disaster risk reduction.

Based on the literature review concerning indicators of socio-economic resilience, a structure for applying research method is summarized in Figure 1-1. This framework embraces three phases that include (1) examining socio-economic factors contributing to vulnerability and resilience within counties affected by natural disasters (flooding) and environmental change using cross-sectional and time-series studies (Phase I in Chapter 3); (2) evaluating the quality of natural disaster mitigation plans within study areas using qualitative text analysis (content analysis) (Phase II in Chapter 4); and (3) applying resilience principles to evaluate flood-prone community response to flooding (Phase III in Chapter 5).

Along with the structure of methods, Figure 1-2 shows the structure of study area selection according to each phase. For the first phase, among about 1,600 counties within the Mississippi River Basin areas, I selected 1,266 counties in 22 states by flooding experience and presidential disaster declaration during the last 20 years. For the second phase, I selected 160 counties among the 1,266 counties in accordance with the criteria of having a local hazard mitigation plan and a high flood risk level. In addition, for the third phase, I selected 85 counties among 1,266 counties with the criteria of spatial clustering of risk. In addition, I selected two local rural communities, Hancock County in Illinois and Crawford County in Wisconsin according to their similar spatial clustering of risk levels, similar high flood risk levels, and socio-economic conditions.

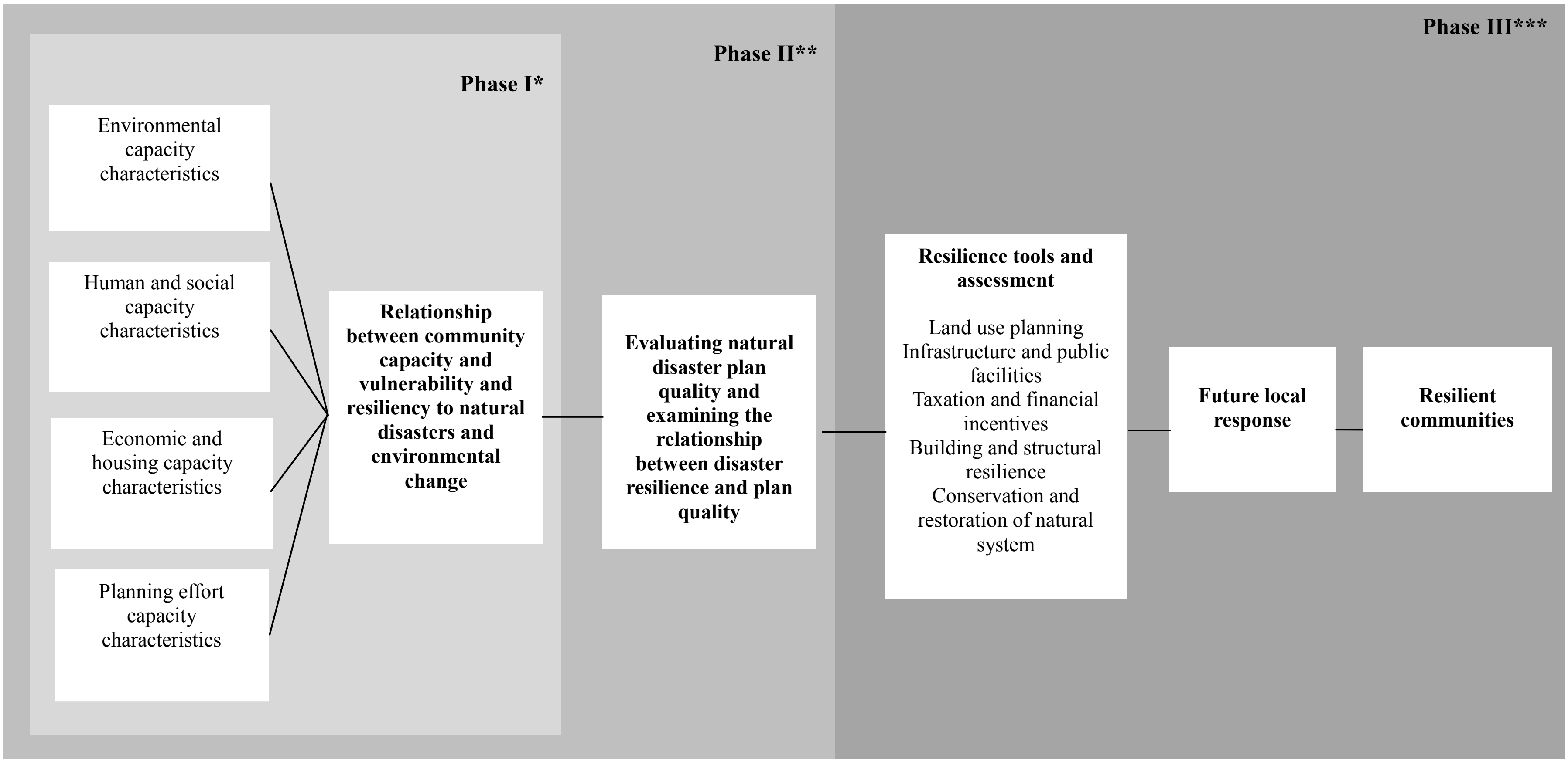

Figure 1-1. Structure of Methods Used in This Study

Note: * secondary data based spatial analysis, ** document based analysis (content analysis), *** case study and document based descriptive analysis

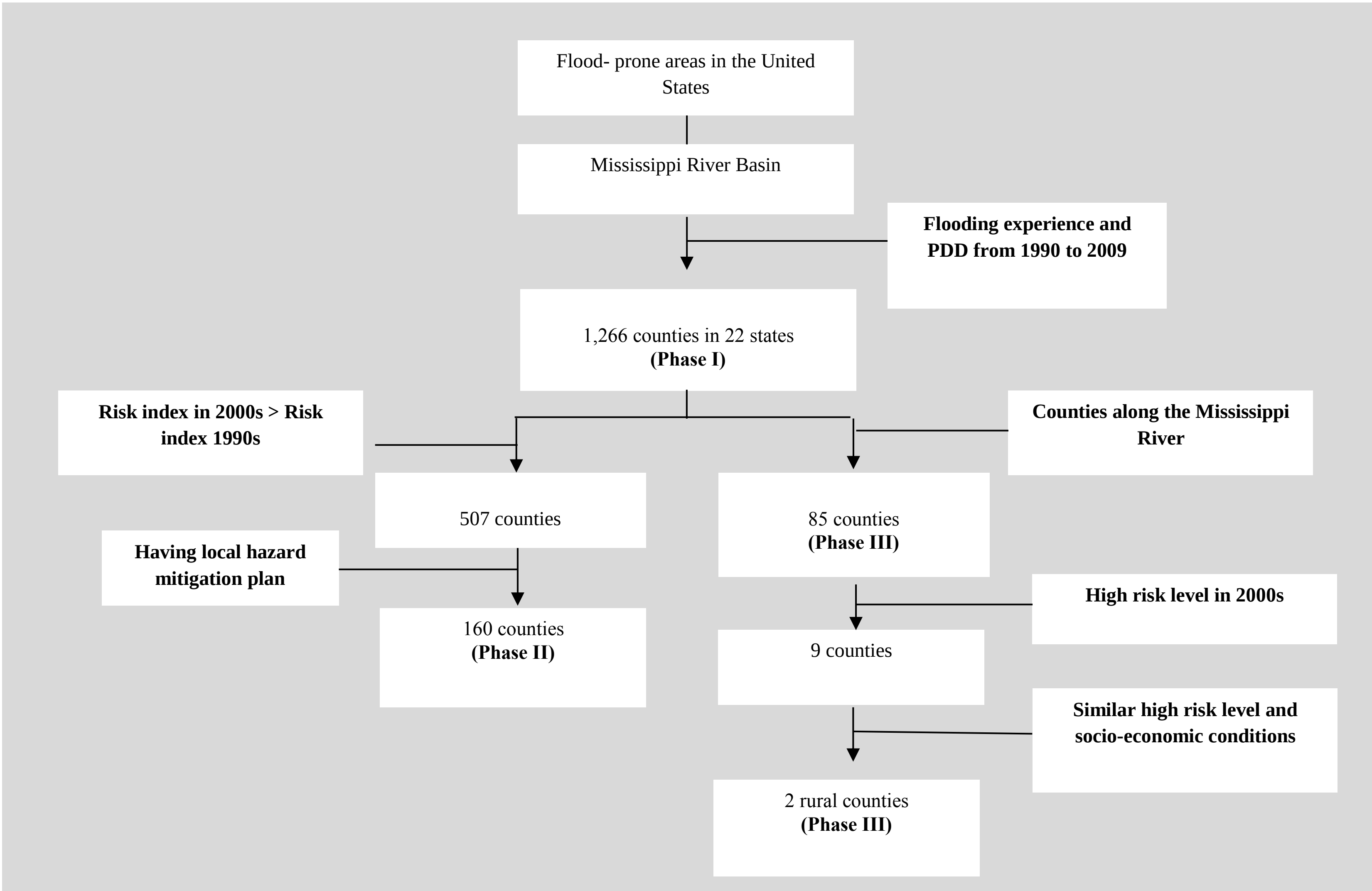

Figure 1-2. Structure of Study Area Selection Used in This Study

More specifically, with respect to Phase I, as depicted in Figure 1-1a, community capacity characteristics that include various environmental and geographical characteristics, human and social capital characteristics, economic and housing characteristics, and planning effort characteristics can be determined in line with thematic domains involving social and economic change, environmental change and spatial domains such as individual, community, and region.

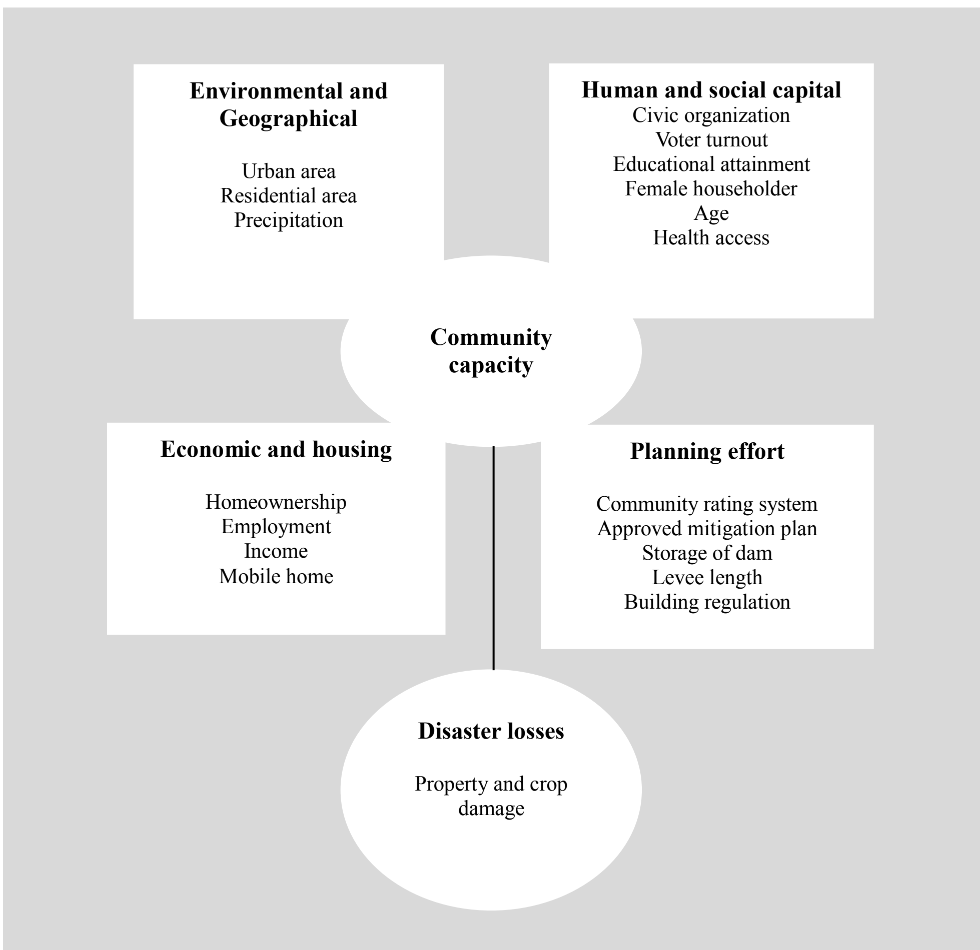

Figure 1-1a. Structure of Methods Used in Phase I

In Chapter 3, I analyze data for 1, 266 counties (from 21 states) across the Mississippi River basin areas affected by flooding during the past 20 years (from 1990 to 2009) in an effort to determine community resilience indicators. This chapter is based on the available data collected from several official research sources from the National Oceanic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), the U.S. Census Bureau (USCB), U.S. County Business Pattern (USCBP), National Center for Charitable Statistics (NCCS), Dave Leip's Atlas of U.S. Presidential Elections (DLAP), National Levee Database (NLD) and National Inventory of Dams (NID) from U.S. Army Corps of Engineers, PRISM Climate Group (PRISM), Economic Research Service (ERS),and the Spatial Hazard Events and Losses Database for the United States (SHELDUS).

In light of Phase II in Chapter 4, natural disaster mitigation plan quality will be assessed to identify the role of planning effort in disaster risk reduction by using content analysis (see Figure 1-1b). More recently, studies on plan quality and evaluation have been conceptualized and systemized by contemporary researchers (e.g., Berke, 1994; Berke and French, 1994; Berke et al., 1996; Berke et al., 2012; Berke et al., 2014a, 2014b; Brody, 2003a, 2003b; Burby and Dalton, 1994; Lyle et al., 2014a, 2014b; Stevens and Shoubridge, 2014) who have evaluated comprehensive plans related to natural disasters.

Supported by these plan quality studies, Smith and Glavovic (2014, p. 408) demonstrated that having a high quality natural disaster hazard plan can "play a pivotal role in building capacity and facilitating more collaborative ways of thinking and working to achieve resilience and sustainability." These efforts have established a consensus of the characteristics of plan quality that most affect local government decisions, and thus are most likely to achieve plan implementation (Berke and French, 1994). With an emphasis on the characteristics of plan quality suggested by Chapin and Kaiser (1979) and Kaiser et al. (1995), three elements of plan quality have been identified: fact basis, goals and objectives, and policies, tools, and strategies.

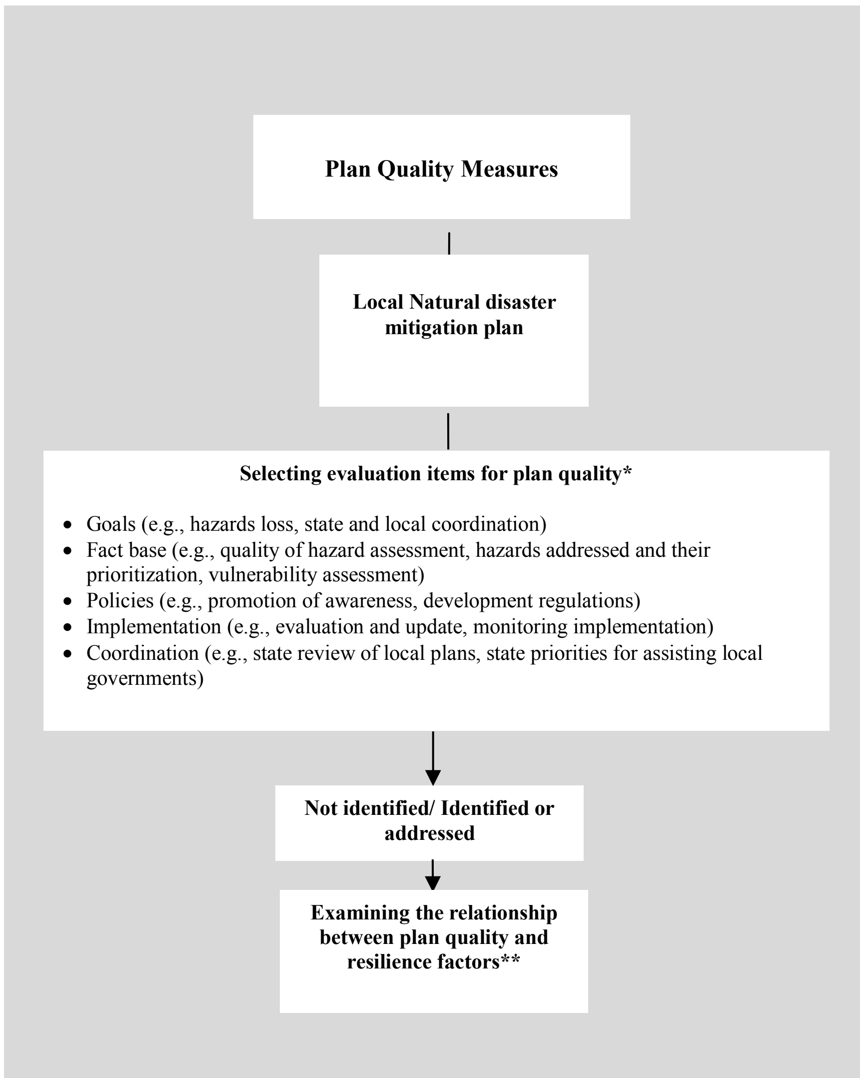

Figure 1- 1b. Structure of Methods Used in Phase II
Note: * content analysis method, ** selected variables in Phase I

Fact basis draws implications of the existing and emerging local status and identifies needs in the context of a community's physical development. Goals and objectives, as one of the plan's quality characteristics, represent general aspirations, problem alleviation, and needs that are premised on shared local values. Policies, tools, and strategies, including actions, serve as a general guide for decisions about the location, density, type and timing of public and private development to assure that plan goals are achieved. Further, based on the above three components of plan quality, contemporary researchers (e.g., Berke and French, 1994, Berke et al., 1996; Berke et al., 2012; Berke et al., 2014a, 2014b; Burby, 1998; Deyle and Smith, 1998; Lyle et al., 2014a, 2014b; Smith and Glavovic, 2014; Stevens and Shoubridge, 2014) have developed a coding protocol which incorporates hazard mitigation measurement into these components. In addition to these components, the plan quality research analyzed plan contents. As illustrated in Figure 1-1b, based on these principles of plan quality, I will evaluate a sample of 160 local plans related to natural hazard mitigation to determine how well they support natural disaster risk reduction. These selected resilience indicators are also closely associated with resilience principles.

With regard to Phase III, Chapter 5 is based on Beatley's work (2009) on the "tools and techniques for enhancing and strengthening coastal resilience" (pp. 72-96), Masterson et al. (2014) on "planning for community resilience," and Daniels (2014) "environmental planning handbook." In this Chapter, I address the application of resilience and the evaluation of a rural community's responses to natural disasters. As illustrated in Figure 1-1c, I will select several disaster resilience principles suitable for the context of selected communities. Relying on multiple resources, this qualitative approach can be contextually based and triangulated. In this regard, my analytical process will be useful in providing important insights on how to make communities more resilient to the adverse impacts of natural disasters and in underscoring the critical importance of a local hazard mitigation plan in contributing to resilience.

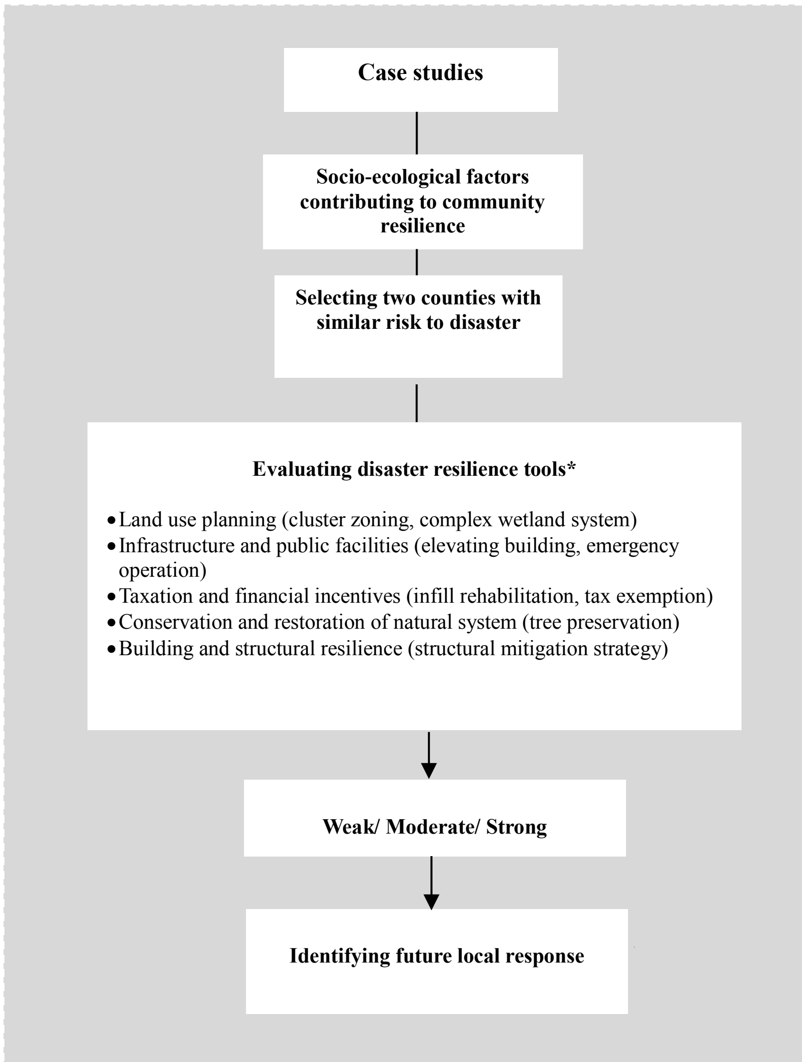

Figure 1-1c. Structure of Methods Used in Phase III
Note: * adopted from Beatley (2009), Daniels (2014), and Masterson et al. (2014)

1.4 References

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CHAPTER 2

LITERATURE REVIEW

DISASTER RISK, COMMUNITY CAPACITY, AND PLANNING EFFORT: PERSPECTIVES ON SPATIO-TEMPORAL VULNERABILITY AND RESILIENCY

Abstract

In this chapter, I address the links between disaster risk, community capacity, and planning effort within the context of previous theoretical and empirical literature. By identifying the shortcomings of the dominant disaster management paradigm, I develop a spatio-temporal conceptual model for disaster risk reduction that involves local vulnerability and resiliency. Three theoretical hypotheses are proposed. First, disaster effects will have a negative association with social and economic development metrics; second, the higher the levels of community social and economic conditions the lower the disaster losses; and third, better planning efforts (including plan quality), social capital, and social justice metrics in place before a natural disaster will lead to lower disaster losses. Findings suggest that sustainable and resilient communities should be able to recover rapidly from disasters whenever they occur. Sustainable development and resilience are contingent on careful planning and organization of society, both to ameliorate disaster impacts and to facilitate the recovery processes.

Keywords: Community capacity, Natural disaster, Resilience, Spatio-temporal model, Sustainable development

2.1 Disaster Risk, Community Capacity, and Social Framework

2.1.1 Historical natural disaster risk and environmental change

The Indian tsunami of 2004, the Haiti earthquake of 2010,[1] the Japanese Tsunami of 2011, Hurricanes Katrina and Rita in 2005 and Sandy in 2012, together with the current worldwide evidence of climate change underscore the fact that communities and people are becoming increasingly vulnerable to natural hazards. It is estimated that in the last ten years, major natural disasters affected more than 3 billion people, killed over 750,000 people, and cost about US$600 billion (Birkmann, 2006). This significant loss of human lives and property damage suggests that our communities are not as resilient as they could be to natural disasters.

With respect to increasing disaster losses, Figure 2-1 shows cumulative US natural disaster losses with more than US $ 10 million during the past 40 years in the United States. From this figure, we can surmise that the largest disaster losses in the United States during the recent past have occurred in coastal areas and the Midwest. If we focus on the darkest shaded areas, earthquakes were typical disaster types in western coastal areas, hurricanes marked typical disasters along the Gulf of Mexico and Atlantic coast. Floods and tornado events were typical disaster types in the Midwest.

Every year, potentially damaging natural disasters (e.g., floods, droughts, temperature extremes, hurricanes, and earthquakes) occur around the world. In recent years, such natural events have been occurring more frequently and with greater intensity (Schipper and Pelling,

[1] According to Munich Re NATCATSERVICE (Geo Risks Research, www.munichre.com), fatalities in the Indian tsunami were 220,000 and overall economic losses were about 10,000 US $ million. In the Haiti earthquake of 2010, there were 222,570 fatalities and about 8,000 million US$ in overall economic losses. In addition to Munich Re, we can find the quantitative data related to disaster losses and environmental risk at the global level in CRED database (www.cred.be) and Swiss Re (www.swissre.com) (Smith, 2013).

2006). Results of a recent study conducted by the National Oceanic and Atmospheric Administration (NOAA) (2009) suggest that hurricane wind speeds have increased 5-10% as a result of a 2.2°C warming of the sea surface. Further studies attribute this increase to global climate change, which is expected to gradually increase the number and severity of these events in coming years (Prasad et al., 2009; Ruth and Ibarrarán, 2009).

The increased intensity, size and frequency of natural disasters precipitated by global climate change can potentially lead to an incremental rise in the vulnerability of economic, social, and environmental systems that affect such human needs as food or water availability, shelter and transportation infrastructure, public and personal health, and ecosystems (Botzen and Van Den Bergh, 2009). Modern societies have become more vulnerable to social and economic damage from natural hazard events because infrastructure has become more elaborate and populations have grown larger and are more concentrated (McBean and Ajibade, 2009). Ultimately, more severe weather-related hazards caused by global climate change are expected to give rise to increasingly serious problems involving threats to human health, physical damage to infrastructure, economic losses, and alterations to biodiversity and ecosystem health.

Considering adaptation to climate change within the context of natural and social systems (Turnbull et al., 2013) requires objectives that reflect a process of adjustment to anticipated futures. The Intergovernmental Panel on Climate Change (IPCC) (2012, p. 5) proposed that such objectives involve policies that "…moderate harm or exploit beneficial opportunity." Such adaptation refers to any adjustment that takes place in natural or human systems in accordance with expected vulnerabilities to natural disasters posed by climate change. For this reason, my research incorporates a number of characteristics that reflect how communities adapt to and prepare for natural disasters with a specific focus on disaster resilience.

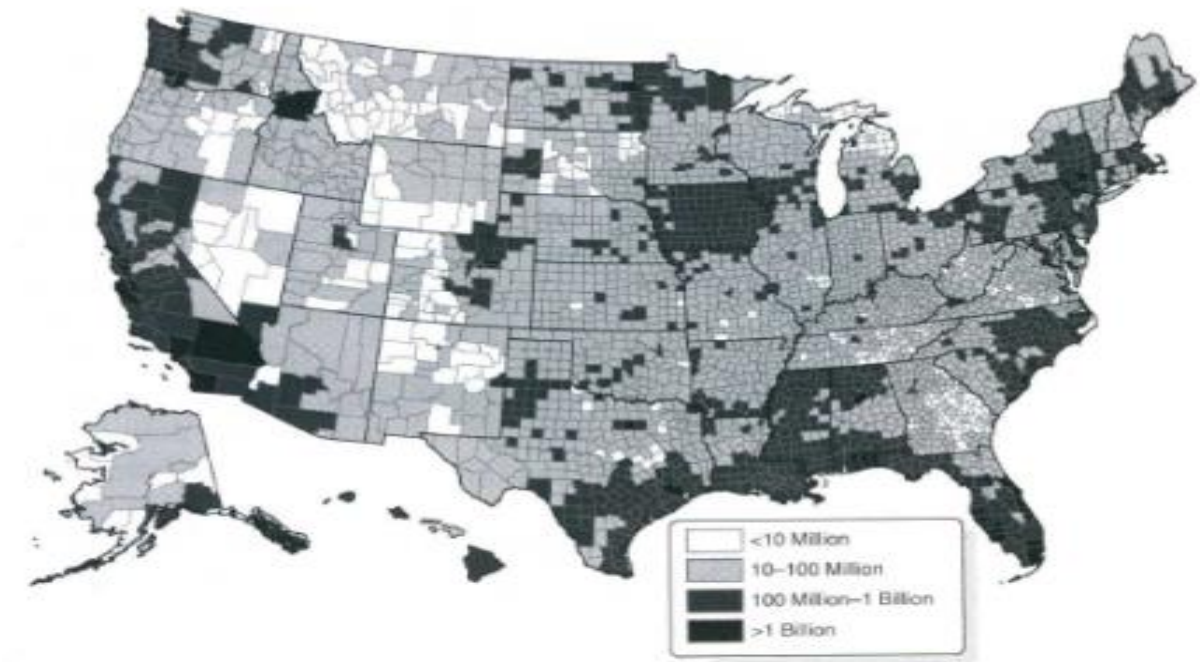

Figure 2-1. Total Losses from All Natural Hazards from 1960 through 2004 (in 2009 US$)
Source: Cutter et al. (2008b).

2.1.2 Understanding disasters and environmental sustainability within a social framework

How we create our communities and where we choose to live determines how resilient we are to the impacts of hazards (Schwab et al., 2007). Attempts to reduce the impacts of natural disasters are fundamentally related to making a more sustainable human settlement. The “crisis” element of a major natural disaster, in the sociological sense, can be thought of as failures of a social system to support communities in adapting to an environmental event (Sairinen, 2009; Vollmer, 2013a). Failures are not simply the result of an isolated high impact natural phenomenon. They can be viewed as failures to develop and distribute housing, business services, and community infrastructure capable of withstanding and rapidly recovering from such an event.

From this perspective, community recovery from natural disasters can be regarded as a process by which groups and organizations making up the community attempt to re-establish social networks to conduct recuperative elements necessary to return stability to the routines of daily life (Tierney, 2014). Community residents seeking livelihood or simply the amenities and recreation value of hazard- prone lands or people pushed into dangerous areas by virtue of poverty and land scarcity, are examples of the interactive process at work.

As illustrated in Figure 2-2, the characterization of natural disasters as sociological processes can be better understood by tracking the historical development of the hazard research paradigm over time. In the 1930s, sociologist John Dewey noted that environmental perils are defined, reshaped, and redirected by human actions (Kates and Burton, 1986; Kreps, 1989; Mileti, 1999). This perspective of conceptualizing natural disasters as a social process, in addition to its usual consideration as natural process, was emphasized in the 1940s through the 1970s by the geographer Gilbert White. White proposed that natural hazards are a result of interacting natural and social forces (Kates and Burton, 1986).

In addition, with an emphasis on the social sciences to suggest directions for national policy, White and Haas conducted the nation’s first assessment of research on natural hazards in 1975 (Mileti, 1999; Platt and Rubin, 1999). Since then, the hazard adjustment paradigm (or components of disaster management) has primarily focused on a four-stage cycle: preparedness, response, recovery, and mitigation. In recent iterations, this hazard paradigm tends to integrate sustainable hazard mitigation as well as disaster vulnerability and resiliency (Dovers and Handmer, 2014; Mileti, 1999; Platt and Rubin, 1999; Topping and Schwab, 2014).

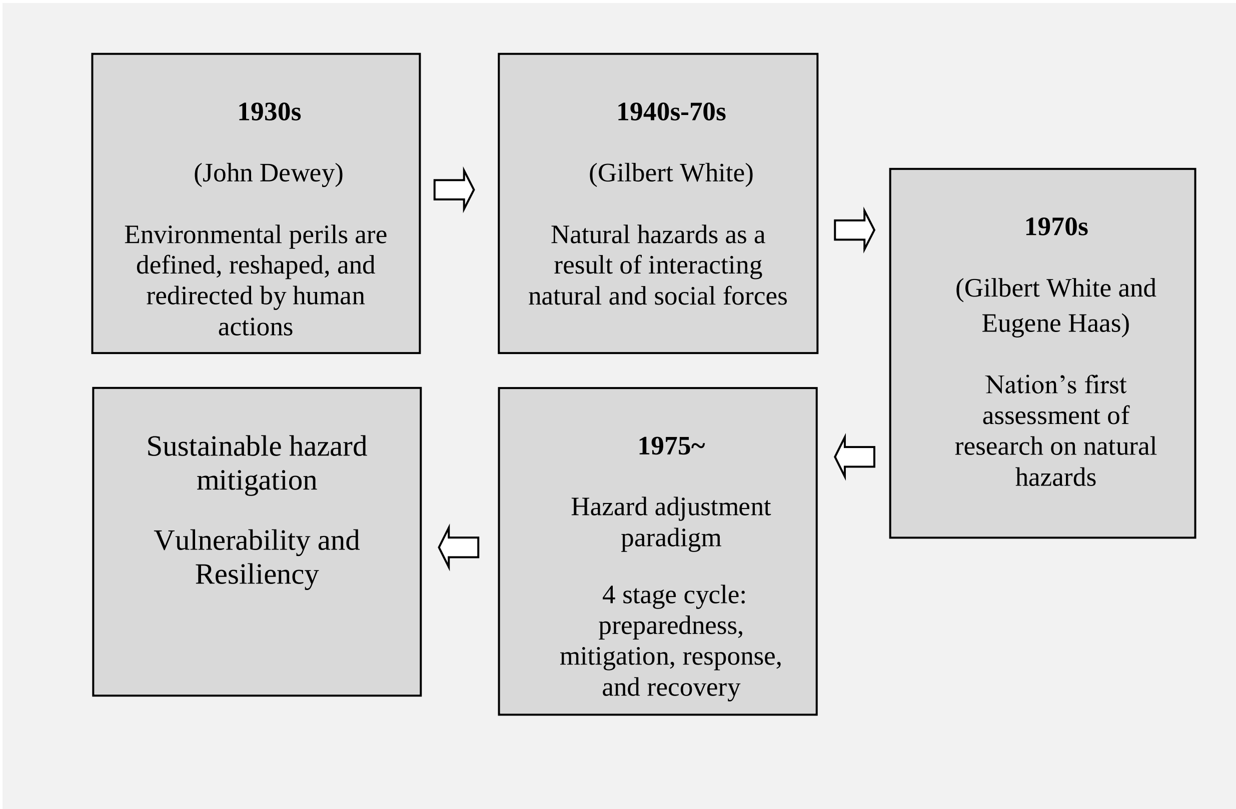

Figure 2-2. Tracing the Hazard Research Paradigm
Source: Modified from Mileti (1999, pp.17-24), Kates and Buton (1986), Kreps (1989), and Dovers and Handmer (2014)
Note: Arrow means time flow, parentheses indicate related scholars

The theoretical background of social change associated with disasters set forth by Peacock et al. (1997) supports the hypothesis that disasters provide an impetus for major social changes (processes). First, by placing the social structure under stress, disasters test the structural capacity to perform vital functions and, in the process, existing weaknesses are made visible and are exacerbated. The system is forced to adapt and some of these adaptations will likely become permanent changes (H_1 :Existing weaknesses revealed). Second, disasters bring new groups and organizations into being and provide circumstances that foster new forms of contact, cooperation, and conflict between existing groups and organizations (H_2 : New groups and organizations). Third, disasters frequently result in a large influx of outside resources, both human and material.

This may produce an economic boom, as well as bring in new ideas and ways of behavior. These outside resources, ideas, and behaviors can result in fundamental changes in the community and its social structure (H_3 : External resources and ideas).

Fourth, disasters differently affect socio-economic and ethnic groups, as well as different sectors of the community's division of labor. As a consequence, the stratification system may be affected and differential decline and growth may occur in various sectors of the social structure (H_4: Differential effects on preexisting strata). Fifth, disasters frequently destroy or severely damage outmoded infrastructure and force its replacement with more modern technology. Such technological updates may result in alteration of the stratification system or the division of labor, and may result in both differential growth and elaboration of sectors of the system's structure (H_5 : Changed infrastructure). Last, social conflicts often emerge in the aftermath of a disaster over the distribution of scarce resources and over the equity principles that should guide the reconstruction effort. These conflicts may have serious political implications and result in permanent changes in the relationships between the government and other units comprising the system (H_6 : Conflict over scarce resources).

According to Rob (2004), as described in Figure 2-3, disasters impacts cause sudden, dramatic alterations in social structures with victims "debonding" from the social structure of their community (stable communities) under the threat. This is followed by a community-wide process of "fusion state" bringing about a social system adapted to meeting its immediate needs but not to long-term recovery (reconstruction). Over time, tensions between the systems develop leading to the appearance of "cleavage planes" between conflicting groups. An alternative form of constructive social differentiation follows with coordinated recovery interventions.

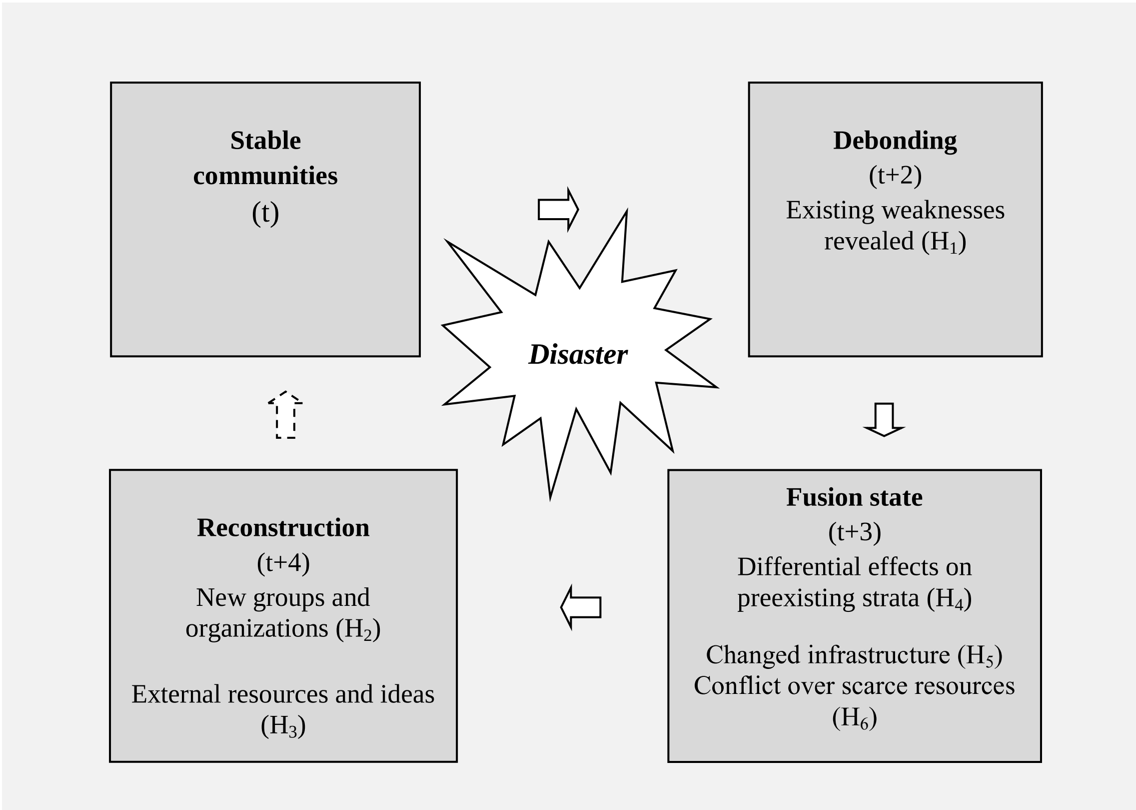

Figure 2-3. Disaster and Social Process
Source : Rob (2004), Bates and Peacock (1993)
Note: Arrow means time flow, parentheses indicate related scholars, dashed arrow indicates feedback loop, t is time, t+α, α is time flow

Based on this sociological sense, Rodriguez and Russell (2006, p. 194) concluded that “disasters are not caused by the ‘natural’ environment but are the result of the social, political, and economic environment[s] and reflect a community’s inability to prepare for and manage the outcomes of such events.” Some communities are better able to prepare for, respond to, and recover from hazard events while others have a limited capacity to resist and recover from the catastrophic effects of a hazard event (Vollmer, 2013b). Without pro-active planning, the conventional wisdom is that natural disasters lead to extensive human suffering and significant losses to economic well-being of the affected population. This perspective can lead to a way to "the purposeful development of institutions, policy and practice aimed at reducing vulnerability and enhancing resilience" (Handmer and Dovers, 2013, p. 20).

From the sociological viewpoints on natural disasters, I adopted social justice and disaster justice (Verchick, 2012), social roots of risk (Tierney, 2014), double exposure (O'Brian and Leichenko, 2000) from environmental change, and social contours of risk (Kasperson and Kasperson, 2005) within the relationships between natural disasters and social and economic characteristics with a focus on the community level. Especially, I also adopted "spatial and resilience planning" (Eraydin and Tasan-Kok, 2013) and "spatial planning, climate change, and sustainable development" (Wilson and Piper, 2010). Unlike the existing planning paradigm such as collaborative and communicative planning, these perspectives address flexible solutions to social change with spatial heterogeneity, temporal change, and long-term perspectives. Based on natural disasters within a social framework, I considered natural disasters as failures of social systems to support communities in adapting to environmental change.

2.1.3 Disaster resilience, community capacity, and sustainable development

Over the past several decades, sustainable development has emerged as a paradigm along with the potential to give people the perspective and the power needed to live more securely and sensibly (Pine, 2009). In its classic sense, sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, WCED, 1987). Further, the basic concepts of sustainable development include excellence in development, smart growth, sustainable ecosystems, and livability. Likewise, sustainable development indicates the principle of living within our means, treating land and other natural resources as finite, and reducing the human footprint on the earth (Schwab et al., 2007).

In addition to its most widely used definition described above, since the 1990s the concept of sustainability has been adopted by many disaster researchers and applied to stages of disaster response such as mitigation, preparedness, response, and recovery (Smith and Wenger, 2006). In this regard, sustainability or sustainable development also means that a community or other spatial levels can tolerate or overcome damage, diminished productivity, and reduced quality of life from a natural hazard event without significant outside assistance (Mileti, 1999).

A community has a better chance to retain its unique character over time, and to be a livable place for current and future residents when it is resilient in the face of multiple hazards. Accordingly, an essential characteristic of sustainable development is its resilience to disasters. The sustainable development approach to natural hazards implies efforts to create and maintain communities that can avoid or mitigate natural disasters. In addition, this approach suggests that the most effective way to reduce vulnerability of people and property is to preserve a healthy and well-functioning ecosystem (Beatley, 1998; Pine, 2009).

More specifically, in terms of resilience to disasters, Carpenter et al. (2001), Rose (2004), and Tierney and Bruneau (2007) proposed that inherent and adaptive responses to disasters contribute to the ability of individuals and communities to avoid potential losses. In recent studies, resilience has been defined as involving the extent to which a system can build and increase the capacity for learning and adaptation (Carpenter et al., 2001; Klein et al., 2003; Peacock et al., 2008). The existing social and economic situation has been shown to be quite resilient as long as exogenous baseline assumptions are managed or maintained to cope with natural disaster damage (Berke and Campanella, 2006; Pine, 2009; Vale and Campanella, 2005).

Since wealthier residents seem to have a better capacity to adapt to or cope with hurricane losses, the value of real and personal property is higher in areas with higher incomes (McBean and Ajibade, 2009; Stevens et al., 2010).

Likewise, sustainable development encompasses the capacity to manage the natural environment and to make wise decisions about its current and future use. Along with this capacity and use, sustainable development also involves providing for the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). Therefore, sustainable development is focused not only on environmental management, but also on social and economic or political management ranging from the individual to an international level (Bosher et al., 2007; Walker et al., 2004).

By increasing resilience to natural disasters, a variety of approaches or policies should be taken into account as a means of ensuring sufficient flexibility to allow for an uncertain future (Schipper and Pelling, 2006). As depicted in Table 2-1, most recent literature on community capacity (e.g., Brown and Westaway, 2011; Ross, 2014; Sherrieb et al., 2010; Stofferahn, 2012) addressed that increasing the capacity of communities (including various factors such as social capital, economic development, human capital, financial capital, natural capital) to adapt to damage from natural disasters contributes to the accomplishment of wider societal goals of community resiliency and sustainable development.

As suggested above, it is noteworthy that disaster resilient communities will be more sustainable than those that do not develop a comprehensive strategy that incorporates hazard mitigation into their current and ongoing construction, design, and planning activities. Communities need to take actions that reach a state of resilience in line with “disaster prevention, risk minimization, loss reduction, hazard avoidance, hazard resistance, strategic retreat, as well as mitigation and preparedness” (Schwab et al., 2007, p. 485). These efforts formulate a similar goal in making communities more resilient against the impacts of natural hazards by preparing for and mitigating their impacts, reducing the losses, and minimizing the risk for possible losses. In this respect, since disaster mitigation is one of the more action- oriented ways to build resilience, it is essential to focus on mitigation as a vital step for sustainable development.

With an emphasis on pro-action rather than re-action, natural hazard mitigation is related to advance action taken to reduce or eliminate long-term risks to people and property from hazards and their effects (Godschalk et al., 1999) undertaken by various government entities, whether municipal, county, state or federal (Peacock et al., 2008). Carried out as part of a coordinated strategy, physical and structural mitigation action such as building levees and dams or nonstructural mitigation related to land use and building code policies (Mileti and Gailus, 2005; Schwab et al., 2007), mitigation is most effective when based on a comprehensive, community-wide, and long-term approach (Burby, 1998). For example, carrying out a slate of coordinated mitigation activities over time is the way to ensure that communities will be physically, socially, and economically resilient to the impacts of future hazards.

As such, mitigation can be helpful in building community resilience which in turn contributes to community sustainability. Based on the issues of economic vitality, environmental integrity, and social equity, Schwab et al. (2007, pp. 487-511) emphasized that resilience and hazard mitigation can contribute to the three spheres of sustainable development. In this sense, disaster mitigation is necessary to foster community, social and environmental sustainability, and resiliency (Godschalk et al., 1999; Pine, 2009; Smith and Wenger, 2006).

Table 2-1. Community Capacity Studies and Factors

Investigators	Topic	Factors	Settings	Analysis approach
Brinkman et al. (2012)	Watershed management conservation	• Collective action (collaborative governance, social network) • Community empowerment (community competency, sense of responsibility) • Shared vision (perceptions of environmental threats, issues related to growth and development, environmental sense of place, quality of life)	Southwestern Illinois (Lower Kaskaskia River watershed)	Principal component analysis, Regression analysis
Davenport and Seekamp (2013)	Sustainable watershed management	• Member engagement (knowledge & beliefs, awareness & concern about consequence, personal sense of responsibility, perceived control, engagement in pro-environmental behaviors) • Relational networks (informal social networks, sense of community, common awareness, collective sense of responsibility) • Organizational development (leadership & member engagement, member diversity, formal networks, collective memory, collaborative decision making process, conflict management) • Programmatic coordination (transboundary coordination, collective action, integrated systems monitoring & program evaluation, adaptive learning & flexibility)		
Sherrieb et al. (2010)	Community resilience to disasters, post-trauma and mental health problems	• Economic development (level of economic resources, degree of equality in the distribution of resources, scale of diversity in economic resources) • Social capital (social support, social participation, community bonds)	Mississippi counties	Correlation
Stofferahn (2012)	Community capitals and disaster recovery	• Cultural capital, social capital, political capital, human capital, financial capital, built capital, natural capital	Northwood, ND	
Beckley et al. (2008)	Community capacity model	• Forms of capital (assets underlying community capacity; social capital, economic capital, natural capital, human capital), Capacity catalysts (opportunities and threats), Spheres of social relations (combining capital to produce outcomes), Capacity outcomes		
Chaskin (2001) and (2008)	Building community capacity in multisite comprehensive initiative	• Sense of community, Level of commitment among community members, Ability to solve problems, Access to resources, interaction of human capital, organizational resources	Milwaukee, Hartford	Case studies
Bowen et al. (2000)	Community capacity: Antecedents and consequence	• Social capital (formal & informal networks), community capacity (accumulated experiences of community members, more than the sum total of the contributions of individual community members, emergent properties that develop in the context of interaction between group members, collective capacity), community results		
Brown and Westaway (2011)	Agency, capacity, and resilience to environmental change (community resilience as networked set of capacities)	• Economic development (level and diversity of economic resources, fairness of risk and vulnerability to hazards, equity of resource distributions), information and communication (narratives, responsible media, trusted sources of information, skills and infrastructure), social capital (received social support, perceived social support, social embeddedness, organizational linkages and cooperation, attachments to place, sense of community, citizen participation, leadership, and rules, community competence (community action, political partnerships, collective efficacy, empowerment, flexibility and creativity, critical reflective and problem-solving skills)		

Disaster recovery, as actions that begin after the disaster, involves short-term activities to restore vital support systems and long-term activities to return life to normal (Mileti, 1999). An initial step in the process of recovery is a comprehensive damage assessment to set priorities. Further, recovery encompasses repairing and reconstructing houses, commercial establishments, public buildings, lifelines, and infrastructure, organizing and dealing with volunteers and donated goods, delivering disaster relief, restoring and coordinating vital community services, expediting permit procedures, and coordinating activities among governments (Mileti, 1999).

In this respect, disaster resilience can aid recovery -- the speed and extent to which a community bounces back from disaster is a measure of resilience (Burby, 1998; Paton and Johnston, 2006). To ensure that a community has a sustainable recovery from a future disaster it is necessary to prepare a comprehensive and holistic plan (Smith and Wenger, 2006).

But even if a community has not prepared such a plan, there are many things that can be implemented during the recovery process that will make a community more sustainable than it was before. Integrating sustainable development into disaster recovery requires some shifts in current thinking, land use, and policies. In terms of future directions for sustainable disaster recovery, disasters should be viewed as providing unique opportunities for change, not only to build local capabilities for recovery, but for long term sustainable development (Mileti, 1999; Smith and Wenger, 2006). As a consequence, it is necessary that a community be developed or redeveloped to minimize the social and economic disruptions as well as human, environmental, and property losses caused by natural hazards.

As illustrated in Figure 2-4, the concept of sustainable development in addition to living in harmony with the natural environment offers better social, environmental, and economic status for current and future generations (Beatley and Newman, 2013). The complementary aims of hazard mitigation and recovery and disaster resilience can be added to the conceptual framework of the four realms. These realms are linked to Godschalk et al. (1998, pp. 85-118)’ three legged tool (i.e., environmental, economic, and social value of resiliency) for hazard mitigation planning to support disaster resiliency and community sustainability. Many hazard researchers have stressed the need to add mitigation into pre-and post-disaster recovery decision making to facilitate disaster resilience (Smith and Wenger, 2006). Sustainable and resilient communities should be able to withstand extreme geophysical processes and recover rapidly from disasters whenever they occur (Berke and Smith, 2009). Therefore, sustainability (sustainable development) and resilience are contingent on careful planning and organization of society to ameliorate disaster impacts and to facilitate the recovery processes (Beatley and Newman, 2013; Desouza and Flanery, 2013).

Furthermore, the linkage between sustainable development, mitigation and recovery, and resilience can be observed in the concept of “sustainable hazards mitigation and recovery.” Similar to the concept of sustainable hazard mitigation suggested by Mileti and Gailus (2005), sustainable hazards mitigation and recovery links the wise management of natural resources with local economic and social resilience and views mitigation and recovery as an integral part of a much larger set of issues such as sustainable and resilient communities (development).

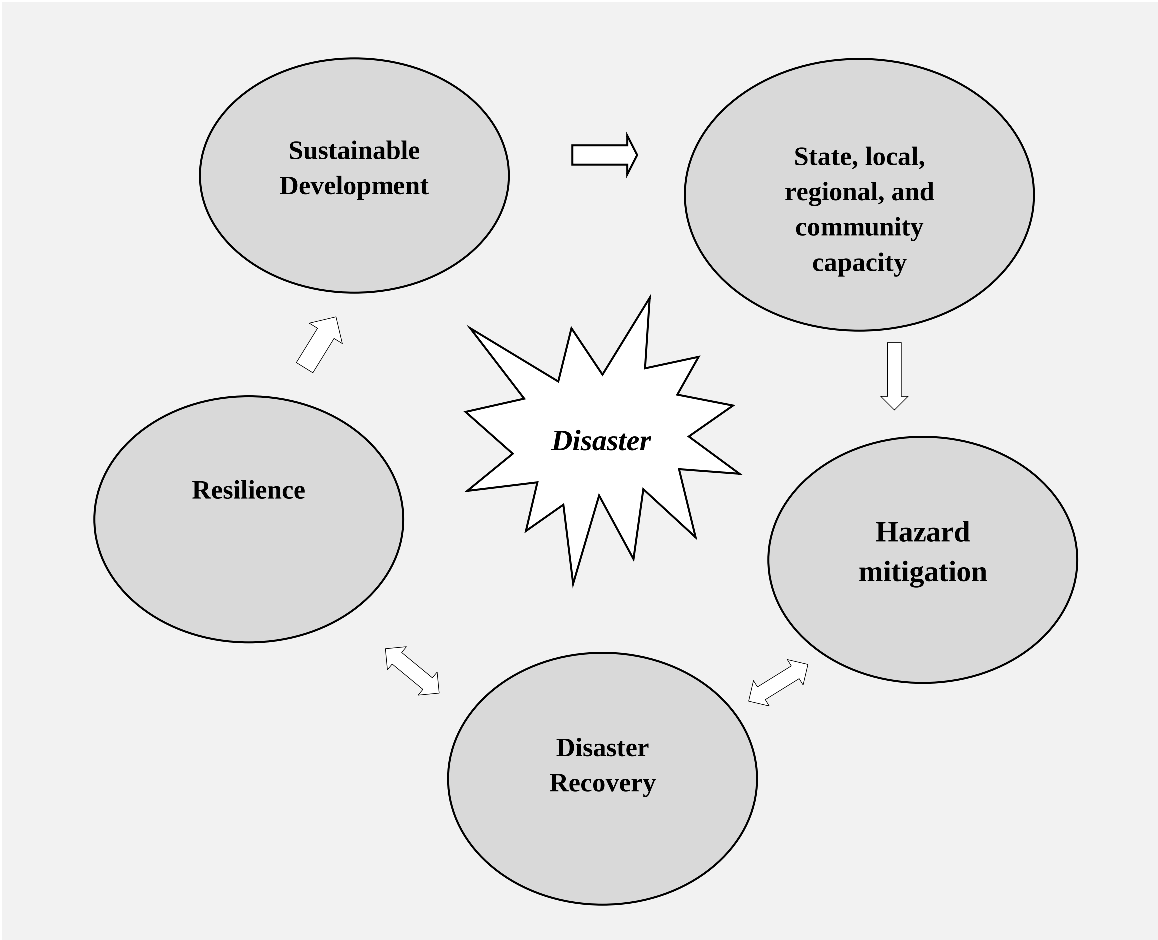

Figure 2-4. Cyclic Integration of Sustainable Development, Hazard Mitigation, Disaster Resilience, and Community Capacity
Source: adapted from Godschalk et al. (1999), Berke and Smith (2009)

2.2 Community-based Risk Management and Measuring Vulnerability and Resiliency

2.2.1 Community vulnerability and resiliency conceptual models and indicators

Natural disasters can be a catalyst for much larger social disasters that separate and displace communities (e.g., New Orleans in the wake of Hurricane Katrina, the 2004 Indian Ocean tsunami, the 2008 Sichuan earthquake in China, the 2011 Japanese earthquake, tsunami and nuclear event triple disaster) (Esnard and Sapat, 2014; Swan and Bates, 2007). In particular, Oliver-Smith (1998, p.186) regarded disaster as “an event that combines destructive agents with a vulnerable population disrupting social needs for physical survival, social order and meaning” (as cited in Sairien, 2009, p. 141). Such disaster processes are socially construed as being outside of ordinary experiences, overwhelming usual individual and collective coping mechanisms, disrupting social relations, and at least temporarily disempowering individuals and communities (Esnard and Sapat, 2014; Holcombe, 2010; Miller, 2012). In an effort to address the challenges and opportunities faced by communities responding to disaster effects, my work attempts to address the relationships between vulnerability, resiliency to disasters, and community responses.

Whereas risk refers to the likelihood of an occurrence of specific extreme events, hazard is the likelihood of people being affected (Cardona, 2004; Wisner et al., 2004). In this vein, the concept of vulnerability to natural disasters and climate change relates to the ability to deal with the impact of natural hazards, to withstand the potential negative consequences on an affected region or county, and to cope with the resulting damage in a timely manner. Vulnerability can be conceived of as the outcome of the interaction between exogenous factors determined by the incidence and intensity of disasters as well as the ability of a country or region to deal with the impact of endogenous elements or factors (Sadowski and Sutter, 2005).

Vulnerable communities are assumed to be those that find it hardest to reconstruct their livelihoods following disaster and climate risk effects. This process makes the endangered communities more vulnerable to the effects of subsequent extreme climate events. Presumably, the communities have insufficient resources to cope with any disruptions to livelihoods or ill-health that may result from such exposure. In addition, risks in communities accumulate in the degraded infrastructure, dysfunctional institutions, eroded natural capital, and constrained livelihoods of those at risk (Pelling, 2012). For this reason, my work concludes that such conditions that lead to a slow recovery (e.g., lack of preparedness and planning, poor economy, isolation, etc.) can contribute to a community's vulnerability to disasters and climate change.

In line with Paton and Johnston's claim (2006) that "knowledge of hazards; shared community values; established social infrastructure; positive social and economic trends; partnerships; and resources and skills have an impact on community resilience" (as cited in Atkinson, 2014, p. 16), resiliency is dependent on individuals and resources as well as competencies to manage the demands, challenges, and changes encountered. Existing community social and economic conditions have either a positive or negative effect on disaster or climate change induced damage. For example, economic conditions, not surprisingly, have been negatively correlated with the degree of natural disaster damages.

In general, community represents socio-economic dynamics, collective behavior or action, and shared experiences. Similar to the community capitals and community assets approach, if a community has higher levels of social capacity and decision-making ability, the community can more effectively respond to change, take advantage of opportunities, and meet the needs of residents (Magis, 2010). Wealthier residents seem to take more precautions (e.g., having well-constructed homes, and Leadership in Energy & Environmental Design, LEED-registered buildings) to mitigate disaster losses and adapt to climate changes.

As outlined in Table 2-2, the literature on social and economic resilience indicators (as a community capacity or capital) has been addressed through assessment of demographics, social networks (i.e., social capital), community value-cohesion, faith-based organizations, employment characteristics, values of property, wealth generation, health and wellness, quality of life, and municipal finance or revenues (e.g., Bruneau et al., 2003; Building Resilience Regions, 2011; Cutter et al., 2010; Emmer et al., 2008; Fisher et al., 2010; Kapucu and Özerdem, 2013;

Longstaff et al., 2010; Magis, 2010; Norris et al., 2008; Nowell and Steelman, 2013; Peacock, 2010; Razafindrabe et al., 2015; Ross, 2014; Turnbull et al., 2013; Waugh and Liu, 2014; Wilson, 2012).

Emphasizing the value in dealing with equity in natural disasters, Patterson (2013, p. 101) proposed that a thorough analysis of the myriad pre-disaster vulnerabilities at the local level is necessary to "design policies, programs, processes, and infrastructure that encompass the needs of all." Measures to assess circumstances in disasters that deepen vulnerabilities or create new risks and hazards for some more than others need to be included. Most community policies before and after disasters have created inequitable school reforms as well as marginalizing and redistricting processes, and redevelopment (Patterson, 2013). In order to create mechanisms to ensure equitable recovery in all sectors, disparate property and small-business losses should be examined.

Regarding social justice in vulnerability considerations, most deliberations about local social and economic equity (e.g., equal access to quality education, affordable housing, health care, job opportunities) are incomplete and propose key elements of natural disaster losses (further climate change problems) that need to be addressed in developing social justice principles (Bates and Swan, 2007; Brown-Jeffy and Kroll-Smith, 2009; Kasperson et al., 2005; Schwab et al., 2007). For instance, racial segregation in New Orleans caused predominantly African-American communities to be physically vulnerable to natural disasters, and even worse, led to local government neglect (Angel et al., 2012; Miller and Rivera, 2007). During the Mississippi River flood of 1927, which covered a 27,000-square-mile area from Illinois to the Gulf of Mexico, dislocating almost a million people (Smith, 2011), survival problems were exacerbated in predominantly African-American communities by flawed drainage systems and a lack of political interest (by predominantly Anglo-Americans) in aiding these communities (Rivera and Miller, 2006).

As part of the social and economic conditions at the local level, planning and public policy components are associated with disaster preparedness and mitigation in the disaster management cycle (Mileti, 1999; Schwab et al., 2007). Several studies (e.g., Burby et al., 1998; Kapucu et al., 2013; Nelson and French, 2002; Olshansky, 2001) argued that careful attention to natural hazard in the preparation of local comprehensive plans (including a hazard mitigation plan) can result in a reduction in disaster related losses. Identifying a plan's dimensions, such as policy recommendations and citizen involvement, Burby (2005, p. 68) suggested that there are eight reasons for demonstrating that "local government comprehensive plans and the process of preparing them can result in lower exposure to losses from natural disasters."

More specifically, community disaster planning and public policy before a disaster involves planning (e.g., local emergency management plans, and local land use planning), development regulations (e.g., zoning ordinances), building standards (e.g., building codes), property acquisition (e.g., building relocations), critical and public facilities, and taxation information dissemination (Beatley, 2009; Olshansky, 2001; Olshansky and Kartez, 1998) in accordance with disaster types. As for the non-structural flood mitigation approaches, local land use planning techniques allow communities to be more resilient to flooding, as suggested by previous studies (e.g., Godschalk et al., 1998; Gruntfest, 2000).

Table 2-2. Selected Studies on Disaster Resilience Indicators in the Context of Spatial and Temporal Scale

References	Spatial and temporal context	Resilience indicators		Characteristics
Waugh and Liu (2014), **Integrated Model of Community Resilience**	• Spatial : Local, regional, state level available • Temporal: not designated	• Social vulnerability index	Demographic characteristics (e.g., age, race/ethnicity, immigrant status, language proficiency), social and economic status (e.g., employment status, income, automobile availability, household wealth), housing structure characteristics (e.g., housing tenure, dwelling type, lot size)	'Whole Community' approach
		• Economic structure	Features of local economy (e.g., industrial composition)	
		• Business diversity	Size and characteristics of small businesses (e.g., minority-owned business)	
		• Nonprofit density	Density of non-government organization	
		• Government capacity	Emergency management program (e.g., Emergency Management Accreditation Program)	
BRR (2011), **Resilience Capacity Index (RCI)**	• Spatial : Local, regional, state level available • Temporal: not designated	• Regional economic capacity	Income equality, Economic diversification, Regional affordability, Business environment	
		• Socio-demographic capacity	Educational attainment, Without disability, Out of poverty, Health-insured	
		• Community connectivity capacity	Civic infrastructure, metropolitan stability, homeownership, voter participation	
Cutter et al. (2010), **Disaster resilience indicators for benchmarking baseline conditions**	• Spatial : Local, regional, state level available • Temporal: not designated	• Social resilience	Educational equity, Age, Transportation access, Communication capacity, Language competency, Special needs, Health coverage	
		• Economic resilience	Housing capital, Employment, Income and equality, Single sector employment dependence, Employment, Business size, Health access	
		• Institutional resilience	Mitigation (hazard mitigation plan), Flood coverage, Municipal services, Mitigation (CRS), Political fragmentation, Previous disaster experience, Mitigation and social connectivity, Mitigation (Storm Ready communities)	
		• Infrastructure resilience	Housing type, Shelter capacity, Medical capacity, Access/evacuation potential, Housing age, sheltering needs, Recovery (public schools)	
		• Community capital	Place attachment (net international migration, population born in a state), Political engagement, Social capital-religion, civic involvement, advocacy, Innovation	
Fisher et al. (2010), ***Resilience index for* the enhanced critical infrastructure program**	• Spatial : Local, regional, state level available • Temporal: not designated	• Robustness	Redundancy, prevention, maintaining key function	
		• Resourcefulness	Training/exercise, Awareness, Protective measures, Stockpiles, Response, New resources, Alternatives sites	
		• Recovery	Restoration, Coordination	
Boyd (2012), **Social-ecological and institutional resilience**	• Spatial : Local, regional, state level available • Temporal: not designated	• Ecological resilience features	Self-organising, Buffering, Feedback	Adding a resilience perspective to evaluating adapting institutions
		• Social-ecological resilience features	Self-organising: scaling up relations through small pockets of social-ecological nodes, linking ecological knowledge and sociology; Leadership capacity, managing integrated wetlands, conservation and development ; Monitoring, taking stock, inventories, learning	
		• Institutional resilience features	Networks: informal spaces where decisions are made based on tacit knowledge, experience and chance; Leadership capacity within an institution, navigating, planning and backup, vision and strategy for unknowns, setting objectives; Mechanisms for feedback of information and experiences, evaluation of objectives and capturing learning	

Table 2-2. Continued

References	Spatial and temporal context	Resilience indicators		Characteristics
Peacock ed. (2010), **Community Disaster Resilience Index (CDRI)**	• Spatial : community available • Temporal: not designated	• Social capital	Registered nonprofit organizations, Recreational centers and sport organizations, Registered voters, Civic and political organizations, Census response rate, Religious organizations, Owner-occupied housing units, Professional organizations, Business organizations	'Four phases of the disaster management cycle'+ Community capital assets (excluding natural capital)
		• Economic capital	Per capita income, Median household income, Population in labor force, Median value of owner-occupied housing units, Business establishments, Population with health insurance	
		• Physical capital	Building construction establishments, Heavy and civil engineering construction establishments, Highway, street, and bridge construction establishments, Architecture and engineering establishments, Land subdivision establishments etc.	
		• Human capital	Population with more than high school education, Physicians, Population employed in health care support, Population employed in building construction establishments, Population covered by comprehensive plan, Population covered by building codes, Community rating system score, Population covered by FEMA approved mitigation plan etc.	
Norris et al. (2008), **Community Resilience Model**	• Spatial : community available • Temporal: not designated	• Information and communication	Narratives, Responsible media, Skills and infrastructure, Trusted sources of information	'A set of networked adaptive capacities'
		• Economic development	Fairness of risk & vulnerability to hazards, Level and diversity of economic resources, Equity of resource distribution	
		• Social capital	Received (enacted) social support, Perceived (expected) social support, Social embeddedness (informal ties), Organizational linkages & cooperation, Citizen participation, Leadership & roles (formal ties), Sense of community, Attachment to place	
		• Community competence	Community action, Critical reflection & problem solving skills, Flexibility and creativity, Collective efficacy empowerment, Political partnerships	
Wilson (2012), **Resilience issues and indicators**	• Spatial : community available • Temporal: not designated	• Economic capital	Gross Domestic Product, Employment levels, Poverty, Dependency on external streams, Economic sectors, Economic development over time, Sources of income, Development of new income streams, Connectivity, Housing, Community goals and economic decision-making, Value added for local products	
		• Social capital	Community identity, Community cohesiveness and trust, Relationships, Contentment with life, Conflicts, Communication between stakeholder groups, Power, Political structure, Engagement of young people, Responses to and opportunities for influencing change, Learning and Knowledge, Knowledge utility and transfer, Learning from experience, Participation in decision-making, engagement of community resources, Stakeholder agency	
		• Environmental capital	Access to environmental resources, Resource limitations, Land and resource use, Sustainability of resource use (water, soil), Responses to environmental degradation etc	
Wilkinson (2011), **Strategies for resilience**	• Spatial : community available • Temporal: not designated	• Assume change and uncertainty	Buffering, redundancy and modularization, evoking disturbance, strategic foresight, learning from crisis, adaptive planning	
		• Nurture conditions for recovery and renewal after disturbance	Social capital	
		• Combine different types of knowledge for learning	Social-ecological memory, ecological diversity, combine experimental and experiential knowledge tight feedbacks	
		• Create opportunities for self-organization	Multi-scale networks and connectivity, interplay between diversity and disturbance	

Table 2-2. Continued

References	Spatial and temporal context	Resilience indicators		Characteristics
Emmer et al. (2008), **Coastal Resilience Index**	• Spatial : community available • Temporal: not designated	• Critical infrastructure and facilities	Wastewater treatment system, Transportation/evacuation routes, City hall or other local government building, Emergency operation center	'The Low, Medium, High resilience ratings
		• Transportation issues	Will flood-prone areas be operational within one week?	
		• Community plans and agreements	Have a certified floodplain manager?	
		• Mitigation measures	Relocation of buildings and infrastructure	
		• Business plans	Generators	
		• Social systems	Strong faith-based networks	
Magis (2010), **Community Resilience: An Indicator of Social Sustainability**	• Spatial : community available • Temporal: designated	• Community resources	Natural, human, cultural, social, financial/built, and political capital	
		• Development of community resources	New kinds of business and employment opportunities, Preparedness of youth with important work habits	
		• Engagement of community resources	The effectiveness of community government in dealing with important problems facing the community	
		• Active agents	Community members' belief in their ability to affect the community's well-being	
		• Collective action	The extent to which community leaders facilitate collaboration between groups to work on community objectives	
		• Strategic action	The extent to which information on community resources is used in planning community endeavors	
		• Equity	Access of various groups to the community's natural resources	
		• Impact	The changes in number and variety of external controls over time	
Colussi (2000), **Community Resilience Manual**	• Spatial : community available • Temporal: not designated	• People in the community	Leadership, Community members are involved in significant community decision, the community feels a sense of place, there is a strong belief in education	
		• Organization in the community	A variety of organizations well served: access to equity, access to credit, human resource development, Planning, research, advocacy, infrastructure	
		• Resources in the community	Employment, openness to economic activity	
		• Community process	Community economic development plan	
Longstaff et al. (2010), **Resilience Analysis Breakdown Model**	• Spatial : community available • Temporal: not designated	• Resource robustness	Resource performance, Resource redundancy, Resource diversity	'Community subsystems: ecological, economic, civil society, governance, and physical infrastructure
		• Adaptive capacity	Institutional memory, Innovative learning, Connectedness	
Becker (2014), **Fourteen central aspects of capacity development for resilience**	• Spatial : community available • Temporal: not designated	Quality of link between partners : Relationship and Friendship; Ability to overcome differences to find common goals: Bipartisanship; Requisite skill sets: Scholarship, Craftsmanship, Grantsmanship, and Penmanship; Roles and responsibilities: Authorship, mentorship, stewardship, leadership, and championship; Overarching aspects of roles, responsibilities, and relationships: Ownership and Partnership		

Table 2-2. Continued

References	Spatial and temporal context	Resilience indicators		Characteristics
Kapucu and Özerdem (2013), **Culture of Preparedness and Resilient Communities**	• Spatial : community available • Temporal: not designated	• Social capital	Networks within the community	
		• Community competence	Flexibility and problem-solving skills	
		• Information and communication	Communication skills, infrastructure, trusted source of information	
		• A strong economy	Diverse and evenly distributed economic resources and risk	
Turnbull et al. (2013), **Toward Resilience**	• Spatial : individual, household, population group, and community available • Temporal: not designated	• Institutional	Resources, Planning, Responsiveness, Accountability, Rule of law	Based on "Equity and Risk knowledge," resilience is not a fixed end state, but is a dynamic set of conditions and processes.
		• Political	Leadership, Participation, Representation	
		• Cultural	Knowledge transfer, Belief systems, Customs	
		• Social	Communications, Support networks, Organization, Inclusion, Conflict, Resolution	
		• Environmental	Land use, Access to natural resources, Sustainability	
		• Human	Food security, Health, Education	
		• Economic	Income security, Access to markets and employment, Livelihood diversity and flexibility, financial services, Land tenure	
		• Physical	Structures, Water supply, Sanitation	
Bruneau et al. (2003), **Multidisciplinary Center for Earthquake Engineering Research framework**	• Spatial and Temporal: not designated	• Robustness	The inherent strength or resistance in a system to withstand external demands without degradation or loss of functionality	Focused on resilience across all infrastructure sectors
		• Redundancy	System properties that allow for alternative options, choices, and substitutions under stress	
		• Resourcefulness	The capacity to mobilize needed resources and services during emergencies and disasters	
		• Rapidity	The speed with which disruption can be overcome and safety, services, and financial stability restored	
Ross (2014), **Adaptive Capacity for Disaster Resilience Indicators**	• Spatial : community available • Temporal: not designated	• Social resilience	Education, Transportation access, Communication capacity, Language competency, Non-vulnerable population, Health care coverage	
		• Community capital	Place attachment, Political engagement, Social capital	
		• Economic resilience	Housing capital, Employment, Income equality, Economic diversity, Business robustness, Health care access	
		• Institutional resilience	Mitigation plans, Mitigation organizations and activities, Emergency services, Administrative decentralization, Disaster experience	
		• Infrastructure resilience	Housing vulnerability, Evacuation capacity, Medical capacity, Shelter capacity, service restoration	
		• Ecological resilience	Wetland preservation, Impervious surfaces, Floodplain development	
Frazier et al. (2013), **Common resilience indicator themes**	• Spatial : community available • Temporal: not designated	• Place-specific	Tourism-dependent economy, North-south arterial road access, Age of residents, biophysical factors	Identified in the plan review, focus group sessions and spatial analysis
		• Differentially weighted	Elevation, Plans/regulations, funding	
		• Temporal component	Regulation less important in emergency phase	
		• Spatial component	Spatial clustering of elderly people	

Table 2-2. Continued

References	Spatial and temporal context	Resilience indicators		Characteristics
Razafindrabe et al.(2015), **Components and indicators**	• Spatial and Temporal: not designated	• Built environment	Electricity, water, road network, housing and land use, sanitation and solid waste disposal	
		• Social environment	Population, health, education and awareness, social capital, community disaster preparedness	
		• Economic environment	Income, employment, household asset, finance and savings, budget and subsidy	
		• Institutional environment	Disaster management, Institutional collaboration, Knowledge dissemination and management	
Maclean et al. (2014), **Six attributes of social resilience**	• Spatial and Temporal: not designated	• Knowledge, skills and learning	Knowledge partnerships, technology and innovation, skills development, consolidation	
		• Community network	Community capacity, identifying opportunities, providing a focus for renewed optimism and hope	
		• People-place connections	Social-ecological systems, integrated and holistic management approaches, stewardship	
		• Diverse and innovative economy	Importance of a regional economy	
		• Engaged governance	Effective and equitable decision making, inspired leadership, shared vision, appropriate communication, systems thinking, institutional capacity building and institutional learning	
		• Community infrastructure	Medical, dental and human services, community center and youth recreation facilities, appropriate transport options, local arts, music and food markets	
Ross and Berkes (2014), **Possible ways to conduct community resilience monitoring**	• Spatial and Temporal: not designated	Persistence, Problem solving, Leadership, Social network, Engaged governance, Sets of attributes of social resilience		Aspects of resilience to monitor
Joerin et al. (2014), **Climate disaster resilience index**	• Spatial : community available in a city • Temporal: not designated	Physical	Electricity, water, sanitation and solid waste disposal, accessibility of roads, housing and land use	
		Social	Population, health, education and awareness, social capital, community preparedness during a disaster	
		Economic	Income, employment, household assets, finance and savings, budget and subsidy	
		Institutional	Mainstreaming of disaster risk reduction and climate-change adaptation, effectiveness of zone's crisis management framework, knowledge dissemination and management, institutional collaboration with other organizations and stakeholders during a disaster, good governance	
		Natural	Intensity/severity of natural hazards, frequency of natural hazards, ecosystem services, land use, environmental policies	
Kulig et al. (2013), **Index of Perceived Community Resilience**	• Spatial : community available • Temporal: not designated	The physical environment in my community negatively affects my health	Leaders in my community listen to the residents	Attempt to compare 'community and regional resilience initiative model' and 'Disaster resilience of place'
		People in my community help one another out	My community has strong community leadership	
		Residents in my community feel isolated from other parts of the province	The changes in my community are positive	
		People who live in my community have similar values or ideas	When a problem occurs, community members are able to deal with it	
		There is a sense of pride among people in my community	Residents of my community participate in community events	
Davies et al. (2015), **Development process resilience**	• Spatial : community available • Temporal: not designated	Income and income diversity, Asset and asset diversity, Rangeland ecosystem health, security, equity, local governance, resource rights (including land, water, forests), market access and transaction costs, urban growth and integration		Insights from the Drylands of Eastern Africa

Table 2-2. Continued

References	Spatial and temporal context		Resilience indicators	Characteristics
Miles (2015), **WISC framework and conceptual model on static community resilience**	• Spatial : community available • Temporal: not designated	• Community	Well-being: affiliation, satisfaction, autonomy, material needs, health, security Identity: equity, esteem, empowerment, diversity, continuity, efficacy, distinctiveness, adaptability	Human settlement
		• Infrastructure	Service: rivalrousness, centrality, excludability, redundancy, robustness, gravity, marketability, substitutability, connectedness Capitals: cultural, social, political, human, built, economic, natural	
Sherrieb et al. (2010), **Economic development and social capital**	• Spatial : community available • Temporal: not designated	• Economic development	Resource level: employment, income, tax revenues, creative class occupations Resource equity: income equity, less than high school education Resource diversity: net business gain/loss rate, occupational diversity, urban influence	
		• Social capital	Social support: ratio of two parent households with children Social participation: N of arts/sports organizations, N of civic organizations, voter turnout, religious adherents Community bonds: net migration rate, property crime rate	
Cutter et al. (2014), **Geographies of community disaster resilience**	• Spatial : community available • Temporal: not designated	• Social	Educational attainment equality, Pre-retirement age, transportation, communication capacity, English language competency, Non-special needs, Health insurance, Mental health support, food provisioning capacity, physician access	
		• Economic	Homeownership, employment rate, race/ethnicity income equality, non-dependence on primary/tourism sectors, gender income equality, business size, large retail-regional/national geographic distribution, federal employment	
		• Community capital	Place attachment-not recent immigrants, place attachment-native born residents, political engagement, social capital-religious organization, civic organizations, and disaster volunteerism, citizen disaster preparedness and response skills	
		• Institutional	Mitigation spending, flood insurance coverage, jurisdictional coordination, disaster aid experience, local disaster training, performance regimes-state capital, nearest metro area, and population stability, nuclear plant accident planning, crop insurance coverage	
		• Housing /infrastructural	Studier housing types, temporary housing availability, medical care capacity, evacuation routes, housing stock construction quality, temporary shelter availability, school restoration potential, industrial re-supply potential, high speed internet infrastructure	
		• Environmental	Local food suppliers, natural flood buffers, efficient energy use, pervious surfaces, efficient water use	
Skerratt (2013), **Rural community resilience**	• Spatial : community available • Temporal: not designated	• Proactive human agency	The source of the outcome, rather than solely the outcome Contingent on deployment and management of individual, community and/or externally-networked stocks of resources and vulnerabilities Cumulatively built through repeated mechanisms and pathways over time or life-course Multi-scale: individual, community, and region Where change is constant not only episodic Not neutral but with often-implicit normative associations	Rural community resilience

Table 2-2. Continued

References	Spatial and temporal context	Resilience indicators		Characteristics
Wilson (2010), **Multifunctionality of rural communities**	• Spatial : community available • Temporal: not designated	• Economic capital	Economic well-being, diversified income streams, low dependency on external funds (e.g. agricultural subsidies), Multifunctional businesses	Strongly developed capital and weakly developed capital
		• Social capital	Close interaction between rural people, availability of skills training and education, good health and sanitation, Multifunctional services, good communication between stakeholder groups, female empowerment, open-minded communities, good and transparent land ownership regulation, rural stakeholders in control of development trajectories, strong governance structures at multiple geographical scales	
		• Environmental capital	High levels of biodiversity, good water quality and availability, sustainable soil management, predictable agricultural yields, sustainable management of environmental resources in rural community, multifunctional environmental resources	
Provitolo (2013), **Resiliencery vulnerability**	• Spatial : community available • Temporal: not designated	• Reactions and changes	Adaptation, innovation, self-organization, diversity, learning	A systemic risk model
		• Capacities	Proactive-, reactive-, and post-active adaptability, Proactive-, reactive-, and post-active response	
		• Potentialities	Resources, resistance, and sensitivity	

In addition, infrastructure elements of comprehensive plans are important in providing resilient and adequate infrastructure linked with a hazard mitigation strategy for protection in storm events and ensure quick recovery and use during emergency situations (Beatley, 2009). For instance, Galveston County in Texas adopted local emergency management plans and a land use plan within a hazard mitigation plan before being affected by Hurricane Ike (2008). The plan has fostered greater resilience to natural hazards. In addition, the structural measures (e.g., dikes, dams, levees, river banks, building elevation) in the comprehensive plan provided resilient and adequate infrastructure linked with a hazard mitigation strategy to protect the infrastructure in storm events and ensured quick recovery and use during emergency situations (Beatley, 2009; Burby, 1998; Jonkman et al., 2012; Kusky, 2013; Sayers et al., 2014).

2.2.2 Recap of vulnerability and resiliency model

Conceptual models of disaster vulnerability and resiliency are important frameworks upon which organization and discussion of theoretical relationships can be made. Indeed, these frameworks provide a critical basis upon which to build empirical models describing the effects of disaster events on communities (vulnerability and risk), to minimize loss resulting from such events (resiliency), and integrative disaster planning over time. One recent approach, known as the Resiliency and Vulnerability Observatory Network (or RAVON) developed by Peacock et al. (2008, p. 4), outlines the imperative "to reduce the vulnerability associated with natural hazards and enhance the resiliency of individuals and communities" through coordination among planning institutions.

As depicted in Table 2-3, others, including the Disaster Resilience of Place (DROP) model (Cutter et al., 2008a), the Pressure and Release (PAR) model (Blaikie et al., 1994; Wisner et al., 2004), the Bogardi, Birkmann, and Cardona (BBC) conceptual framework (Bogardi and Birkmann, 2004; Cardona, 2004), the MOVE framework (Birkmann et al., 2013), the Resilient city planning framework (Jabareen, 2013), and social vulnerability framework (e.g., Balica and Wright, 2010; Flanagan et al., 2011; Sairinen, 2009; Turner et al., 2003; Yoon, 2012), mainly attempt to identify vulnerability or resiliency indicators derived from social and ecological elements in various disciplines; however, these approaches often yield snapshots in time without capturing the dynamics of the system (Engle, 2011).

Building upon this previous literature, an integrative disaster planning model was formulated and is illustrated in Figure 2-5. Note from this figure that spatial and temporal elements were used to reflect important conceptual insertions where both vulnerability and resiliency can affect event outcomes. These notations t_a, t_a-n, and t_a+m reflect temporal elements, where t denotes the point in time when a disaster event occurs and subscript a represents a location or community affected by the event; and n and m indicate time (with t_a-n reflecting a pre-disaster time period and t_a+m reflecting time post-disaster). Note further that this model identifies i as the interval between disaster events, and is equal to n+m . The interval between disaster events can serve as a key element involved in disaster planning effectiveness, as longer intervals can lead to complacency, while shorter intervals can lead to increased urgency in resiliency planning spirally into despair.

Table 2-3. Vulnerability, Resiliency, and Risk Models in the Context of Natural Disaster or Environmental Hazard

Literature and referenced framework	Vulnerability		Resiliency		Risk	
	Factors	Characteristics	Factors	Characteristics	Factors	Characteristics
Bohle (2001) : **Conceptual framework for vulnerability analysis**	• Exposure (the external side of vulnerability) • Coping (the internal side of vulnerability)	• Human ecology perspectives • Entitlement theory • Action theory approaches • Models of access to assets				
DFID (1999) : **The sustainable livelihood framework**	• Shock • Trends • Seasonality	• Livelihood assets (Human, natural, financial, physical, social capitals) • Influence and access to livelihood strategies				
UN/ISDR (2004) : **ISDR framework for disaster risk reduction** Fizri et al. (2014): **Strengthening the capacity of flood-affected rural communities**		• As a tool and a precondition for effective risk assessment			• Vulnerability • Hazards	Risk=Hazards× Vulnerability/ Capacity*
Turner et al. (2003) : **Vulnerable framework**	• Exposure • Sensitivity • Resilience	• Human and environmental influences outside the place • Global environmental change	• Adaptation			
Bogardi/Birkmann (2004) : **The Onion framework**		• Different hazard impacts related to the economic and social sphere • Potential losses and damages				
Blaikie et al. (1994) and Wisner et al. (2004) : **The Pressure and Release (PAR) model**	• Root causes • Dynamic pressure • Unsafe conditions	• Vulnerability and the development of a potential disaster • A process involving increasing pressure and opportunity			• Risk = Hazard × Vulnerability	
Cardona (2004) : **Holistic approach to disaster risk assessment and management**	• Exposure and physical susceptibility • Social and economic fragilities • Lack of resilience or ability to cope and recovering	• Control system (Risk management)			• Risk = (Hazard, Vulnerability)	• Hard risk: potential damage to physical infrastructure and environment • Soft risk: potential socio-economic impacts to communities and organizations

Table 2-3. Continued

Literature and referenced framework	Vulnerability		Resiliency		Risk	
	Factors	Characteristics	Factors	Characteristics	Factors	Characteristics
Bogardi /Birkmann (2004) and Cardona (2004) :**BBC conceptual framework**	• Exposed and vulnerable elements • Coping capacity	• Environmental, social, and economic sphere			• Environmental • Social • Economic	
Cutter (1996), Cutter et al. (2000) : **Hazard-of-place model**	• Exposure	• Integrating exposure and social vulnerability				
Cutter et al. (2008a) : **Disaster resilience of place (DROP) model**	• Antecedent conditions (inherent vulnerability, inherent readiness)		• Ecological (e.g., wetland loss) • Social (e.g., social network) • Economic (e.g., employment) • Institutional (e.g., hazard mitigation plans) • Infrastructure (e.g., commercial establishments) • Community competence (e.g., quality of life)	• Disaster management cycles (preparedness, mitigation, response, and recovery) • Feedback loop		
Lew (2014): **Scale, change and resilience (SCR) in tourism**			• Maintenance programs • Training and diversification • Natural and cultural conservation • Social support system: social welfare and infrastructure	• Tourism and resilience contexts (e.g., community tourism-slow change and sudden shock, entrepreneur tourism-slow change and sudden shock)		
Jabareen (2013): **Resilient city planning framework**	• Uncertainty, informality, demography, spatiality	• Vulnerability analysis matrix	• Uncertainty oriented planning (adaptation, planning, and sustainable form) • Urban governance (equity, integrative, economics) Prevention (mitigation, restructuring, alternative energy)	• Resilience city transition		

Table 2-3. Continued

Literature and referenced framework	Vulnerability		Resiliency		Risk	
	Factors	Characteristics	Factors	Characteristics	Factors	Characteristics
Marre (2013)	• Demographic (population growth, urbanization, settlements near coastal areas) • Economic development (poverty, modernization processes) • Environmental change (climate changes, degradation and depletion of resources) • Political factors • An increase in tangible assets • Effects of disaster protection structures and research • The interactions of the causes of disasters	• Vulnerability=Hazard (probability of the hazard or process; shock value; predictability; prevalence; intensity/strength)-Coping (perception of risk and potential of an activity; possibilities for trade; private trade, open trade)				
Bollin and Hidajat (2013): **Conceptual framework of a community-based indicator system**	• Physical/demographic (density, unsafe settlement) • Social (access to basic pressure, poverty level, literacy rate, attitude) • Economic (community participation, local resource base, small business) • Environmental (area under forest, degraded land)				• Risk=[Hazard (Probability, severity)+Exposure (structures, population, economy)+Vulnerability (physical, social, economic, environmental)]-Capacity* (physical planning and engineering, social capacity, economic capacity, management and institutional capacity)	
Sairinen (2009): **Social vulnerability as a complex set of characteristics**	• • Initial well-being • Livelihood and resilience • Self-protection • Social and political networks and institutions		• Natural capital • Financial capital • Human capital • Social capital • Physical capital	As capacities of adaptation		
Kron (2005)**: Flood risk**					• Risk=Hazard (probability of occurrence)×Values (buildings, items, humans)×Vulnerability (lack of resistance to damaging, destructive forces)	

Table 2-3. Continued

Literature and referenced framework	Vulnerability		Resiliency		Risk	
	Factors	Characteristics	Factors	Characteristics	Factors	Characteristics
Balica and Wright (2010): **Complexity of the flood vulnerability index**	• Social (human health, housing, education levels, recreational opportunities, social equity) • Economic (capacity to produce and distribute goods and services) • Environmental (industrialization, agriculture, urbanization, afforestation, deforestation) • Physical (heavy rainfall, flood return periods, proximity to river, river discharge)	• Vulnerability=Exposure (elements at risk characteristics of floods)+Susceptibility (Awareness/preparedness capability to cope)-Resilience (Coping capacity, recovery capacity)				
Birkmann (2006)		Vulnerability= (Exposure ×Susceptibility)/Coping capacity				
Yoon (2012) : **Social vulnerability index**	• people's social vulnerability (social ascribed status; social achieved status) • place's vulnerability (economic status, built environmental characteristics)					
Flanagan et al. (2011): **A social vulnerability index for disaster management**	• socioeconomic status (income, poverty, employment, education) • household composition/disability (age, single parenting, disability) • Minority status/language (race, ethnicity, English language proficiency) • Housing/transportation (housing structure, crowding, vehicle access)				•Risk=Hazard ×(Vulnerability-Resources)	

Table 2-3. Continued

Literature and referenced framework	Vulnerability		Resiliency		Risk	
	Factors	Characteristics	Factors	Characteristics	Factors	Characteristics
Pendall et al: (2012) **vulnerable people, precarious housing, and regional resilience**	• Black, non-Hispanic • Hispanic • American Indian • At least one disability • Military veteran • Post-1990 immigrant • Not a high school graduate • Single-parent household • Below poverty • Under age 18 • Age 75 or over	• Vulnerable people and precarious housing conditions				

The extent or forcefulness of disaster events makes up the central exogenous shock and internal elements serve as exposure in the work of West and Lenze (1994). These authors and others outline factors that contribute to the extent of disaster losses (Raddatz, 2007). While the event itself serves as the exogenous shock, critical elements within a disaster-prone region can be thought of as endogenous exposures that exacerbate loss. These include internal conflict, political instability, lack of organized planning, and economic mismanagement (Acemoglu et al., 2003; Ahmed, 2003; Raddatz, 2007). In this spatial and temporal context, the extent of loss attributed to exogenous shock vs endogenous exposure at t_a depends on the intensity of the disaster event, exposure (or vulnerability), and the prior disaster experience of the community. Disaster shocks have been defined as exceptional events operating outside “normal” development theory and practice (Baade et al., 2007).

Vulnerability to disaster, conceptualized as a potential for loss, refers to the likelihood of exposure to disaster damage (Etkin et al., 2004). In this context, vulnerabilities (t_a-1) during the first stage before a disaster period (t_a-n) include numerous characteristics that determine the ability of local institutions to absorb the shock of natural disaster events. Social and economic conditions of a community might make them more likely to suffer losses relative to adjacent and similarly affected communities. Conditions that lead to increased exposure can include a multitude of items, such as a lack of disaster preparedness and planning, high unemployment, low income levels, high poverty incidence, social isolation, weak housing infrastructure, high levels of impervious surfaces, and low levels of preventive infrastructure (Pelling, 2003; Wisner, 2009).

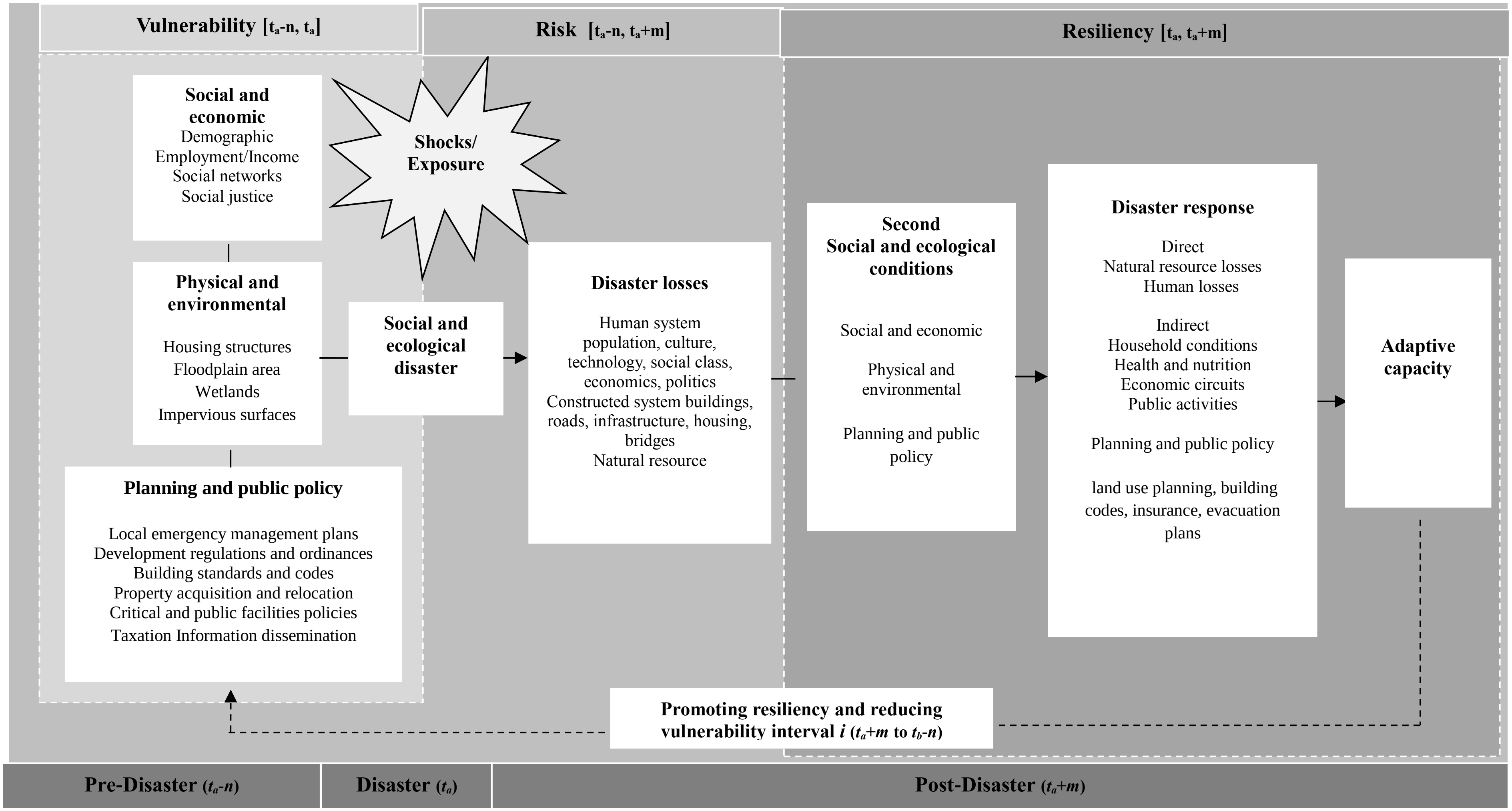

Figure 2-5. Integrative Spatial and Temporal Disaster Planning Model

Adapted from Kim and Marcouiller (in press)

Note : arrow indicates causal relationships, dotted arrow indicates feedback loop

In addition, community planning and public policy prior to a disaster event (t_a-n) serve as an important vulnerability criterion. These attributes involve the extent to which the community has local emergency management plans, land use planning, development regulations (e.g., zoning ordinances), building standards (e.g., building codes), property acquisition (e.g., building relocation), critical public facilities, and taxation information (Beatley, 2009; Berke et al., 2014; Burby, 1998; Kacupu et al., 2013; Olshansky and Kartez, 1998). In the process, the geographical and political characteristics of each community must be considered in light of vulnerability factors that vary in accordance with differing community attributes.

As illustrated in Figure 2-5, the disaster losses (t_a+1) in the first post-disaster stage (t_a+m) result from interactions among social and ecological systems (e.g., human systems, constructed systems, natural resource systems) and their many subsystems (population, culture, technology, social class, economics, politics, infrastructure). In line with the premise that social processes of disasters "determine unequal access to opportunities and unequal exposure to hazards" (Wisner et al., 2004, p. 8), disaster losses change a communities' social and economic conditions and can affect vulnerability to subsequent disaster events. Unlike previous studies which focused on shocks, exposure, seasonality, trends, institutional structure, and processes (e.g., Bogardi and Birkmann, 2004; Bohle, 2001; Chambers and Conway, 1992; Turner et al., 2003), the vulnerability framework addressed an integrated social and economic sphere within a community level planning and public policy context.

The conditions (t_a+2) in the second stage after a disaster (t_a+m) have been addressed in the literature (e.g., Brody and Gunn, 2013; Brody et al., 2014; Cutter et al., 2008a; Hawkins, 2014; Kapucu et al., 2013; Pelling, 2012; Ross, 2014; Wisner, 2009) as including social and economic systems (e.g., demographic, employment, income, social networks), physical and environmental systems (e.g., housing structure, floodplain area, wetlands, impervious surfaces), and community planning and public policy (e.g., disaster plans, development regulations, building standards, property acquisition, public facilities, taxation, number of professional planners, and a formal plan review).

Further along in the post-disaster phase, elements of adaptive resiliency become more evident. In the third stage (t_a+3) post-disaster (t_a+m), new community conditions damaged by natural disasters will show a considerable number of disaster responses such as natural resources losses, household conditions, and community planning. For instance, communities with a more diverse economy before the disaster loss may experience fewer disaster losses and require less time to recover from disasters. In the process of disaster response (t_a+4), communities with an adaptive capacity can mitigate or reduce disaster losses and shorten the period of disaster recovery. As a fifth stage (t_a+5) post-disaster, this process leads to vulnerability reduction and a new disaster preparedness and mitigation stage.

With an emphasis on risk management, Cardona (2004) divides “risk” into two major categories – hard and soft risk. Whereas hard risk indicates potential damage to physical infrastructure and environment, soft risk reflects potential socioeconomic impacts on communities and organizations. Furthermore, the Disaster Resilience of Place (DROP) model (Cutter et al., 2008a) derived from the hazard-of-place model (Cutter, 1996; Cutter et al., 2000), integrates vulnerability (i.e., antecedent conditions) and resiliency assessment with an emphasis on factors associated with resiliency (i.e., ecological, social, economic, institutional, infrastructure, and community competence) (see Table 2-3). This model includes disaster management cycles such as preparedness, mitigation, response, and recovery. The integrative disaster planning model addresses a comprehensive understanding of community vulnerability and resiliency. In line with the integrated nature of the social and ecological spheres, this model compares hazard and disaster in accordance with disaster management cycles. Furthermore, this framework attempts to address the role of disaster management planning in reducing or mitigating community development losses.

2.3 Planning and Policy for Disaster Risk Reduction and Community Resilience

Based on the theoretical foundations of the relationships between social and economic conditions and disaster resiliency, particularly at the local level, specific tools and techniques for enhancing and strengthening community planning associated with resiliency to natural disasters were identified in the works of Beatley (2009), Daniels (2014), Masterson et al. (2014), and Olshansky and Kartez (1998). Such policies include: 1) land use planning, 2) local infrastructure and public facilities, 3) taxation and financial incentives, 4) conservation and restoration of natural systems, and 5) building and structural resilience.

First, local land use planning, as one of the non-structural flood mitigation approaches, allows communities to be more resilient to flooding, as suggested by previous studies (e.g., Godschalk et al., 1998; Gruntfest, 2000). For instance, Galveston County in Texas has adopted a land use plan with emphasis on land use in natural disasters after being affected by Hurricane Ike (2008). The plan has fostered greater resilience to natural hazards like flooding. Other possible considerations include the use of cluster zoning or other land use conservation measures for future development in accordance with a hazard mitigation strategy incorporating setbacks for natural resources (e.g., dune systems and wetlands) (Beatley, 2009; Brody and Highfield, 2013).

Furthermore, protecting dune vegetation and dune stability should be deemed a priority, particularly in coastal community development ordinances, in line with a disaster response plan and a long-term recovery plan. In addition, the seawall was designed to function as protection and mitigation against destructive flooding and surges (Blackburn et al., 2012). Through code revisions, it is important that communities evaluate the opportunities and challenges presented by further development of this area and determine specific standards and criteria for potential projects such as seawalls.

A second policy is to design local infrastructure and public facilities for community resilience. The infrastructure element in the comprehensive plan provides resilient and adequate infrastructure linked with a hazard mitigation strategy to protect the infrastructure in storm events and ensure quick recovery and use during emergency situations. This element calls for the alignment of land use decisions with public facilities and infrastructure investments determined by the community's carrying capacity, anticipated demands, and financial feasibility.

For more resilient facilities, it is necessary that the community assess all municipal facilities to determine if the structures can be strengthened or made more resistant to damage from such catastrophic events. This would include retrofitting for wind resistance, elevating buildings or raising critical mechanical systems above flood levels as has been done in other disaster-prone communities (Emmer et al., 2008). In addition to structural design for resilience, it is necessary for a community to consider the construction of an elevated emergency operations center to provide a protected location for critical personnel and equipment as suggested by the comprehensive plan. For instance, Galveston County had to update and protect its public transportation system after its buses and trolleys were severely damaged by flooding in Hurricane Ike.

With regard to taxation and financial incentives, numerous communities like Collier County (Florida), Montgomery County (Maryland), and Portland (Oregon) have tried to encourage small subdivisions on larger properties comprising a block or more of land.

Encompassing an expedited development review, waivers of permit fees, potentially short-term abatement of property taxes for new homeowners and developers in these areas, and capital improvements to infrastructure systems and neighborhood amenities, such financial incentives may be relatively passive in nature. Since infill development reinforces existing neighborhoods and supports existing commercial uses, it can be a particularly sustainable form of development and urban reinvestment (Porter, 2000). For instance, in the aftermath of Hurricane Ike, Galveston County has seen an increase in the number of demolitions and new vacant lots. The Old Central/Carver Park neighborhood in the county includes infill potential associated with a fragmented pattern of vacant lots. Furthermore, the present tax exemption program encourages rehabilitation of commercial structures within designated historic districts.

The fourth policy for meaningful responses to natural disasters is related to conservation and restoration of natural systems for coastal community resilience. Trees (canopy)—as a natural system—improve air quality, provide shade, protect against erosion, lessen the impact of storm water, and serve as wildlife habitat (Porter, 2000). In addition, by cooling and shading parking lots with trees, the heat island effect of impervious surfaces can be reduced. By restoring the natural bay environment, there will be a greater opportunity for the marshes and wetlands to provide a buffer from the wave action of the bay. Therefore, the natural system can reestablish the typical barrier island defenses against coastal erosion forces similar to Charleston County's (one of the coastal communities in South Carolina) efforts to develop a comprehensive greenbelt with regard to a green infrastructure system (Beatley, 2009).

According to previous studies (Walker and Salt, 2006), marshes and wetlands can absorb storm water runoff and provide flood control by holding water and releasing it slowly into the bay. In light of ecological resilience, wetlands provide vital habitat for many species of plants, fish, birds, and other wildlife and are an important source of nutrients and organic matter that becomes food for organisms throughout the estuary (Porter, 2000; Walker and Salt, 2006).

A less-costly alternative to the community would be to include open space acquisition as an expense item in the annual budget, although this option requires annual reauthorization and does not constitute a clear commitment to the program. Another alternative action could be the purchase of development rights (i.e., conservation easement). Generally, a land trust or another organization linked to the local government (e.g., coastal land trust of Maui in Hawaii) (Beatley, 2009), would offer to buy development rights to a parcel. Since the program will be voluntary, the property owner may choose to accept, refuse, or negotiate the price. If an agreement is made, a permanent deed restriction is placed on the property in perpetuity that restricts the types of activities that may take place on the land.

A final policy is related to building and structural resilience. As a result of natural hazards like Hurricane Ike, significant deposits can be and were left in the storm sewer system. This causes a reduction in the capacity of the pipes and creates greater recurrences of flooding. To solve this problem, in 2010 after Hurricane Ike, Galveston County undertook a system-wide cleaning of the storm-related deposits with assistance from the Federal Emergency Management Agency. Other ongoing factors allow debris to enter the system as well, such as wind-driven sand, yard debris, lack of curbing, unpaved alleys, and cleanliness. Thus, the community needs to address a variety of factors. It is necessary for the community to increase the required erosion controls at construction sites and study the effects of industrial traffic, similar to the aforementioned example of Worcester County in Maryland (Beatley, 2009). Storm water retention systems can reduce the demand on the storm sewer system during rain events (Emmer et al., 2008; Porter, 2000). Thus, similar communities should encourage the use of rain gardens—

landscaped areas that hold water until it can be absorbed into the ground—and rainwater harvesting systems (Kim et al., in press) as noted in its comprehensive plan.

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CHAPTER 3

COMMUNITY RESILIENCE, NATURAL DISASTER RISK, AND GLOBAL CLIMATE CHANGE: SPATIO-TEMPORAL VULNERABILITY AND RESILIENCY IN THE U.S. MISSISSIPPI RIVER BASIN

Abstract

In this study, I examined the association between community capacity and community resilience with specific reference to social, economic, environmental, and planning related characteristics at the county-level within the U.S. Mississippi River basin over the past 20 years. Using the basic premise that natural disaster effects are social frameworks that require pro-active planning, I developed a spatio-temporal conceptual model for disaster risk reduction, climate change adaptation, and environmental change that involves local vulnerability, risk, and resiliency processes. Based on socio-ecological resilience and community capacity characteristics, I temporally and spatially analyzed community vulnerability using an integrative index and spatial clustering. In addition, I estimated the role of community capacity and planning effort in disaster risk reduction and environmental sustainability using spatial lag models. Results suggest that disaster losses have inverse associations with community social and ecological structures and that engaged social capital and social justice characteristics combined with local proactive planning in place before a disaster brings about lower disaster losses and enhancements to community resilience and environmental sustainability. Further, disaster planning for community resiliency is the best approach from multi-disciplinary perspectives that involve social, economic, and cultural attributes.

Keywords: Community capacity, Planning, Resiliency, Spatial analysis, Vulnerability

3.1 Introduction

Patterson et al. (2010, p. 137) noted that

> "…Community responses to Hurricane Katrina demonstrate the importance of local knowledge, resources, and cooperative strategies in determining their survival and recovery, that is, their resilience. These responses can also greatly inform theories and practice of disaster preparedness and risk perception planning, and help us see better how communities' strengths and capabilities can be integrated into these processes…"

This passage emphasizes the fact that many communities are "becoming ever more vulnerable to natural hazards while simultaneously becoming less disaster resilient" (Masterson et al., 2014, p. 3). Further, this trend suggests that efforts of communities are essential to reduce vulnerability, enhance response and recovery, and strengthen resiliency to natural disasters (Frazier et al., 2013; Peacock et al., 2012; Zandt et al., 2012).

The damages and losses[2] caused by unexpected disaster events or weather events have adverse and significant impacts on socio-economic conditions and the environment (Gopalakrishnan, 2013; Zakour and Gillespie, 2013). One of the critically important issues related to minimizing these losses is the spatial and temporal configuration for identifying socio-economic conditions before and after the events. Prior research of natural disaster effects (in particular, Cutter et al.'s [2008] disaster resilience of place model) attempted to reflect the spatial and temporal characteristics of socio-economic situations or social systems (Cutter et al., 2014; Frazier et al., 2013). However, the results of previous studies generally lacked spatio-temporal

[2] According to National Research Council (1999, p.45), disaster losses " include direct physical destruction to property, infrastructure, and crops, plus indirect losses that are the consequence of disasters, such as temporary unemployment and lost business. In this study, I use "disaster losses" as a broad term that reflects direct physical damages by natural disasters.

changes and spatial dependencies with other places even though the impacts of non-routine events have changed over time at the local level (Frazier et al., 2013; Kim et al., 2015).

In this research, I fill in the void by exploring the socio-economic components of community resilience (as community capacity) that can contribute to reducing disaster vulnerability and improved disaster recovery with an emphasis on spatial and temporal scales. Together with the application of socio-economic resilience to the study areas and developing " the capacity to address various structuring of components and their interactions with the ultimate goal of achieving resilience" (Desouza and Flanery, 2013, p. 89), in this Chapter I set out to accomplish the following research objectives:

- To describe an integrative spatial and temporal framework in disaster vulnerability and resiliency
- To integrate various community capacities with the dynamics of short-run and long-run disaster losses and with the Mississippi River basin region, based on the context of different places and different impacts and geographically uneven resilience

Following this introduction, Chapter 3 is organized into four subsequent sections. First, I connect community capacity and community resilience with an attention to social frameworks. This is then followed by a proposed spatio-temporal vulnerability and resiliency model with an overview of the recent literature on vulnerability and resiliency within a community planning context. This includes both an acknowledgment and discussion of existing knowledge that significantly contributes to the formation of disaster risk reduction. The next section empirically investigates the role of community capacity in enhancing resilience to natural disasters with a spatial model, along with a vulnerability index and spatial clustering. The final section provides conclusions and relevant policy implications.

3.2 Community Capacity, Community Resilience, and Disaster Risk Reduction

Community represents socio-economic differentiation, linkage and dynamics, collective behavior or action, and shared experience (Twigg, 2007). Current community development studies use a livelihood framework to understand quality of life, social and economic security, and economic opportunities (Wisner, 2009). This approach looks holistically at the strategic use of a variety of "community capitals," "community assets," "community capacity," and "community capability or capacity development," in securing a livelihood over time (Brinkman et al., 2012; Chaskin et al., 2001; Davenport and Seekamp, 2013; Donoghue and Sturtevant, 2007; Emery and Flora, 2006; Hagelsteen and Becker, 2013; Kusumasari et al., 2010; Lindbom et al., 2015; Stofferahn, 2012; UN/ISDR, 2004).

Based on the literature related to community responses to water resource threats, Davenport and Seekamp (2013) established a multilevel community capacity model for sustainable watershed management through four levels of capacity (i.e., member engagement, relational networks, organizational development, and programmatic coordination). By highlighting the importance of a local government capability (also defined as capacity) and preparedness in managing natural disasters, Kusumasari et al. (2010, p. 441) suggested six key functional success factors: institutional, human resources, policies for effective implementation, financial, technical, and leadership. With more attention to social resilience in local rapid and crises-driven change, Maclean et al. (2014) exemplified six attributes: knowledge skills and learning, community networks, people-place connections, community infrastructure, diverse and innovative economy, and engaged governance.

Among the many possible diverse terms describing community development in relation to risk, vulnerability, and resiliency, I selected the term, "community capacity" since it has been used to account for the role of community or the collective ability of residents in a disaster response or disaster risk reduction (e.g., Berkes and Ross, 2013; Bollin and Hidajat, 2013; Brown and Westaway, 2011; Flint and Brennan, 2007; Frazier et al., 2013; Gaillard, 2010; Jabareen, 2013; Kim and Marcouiller, in press; Magis, 2010; Newman et al., 2014a; Patterson et al., 2010; Razafindrabe et al., 2015; Ross, 2014; Ross and Berkes, 2014; Sherrieb et al., 2010; Wilson, 2012). In particular, “community capacity” can be appropriate in connecting the notion of disaster resilience and capacity building (Joerin et al., 2014; Twigg, 2007).

Encompassing a variety of thematic disciplines such as economic, social, human, political, cultural, built and environmental capacities, such community capacities can be regarded as central to understanding a disaster response. The loss or devaluation of settlement, livelihood, assets, social security, and status at the local level through natural hazards can create new vulnerabilities or risks associated with social discrimination, social exclusion, and violence. Furthermore, as argued by Sherrieb et al. (2010, p. 244), the research on “the distribution of capacities and disaster risk can help to target specific interventions to facilitate resilience”

Drawing upon the proposition that disasters are “socially constructed” or failures of a social system to support communities in adapting to an environmental event (Birkland, 2006, p. 104; Bowden, 2011; Vollmer, 2013), social frameworks in disasters can be connected to “social contours of risk” (Kasperson and Kasperson, 2005), “disaster justice” (Verchick, 2012), “socio-cultural justice influencing flood management” (Sayers et al., 2014), “double exposure in environmental change and globalization” (O’Brien and Leichenko, 2000), and “geographical differentiation of resilience” (Pike et al., 2010). Communities affected by extreme climate events have insufficient resources to cope with any disruptions to livelihoods (e.g., lack of preparedness and planning, poor economy, social injustice, social isolation). For instance, with respect to weak governance capacity to disaster, Tierney (2012, p. 347) argued that the Haiti earthquake in 2010 is the "prototypical example of how physical hazards and the social vulnerability that is characteristic of less-developed nations combine to produce a catastrophe." In this regard, community capacity reflects attributes of vulnerability and resiliency to natural disasters (Fizri et al., 2014; Magis, 2010; Wilson, 2012).

The existing social and economic climate has proven to be quite resilient as long as the social and economic conditions are well managed or maintained after a natural disaster. For this reason, increasing the adaptive capacity (as "a property of the social part of the social-ecological system" of counties, regions, communities, and social groups) will support a wider societal goal of sustainable development (Berkes and Ross, 2013, p. 15). Based on identifying differential social vulnerabilities, Henly-Shepard et al. (2015, p. 360) highlighted "community-based coping and adaptive capacity building and leadership development" in order to enhance social–ecological resilience and planning at the community level. In this sense, my empirical research responds to Thomson's work (2013, p. 12) emphasizing the role of community capacity and long term strategy in disaster risk reduction:

> "Building capacity in the disaster response community to use climate and environmental information in disaster risk assessment, risk reduction and disaster response requires a long-term strategy."

Vulnerability can be determined by the incidence and intensity of natural disasters as well as the ability of a country/region to deal with the impact of natural disasters (Zahran et al., 2008). Among vulnerabilities, when it comes to the role of social vulnerability, Blakie et al. (1994) and the Hines Center (2000) have stressed that "…social vulnerability which is generally understood as the capacity of individuals or social systems of various scale to anticipate, cope with, resist and recover from the impacts of a hazard agent…" (as cited in Peacock et al., 2008, p. 5). In an effort to address the challenges and opportunities faced by a community in response to natural hazards in this context, my work reported here examines the role of community capacity in disaster risk reduction based on the principles of social and economic vulnerability and resilience to natural disasters.

From an ecological perspective, resilience is defined by Holling (1973, p. 17) as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables." More recently, Walker et al. (2004, p. 3) described resilience as "the capacity of a system to withstand disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks." Resiliency is the capacity of people and systems to recover from significant disturbances and is dependent on community capacity to manage demands (e.g., democratic characteristics, social networks, land use planning).

The measurement or indicator of social resilience can be more specifically observed in the work of Cutter et al. (2008) and Cutter et al. (2014). Based on community resilience to natural disasters from a variety of research perspectives, variables for measuring resilience were described in combination with the competence of ecological, social, economic, institutional, infrastructure, and community systems (Cutter et al., 2008; Cutter et al., 2014; Kapucu et al., 2013; Kim and Marcouiller, in press; Peacock et al., 2012; Ross, 2014). In particular, under the attributes of natural disasters and disaster risk reduction (Cutter et al., 2008; Mercer et al., 2007), ecological and institutional systems are determined by factors like floodplain area, soil permeability, wetlands acreage and loss, erosion rates, impervious surfaces, precipitation, biodiversity (Brody and Gunn, 2013), participation in hazard reduction programs, hazard mitigation plans, emergency services, zoning and building standards, emergency response plans, and continuity of operations plans (Cutter et al., 2008).

Similar to the social resilience factors proposed by Adger (2000), Cutter et al. (2008), Cutter et al. (2014), Maclean et al.(2014), Peacock et al. (2012), Ross (2014), and Wilson (2014), social and economic factors, infrastructure, and community competence factors were suggested as resilience components. Social and economic resilience indicators can be addressed by demographics, social networks and social capital, community value-cohesion, faith-based organizations, employment, values of property, wealth generation, and municipal finance or revenues (Aldrich, 2012; Aldrich and Meyer, 2014; Ersing and Kost, 2012; Nowell and Steelman, 2013). In addition, infrastructure resilience factors in the context of environmental hazards include lifelines and critical infrastructure, transportation networks, residential housing stock and age, and commercial and manufacturing establishments (Cutter et al., 2008; Cutter et al., 2014). These indicators address physical systems and dependence or interdependence on other infrastructures.

Based on community attributes, indicators of community competence resilience involve health and wellness, quality of life, and absence of psychopathologies (Deshkar et al., 2011). A resilient system is forgiving of external shocks. Resilience shifts attention from purely growth and efficiency to needed recovery and flexibility (Pine, 2009; Walker and Salt, 2006). In this regard, resilience can be defined as the capacity of a system to absorb disturbances and reorganize while undergoing changes so as to still retain essentially the same function, structure and feedback—and therefore the same identity. Likewise, exploring interconnected notions of community “vulnerability, resilience, and adaptive capacity to existing and potentially unprecedented environmental conditions and threats is an important step" to support community coping with the environmental hazard regime (Newman et al., 2014a, p. 21).

3.3 Spatio-Temporal Framework in Disaster Vulnerability and Resiliency and Testable Hypotheses

As noted earlier in Figure 2-5 (from Chapter 2), spatial and temporal elements can be used to represent disaster vulnerability and resiliency. Namely t_a, t_a-n, and t_a+m reflect temporal elements, where t denotes the point in time when a disaster event occurs and subscript a represents a location or community affected by the event; and n and m indicate time (with t_a-n reflecting a pre-disaster time period and t_a+m reflecting time post-disaster). In this model, i is identified as the interval between disaster events, and is equal to n+m . The interval between disasters can serve as a key element involved in disaster planning effectiveness, as longer intervals can lead to complacency, while shorter intervals can lead to increased urgency in resiliency planning. In this spatial and temporal context, the extent of loss attributed to shock or exposure at t_a depends on the intensity of the disaster event, exposure (or vulnerability), and the prior disaster experience and preparedness of the community. Furthermore, the "n+m" can address global climate change period as to whether the severity of a disaster increases or decreases.

Vulnerability to disaster, conceptualized as a potential for loss, refers to the likelihood of being exposed to disaster damage (Ager, 2006; Cutter, 2003; Etkin et al., 2004; Turner et al., 2003). Vulnerabilities (t_a-1) during the first stage before a disaster period (t_a-n) include numerous characteristics that determine the ability of local institutions to absorb the shock of natural disaster events. Social and economic conditions of a community might make them more likely to suffer losses relative to adjacent and similarly affected communities (Frazier et al., 2013).

Conditions that lead to increased exposure can include a multitude of items, such as a lack of disaster preparedness and planning, high unemployment, low income levels, high poverty incidence, social isolation, weak housing infrastructure, high levels of impervious surface, and low levels of preventive infrastructure (Pelling, 2003; Wisner, 2009). Based on these diverse factors, I can assess the degree of community vulnerability to disaster events. Following this logic, one hypothesis is that *disaster impacts will have a negative association with social and economic development metrics*.

In addition, community planning and public policy prior to a disaster event (t_a-n) serve as an important vulnerability criterion. These attributes involve the extent to which the community has local emergency management plans, land use planning, development regulations (e.g., zoning ordinances), building standards (e.g., building codes), property acquisition (e.g., building relocation), critical public facilities, and taxation information (Beatley, 2009; Berke et al., 2014; Kacupu et al., 2013; Nelson and French, 2002; Olshansky and Kartez, 1998). In the process, the geographical and political characteristics of each community must be considered in light of vulnerability factors that vary in accordance with differing community attributes. In this regard, I further hypothesize that *having a high quality natural hazard mitigation plan in areas that are disaster prone can lead to lower vulnerability and higher social and economic resilience*.

Disaster losses (t_a+1) in the first post-disaster stage (t_a+m) result from interactions among social and economic systems and their many subsystems (population, culture, technology, social class, economics, politics, and infrastructure). Disaster losses change a communities' social and economic condition and can affect vulnerability to subsequent disaster events. Such a vulnerability framework addresses an integrated social and economic sphere (Davidson, 2010) within community level planning and the public policy context. The third hypothesis can be stated as follows: *Better social capital and social justice metrics in place before a natural disaster will lead to lower disaster losses*.

The conditions (t_a+2) in the second stage after a disaster (t_a+m) have been addressed in the literature (e.g., Brody and Gunn, 2013; Cutter et al., 2008; Hawkins, 2014; Kapucu et al., 2013; Pelling, 2012; Ross, 2014; Wisner, 2009) as including social and economic systems (e.g., demographic, employment, income, social networks), physical and environmental systems (e.g., housing structures, floodplain areas, wetlands, impervious surfaces), and community planning and public policies (e.g., disaster plans, development regulations, building standards, property acquisition, public facilities, taxation, number of professional planners, and a formal plan review).

Further along in the post-disaster phase, elements of adaptive resiliency become more evident. In the third stage (t_a+3) post-disaster (t_a+m), new community conditions damaged by natural disasters will show a considerable number of disaster responses such as natural resources losses, household conditions, and community planning. For instance, communities with a more sizable and diverse economy before the disaster loss may experience fewer disaster losses and require less time to recover from disasters. In the process of disaster response (t_a+4), communities with an adaptive capacity can mitigate or reduce disaster losses and shorten the period of disaster recovery. As a fifth stage (t_a+5) post-disaster, this process leads to vulnerability reduction and a new disaster preparedness and mitigation stage. Based on these prior research findings, I can hypothesize that *the higher the levels of a community's social and economic capacities, the lower the disaster losses*.

3.4 Research Design and Methods

3.4.1 Analytical framework and data collection

Based on the spatio-temporal dynamics in disaster risk reduction concerning community capacity and community resilience, an analytical framework was devised to address the empirical as well as theoretical approach for the case study. This framework embraces two phases: (1) measuring the vulnerability and risk index and then identifying the spatial clustering of the vulnerability and risk index and (2) evaluating the role of community capacity in disaster risk reduction using spatial analysis models. More specifically, with respect to the first phase, socio-economic vulnerability characteristics encompassing various environmental and geographic, human and social capital, economic and housing, and planning effort factors were selected. As described in Table 3-1, this phase is based on the available data collected from several public and freely accessible research sources such as the U.S. Census Bureau (USCB), U.S. County Business Pattern (USCBP), Dave Leip's Atlas of U.S. Presidential Elections (DLAP), the Federal Emergency Management Agency (FEMA), National Levee Database (NLD) and National Inventory of Dams (NID) from U.S. Army Corps of Engineers (USACE), PRISM Climate Group (PRISM), NASA's Moderate Resolution Imaging Spectroradiometer classification (MODIS), Economic Research Service (ERS), and the Spatial Hazard Events and Losses Database for the United States (SHELDUS) at the Hazard Research Lab at the University of South Carolina.

Selecting 1,266 counties within the Mississippi River basin areas (from 22 different states) affected by flooding during the last 20 years, the socio-economic vulnerability index was measured using normalization by scaling methods (including min-max transformation, Z score, Maximum value transformation) and the index was mapped. For the risk index measure, flood duration and flood damage severity characteristics (one of the disaster exposure attributes) were added into the estimated composite vulnerability index in accordance with the equation (Risk=

Vulnerability + Exposure) suggested by Bollin and Hidajat (2013). The flood duration variable indicates days affected by the flooding during the study period and flood damage severity was categorized into eleven levels (from 1 to 11) by each county's flooding damage value divided by total damage.

In an attempt to investigate the temporal differentiation or transition in vulnerability and risk, the composite index among 1990s, 2000s, and the entire study period (1990 to 2009) were compared. Based on the temporal comparison of vulnerability and risk, a spatial clustering of vulnerability and risk was estimated by incorporating the urban and rural continuum (including areas newly categorized into urban, suburban-exurban, and rural).[3] Such spatial and temporal comparisons were devised to examine the relationships between vulnerability or risk and the urban and rural spatial effects.

With regard to Phase II, as described in Table 3-1, the social-economic factors contributing to community resilience can be determined in line with community capacity characteristics that include human and social capital, economic and housing capacity, environmental and geographic capacity, and planning effort capacity. In the second phase, along with the log-linear model, a spatial lag model[4] was conducted in order to estimate the spatial effects on the relationship between community capacity and disaster losses. In this study, 1,266 flooding prone counties within the Mississippi River basin areas were analyzed in an effort to determine community capacity and community resilience indicators.

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[3] Based on the Beale Code that classified all US counties into nine categories on the basis of the county size and its proximity to a metropolitan area (USDA, Economic Research Service, 2004, http://www.ers.usda.gov), I reorganized the spatial classifications into urban area (0-3 categorized in the Beale Code), suburban-exurban area (4, 6, and 8 classified in the Code), and rural counties (5,7, and 9 classified in the Code).

Table 3-1. Concept measurement, descriptive statistics, and temporal comparison

Variable name	Definition /measurement	Data source	Model 1 (n=1,266)		Model 2 (n=1,266)		Model 3 (n=1,266)		t-value
			Mean	SD	Mean	SD	Mean	SD	
Disaster loss variables									
Property	Average property damage (1,000,000US$) [a]		20.68	226.5	5.65	17.2	14.32	240.1	
	Per capita property damage (US$)	SHELDUS	418.29	6,033.7	331.13	1,012.6	505.45	11,054.8	
Crop	Average crop damage (1,000,000US$)[a]		6.70	20.9	3.63	14.7	1.41	10.07	
	Per capita property damage (US$)		117.12	533.83	177.54	670.58	56.71	397.09	
Human and social capital capacity variables									
Civic	Civic organizations per 10,000 population	County Business Pattern	15.88	16.10	14.93	5.79	16.83	30.64	-2.24*
Telephone	Telephone-service (%)	US census bureau	94.46	3.30	91.71	5.67	97.21	1.62	-38.33**
Voter	Voter turnout (%)	Dave Leip's Atlas of presidential elections	43.08	6.23	42.15	6.34	44.00	6.47	-21.96**
Moving in	Year householder moved into unit (%)		56.14	6.48	55.32	6.86	56.97	6.80	-13.66**
Language	Language other than English (%)		4.35	4.04	4.05	4.33	4.66	4.05	-9.50**
Bachelor	Bachelor degree and over (%)		16.11	6.32	17.25	6.52	14.98	6.37	32.87**
White	White (%)	US Census Bureau	90.45	14.09	91.58	13.68	89.32	14.60	31.28**
Age	65-year old and over (%)		15.56	3.87	15.76	4.03	15.36	3.81	10.91**
Female	Female householder (%)		10.87	4.51	11.90	5.23	9.85	3.97	32.31**
Health access	Total physicians per 10,000 population		12.00	14.18	11.39	14.31	12.00	14.65	-7.48**
Economic and housing capacity variables									
Poverty	Poverty rate (%)		15.38	7.46	16.75	8.16	14.01	6.97	35.06**
Homeowner	Owner-occupied housing (%)		74.43	6.28	73.85	6.38	75.02	6.30	-22.87**
Per capita income	Per capita income (1,000 US$)		23.34	4.16	18.29	3.32	28.39	5.18	-1.42e+02**
Housing age	Year housing structure built (%)	US Census Bureau	14.51	6.27	16.77	7.46	12.24	6.24	28.72*
Employ	Employment rate (%)		50.22	6.52	42.50	5.72	57.94	7.61	-1.6e+02**
Housing value	Median housing value (1,000 US$)		74.03	25.36	42.46	14.56	105.60	37.51	-87.01**
Mobile home	Mobile home (%)		11.86	7.17	12.00	6.59	11.86	8.12	2.82*
Economic diversity	Farming, fishing, forestry industry (%)		0.86	1.65	0.96	1.95	0.76	1.48	6.88**
Resilient industry	Disaster-resilient industry (%)	County Business Pattern	12.86	3.37	11.98	3.91	13.74	3.64	-18.38**
Business diversity	Small business establishments (%)		96.06	1.56	96.07	1.59	96.06	1.59	0.80
Environmental and geographical capacity variables									
Residential	Residential area (%)	NASA's MODIS classification	16.47	17.88	15.48	17.44	17.47	18.39	-27.67**
Precipitation	Number of times precipitation exceeded the 75 percentile	PRISM Climate Group	16.35	7.03	7.95	3.32	8.39	3.78	-13.56**
Urban influence	Population covered by urban characteristics per 1,000 population	Economic Research Service, USDA	0.33	0.32	0.13	0.31	0.55	0.48	-30.42**
Flooding Duration	The length of a flood (days)		61.73	68.61	36.77	54.09	19.40	24.01	
Flooding Severity	Categorized severity based on flooding damage costs	SHELDUS	2.56	2.58	1.43	1.43	1.20	1.03	

Note: Mode1 1 is for entire study period, Model 2 is for 1990s, Model 3 is for 2000s, a: adjusted in 2010, * : statistical significance at 5%, **: statistical significance at 1% , bold italic characters indicate variables used in measuring vulnerability index

Table 3-1. Continued

Variable name	Definition /measurement	Data source	Model 1 (n=1,266)		Model 2 (n=1,266)		Model 3 (n=1,266)		t-value
			Mean	SD	Mean	SD	Mean	SD	
Planning effort capacity variables									
Regulation	Building regulation (1=minimalist, 2=enabling, 3=mandatory, 4=energetic)	May (2013)'s State regulation provisions	2.12	1.14	2.12	1.14	2.12	1.14	
CRS class	Community Rating System Class (1-10, 11: no class)	FEMA	10.54	1.24	10.54	1.24	10.54	1.24	
Mitigation plan	Population covered by multi-hazard approved mitigation plan (1,000 person)		41.77	112.10	40.25	109.95	43.24	114.53	-9.08**
Storm-ready	Population in Storm-ready counties (1,000 person)		26.50	101.66	25.34	99.43	27.72	104.19	-6.98**
Levee	Levee length (mile)	National Levee Database, USACE	14.68	425.60	14.68	425.60	14.68	425.60	
Dam	Storage of Dams (1,000Acre-feet)	National inventory of dams, USACE	8.13	58.58	8.13	58.58	8.13	58.58	

Note: Mode1 1 is for entire study period, Model 2 is for 1990s, Model 3 is for 2000s, a: adjusted in 2010, **: statistical significance at 1% , bold italic characters indicate variables used in measuring vulnerability index

As described in Table 3-1, I divided my approach into three models (i.e., Models 1, 2, and 3) in order to investigate the temporal differentiation or transition in community resilience and capacity among 1990-2009, 1990s, and 2000s, respectively. As a dependent variable, the U.S. dollar value of per capita disaster losses (adjusted for inflation in 2010) aggregated to the county level was log transformed in order to better approximate a normal distribution. Collected from multiple data bases such as USCBP, USCB, and DLAP, the human and social capital characteristic variables and economic and housing characteristic variables, as controlling and independent variables, during the last 20 years (from 1990 to 2009) include educational attainment (percent of population with a bachelor's degree), race (percent of white population), age (percent of population over 65), female-headed householder, health access (total physicians per 10,000 population), housing characteristics (percent of housing units built in 1989 or earlier, the percent of mobile housing units, percent of homeownership, and housing value), and language (the percent of population using a language other than English).

In the economic characteristic variables, five variables that included poverty (percent of poverty), per capita income, employment rate, economic diversity, and resiliency industry were involved in the community economic capacity. As a single-sector economic base variable (non-economic diversity or degree of ruralness characteristics) (Ganapati et al., 2013), I selected percentage of primary sectors such as agriculture, forestry, fishing, and hunting industry (11 coded industries classified by the North American Industry Classification System, NAICS). The resiliency industry variable (percent of public administration, education, and health care services, 56, 61, and 62 coded industries categorized by NAICS) was selected as part of community resiliency characteristics. These sectors can be expected to be more disaster-resilient and recover at a faster rate. Responding to the suggestion by Edwards (2013, p.37) that "small local businesses are a key to economic recovery in a community hit by disaster," I selected percentage of small business (with less than 500 employees) establishments as business diversity characteristics. Those economic capacity variables can be crucial drivers in reducing disaster losses.

In line with the research findings of the positive role of social capital in enhancing community resilience from natural disasters (e.g., Aldrich, 2012; Deshkar et al., 2011; Kim and Marcouiller, in press ; Rivera and Settembrino, 2013; Ross, 2013), as proxies for the social capital characteristic variables and the controlling and explanatory variables, voter participation (percent of voter turnout in the presidential general election in 1992, 1996, 2000, 2004, and 2008) and civic organization (number of civic organizations consisting of religious, grantmaking, civic professional, and similar organizations, 813 coded industries classified by the NAICS) was collected from the official website USPE and USCBP.

Collected from the ERS, environmentally and geographically influenced characteristics involved whether or not each study area had urban characteristics. Represented by a geographical location such as a metropolitan area, the urban influence attributes are also associated with economic characteristics as noted before. The planning effort characteristic variables encompass non-structural mitigation and structural mitigation measures to reduce natural hazard losses. As non-structural mitigation measures, building regulation status (categorized into minimalist, enabling, mandatory, and energetic, as suggested by May (2013)'s state regulation provisions[5]),

[5] In terms of states' building regulation, May (2013, p. 132) categorized minimalist, enabling, mandatory, and energetic. The four categories indicate " the extent to which states mandate and oversee local building regulation" Whereas minimalist states are "those without state codes or provisions that are limited to restricted situations (e.g., state provisions governing schools, public buildings, or state buildings), energetic states are those with mandatory local codes and state oversight of enforcement of codes by local governments". In this study, states such as Colorado, Illinois, Kansas, Missouri, Mississippi, North Dakota, Oklahoma, Pennsylvania, South Dakota are classified 'Minimalist' and Arkansas, Iowa, Louisiana, Minnesota, Nebraska, and West Virginia are included in 'Enabling.' Wisconsin is categorized

community rating system class (classified from 1 to 11 by FEMA), population covered by multi-hazard approved mitigation plan, and population covered by storm-ready counties designated by FEMA were selected, In addition, levee length and storage dams were selected as variables to represent structural mitigation measures. Data on damage or losses after a flood occurred, such as property damage, and crop damage at the county scale, were obtained from the SHELDUS. The increasing frequency and severity of flooding along the local communities within the Mississippi River basin have put a large number of people and resources at risk. These selected communities are deemed ideal for examining the effects of flooding on social and economic factors during the last 20 years.

3.4.2 Study area and descriptive analysis

Along with the trend of growing disaster losses over time, the increasing frequency and severity of flooding along the Mississippi River basin areas have put a large number of people and resources at risk. According to Peterson et al. (2013) on the number of flood events that caused at least $50,000 in damages to property and crops from 1990 to 2009, the Mississippi River basin areas (encompassing four big rivers, the Missouri, Mississippi, Ohio, and Arkansas river) have experienced approximately 40 % of overall flood events in the U.S. (see also Appendix 3-1). During this period, the 1993 floods within the Missouri and Mississippi River systems caused an "estimated US$16 billion in damage and cost the federal government about US$5.5 billion" (Daniels, 2014, p. 389). For this reason, flooding in the Mississippi River basin is an increasingly significant issue of community disaster planning.

'Mandatory' and Kentucky and Tennessee states are associated with 'Energetic.' Likewise, Hokanson and Schwab (2014) pointed out the state regulatory role (e.g., state building code) in influencing local planning for post-disaster recovery and community resiliency.

As a flood-prone area, the basin involves 24 states and about 1,600 counties in the U.S. Among the counties, as depicted in Figure 3-1, I focused on 1,266 counties (22 states) designated in presidential disaster declarations based on flood losses during the past 20 years, from 1990 to 2009 (FEMA). The selected 1,266 counties were deemed ideal for investigating flood impacts on local social and economic status and examining social-ecological factors contributing to community resilience given their comparatively long history of flooding and primarily because they were declared federal disaster areas after flooding occurred. Within the study areas, physical damage costs including property and crop losses derived from flood totaled roughly US$43 billion during the last 20 years, with the expectation that the damage costs in the 2000s would increase compared to the 1990s (see Table 3-1). Most of the community capacity variables in the 2000s increased compared to the 1990s (except for the educational attainment, percentage of bachelor degrees and over). Among human and social capital capacity characteristic variables, a proxy variable for social capital, an increasing rate of the number of civic organizations per 10,000 population represents about 2% and voter participation shows a 5% point increase.

As a social justice characteristic variable, the health access variable indicating total physicians per 10,000 population within the study areas also increased 1.3% points. Overall, most of the variables associated with economic and housing capacity showed economic growth and physical improvement in housing that can be helpful in dealing with unexpected events and developing resilient communities. Furthermore, with regard to local economic structure, three proxy variables in the 2000s used for economic diversity, resilient industry, and business diversity characteristics represent a small increase compared to the 1990s. Responding to the temporal effects on community capacity characteristics with comparison between the 1990s and the 2000s using a t-test, most variables represented a statistically significant temporal difference, except for the business diversity variable. Over 20 years, it is expected that there will be little change in the percent of small businesses within the study areas.

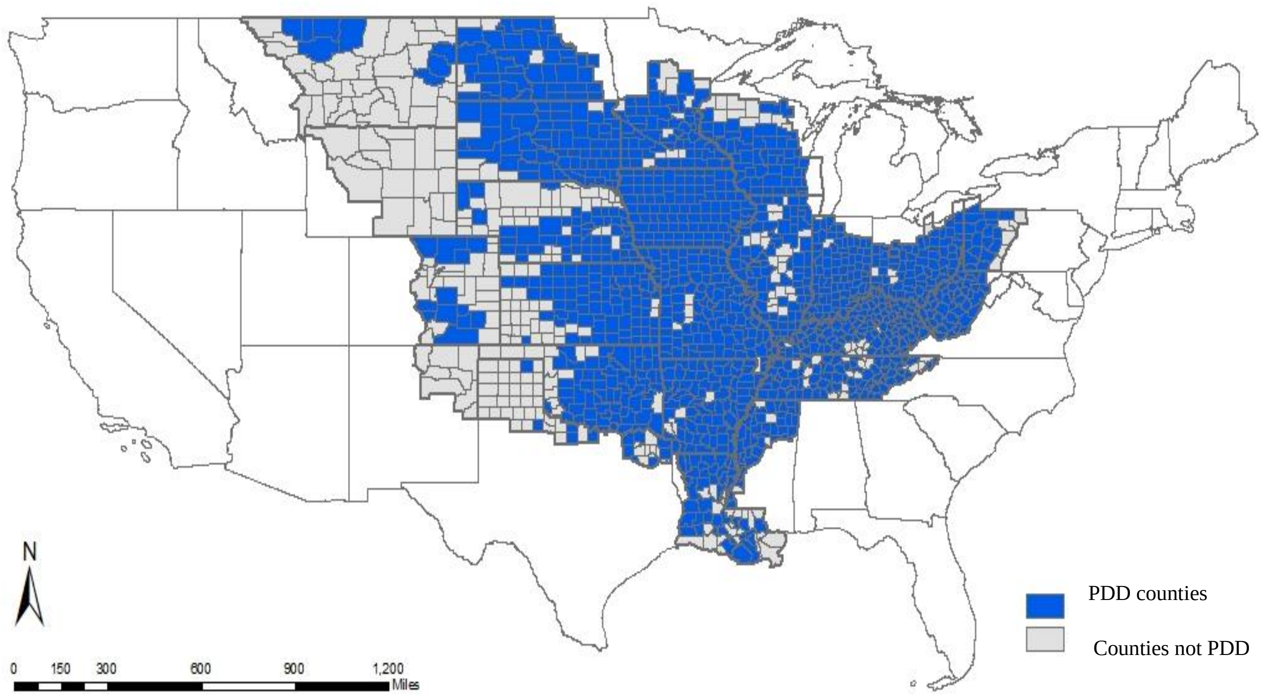

Figure 3-1. Study area
Note: PDD indicates Presidential Disaster Declaration

3.5 Findings

3.5.1 Spatial distribution and spatial clustering of flooding vulnerability and risk

I measured the vulnerability index using equal weighted and normalized scaling methods that include min-max transformation, Z score, and maximum value transformation, based on the various factors such as environmental and geographical, human and social capital, economic and housing, and planning effort. As suggested in the work of Cutter et al. (2008), Tate (2012), and Yoon (2012), I measured the vulnerability index using equally weighted and normalized scaling methods with the selected 21 variables[6] as described in Table 3-1. Among the methods, I conducted min-max transformation ($\frac{Xi-Xmin}{Xmax-Xmin}$), Z score ($\frac{Xi-\bar{X}}{s}$), and maximum value transformation ($\frac{Xi}{Xmax}$) (see also Appendix 3). In those formulae for the normalized scaling, X_i indicates each value of variable in county *i* and X is total value of each variables among counties. s is standard deviation and X_{max} and X_{min} are maximum value and minimum value of X, respectively. Even though the values of each method were different, the ranking of vulnerability and risk index measured by each method was the same.

In a similar way, to measure the risk index, I used the equation risk is vulnerability plus exposure. For exposure, I reclassified severity by the level of flood damage and calculated flood duration. Based on these indices, I mapped the spatial distribution of vulnerability and risk index. The spatial distribution of vulnerability and the risk index between 2000 and 2009 is mapped in Figure 3-2. On the upper side, a dark red color indicates a high level in the vulnerability index and the bright red color indicates a low level in the vulnerability index. This vulnerability index is based on a min-max transformation normalized method (values range from 0 to 1) (see Appendix 3-2).

Within the study area, many counties adjacent to the Mississippi River reflect a somewhat higher vulnerability index than other counties. Among most disaster vulnerable

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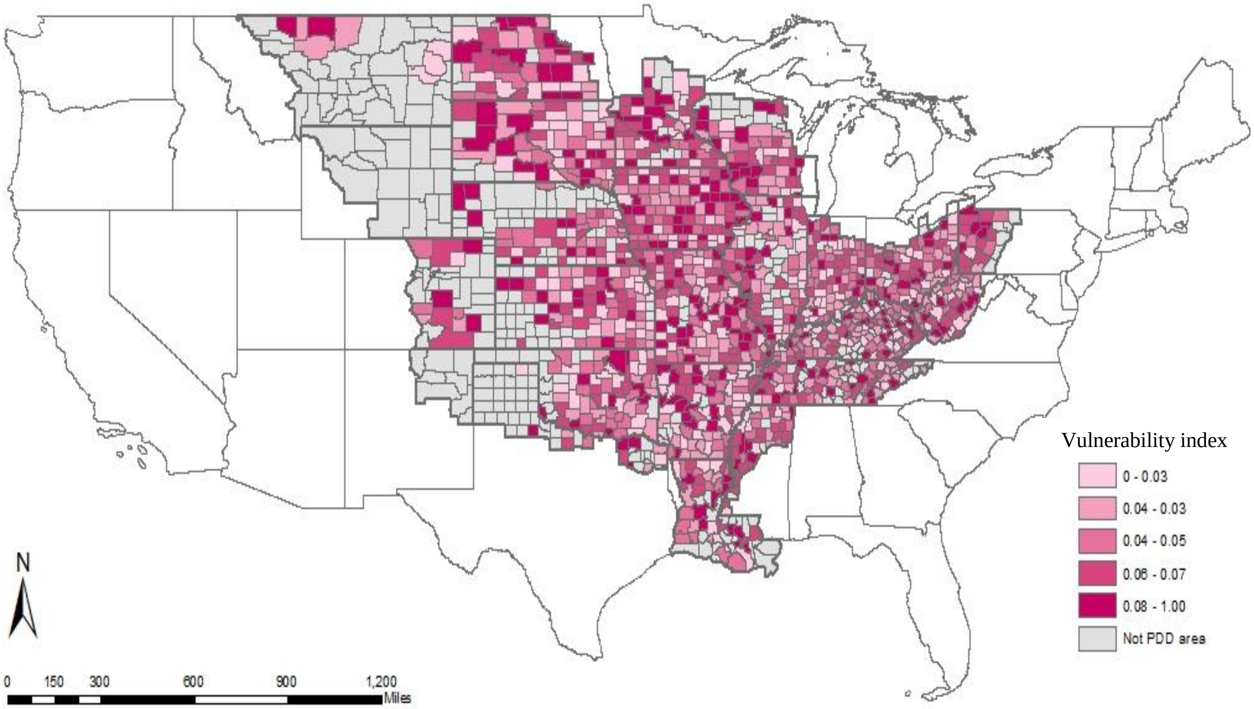
[6] To represent capacity characteristics over time, I selected 21 variables among a total of 31 variables to measure vulnerability index (described in bold italic characters in Table 3-1). For human and social capital characteristics, I selected 9 variables that included *Civic*, *Voter*, *Moving in*, *Language*, *Bachelor*, *White*, *Age*, *Female*, and *Health access*. For economic and housing and environmental and geographical characteristic variables I selected *Poverty*, *Homeownership*, *Per capita income*, *Housing age*, *Employ*, *Mobile home*, *Economic diversity*, *Resilient industry*, *Business diversity*, and *Residential*. For planning effort characteristics, I selected *Mitigation plan* and *Storm-ready* variables.

counties, Franklin County in Missouri (calculated vulnerability index is 1.000), Greene County in Missouri (0.936), Vernon County in Missouri (0.8998), Lawrence County in Kentucky (0.7918), and Renville County in Nebraska (0.7720) are ranked in the top five. By contrast, in accordance with the estimated vulnerability index, McLean County in Kentucky (0.000), Adair County in Iowa (0.0027), Knox County in Ohio (0.0080), Scott County in Kentucky (0.0086), and Rock Island County in Illinois (0.0095) are ranked as the least vulnerable to flood events among all the areas in the study during the last ten years. By and large, those counties reflect the inland portion of the study area.

Along with the assumption that risk index increases over time (see Appendix 3-2),[7] the lower side in Figure 3-2 shows the spatial distribution of the risk index between 2000 and 2009. A dark red color indicates a higher risk level and the bright red color indicates a lower level on the risk index. Similarly to the spatial distribution of the vulnerability index, looking over the counties along the Mississippi River, there remain a lot of counties with a higher risk index (ranged from 0 to 663.04) (see also Appendix 3-2). These communities, Hancock County in Illinois (663.04), La Crosse County in Wisconsin (616.03), Randolph County in Illinois (594.06), Brown County in Illinois (583.07), and Jersey County in Illinois (570.09) are ranked in the top five in flood-risk related communities. When it comes to communities with a lower disaster risk from flood events, McLean County (0.000), Scott County (0.0086), and Harrison County (0.0147) are ranked among the top five among the study areas and all are located in Kentucky.

[7] As illustrated in Appendix 3-2, most counties had an increasing risk index, except for counties within Iowa. Compared to the 1990s, the flood losses of Iowa decreased in the 2000s.



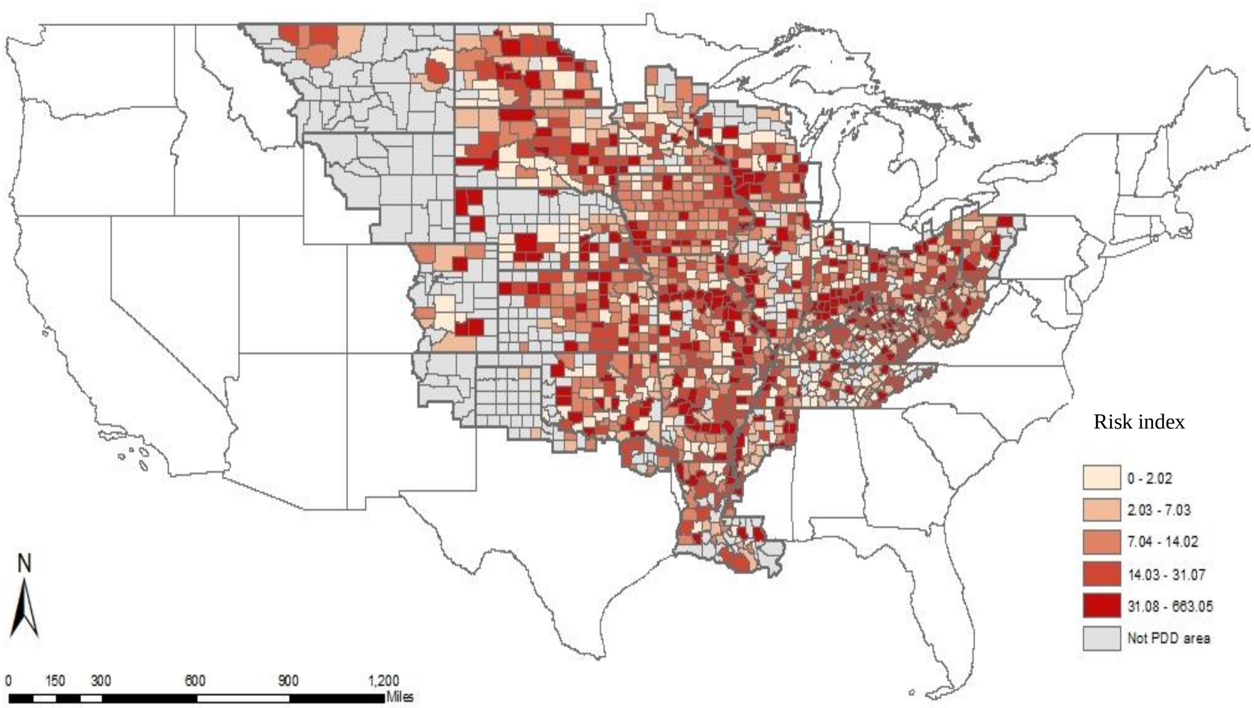
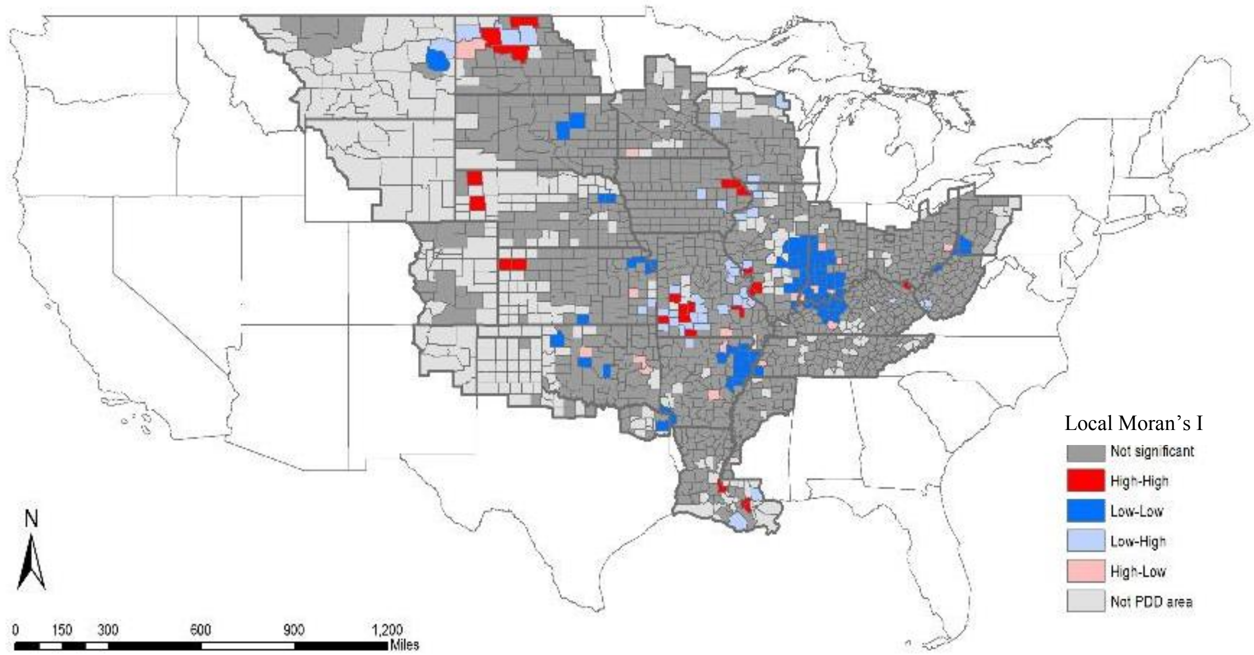


Figure 3-2. Spatial Distribution of Vulnerability Index (Upper Side) and Risk Index (Lower Side) between 2000 and 2009

Based on the estimated flood vulnerability index discussed earlier, I attempted to examine whether there were spatial associations for the vulnerability index and risk index by using Local Moran's *I*. In the upper side of Figure 3-3, the red color indicates a positive autocorrelation with a clustering of high values in the vulnerability index and the blue color shows a positive autocorrelation with a clustering of low values in the index. As suggested by Anselin (1988a, b, 2009) and Mitchell (2014), in terms of spatial econometric modelling and a Moran scatter plot (see Appendix 3-4), the former represents High-High (within the upper-right quadrant) and the latter is called Low-Low (within the lower-left quadrant) among the four different types of spatial associations.

As hotspots with flood vulnerability, several counties that included Dubuque and Jackson County in Iowa, Jersey, St. Clair, and Monroe County in Illinois, Henry, Camden, Hickory, Taney, Greene, and Polk County in Missouri were associated with spatial clustering of vulnerability. Similarly, based on the calculated flood risk index, I identified whether there were spatial associations for the risk index by using Local Moran's *I*. As illustrated in the lower side of Figure 3-3, if we focus on the red color and the blue color (High-High and Low-Low), there were several counties representing a spatial clustering of the flood risk index along the Mississippi River.



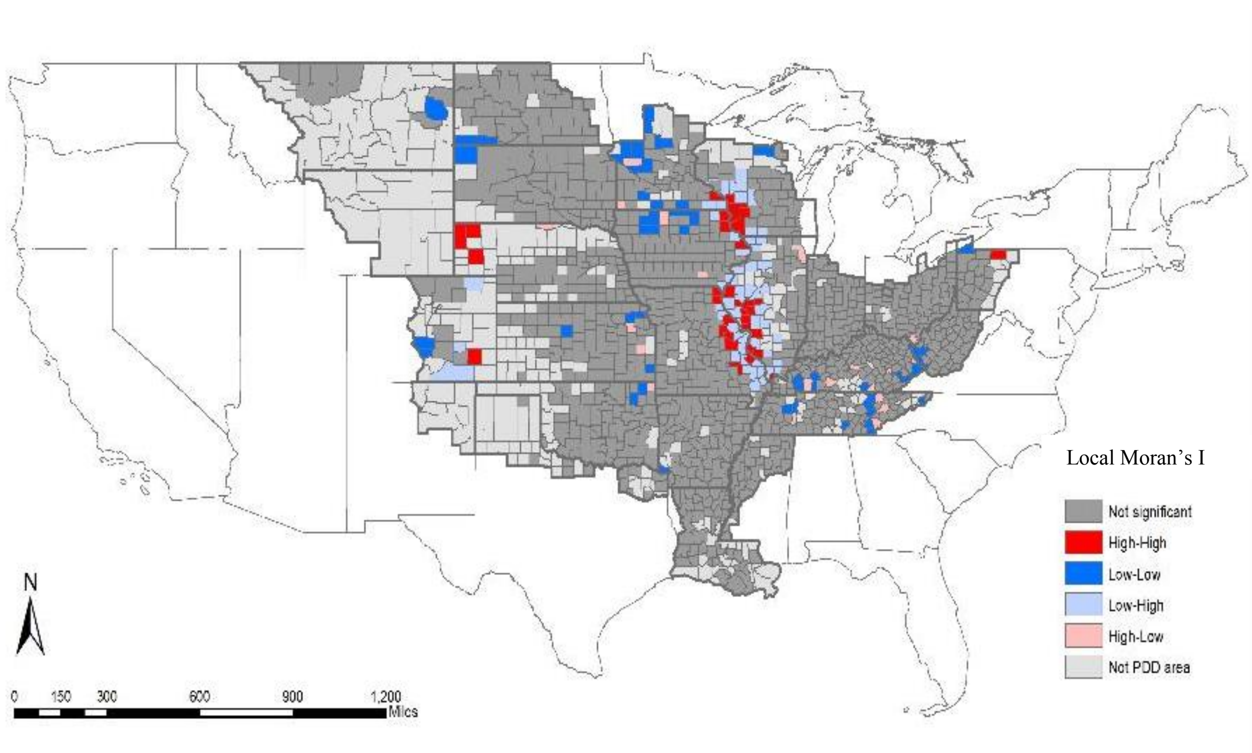


Figure 3-3. Spatial Clustering of Vulnerability Index (Upper Side) and Risk Index (lower Side) between 2000 and 2009

3.5.2 Examining the role of community capacity in mitigating flood risk

In line with the result of the spatial distribution of vulnerability and risk index[8] and spatial clustering of the index over time, I used a spatial analysis model in order to investigate the spatial relationships between community capacity characteristics and disaster losses in the Mississippi River basin areas during the last 20 years. Prior to estimating the spatial associations among the characteristics, I conducted a log-linear regression model with an emphasis on the existence and magnitude of potential multicollinearity among independent variables. I compared the Variance Inflation Factor (VIF) results to acceptable standards as identified by Studenmund (2006) and other econometricians. Within analogous social science empirical research, a VIF greater than 5 reflects serious multicollinearity results. The VIF (of 4.56) was below this threshold of 5.

As discussed earlier, in an effort to examine the determinants of community resilience in the study areas, a log-linear regression model was employed with the dependent variable (the per capita dollar value of flood losses), *FL*. Along with various human and social capital capacity (*HSC*), economic and housing capacity (*EHC*), environmental and geographical capacity (*EGC*), and planning effort capacity (*PEC*), and each flood damaged county *i*, the empirical model can be addressed by the following equation:

$$\ln (FL_{\mathrm{i}}) = f\,(HSC_i, EHC_i, EGC_i, PEC_i) \qquad (3\text{-}1)$$

Drawing upon the results of the log-linear regression model, I attempted to test spatial dependence to check the validity of the model in accordance with the work of Anselin (1998a).

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[8] In terms of the correlation between the vulnerability index and risk index, as expected positive correlation (r=0.6849, P<0.001) were obtained.

The diagnostic results suggested that there were statistical significances in both the LM-lag (for example, in Model 1, LM-lag = 37,881, $p<0.001$) and LM-error (in Model 1, LM-error=20,669, $p<0.001$)[9] for spatial lag dependence and spatial error dependence. In this case, since a robust LM-lag (for example, in Model 1, robust LM-lag = 93,144, $p<0.001$) is statistically significant compared to the LM-error (in Model 1, robust LM-error = 93,114, not significant),[10] I selected the spatial lag model. This model reflects that the dependent variable relies on the dependent variable observed in neighboring units and on a set of observed local characteristics (LeSage and Pace, 2010). Based on the equation (3-1) , the spatial lag model on the effect of community capacity characteristics (*HSC*, *EHC*, *EGC*, and *PEC*) on disaster losses (*FL*) and each flood damaged county *i* can be addressed by the following equation (3-2):

$$\ln (FL_{\mathrm{i}}) = \delta W \ln(FL_{\mathrm{i}}) + \alpha_0 (HSC_{\mathrm{i}}) + \alpha_1 (EHC_i) + \alpha_2 (EGC_{\mathrm{i}}) + \alpha_3 (PEC_i) + \varepsilon_i \qquad (3\text{-}2)$$

Where α indicates parameters and ε_{i} is the error term. δ denotes the spatial autoregressive coefficient and W indicates a spatial weights matrix with elements (i.e., W =1 indicating two different spatial units are neighbors and W =0 otherwise).

As illustrated in Table 3-2, the result of the spatial lag model is similar to that of the log-linear regression model. Along with these defined test results for model validity, I examined the role of community capacity and community resilience in mitigating disaster losses. As a dependent variable, I selected per capita disaster losses (including property and crop damages) by floods during the study period in accordance with temporal change (as noted in the models in

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[9] In Model 2, LM-lag =35,112 ($p<0.001$) and LM-error =18,935 ($p<0.001$). In Model 3, LM-lag = 36,337 ($p<0.001$) and LM-error =19,119 ($p<0.001$).

[10] In Model 2, robust LM-lag =89,229 ($p<0.001$) and robust LM-error =88,489 (not significant). In Model 3, robust LM-lag = 91,526 ($p<0.001$) and robust LM-error =90,234 (not significant)

Table 3-2). Explanatory variables reflect various community capacity characteristics that include human and social capital, economic and housing, environmental and geographical, and planning effort characteristics. Several factors associated with community resilience play a pivotal role in modifying the disaster losses caused by flood events at the county level for temporal variations.

More specifically, consistent with the work of Aldrich (2012), Aldrich and Meyer (2014), Chamlee-Wright and Storr (2009), Ersing and Kost (2012), Kim and Marcouiller (in press), and Townshend et al. (2015), variables used as proxies for social capital and social network that include number of civic organizations, voter turnout, and percentage of householders that have moved into the current county within ten years mitigate the amount of flood losses. As predicted, an increase in the social service asset characteristic variable significantly decreases property and crop damages by floods regardless of temporal change. Responding to the temporal comparison or effects on community capacity in flood risk reduction, by and large, there are little differences in the role of various community capacity characteristics between the 1990s and 2000s in Models 2 and 3 shown on Table 3-2.

With respect to economic and housing capacity characteristics, similar to the findings of Toya and Skidmore (2007) who documented that lower economic and housing status is positively associated with natural disaster losses, counties with a lower poverty rate and higher housing age had no discernible influence on reducing the flood damages. On the contrary, in line with the suggestions of Kellenberg and Mobarak (2008) and Zhou et al. (2010), counties with higher economic and housing capacities such as homeownership, income level, and business diversity (number of small businesses) were negatively associated with flood losses regardless of temporal effects during the two decades.

Table 3-2 Spatial Lag Model and Temporal Effect Results on Community Resilience

Variable name	Model 1	Model 2	Model 3
Human and social capital capacity characteristics (*HSC* i)			
Civic	-0.002 [0.001]	-0.025*** [0.005]	-0.003* [0.001]
Voter	-0.010** [0.004]	-0.008 [0.006]	-0.008* [0.007]
Moving in	-0.038*** [0.007]	-0.039*** [0.008]	-0.021** [0.009]
Language	0.003 [0.004]	0.0007 [0.005]	0.020** [0.008]
Bachelor	-0.005 [0.006]	-0.027*** [0.007]	-0.013* [0.009]
White	-0.009** [0.002]	-0.0004 [0.003]	-0.007* [0.005]
Age	0.019 [0.008]	0.035*** [0.010]	0.003* [0.014]
Female	0.013 [0.010]	0.002 [0.012]	0.019 [0.023]
Health access	-0.005** [0.001]	-0.015** [0.005]	-0.006** [0.002]
Economic and housing capacity characteristics (*EHC* i)			
Poverty	-0.004 [0.007]	-0.017** [0.0001]	-0.005* [0.010]
Homeowner	-0.028*** [0.006]	-0.038** [0.008]	-0.003* [0.009]
Per capita income	-1.34E-06 [8.60E-06]	-0.0004** [0.0001]	-2.85E-06* [0.0001]
Housing age	0.024*** [0.006]	0.053*** [0.007]	0.006* [0.008]
Employ	0.002 [0.006]	0.003 [0.008]	0.008 [0.008]
Mobile home	0.0003 [0.004]	0.007 [0.005]	0.005 [0.006]
Resilient industry	-0.003 [0.005]	-0.007 [0.006]	-0.007 [0.010]
Business diversity	-0.035** [0.018]	-0.018* [0.018]	-0.062** [0.028]
Environmental and geographical capacity characteristics (*EGC* i)			
Residential	0.005*** [0.001]	0.007** [0.002]	0.003* [0.002]
Precipitation	0.006* [0.003]	0.109*** [0.010]	0.025** [0.012]
Urban influence	0.0001* [0.0009]	0.0002* [0.0001]	0.0002*** [0.00006]

Note: Dependent variable: log per capita flood losses, Model 1: 1990 to 2009, Model 2: 1990 to 1999, Model 3: 2000 to 2009, * : statistical significance at 10%, **: statistical significance at 5%, ***: statistical significance at 1%, standard errors in Brackets

Table 3-2. Continued

Variable name	Model 1	Model 2	Model 3
Planning effort capacity characteristics (*PEC* $_i$)			
Regulation [a]	-0.036* [0.022]	-0.086** [0.026]	-0.045* [0.034]
CRS class [a]	-0.031* [0.019]	-0.011** [0.025]	-0.058** [0.027]
Mitigation plan [a]	1.06E-07 [3.86E-07]	1.08E-06 [4.62E-07]	2.78E-07 [5.22E-07]
Storm-ready [a]	-5.44E-07* [3.36E-07]	-8.91E-07** [4.00E-07]	-7.09E-07* [5.32E-07]
Levee [b]	-0.0008* [0.002]	-0.007** [0.002]	-0.011** [0.003]
Dam [b]	-1.74E-07 [1.87E-07]	-3.01E-07 [3.33E-07]	-2.96E-07 [4.15E-07]
Constant	12.84*** [1.86]	15.05*** [2.09]	11.61*** [3.51]
Number of Observation	1,266	1,266	1,266
Measures of fit			
Log likelihood	-204,824	-204,824	-204,525
AIC	409,675	385,234	399,117
SC	409,791	355,112	407,336
Likelihood ratio	10,292**	9,899**	10,005**
Spatial dependence test			
Moran's I (error)	0.501***	0.438***	0.496***
LM (lag)	37,992***	35,765***	37,110***
LM (error)	90,362	85,626	87,117

Note: Dependent variable: log per capita flood losses, Model 1: 1990 to 2009, Model 2: 1990 to 1999, Model 3: 2000 to 2009, a : nonstructural mitigation measures, b: structural mitigation measures, * : statistical significance at 10%, **: statistical significance at 5%, ***: statistical significance at 1%, standard errors in brackets, AIC is Akaike Info Criterion, SC is Schwarz Criterion

Among various environmental and geographic capacity characteristics, urban physical characteristics such as impervious surfaces and level of urbanization were positively associated with disaster losses. Consistent with the results of Brody and Gunn (2013) and Brody et al. (2014), both nonstructural hazard mitigation strategies such as a community rating system and building regulations and structural hazard mitigation measures such as levee length were inversely correlated with disaster losses.

3.6 Conclusions and Discussion

Natural disasters exacerbated by global climate change can potentially lead to an incremental rise in the vulnerability of economic, social, and environmental systems that affect such human needs as food or water availability, shelter, transportation, health, and ecosystem function. Across the globe, communities are becoming more vulnerable to natural hazards while simultaneously becoming less disaster resilient. In this study, I examined the association between community capacity and community resilience with specific reference to social, economic, environmental, and planning related characteristics at the county-level within the U.S. Mississippi River basin over the past 20 years.

Using the basic premise that natural disaster effects are social frameworks that require pro-active planning, I developed a spatio-temporal conceptual model for disaster risk reduction, climate change adaptation, and environmental change that involved local vulnerability, risk, and resiliency processes. Prior research on natural disaster effects attempted to reflect the spatial and temporal characteristics of socio-ecological situations or social systems. However, the results of previous studies generally lacked spatio-temporal changes and spatial dependencies with other places even though the impacts of non-routine events have changed over time at the local level. In this research, I filled this void by exploring the socio-ecological components of community resilience (as community capacity) that can contribute to reduced vulnerability to natural disasters and lead to enhanced disaster resilience.

Drawing upon socio-economic resilience and community capacity characteristics, I temporally and spatially analyzed community vulnerability using an integrative index and spatial clustering. In addition, I estimated the role of community capacity and planning effort in disaster risk reduction and environmental sustainability using spatial lag models. Results suggested that disaster losses had inverse associations with community social and economic structures, and that engaged social capital and social justice characteristics combined with local proactive planning in place before a disaster resulted in lower disaster losses and enhances to community resilience and environmental sustainability.

As discussed earlier, findings suggested that better community capacity and planning efforts prior to the occurrence of natural disasters lead to smaller disaster losses. To mitigate vulnerability, communities should set aside resources to make residents safer. For this, policy makers or planners at the local level need to work with residents planning for disaster mitigation or resiliency activities. Moreover, effective and proactive local policy making and planning can help minimize disaster loss while helping to make disaster-prone communities more resilient to future events.

Results suggested that disaster damage had a negative association with social and economic conditions and that engaged social capital, more equitable distributional characteristics, and local proactive planning in place before the disaster lead to lower disaster losses. Ultimately, community resiliency to natural disasters leads to sustainable development at the community level. Furthermore, sustainable development increases the opportunity for achieving disaster resiliency in a community. For this reason, lessons learned from past natural disasters can help planners and policy makers predict problems, prepare for future disasters and provide " an opportunity to influence public policy focused on disaster risk" (Cutter et al., 2014, p. 65).

In addition, lessons to be learned here are that with crucial disaster resilience practice—in collaboration with local responses to natural hazards, sharing hazard mitigation plans and comprehensive plans with regard to social and ecological issues—can improve local responses to natural disasters in the future and promote tools for resilience. Therefore, it is necessary that local communities implementing integrated disaster resilience solutions (that combine structural and non-structural measures) (Jha et al., 2012) recognize the principles of social and ecological resilience and pursue specific tools and techniques for enhancing and strengthening responses to natural disasters.

Although this research offers empirical insights into community resilience to natural disasters, it is still quite preliminary and contains important limitations. As with many studies utilizing standardized secondary data, I was constrained by the limited number of analytical variables. It is difficult to use existing data to address individual-level perceptions or behavioral responses reflective of diverse economic and social variables affected by natural disasters. As suggested by Deshkar et al. (2011), Rivera and Settembrino (2013), Yamamura (2013), and Newman et al. (2014b), future research needs to include data on resident or community risk perceptions or behavioral responses of diverse economic and social status affected by natural disasters. Examples of which include the extent to which natural disasters affect perceptions of social and economic inequality and social capital (or social networks). This could be done through a variety of primary data collection mechanisms within disaster affected study areas.

In addition, given that there are spatial and temporal attributes of social and economic status influenced by unexpected natural disasters, I was limited by nonlinear causality and spatial heterogeneity in addressing disaster resilience due to the lack of efficiently scaled geographic datasets. In order to overcome this limitation and conduct truly meaningful spatial and temporal analysis, future research needs to utilize spatial data at more micro-levels (e.g., sub-county geographic units) across broader time frames. Despite these limitations, this study addresses an overview of natural disaster vulnerability and resiliency estimation from spatial-temporal perspectives in hazard-prone areas. Such a theoretical and practical approach can help to remove the limitations of previous related studies (i.e., nonlinear causality regarding unexpected events) (Kim et al., 2015).

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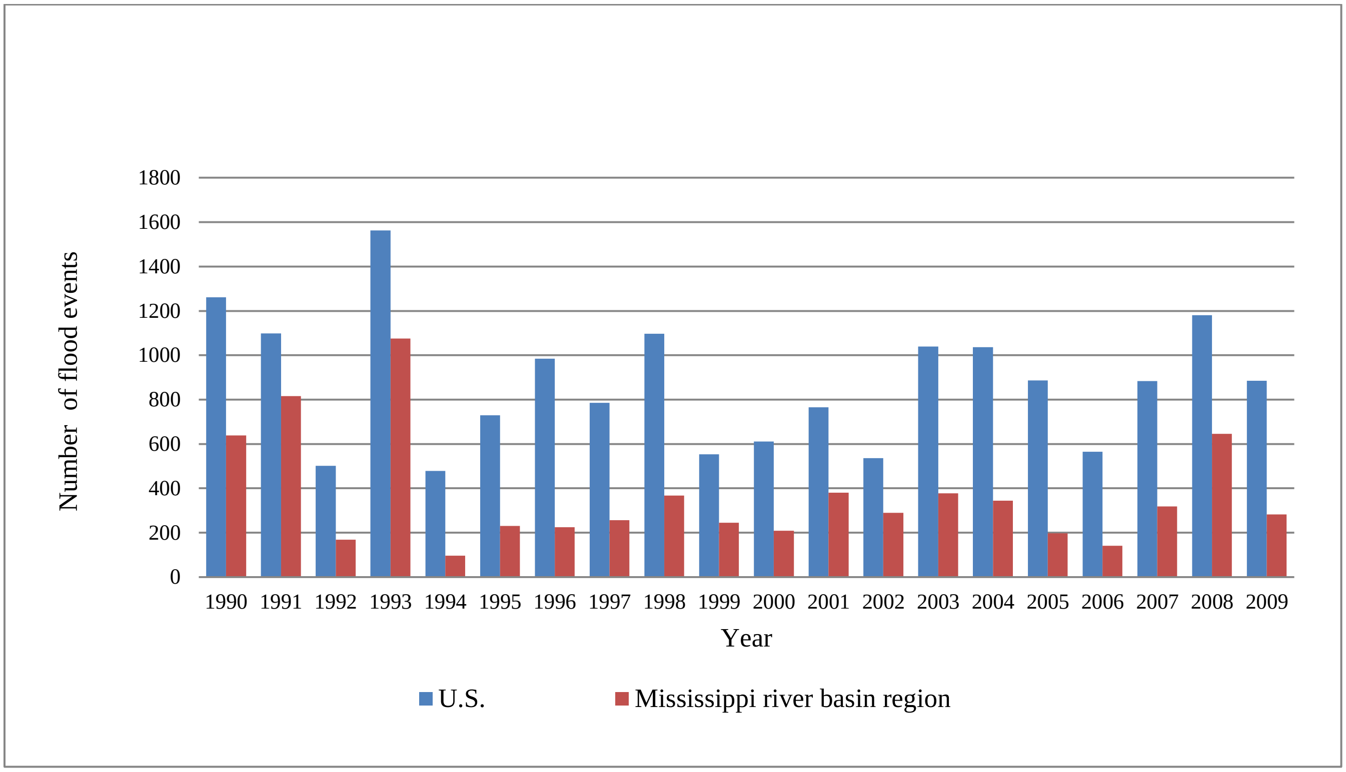
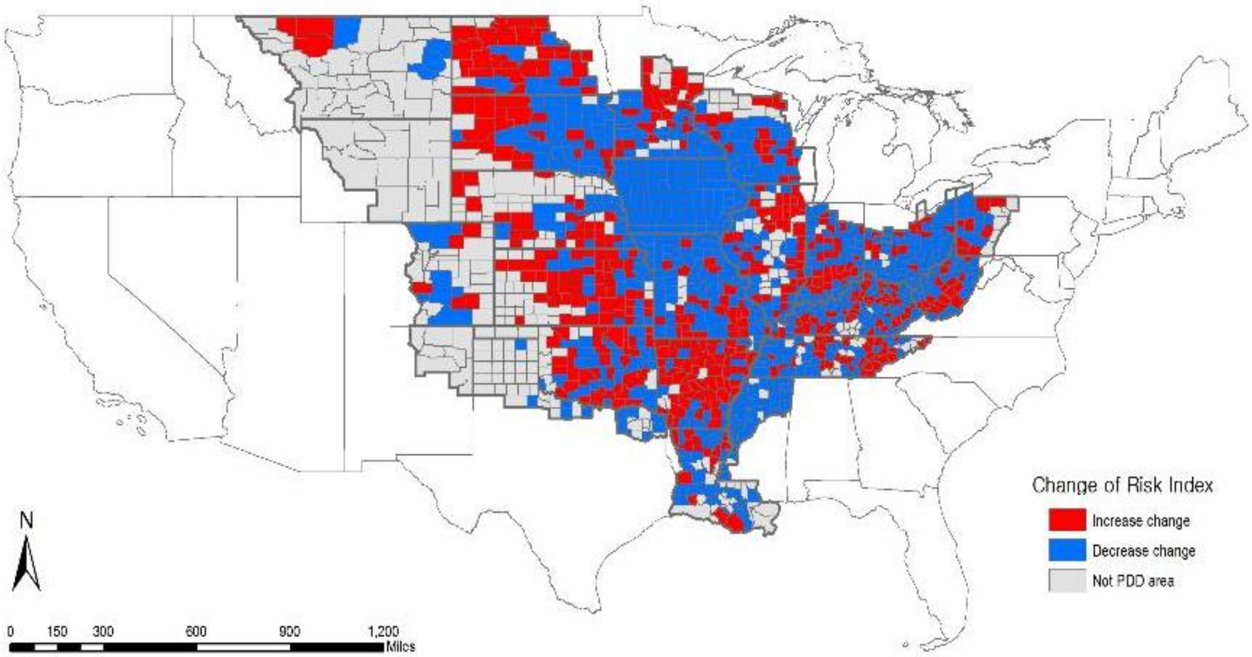


Appendix 3-1. Total Number of Flood Events That Caused at Least $ 50,000 in Damages to Properties and Crops from 1990 to 2009

Source : Peterson et al. (2013)

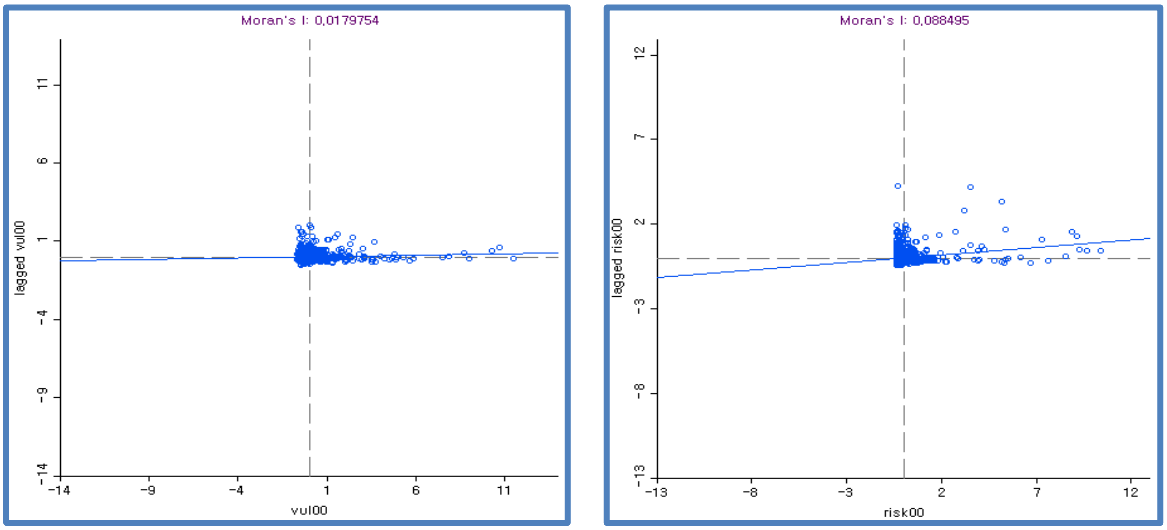


Appendix 3-2. Two Decades Change in Risk Index from 1990 to 2009

Appendix 3-3. Rankings of Flood Vulnerable and Risk Communities among the Study Areas

		Vulnerability index				Risk index	
	Rank	Counties	Index1[a]	Index 2[b]	Index 3[c]	Counties	Index 1[a]
Top 20 vulnerable and risk communities	1	Franklin (MO)	1.0000	11.474	1.0000	Hancock (IL)	663.04
	2	Greene (MO)	0.9361	10.694	0.9377	La Crosse (WI)	616.03
	3	Vernon (MO)	0.8998	10.251	0.9023	Randolph (IL)	594.06
	4	Lawrence (KY)	0.7918	8.9325	0.7969	Brown (IL)	583.07
	5	Renville (ND)	0.7720	8.6903	0.7776	Jersey (IL)	570.09
	6	Scott (IA)	0.7026	7.8422	0.7099	Whiteside (IL)	548.20
	7	St. Croix (WI)	0.6724	7.4735	0.6804	Jefferson (PA)	492.05
	8	Champaign (OH)	0.5369	5.8187	0.5483	Morgan (IL)	472.25
	9	Dickey (ND)	0.5202	5.6146	0.5320	Otero (CO)	436.03
	10	Ringgold (IA)	0.4890	5.2331	0.5015	Saline (MO)	404.05
	11	Sevier (TN)	0.4636	4.9237	0.4768	Mississippi (MO)	363.11
	12	Woodford (KY)	0.4558	4.8275	0.4692	Ramsey (MN)	355.01
	13	St. James (LA)	0.4498	4.7548	0.4634	Cass (IL)	352.12
	14	Knox (KY)	0.4383	4.6138	0.4521	Morgan (CO)	350.01
	15	Oneida (WI)	0.4249	4.4508	0.4391	Sioux (NE)	342.24
	16	Leflore (MS)	0.4064	4.2248	0.4210	Madison (AR)	341.12
	17	Raleigh (WV)	0.3848	3.9606	0.3999	Merrick (NE)	319.05
	18	McKenzie (ND)	0.3625	3.6882	0.3782	Jackson (IA)	285.24
	19	Sherman (KS)	0.3599	3.6569	0.3757	Vernon (WI)	275.08
	20	Bedford (TN)	0.3522	3.5624	0.3681	Hot Spring (AR)	270.09
Bottom 20 vulnerable and risk communities	1	McLean (KY)	0.0000	-0.7402	0.0246	McLean (KY)	0.0000
	2	Adair (IA)	0.0027	-0.7069	0.0272	Scott (KY)	0.0086
	3	Knox (OH)	0.0080	-0.6415	0.0324	Harrison (KY)	0.0147
	4	Scott (KY)	0.0086	-0.6351	0.0330	Scioto (OH)	0.0149
	5	Rock Island (IL)	0.0095	-0.6240	0.0338	Johnson (KS)	0.0152
	6	Iroquois (IL)	0.0098	-0.6198	0.0342	Casey (KY)	0.0152
	7	Edmunds (SD)	0.0098	-0.6196	0.0342	Scott (MN)	0.0185
	8	Johnson (TN)	0.0102	-0.6150	0.0346	Summers (WV)	0.0196
	9	Woodford (IL)	0.0105	-0.6113	0.0349	Elliott (KY)	0.0201
	10	Clay (AR)	0.0108	-0.6079	0.0351	Redwood (MN)	0.0202
	11	Williams (ND)	0.0108	-0.6074	0.0352	Franklin (AR)	0.0209
	12	Winnebago (IA)	0.0110	-0.6055	0.0353	Wyandotte (KS)	0.0210
	13	Dekalb (IL)	0.0110	-0.6050	0.0354	Hughes (OK)	0.0211
	14	Ashtabula (OH)	0.0114	-0.6041	0.0354	Van Buren (IA)	0.0213
	15	Blount (TN)	0.0111	-0.6038	0.0355	Harrison (IN)	0.0222
	16	Fulton (AR)	0.0112	-0.6032	0.0355	Jackson (SD)	0.0223
	17	Kanawha (WV)	0.0113	-0.6011	0.0357	Richland (MT)	0.0226
	18	Huntington (IN)	0.0118	-0.5954	0.0361	St. Francis (AR)	0.0228
	19	Ramsey (MN)	0.0119	-0.5939	0.0363	Franklin (IL)	0.0228
	20	Pike (AR)	0.0123	-0.5896	0.0366	Henry (IA)	0.0228

Note: a : Min-max transformation, b: Maximum value transformation, c: Z score, State name in parentheses



Appendix 3-4. Moran Scatter Plot for Vulnerability Index (Left Side) and Risk Index (Right Side) between 2000 and 2009

CHAPTER 4

PLAN QUALITY MATTERS IN MITIGATING FLOOD RISK AND ENHANCING COMMUNITY RESILIENCE

Abstract

Looking over the severe disaster losses within the U.S. Mississippi River basin areas over the past 20 years, I address the effect of local hazard mitigation plan quality on mitigating disaster risk and the relationship between plan quality and community resilience. Using content analysis and previous principles of plan quality measures, I evaluate local hazard mitigation plans to determine how well they support disaster risk reduction. Incorporating the results of local hazard mitigation plan quality evaluations and selected community resilience factors, I assessed the role of plan quality and community resilience in flood risk reduction using a log-linear model, two stage least squares, and a quantile regression model. Findings suggest that better plan quality and high community resilience results in reducing disaster losses.

Keywords: Community resilience, Flood risk, Plan quality, Quantile regression, TSLS, Vulnerability

4.1 Introduction

The Indian tsunami in 2004 and Japanese tsunami in 2011, Haiti earthquake in 2010, Hurricanes Katrina and Rita in 2005 and Sandy in 2012, together with the current worldwide evidence of climate related disasters and climate change underscore the fact that communities and people are increasingly becoming more vulnerable to natural hazards (Gopalakrishnan, 2013). It is estimated that in the last ten years, major natural disasters affected more than 3 billion people, killed over 750,000 people, and cost about US$600 billion (Birkmann, 2006). The increasing trend in weather disasters combined with the potential for massive losses suggests that our communities are not resilient enough to natural disasters. Natural hazards can have overwhelming short- and long-term impacts on the natural and built environments, ultimately affecting local communities and their social and economic conditions.

As part of social and economic conditions at the local level, planning and public policy components are associated with disaster preparedness and mitigation in the disaster management cycle (Mileti, 1999; Schwab et al., 2007). Several studies (e.g., Baynham and Stevens, 2014; Berke et al., 2014 b; Bunnell and Jepson, 2011; Burby, 2005; Burby et al., 1998; Lyles et al., 2014b; Nelson and French, 2002; Olshansky, 2001; Stevens and Shoubridge, 2014) claimed that careful attention to natural hazards in the preparation of local comprehensive plans (including a hazard mitigation plan, land use planning, local disaster recovery plan, and involvement of local planners) can result in reducing disaster losses thus improving adaption to climate change and assisting with the rebuilding of communities after the impacts of a disaster. Communities with high quality of local hazard mitigation plans and more rigorous hazard mitigation programs can be linked to resilient and sustainable community development (Kacupu et al., 2013).

Most studies (e.g., Berke et al. , 2012; Brody, 2003a; Burby and Dalton, 1994; Horney et al., 2012; Kang et al., 2010; Lyles et al., 2014b) focused on state planning mandates, state or local hazard mitigation plan quality measures, integrating hazard mitigation and local land use planning, and the influence of the quality of the state plan in local plan quality. These provide useful findings in addressing public policy responses to natural disasters within the coastal disaster-prone states that include Florida, California, Georgia, Washington, North Carolina, and Texas. However, few studies have been conducted on the effect of the degree of local natural hazard mitigation plan quality and various community capacity characteristics on enhancing community disaster resilience in inland flood-prone counties within the U.S. Mississippi River basin areas.

Given that this research will involve a qualitative evaluation of local natural hazard mitigation plan quality and quantitative measures for community resilience in the disaster-prone areas, results will be useful in addressing community resilience to natural disasters. Such a theoretical and empirical approach can help public policymakers better understand natural disaster planning and community resilience. Furthermore, as a result, planners can more effectively implement planning and policies to mitigate future natural disaster impacts and improve local community resilience.

In this study, I examine the role of community-based hazard mitigation plan quality in risk reduction and the relationship between the plan quality measures and community resilience. Using content analysis and previous principles of plan quality measures, I evaluate local hazard mitigation plans of 160 counties within the U.S. Mississippi River basin areas to determine how well they support disaster risk reduction. Incorporating results of local hazard mitigation plan quality measures and selected community resilience factors, I assessed the influence of plan quality and community resilience on flood risk reduction using a log-linear model, two-stage least squares, and a quantile regression model.

4.2 Hazard Mitigation and Plan Quality Evaluation

A plan is a document produced as an outcome of the planning process; an important indicator of planning effort and a blueprint for future actions (Baer, 1997; Burby and May, 1997; Wang, 2012). In recent years, a theory has emerged that a plan can indicate both the quality of the planning process and the strength of implementation. Formulating a good plan is a starting point for accomplishing goals and implementing policies. Most planners agree that the implementation of a plan is important, as is keeping the plan updated and maintaining its quality. What is a good plan? Defining the key characteristics of plan quality provides criteria for evaluating whether or not a plan is good.

The study of plan evaluation and quality has evolved with the planning profession and has been more focused on the methods and processes in plan making rather than questioning the components of plan quality (Berke and French, 1994). In the initial stage, there were a few attempts to define what constitutes high quality plans. Based on a compilation of ideas and criteria from a previous study, Baer (1997) suggested a list of about sixty items along with eight basic classifications. The eight classifications were: adequacy of context, rational model considerations, procedural validity, adequacy of scope, guidance for implementation, approach, data, methodology, quality of communication, and plan format.

In addition, through evaluating housing and land use in comprehensive plans, Fishman (1978) noted that the best plan contained specific goals associated with local conditions and policies linked with specifically stated action-oriented language. Likewise, based on the examination of a local emergency plan quality, Wenger et al. (1980) suggested that components for high quality plans consisted of fact finding, frequent community-wide exchanges of information, and proposals for action.

More recently, studies on plan quality and evaluation have been conceptualized and systematized by contemporary researchers (Berke, 1994; Berke and French, 1994; Berke et al., 1996; Burby and Dalton, 1994; Chapin and Kaiser, 1979; Kent, 1991) who have evaluated comprehensive plans related to natural disasters. With an emphasis on the characteristics of plan quality suggested by Chapin and Kaiser (1979) and Kaiser et al. (1995), these scholars identified three elements of plan quality: fact basis, goals and objectives, and policies, tools, and strategies.

Fact basis draws implications from the existing and emerging local status and identifies needs in the context of a community's physical development. Goals and objectives represent general aspirations, problem alleviation, and needs that are premised on shared local values. Policies, tools, and strategies, including actions, serve as a general guide for decisions about the location, density, type and timing of public and private development to assure that plan goals are achieved. Furthermore, based on the above three components of plan quality, many researchers have developed a coding protocol which incorporates hazard mitigation measurement into these components.

Identifying whether state mandates result in a high plan quality related to natural hazard mitigation, Berke and French (1994), Berke et al. (1996), Deyle and Smith (1998), and Burby et al. (1998) suggested that state mandates in natural hazard mitigation can positively enhance local plan quality. By examining the relationship between plan quality and plan use in guiding local government development decisions, Berke and French (1994, p. 238) stated that "the highest quality plans are characterized by the degree to which fact basis defines local needs, goals are clear and comprehensive in demonstrating commitment to address needs, and policies are specific and action oriented in achieving plan goals."

In addition to the three components for plan quality evaluation, studies have included other elements such as intergovernmental relations (Berke, 1994; Burby et al., 1998), local commitment (Norton, 2005) and citizen participation (Brody, 2003a; Burby, 2003). By evaluating environmental plan quality, Brody (2003b) documented the extent to which local comprehensive plans can incorporate ecosystem management principles. The additional components encompassed inter-organizational coordination and capabilities and implementation. While inter-organizational coordination and capabilities refers to the ability of a local government to collaborate with other jurisdictions or organizations (Brody, 2003c), implementation indicates designation of responsibility, a timeline of action, plan updates, and monitoring of resource condition, and policy achievement (Berke et al., 2012; Brody, 2003c).

4.3 Plan Quality and Disaster Resilience

In general, resilience can represent the capacity of individuals or communities to deal with external perturbations (i.e., disturbances, stresses) as a consequence of social, political, and ecological change (Nelson et al., 2007; Norris et al., 2008; Peacock et al., 2012). Disaster resilience persists with the function and structure of diverse changes (Cutter et al., 2008) and recovers or bounces back from the change (e.g., lack of water resources, biodiversity loss or extinction, population displacement) (Beatley, 2009; Perrings, 2006).

As an important resilience factor, planning and public policy at the local level involves the extent to which the community has local emergency management plans, land use planning, development regulations (e.g., zoning ordinances), building standards (e.g., building codes), property acquisition (e.g., building relocation), critical public facilities, and taxation information (Beatley, 2009; Berke et al., 2014b; Burby et al., 1998; Nelson and French, 2002; Olshansky and Kartez, 1998).

Responding to the crucial role of planning and public policy in community disaster risk reduction and resilience, Wang (2012, p. 120) argued that since “planning is both a tool and a predictive take,” disaster management or planning can provide “access to decrease future uncertainties.” More specifically, Smith and Glavovic (2014, p. 408) demonstrated that having a high quality natural disaster hazard plan can “play a pivotal role in building capacity and facilitating more collaborative ways of thinking and working to achieve resilience and sustainability.” These efforts have established a consensus of the characteristics of plan quality that most affect local government decisions, and thus are most likely to achieve plan implementation (Berke and French, 1994; Stevens and Shoubridge, 2014). In other words, having a high quality natural hazard plan, particularly in disaster-prone areas, can lead to lower vulnerability and higher social and economic resilience (Nelson and French, 2002).

4.4 Research Design and Methods

4.4.1 Analytical framework and sample selection

Based on the literature review, an analytical framework was put forth to address the qualitative and quantitative approach for local hazard mitigation plan quality measures and community resilience. This framework included two phases: (1) evaluating local hazard mitigation plan quality within the disaster-prone counties damaged by flood events across the Mississippi River basin over the last 20 years and (2) along with the plan quality measures, examining the effectiveness of plan quality and community capacity in mitigating flood losses.

As illustrated in Figure 4-1, for the first phase on plan quality measure, I selected 1,266 counties with significant flood experience and presidential disaster declarations due to the flood losses within the Mississippi River Basin areas[11] over the last 20 years. Among these flood-prone counties, I reselected 507 counties with severe flood losses in response to the calculation of the flood risk index by comparing risk index between 1990s and 2000s. The selected 507 counties can be deemed ideal for investigating flood impacts on local social and economic status and examining factors contributing to community resilience.

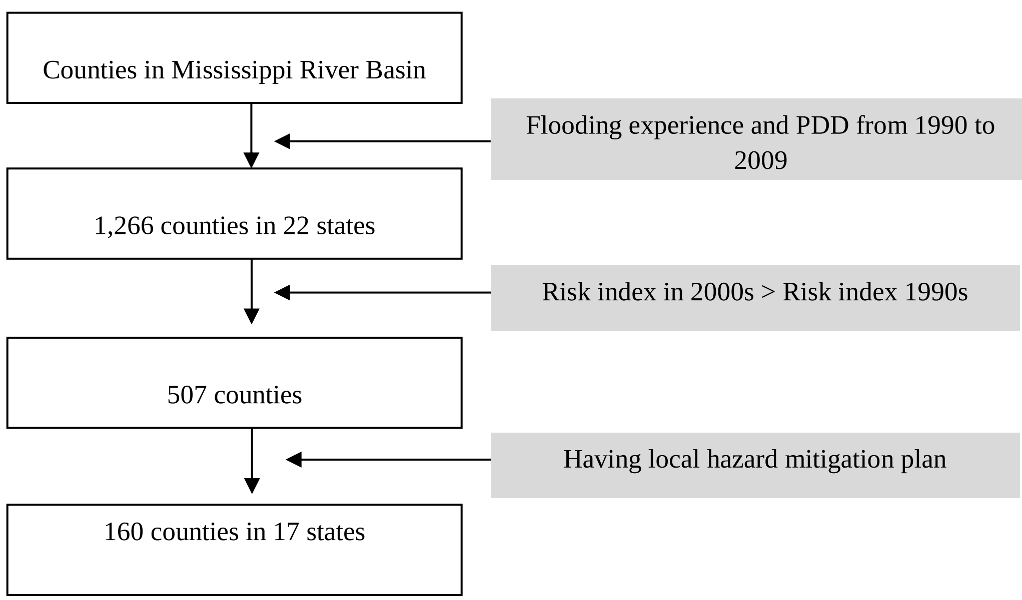


Figure 4-1. Sample Selection for Plan Quality Measure
Note: * PDD indicates Presidential Disaster Declaration

[11] According to the Peterson et al.'s (2013) study on the number of flood events that caused at least $50,000 in damages to property and crops from 1990 to 2009, the Mississippi River basin areas (encompassing four big rivers the Missouri, Mississippi, Ohio, and Arkansas River) have experienced approximately 40 % of overall flood events in the U.S. During that period, the 1993 floods within the Missouri and Mississippi River systems caused an "estimated US$16 billion in damage and cost the federal government about US$5.5 billion" (Daniels, 2014, p. 389). As a flood-prone area, the basin involves 24 states and about 1,600 counties in the U.S.

Among these counties, reconsidering the ability of obtaining local hazard mitigation plan documents from the official local government websites, I finally selected 160 counties in 17 states across the Mississippi River basin areas (see Figure 4-2). All local hazard mitigation plans were adopted between 2005 and 2014. Unlike random sample selection methods and coastal communities used in most previous hazard mitigation studies (e.g., Berke et al., 2012; Lyles et al., 2014a), the refined sample selection procedure used here is deemed appropriate for examining the role of plan quality or planning effort in disaster risk reduction since they were declared federal disaster areas by disaster losses and they have corresponded to the Disaster Mitigation Act (2000).[12]

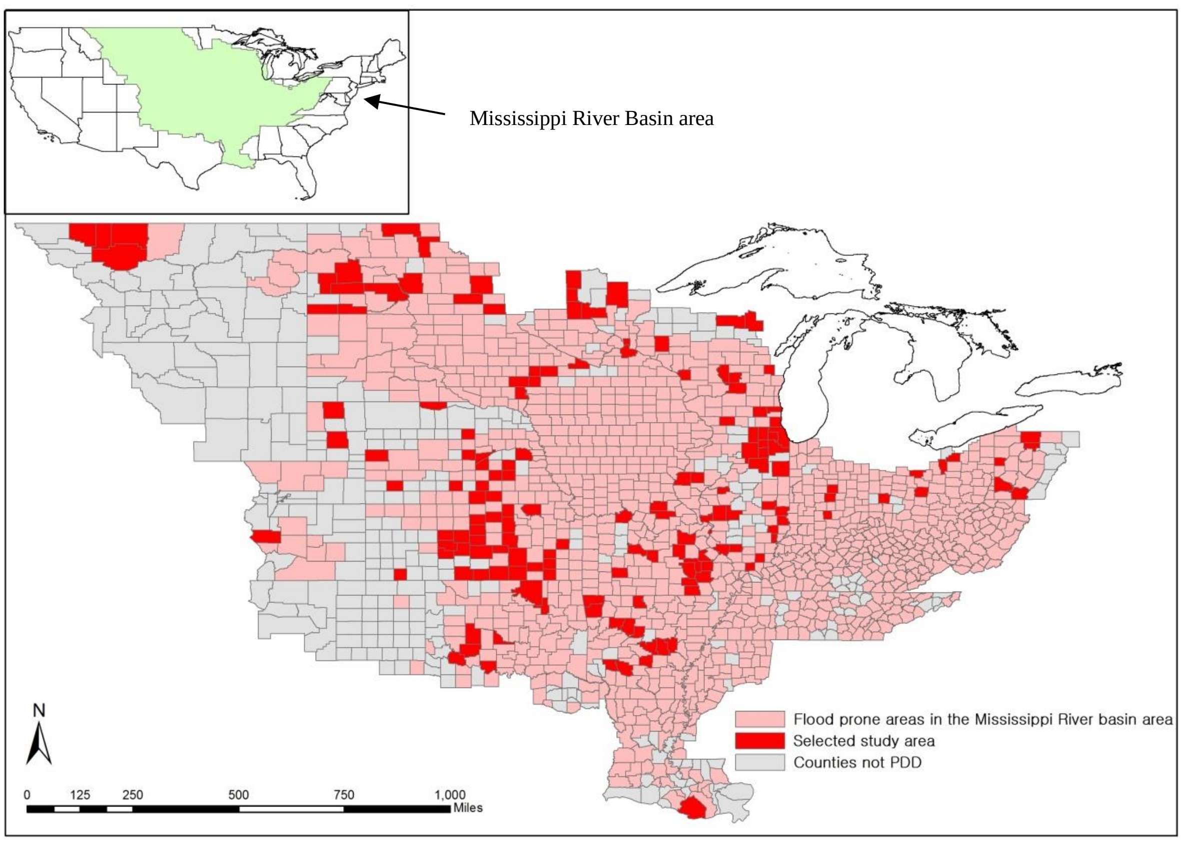


Figure 4-2. Study Area

[12] According to the works of Berke et al. (2012), Lyles et al. (2014a), and Yoon et al. (2012, p. 1), disaster mitigation act of 2000 needs pre-disaster mitigation plans from local governments in an attempt to be “eligible for certain types of federal funding.”

With respect to the second phase, in an effort to determine the effect of community capacity and planning efforts (including the results of plan quality evaluation in the first phase) on disaster losses and determine community resilience indicators, I analyzed the 160 counties (the same counties selected for the first phase) affected by flood events over the last 10 years. This phase is based on the available data collected from several official research sources at the county level. In this regard, this analytical procedure will be useful in providing important insights on how to make communities more resilient to the adverse impacts of natural disasters and in underscoring the critical importance of a local hazard mitigation plan in contributing to resilience. Furthermore, this finding will be helpful in emphasizing the proposition of Kacupu et al. (2013, p. 5) that "planning can reduce vulnerability through targeted emergency management plans or through broader comprehensive plans that incorporate disaster preparation and response elements"

4.4.2 Evaluation items for plan quality and data collection

From the previously referenced extensive literature on local hazard mitigation plan quality for this study, I adopted the definitions and components of plan quality principles derived from the recent works of Lyles et al. (2014a) and Masterson et al. (2014) (see Appendices 4-1 and 4-2). Drawing upon the specific plan quality evaluation items suggested by Stevens and Shoubridge (2014) (see Table 4-2), I conducted a content analysis with local plan documents associated with hazard mitigation. Such selected evaluation items also reflected the FEMA's requirements for local mitigation plans (FEMA, 2004) (see also Appendix 4-2).

As illustrated in Table 4-2, the quality evaluation protocol used in this study is composed of five principles and 60 items that include fact bases (15 items, *PQF* coded in Table 1), goals (9 items, *PQG* coded), policies (23 items, *PQP* coded), coordination (4 items, *PQC* coded), and implementation (9 items, *PQI* coded). As supported by Berke et al. (2012), Berke et al. (2014b), and Lyles et al. (2014a), in an attempt to enhance reliability in the evaluation process, each of the 160 local hazard mitigation plans collected primarily from official county websites were analyzed by two coders who independently coded based upon a plan quality evaluation scoring scheme.. Each item was coded and measured based on an equal weighting binary scale. In the scale, '0' indicated that the item in question was not identified and '1' indicated the item was identified or addressed. As suggested by Berke et al. (2014b) and Lyles et al. (2014a), if there was a point of disagreement between two coders, I attempted to reduce the disagreements by discussing each point and recoding. To check out the internal consistency among the disagreement scores, Cronbach's α was test. The five aggregated principles showed somewhat high level of internal consistency (Cronbach's α value ranged from 0.603 to 0.789) (see Table 4-2).

After the score of each item was summed within each principle, the summed scores were divided by the total score of each principle. Corresponding to the content analysis procedure of plan quality, I evaluated 160 local hazard mitigation plans to determine how well they supported natural disaster mitigation and enhanced community resilience to natural disasters.[13]

In an effort to engage in research on community resilience to natural disasters and evaluate planning efforts in the study areas over the last 10 years, multiple secondary research sources were collected from official websites such as the Federal Emergency Management Agency (FEMA), the U.S. Census Bureau (USCB), the Spatial Hazard Events and Losses Database for the United States (SHELDUS) at the Hazard Research Lab at the University of South Carolina, the U.S. County Business Pattern (USCBP), National Center for Charitable

[13] Based on these measurements, I ranked the top and bottom 10 from 160 counties listed in Appendix 4-3.

Statistics (NCCS), Dave Leip's Atlas of the U.S. Presidential Elections (DLAP), National Levee Database (NLD) and National Inventory of Dams (NID) from the U.S. Army Corps of Engineers, PRISM Climate Group (PRISM), NASA's MODIS classification (MODIS), and Economic Research Service (ERS) from the U.S. Department of Agriculture.

A variety of community capacity characteristics that include human and social capital (*HSC*), economic and housing (*EHC*), and environmental and geographic characteristic variables (*EGC*), planning effort variables (including the result of plan quality evaluation) (*PEC*) and disaster losses variables (*DL*) are reported in Table 4-1. In an effort to examine the role of community capacity in disaster risk reduction based on the assumption that planning effort capacity can be endogenous within the community capacity characteristics, a two-stage least square (2SLS) model[14] was used. Along with the dependent and endogenous variables *DL* (disaster losses) and *PEC* (planning effort) and various community capacities such as *HSC, EHC, EGC*, I investigate endogeneity, simultaneity or reverse causality of the variables, in particular planning effort capacity at each flood damaged county $_i$. The empirical model can be formulated:

$$\text{In } (DL_i) = g\,(HSC_i, EHC_i, EGC_i, PEC_i)$$
$$(PEC_i) = h\,(HSC_i, EHC_i, EGC_i, \text{In } DL_i) \qquad (4\text{-}1)$$

In this Eq. (4-1), as a dependent and endogenous variable (DL_i), the per capita dollar value of physical losses caused by flood events adjusted to year 2010 dollars (including property and crop losses) and aggregated to the county level was log transformed in order to better approximate a normal distribution. As another endogenous variable, planning effort (PEC_i), I used total plan

[14] According to Newey (1987) and Wooldridge (2006), under the presence of simultaneity (or endogeneity of a regressor), use of OLS may result in biased and inconsistent estimates. Such bias can be overcome while the dependent variable is continuous by using an appropriate instrumental variable estimation such as two-stage least squares (2SLS).

quality value variable (*total plan quality* variable)[15] from the evaluation result of each county's plan quality and population covered by multi-hazard approved mitigation plan variable (*mitigation plan* variable) (see Models (2) and (3) of Table 4-3).

In addition to the plan quality measures as non-structural hazard mitigation policies, the first panel showed that four variables, measured as a continuous scale, describe non-structural mitigation measures as well as structural mitigation measures. Based on the literature review on community capacity and community resilience (e.g., Aldrich, 2012; Aldrich and Meyer, 2014; Cutter et al., 2008; Cutter et al., 2014; Ersing and Kost, 2012; Ganapati et al., 2013; Kapucu et al., 2013; Kim and Marcouiller, in press; Nowell and Steelman, 2013; Peacock et al., 2012), the second, third, and fourth panel depicted the degree of human and social capital characteristics, economic and housing attributes, and environmental and geographic characteristics relative to natural disaster impacts all measured on continuous scale.

More specifically, human and social capital variables included educational attainment (percent of population with a bachelor's degree and over), language (percent of persons who can't speak English), race (percent of white population), age (percent of population over 65), health accessibility as a proxy for social justice or social service assets (total physicians per 10,000 population), and civic organizations and voter turnout as proxies for social capital attributes. In the economic and housing characteristic variables, five variables that included poverty (percent of poverty), per capita income, employment rate, economic diversity (as a single-sector economic base variable and non-economic diversity characteristics, percent of farming, fishing, and forestry industry, 11 coded industries classified by the North American Industry Classification System, NAICS), and resiliency industry (percent of public

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[15] In order to reflect the endogeneity of plan quality capacity in community capacity, I selected total plan quality measures instead of each plan quality measure results (*PQF*, *PQG*, *PQP*, *PQC*, and *PQI*).

administrative and education and health care services, 56, 61, and 62 coded industries categorized by NAICS) were involved in the community economic capacity. Housing characteristics included percent of housing units built in 1989 or earlier, the percent of mobile housing units, and percent of homeownership.

Table 4-1. Concept Measurement (*n*=160)

Variable name	Definition /measurement	Data source	Mean	SD	Range
Planning effort variables (*PEC*$_i$)					
Non-structural hazard mitigation principles					
PQF	Fact base score		2.15	0.44	1.16-2.66
PQG	Goals score		2.11	0.83	0-2.66
PQP	Policies score	Local hazard mitigation plan	1.66	0.88	0.01-2.66
PQC	Coordination score		1.71	1.06	0.25-2.66
PQI	Implementation score		1.64	0.77	0.78-2.65
Mitigation plan	Population covered by multi-hazard approved mitigation plan (1,000 person)		55.01	161.26	0-1,332.03
Storm-ready	Population in Storm-ready counties (1,000 person)	FEMA	37.74	155.91	0-1,332.03
Structural hazard mitigation policy					
Levee	Levee length (mile)	National Levee Database	2.88	7.86	0-44.30
Dam	Storage of Dams (1,000Acre-feet)	National inventory of dams	8.58	41.33	0-408.80
Human and social capital variables (*HSC* $_i$)					
Civic	Civic organizations per 10,000 population	County Business Pattern	15.25	9.38	4.35-88.65
Voter	Voter turnout (%)	Dave Leip's Atlas of presidential elections	43.62	6.56	27.08-69.08
Moving in	Year householder moved into unit (%)		57.32	7.46	42.8-77.60
Language	Language other than English (%)		4.76	3.70	0.70-25.1
Bachelor	Bachelor degree and over (%)		15.36	6.32	6.30-42.70
White	White (%)	US Census Bureau	88.14	13.63	39.20-99.10
Age	65-year old and over (%)		15.37	3.64	6.20-26.80
Female	Female householder (%)		10.01	3.73	4.30-25.10
Health access	Total physicians per 10,000 population		12.18	11.25	0-66.32
Economic and housing variables (*EHC* $_i$)					
Poverty	Poverty rate (%)		13.53	6.11	3.40-32.70
Homeowner	Owner-occupied housing (%)		74.84	6.91	51.90-86.50
Per capita income	Per capita income (1,000 US$)		28.37	4.31	18.47-41.56
Housing age	Year housing structure built (%)	US Census Bureau	12.49	7.15	2.40-41.70
Employ	Employment rate (%)		57.18	7.75	36.10-77.30
Housing value	Median housing value (1,000 US$)		108.28	37.91	52.20-247.10
Mobile home	Mobile home (%)		11.32	7.61	0.60-34.80
Economic diversity	Farming, fishing, forestry industry (%)	County Business Pattern	0.99	1.59	0-6.81
Resilient industry	Disaster-resilient industry (%)		13.92	3.42	4.74-24.47
Environmental and geographical variables (*EGC* $_i$)					
Residential	Residential area (%)	NASA's MODIS classification	16.47	18.43	0.19-79.78
Precipitation	Number of times precipitation exceeded the 75 percentile	PRISM Climate Group	8.70	3.47	0-11
Urban influence	Population covered by urban characteristics (1,000 person)	Economic Research Service	0.60	0.47	0-3.99
Disaster losses variable (*DL* $_i$)					
*Disaster losses**	Average flood losses (1,000,000US$)	SHELDUS	9.49	28.33	0-252.60

Note: *: inflation adjusted in 2010

With an emphasis on the proposition that OLS regression model offers "an incomplete picture of the relationship between variables and focuses on change at the conditional mean," I employed a quantile regression in relation to flood losses' magnitude in this study in an attempt to address " the entire conditional distributions of a dependent variable" (Davino et al., 2013; Hao and Naiman, 2007). Similar to the model elaborated in Eq. (4-1), I established a new equation in accordance with the extent of *DL* and community capacity characteristics (*HSC*, *EHC*, *EGC*, and *PEC*) and each flood damaged county *i*.

$$DL_{i\ 0.25} = \alpha_{0.25} + \beta_{0.25,i}, HSC_i + \beta_{0.25,i}, EHC_i + \beta_{0.25,i}, EGC_i + \beta_{0.25,\ i}, PEC_i$$
$$DL_{i\ 0.50} = \alpha_{0.50} + \beta_{0.50,i}, HSC_i + \beta_{0.50,i}, EHC_i + \beta_{0.50,i}, EGC_i + \beta_{0.50,\ i}, PEC_i$$
$$DL_{i\ 0.75} = \alpha_{0.75} + \beta_{0.75,i}, HSC_i + \beta_{0.75,i}, EHC_i + \beta_{0.75,i}, EGC_i + \beta_{0.75,\ i}, PEC_i \qquad (4\text{-}2)$$

In the Eq. (4-2), $DL_{i\ 0.25}$, $DL_{i\ 0.50}$, and $DL_{i\ 0.75}$ represent the degree of flood losses in the three level : 0.25 quantile, 0.50 quantile, and 0.75 quantile, respectively.

4.5 Findings

4.5.1 Assessing local hazard mitigation plan quality

As illustrated in Table 4-2, overall the quality of the 160 local plans provided strong factual bases for natural hazard mitigation or emergency management. A majority of the counties' hazard mitigation plans (over 80%, percentage indicates "percentage of item frequency") delineated the locations and magnitude of multiple hazards, historical record of prior hazard events, damage costs, vulnerable populations, and potential hazardous conditions or assets. However, only 44% of the plans ranked hazard threats to the local communities and about 55% addressed the connection between climate change and increased hazard risks. Only 61% of the plans included location and capacity of shelters and numbers of displaced residents caused by previous natural disasters.

With respect to the goals principle, composed of nine specific items, 79% of the local plans provide future desired conditions that reflect a breadth of values affected by public safety, reducing property damage, and increasing coordination and information. In particular, all of the total 160 plans addressed the protection of population and reduction of private and public property losses from hazards. More than 83% of the plans identified the preservation of natural environment for reducing hazard impacts and addressed hazards awareness programs. In addition, 85% of the local hazard mitigation plans suggested how to minimize fiscal impacts of hazards and measurable objectives for the goals. However, all of the plans failed to provide equal distribution for hazards management and only 67% addressed the overarching statement summarizing broad goals for overcoming natural disasters.

In terms of the policies principle, there were large variations among the 23 items applied in this study. As noted before, this principle provides a general guide to decisions about development and assures that plan goals are achieved. The goals principle consisted of property protection, preventative land use, structural controls, public information and awareness, natural mitigation features, and emergency services (Lyles et al., 2014a). All of the plans suggested on-going maintenance of man-made structures associated with hazard control and prohibition of development in the hazardous areas.

Table 4-2. Local Hazard Mitigation Plan Quality Evaluation Results

Principles and protocol items*	Item frequency (%)		Mean	Score
	0	1		
Fact base principles (15 items)				
• Delineates location of 1+ hazards	0	100	1	**2.66**
• Delineates location of environmental systems that protect people and /or development from hazards	13.1	86.9	0.88	2.35
• References other documents/plans that address hazard risk, vulnerability or mitigation	0.6	99.4	0.99	2.65
• Acknowledges connection between a changing climate and increased hazard risks	45.6	54.4	0.55	1.48
• Historical record of previous hazard events	18.7	91.3	0.81	2.16
• Indicates current numbers of people exposed to hazards	26.2	73.8	0.73	1.96
• Numbers of $ values of private structures exposed to hazards	16.8	83.2	0.83	2.21
• Local knowledge of residents with regards to the environment and potentially hazardous conditions was taken into account	13.7	86.3	0.86	2.30
• Numbers or $ values of different types of public infrastructure or critical facilities exposed to hazards	19.3	80.7	0.80	2.15
• Provides adequate space for expected future growth in areas located outside hazardous areas	5.6	94.4	0.94	2.51
• Delineates magnitude of 1+hazards	0.6	99.4	0.99	2.65
• Ranks hazard threats to community	56.2	43.8	0.43	1.16
• Indicates varying degree of segments within population to prepare, cope, and/or respond to hazard risks	12.5	87.5	0.87	2.33
• Demonstrates community's subjective interpretation of population elements or critical assets that are most vulnerable	17.5	82.5	0.83	2.21
• Location and capacity of shelters, and/or numbers of displaced persons	39.3	60.7	0.60	1.61
Overall mean	19.1	80.9	0.77	2.15
Cronbach's α	0.632			
Goals principles (9 items)				
• Protect/enhance safety of population from hazards	0	100	1	**2.66**
• Reduce hazard impacts that also achieves preservation of natural areas/open space/recreation areas	11.2	88.8	0.88	2.36
• Reducing property losses from hazards	0	100	1	**2.66**
• Overarching statement summarizing broad goals/objectives for addressing hazards	32.5	67.5	0.67	1.80
• Promote hazards awareness programs	16.2	83.8	0.90	2.40
• Reduce damage to public property from hazards	0	100	1	**2.66**
• Minimizing fiscal impacts (other than property loss) of hazards	15.0	85.0	0.85	2.26
• Distribute hazards management costs equitably	100	0	0	0
• Measurable objectives for any goal	17.5	82.5	0.82	2.20
Overall mean	21.4	78.6	0.79	2.11
Cronbach's α	0.789			

Note: * adopted from Stevens and Shoubridge (2014)

Table 4-2. Continued

Principles and protocol items*	Item frequency (%) 0	Item frequency (%) 1	Mean	Score
Policies principles (23 items)				
• References storm/rain water management or watershed management in relation to hazard control	28.7	71.3	0.71	1.90
• References changing/upgrading building standards for hazard risk management	16.8	83.2	0.83	2.21
• References an existing/desired special study area or impact assessment related to hazards	33.7	66.3	0.66	1.76
• References setbacks as a way to reduce hazard exposure	12.5	87.5	0.87	2.33
• Designates specific land uses as a result of hazard identification (other than outright prohibition on development)	20.6	79.4	0.79	2.11
• Capital improvements that include consideration of disaster risk management	43.7	56.3	0.56	1.50
• References public acquisition of hazardous lands/properties	87.5	12.5	0.12	0.33
• Limit access to hazard areas and/or discuss evacuation routing capacities	12.5	87.5	0.87	2.33
• References cluster development as a way of avoiding/reducing development in hazardous areas	99.3	0.7	0.01	0.01
• Location/siting of critical facilities that includes consideration of disaster risk management	15.0	85.0	0.85	2.26
• References maintenance of man-made structures in relation to hazard control	0	100	1	**2.66**
• Prohibit development in hazardous areas	0	100	1	**2.66**
• Hazard early warning/response program	28.7	71.3	0.71	1.90
• Addresses public awareness/education with regards to risk management	10.0	90.0	0.90	2.40
• Measureable indicators for any policy	19.4	80.6	0.80	2.15
• References transfer of development rights as a way of voiding/reducing development in hazardous areas	94.3	5.7	0.05	0.15
• Financial incentives for disaster risk management	74.4	25.6	0.25	0.68
• Proposes/requires real estate disclosure of hazard risk	95.6	4.4	0.04	0.11
• References charging impact fees to support hazard mitigation	71.2	28.8	0.28	0.76
• Placing warning/educational signage in hazardous areas	3.80	96.2	0.96	2.56
• Retrofitting public structures that includes consideration of disaster risk management	12.5	87.5	0.87	2.33
• Addresses providing technical assistance to developers/property owners for mitigation actions	50.6	49.4	0.49	1.31
• References relocating/retrofitting private structures to make them more hazard resilient	30.0	70.0	0.70	1.86
Overall mean	37.4	62.6	0.62	1.66
Cronbach's α		0.610		
Coordination principles (4 items)				
• Desired/actual coordination with regional, or provincial government with regards to hazard mitigation	0	100	1	**2.66**
• Desired/actual coordination with federal government with regards to hazard mitigation	90.6	9.4	0.09	0.25
• Desired/actual coordination with other municipalities with regards to hazard mitigation	12.5	87.5	0.87	2.33
• Desired/actual coordination with private sector entities	40.0	60.0	0.60	1.60
Overall mean	35.7	64.3	0.64	1.71
Cronbach's α		0.603		

Note: * adopted from Stevens and Shoubridge (2014)

Table 4-2. Continued

Principles and protocol items*	Item frequency (%)		Mean	Score
	0	1		
Implementation principles (9 items)				
• Hazard related policies specify procedures for monitoring and evaluating implementation	31.2	68.8	0.68	1.83
• Plan has undergone review within the last five years	70.6	29.4	0.29	0.78
• Hazard related policies specify timelines for implementation	70.0	30.0	0.30	0.81
• References commitments of funds for hazard risk management activities	11.8	88.2	0.88	2.35
• Potential impacts of hazard mitigation activity in surrounding municipalities	0.6	99.4	0.99	**2.65**
• Identify organizations/agencies/individuals responsible for implementing hazard-related policies in plan	10.0	90.0	0.90	2.40
• Indication of a community based risk tolerance criteria that can be applied across hazard type	64.3	35.7	0.35	0.95
• Indicates a method for incorporating new hazard related information as it becomes available	21.2	78.8	0.78	2.10
• Indicates that there has been, or will be, evaluation of losses from hazards over time	65.0	35.0	0.35	0.93
Overall mean	38.3	61.7	0.61	1.64
Cronbach's α	0.718			

Note: * adopted from Stevens and Shoubridge (2014)

In keeping with the proposition that "flood warning services need to be integrated with overall disaster management activities" (Shrestha et al., 2015, p. 249), over 90% addressed public awareness or education with regard to risk management and warning or educational signage in hazardous areas. Over 65% of the selected counties' plan delineated preventive land use tools including building standards for hazard risk management (83.2%), impact assessment (66.3%), setbacks (87.5%), location of critical facilities (85%), and retrofitting or relocating private structures (70%). However, only 12% suggested public acquisition of hazardous land and only 0.7% of the 160 plans identified cluster development as a way of avoiding development in the disaster-prone areas. Additionally, few of them described the transfer of development rights (5.7%) and real estate disclosure of hazard risk (4.4%) as another measure to reduce development in the hazardous areas. This result failed to reflect the suggestions of American Planning Association (December 2014, p. 50) that " …Your plan [comprehensive plans or hazard mitigation plans] and the implementing zoning, may want to consider density transfer techniques - such as cluster and transferable development rights- to protect wetlands, to preserve density so important for smart growth, and to limit claims for takings."

The coordination principle, consisting of 4 items included integration with other planning initiatives, planning processes, and identification of specific techniques to engage the public with regard to hazard mitigation (Lyles et al., 2014a). These generally provided somewhat strong conditions within the selected plans. More than 60% of the counties addressed desired or actual coordination with regional government (100%), other municipalities (87.5%), and private sector entities (60%). However, only 9.4% of the plans suggested coordination with the federal government. In the implementation principle with attention on the assignment of organizational responsibilities, timelines, and funds to implement a plan, 80% or less of the plans suggested funds for hazard risk management activities and potential impacts of hazard mitigation activities. However, less than 36% addressed specific timelines for implementation, community-based risk tolerance criteria, and plans for evaluation of hazard losses over time. Moreover, 70% failed to provide a review process within the last five years.

4.5.2 Identifying the role of plan quality and community resilience in disaster risk reduction

Based on the document-based evaluation of local hazard mitigation plan quality, I examined the effectiveness of plan quality and community capacity in mitigating flood losses in the flood-prone areas. As described in Table 4-3, three different regression models were used to isolate the impacts of selected planning efforts and community capacity components of flood losses. Along with a dependent variable, logged per capita dollar value of physical losses caused by flood events during the last 10 years, from 2000 to 2009, an OLS regression model was estimated on three different types of hazard mitigation measures. Model (1) focused on the effect of non-structural hazard mitigation measures (including the evaluation results of plan quality, population covered by a mitigation plan approved by FEMA, and population covered by storm-ready policies) and varied community capacity attributes on disaster losses revealed that most of the plan quality principles and social capital attributes, educational attainment, social service assets, economic level (including per capital income level, housing value) were negatively correlated with flood losses. Unexpected, structural hazard mitigation measures such as levee and dam construction failed to play an important role in modifying the amount of physical losses from flood events.

As depicted in equations (4-1), based on the diagnostic test result for endogeneity of instrumental variables (Wald test of exogeneity = 8.72 at the 90% confidence level), I used 2SLS estimation on Models (2) and (3). Compared to the OLS result, the result suggested that the magnitude of the coefficient on disaster losses changes slightly after controlling for the endogeneity of planning effort characteristics, *Total plan quality* and *Mitigation plan* variables. Similar to the result in Model (1), social capital attributes, educational attainment, social service assets, economic level (including per capital income level, housing value) were negatively correlated with flood losses.

Table 4-3. OLS, 2SLS, and Quantile Regression Results

Variable name	OLS	2SLS		Quantile regression		
	(1)	(2)	(3)	(4)	(5)	(6)
Human and social capital characteristics						
Civic	0.009	-0.013	-0.017	0.001	0.004	-0.003
	[0.010]	[0.014]	[0.023]	(0.026)	(0.016)	(0.012)
Voter	-0.084**	-0.067**	-0.178*	-0.094*	-0.046*	-0.056*
	[0.035]	[0.029]	[0.101]	(0.062)	(0.037)	(0.028)
Moving in	0.044	0.060	0.054	0.014	0.026	0.029
	[0.036]	[0.046]	[0.054]	(0.038)	(0.038)	(0.029)
Language	0.025	0.019	0.058	0.015	0.017	0.020
	[0.080]	[0.096]	[0.110]	(0.079)	(0.047)	(0.035)
Bachelor	-0.087*	-0.111*	-0.043*	-0.057*	-0.072*	-0.116**
	[0.048]	[0.062]	[0.078]	(0.081)	(0.048)	(0.036)
White	0.029	0.002	0.038	0.027	0.005	0.025
	[0.034]	[0.050]	[0.052]	(0.050)	(0.030)	(0.022)
Age	0.089	0.041	0.188	0.009	0.043	0.109
	[0.069]	[0.083]	[0.157]	(0.124)	(0.074)	(0.055)
Female	0.013	0.097	0.197	0.073	0.004	0.002
	[0.152]	[0.217]	[0.306]	(0.238)	(0.142)	(0.106)
Health access	-0.013*	-0.004*	-0.047*	-0.031*	-0.011*	-0.001*
	[0.019]	[0.019]	[0.046]	(0.034)	(0.020)	(0.015)
Economic and housing characteristics						
Poverty	0.073	0.109	0.027	0.104	0.013	0.041
	[0.048]	[0.065]	[0.084]	(0.100)	(0.060)	(0.045)
Homeowner	-0.016	-0.025	-0.048	-0.012	-0.007	-0.012
	[0.038]	[0.036]	[0.068]	(0.067)	(0.040)	(0.030)
Per capita income	-0.001*	-0.0001*	-0.0001*	-0.001*	-0.005*	-0.006*
	[0.0001]	[0.0006]	[0.0008]	(0.0001)	(0.0006)	(0.0006)
Housing age	0.024	0.019	0.085	0.008	0.011	0.048
	[0.037]	[0.030]	[0.082]	(0.064)	(0.038)	(0.028)
Employ	-0.051	-0.068	-0.017	-0.069	-0.008	-0.007
	[0.036]	[0.044]	[0.069]	(0.056)	(0.038)	(0.025)
Housing value	-9.39e-06	-6.55e-06	-0.0001	-0.0001	-8.91e-07	-8.17e-06
	[9.90e-06]	[0.0001]	[0.0001]	(0.0001)	(8.37e-06)	(6.28e-06)
Mobile home	0.030	0.037	0.018	0.027	0.021	0.004
	[0.028]	[0.028]	[0.041]	(0.055)	(0.033)	(0.025)
Economic diversity	-0.069	0.114	0.132	-0.021	-0.002	-0.063
	[0.088]	[0.125]	[0.109]	(0.180)	(0.108)	(0.081)
Resilient industry	-0.119**	-0.147**	-0.094**	-0.042	-0.050	-0.085**
	[0.048]	[0.058]	[0.031]	(0.085)	(0.051)	(0.038)
Environmental and geographical characteristics						
Residential	0.012	0.018	0.049	0.024	0.011	0.005
	[0.011]	[0.013]	[0.031]	(0.021)	(0.012)	(0.009)
Precipitation	0.009	0.040	0.005	0.007*	0.011*	0.030*
	[0.081]	[0.091]	[0.096]	(0.104)	(0.062)	(0.046)
Urban influence	0.0008*	0.0008*	0.0006*	0.006	0.001	0.001
	[0.0003]	[0.0003]	[0.0003]	(0.005)	(0.003)	(0.002)

Note: Dependent variable for OLS and 2SLS model is log per capita flood losses and for Quantile regression model is per capita flood losses, heteroscedasticity robust standard error in bracket, bootstrapped standard error in parentheses, * : statistical significance at 10%, **: statistical significance at 5%, Model (4) : 0.25 quantile, Model (5): 0.50 quantile, Model (6): 0.75 quantile

Table 4-3. Continued

Variable name	OLS	2SLS		Quantile regression		
	(1)	(2)	(3)	(4)	(5)	(6)
Planning effort characteristics						
Plan quality measures						
Total plan quality		-1.150* [2.710]	+			
(1) *Fact base*	-0.731* [1.828]			-0.064* (2.621)	-0.653* (1.565)	-0.688* (1.174)
(2) *Goals*	-0.603* [1.342]			-0.539* (2.803)	-0.415* (1.674)	-0.694* (1.255)
(3) *Policies*	0.294 [2.183]			-0.295 (3.366)	-1.350 (2.010)	-1.884 (1.508)
(4) *Coordination*	-2.613** [1.000]			-2.304* (1.863)	-0.939* (1.112)	-0.237* (0.834)
(5) *Implementation*	-0.271 [1.164]			-0.171 (0.152)	-0.212 (1.110)	-0.327 (1.272)
Hazard mitigation measures						
Mitigation plan	-1.24e-06 [2.32e-06]	+	-0.0003 [0.0002]	-1.41e-06 (4.08e-06)	-1.58e-06 (2.43e-06)	-1.54e-06 (1.83e-06)
Storm-ready	-4.75e-07 [1.94e-06]	-1.35e-06 [1.35e-06]	-0.0002 [0.0002]	-2.76e-07 (3.74e-06)	-7.73e-07 (2.23e-06)	-1.47e-07 (1.67e-06)
Levee	-0.010 [0.017]	-0.003 [0.019]	-0.011 [0.030]	-0.021 (0.030)	-0.032 (0.018)	-0.005 (0.013)
Dam	-5.70e-07 [2.94e-06]	-8.69e-07 [3.71e-06]	-8.69e-07 [3.71e-06]	-4.5e-07 (5.49e-06)	-7.21e-07 (3.28e-06)	-3.19e-09 (2.46e-06)
Constant	-10.094 [7.138]	-9.497 [7.944]	-15.211 [10.927]	-12.740* (9.191)	-0.124 (5.489)	1.563 (4.117)
Number of Observation	160	160	160	160	160	160
F	2.50**					
Wald-Chi-square		62.87***	42.57**			
R-squared	0.350	0.260	0.251			
Pseudo R-squared				0.229	0.138	0.165

Note: Dependent variable for OLS and 2SLS model is log per capita flood losses and for Quantile regression model is per capita flood losses, heteroscedasticity robust standard error in bracket, bootstrapped standard error in parentheses, * : statistical significance at 10%, **: statistical significance at 5%, Model (4) : 0.25 quantile, Model (5): 0.50 quantile, Model (6): 0.75 quantile

In an attempt to estimate how community capacity characteristics and planning efforts affect flood losses differently at different points in the losses' conditional distribution, a quantile regression model was employed at the 0.25, 0.50, and 0.75 quantiles. In models (4) to (6), per capita cost of flood losses was used as a dependent variable in an effort to represent the effect of community capacity characteristics on a quantile distribution of flood losses. The regression results suggested some important differences across different points in the conditional distribution of flood losses changes. While the resilient industry variable was negative and statistically insignificant at the 0.25 and 0.50 quantile, the variable was positive and significant at the higher end of the distribution.

This finding suggests that the resilient industry variable played a crucial empirical role in mitigating the flood losses at a higher level of the damage distribution. Similar to the result in the OLS regression and 2SLS estimation, whereas most principles among five plan quality measure variables were inversely related to the disaster losses caused by a flood event at all the quantiles, all the structural hazard mitigation measures had no effect on disaster losses. This finding implies that high quality plans associated with hazard mitigation can contribute to mitigate disaster losses and further foster community resilience.

4.6 Conclusions and Discussion

In this study, I empirically examined the effect of local hazard mitigation plan quality and community capacity characteristics on mitigating disaster risk and reducing vulnerability to disasters in the flood-prone areas within the U.S. Mississippi River basin. Using content analysis and previously described principles of plan quality, I evaluated local hazard mitigation plans to determine how well they supported disaster risk reduction and promoted resilience to disasters. Incorporating the result of local hazard mitigation plan quality evaluations and selected community resilience factors, I assessed the role of plan quality and community resilience in flood risk reduction using a log-linear model and a quantile regression model.

In terms of plan quality evaluation, whereas all of the plans failed to provide equal distribution for hazards management and only 67% addressed the overarching statement summarizing broad goals for overcoming natural disasters, most of the plans suggested on-going maintenance of man-made structures associated with hazard control and prohibition of development in the hazardous areas. Less than 36% addressed specific timelines for implementation, community-based risk tolerance criteria, and plans for evaluation of hazard losses over time and 70% failed to provide a review process within the last five years.

By examining the effectiveness of plan quality and community capacity in mitigating flood losses in the flood-prone areas, I concluded that the positive role of better plan quality and high community resilience in reducing disaster losses.

Natural disasters become crises when unambiguous failures of public and private decision-making create outcomes that interrupt local activity. Whereas disaster vulnerability reflects the frequency and intensity of naturally occurring large-scale materialized risks, disaster resilience refers to the capacity of people and organizations to develop adaptive responses to perturbations that protect communities from potential loss. Together with the basic premise that disaster effects are fundamental social process responses that require pro-active planning, a conceptual model of disaster loss factors involves hazard exposure, shock, and loss within the context of inherent social system vulnerability and resiliency (Masterson et al., 2014). Specific research questions involve alternative levels of community development, social system status, and their influence on disaster resilience.

In integrating social and ecological planning (or environmental planning) to alleviate negative effects on the disaster-prone social or ecological conditions, new strategies encompassing these principles that incorporate long-term planning and implementation, land use, and structural and non-structural designs are necessary. The key lesson to be learned here is that with crucial disaster resilience practice—in collaboration with local responses to natural hazards, sharing hazard mitigation plans and comprehensive plans with regard to social and economic issues—can improve local responses to natural disasters in the future and promote tools for resilience. Therefore, it is necessary that local communities (local authorities) implementing disaster resilience plans and “strengthening participatory planning and development capacity” recognize the principles of community resilience and pursue specific tools and techniques for enhancing and strengthening responses to natural disasters (Khailani and Perera, 2013, p.615). In addition, in order to engage communities in building capacity, it is essential for foundation knowledge in decision making to include “community characteristics, specifically hazard exposures, physical vulnerability [or risk], and social vulnerabilities” (Masterson et al., 2014, pp. 183-184).

Drawing upon the proposition that “disasters are manifestations of failures in environmental governance and sustainability, and that linkage should be more explicitly acknowledged” (Tierney, 2012, p. 358), this study takes on both planning and decision-making frameworks that act to simultaneously minimize vulnerability elements of a community while maximizing resiliency elements. Based upon a review of the extant literature, two central theoretical hypotheses are proposed. First, higher levels of community capacity will result in lower disaster-related losses; and second, establishing better planning efforts, social capital, and social justice systems prior to an occurrence of a natural disaster will lead to reduced disaster losses.

This approach improves on previous work by incorporating tacit stages of development, social capital, social justice, and distributional elements that speak to social and economic inequity. Results from this review of extant knowledge suggest that disaster damage likely has an association with social and economic structure, and that engaged social capital, more equitable distributional characteristics, and local pro-active planning in-place before a disaster results in lower disaster losses (Pearce, 2003). In this sense, this study responds to Hawkins’ (2013, p. 146) work on the critical role of planning and policy in disaster risk reduction and community resilience:

> "…plan development and implementation is essential for building community resilience because planning policy can shape land development patterns and reduce the risk to populations within hazardous areas and the vulnerability to disasters…"

Despite the novelty of this study focusing on the role of natural hazard mitigation plan quality and community resilience in disaster risk reduction, limitations exist for the work. Given the limited research area based exclusively on counties within the Mississippi River basin area and flood events, some would assert that generalizing the empirical findings to other locations and natural hazards. For this reason, future research should embrace additional study areas, including coastal disaster-prone states that include Florida, California, Georgia, Washington, North Carolina, and Texas and reflect the impacts of multi-hazards. These broad viewpoints can help to contribute to multi-hazard cross-national comparisons concerning disaster research (Peacock, 2002).

In addition, as to community capacity characteristics, in this study I utilized standardized secondary data. It is difficult to use existing data to address individual-level perceptions or behavioral responses reflective of diverse economic and social variables affected by natural disasters. As suggested by Deshkar et al. (2011), Rivera and Settembrino (2013), Yamamura (2013), and Newman et al. (2014), future research needs to include survey or interview based data on resident or community risk perceptions or behavioral responses of diverse economic and social status affected by natural disasters. Examples of which include the extent to which natural disasters affect perceptions of social and economic inequality and social capital (or social networks). This could be done through a variety of primary data collection mechanisms within disaster affected study areas.

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Appendix 4-1. Definitions and Components of Plan Quality Principles and Items Evaluated in the Prior Studies *

Principles	Definition	Components of principle	Items evaluated in each local hazard mitigation plan quality					
			Stevens and Shoubridge (2014)	Lyles et al. (2014)	Horney et al. (2012)	Tang et al. (2008)[b]	Brody (2003b)	Nelson and French[c] (2002)
Fact base	• Empirical foundation that key hazard problems are identified and prioritized, and mitigation policy-making	Hazard assessment; vulnerability assessment; risk assessment; assessment of administrative, technical and policy capabilities	15	106	60	8	10	21
Goals	• Future desired conditions that reflect breadth of values affected by the plan	Protecting public safety; reducing property damage; increase coordination and information	9	13	14	4	10	11
Policies	• General guide to decisions about development and assure that plan goals are achieved	Property protection; preventative land use; structural controls; public information and awareness; natural mitigation features; emergency services	23	43	108	17	43	42
Coordination	• Recognition of the interdependent actions of state and local organizations that need coordination for plan implementation and ormal and informal actors engaged in preparing the plan	Integration with other planning initiatives (e.g., comprehensive planning, disaster recovery, and emergency operations); planning process and identification of specific techniques to engage public	13	13	184	3		
Implementation	• Assignment of organizational responsibilities, timelines and funds to implement a plan	Information about agencies responsible for actions, proposed timeline and estimated costs		16[a]	188	5		

Note:*: modified from Lyles et al. (2014, p.91), a: including items in monitoring and participation principle, b: Tsunami hazard management plan coding protocol, c: Seismic safety management plan quality components

Appendix 4-2. Components of Local Mitigation Plans according to FEMA Guidelines: Elements and Critical Issues*

Element		Critical issues
Planning process (1)	• Planning process	• Open public involvement process (neighboring communities, business, and other interested parties) • A plan should include the document about planning processes, how the plans were prepared, who was involved in the process, and how the public was involved • Review and incorporation of existing plans, studies, and technical information
Risk assessment (7)	• Identifying hazards	• Description of all natural hazards that can influence the jurisdiction
	• Profiling hazards	• Location or geographic areas of all hazards • Extent of all natural hazards • Probability, likelihood, or frequency that the hazard events would occur • Past history of hazard events (e.g., damage, severity, duration, and date of occurrence)
	• Assessing vulnerability: overview	• Summary of the community's vulnerability assessment
	• Assessing vulnerability : identifying structures	• Description of vulnerable structures in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities
	• Assessing vulnerability: estimating potential losses	• Estimation of the extent of a hazard's impact on the structures in terms of dollar value or percentages of damage • Description of the methods used to estimate impact
	• Assessing vulnerability: analyzing development trends	• General description of land uses and development trends
	• Multijurisdictional risk assessment	• In multijurisdictional plans, the risk assessment must consider the entire planning area
Mitigation strategy (4)	• Local hazard mitigation goals	• Description of mitigation goals that can guide the development and implementation of mitigation actions
	• Identification and analysis of mitigation actions	• Identification of mitigation actions to achieve the aforementioned goals
	• Implementation of mitigation actions	• Description of how the actions are prioritized, implemented, and administered by local governments
	• Multijurisdictional mitigation actions	• List of each jurisdiction's actions in multijurisdictional plan
Plan maintenance process (3)	• Monitoring, evaluating, and updating the plan	• Description of the schedules and methods of monitoring, evaluating, and updating the plans
	• Incorporating into existing planning mechanisms	• Indication of how mitigation plans will be incorporated into other existing plans such as comprehensive plans, capital improvement plans, and zoning and building codes
	• Continued public involvement	• Description of how governments will continue public involvement in the plan maintenance process

Note: * adapted from Masterson et al. (2014, pp. 119-120) , number of elements is parentheses

Appendix 4-3. Rankings of Local Hazard Mitigation Plan Quality Evaluation among 160 Counties

	Rank	Counties	Evaluation value[a]	CRS class[b]	Approved mitigation plan[c]	Building regulation[d]
Top 10 communities with higher plan quality	1	Iroquois, IL	4.8695	11	No	Minimalist
	2	Cook, IL	4.8019	11	No	
		Fremont, CO	4.8019	6	No	Minimalist
	4	Pulaski, AR	4.7826	11	Yes	Enabling
	5	Grant, AR	4.7391	8	No	Enabling
	6	Montgomery, IL	4.6473	11	Yes	Minimalist
		Livingstone, IL	4.6473	11	Yes	
		LaSalle, IL	4.6473	11	No	
	9	Dekalb, IL	4.5797	11	No	
	10	Conway, AR	4.5381	11	Yes	Enabling
Top 10 communities with lower plan quality	1	Dawes, NE	1.9533	11	Yes	Enabling
		Fillmore, NE	1.9533	11	Yes	
		Franklin, NE	1.9533	8	No	
	4	Walworth, WI	2.0043	11	Yes	Mandatory
	5	Terrebonne, LA	2.2190	11	Yes	Enabling
	6	Audrain, MO	2.3301	11	Yes	Minimalist
		Monroe, MO	2.3301	11	No	
	8	Coles, IL	2.6504	11	No	Minimalist
	9	Racine, WI	2.6922	11	Yes	Mandatory
	10	Crawford, IL	2.6939	10	No	Minimalist

Note: a : equal-weighted sum values of 5 principles, b, c : derived from FEMA, d: derived from May (2013)'s state regulation provisions

CHAPTER 5

EVALUATING RURAL COMMUNITY RESILIENCE AND DISASTER RESPONSE: THE CASE OF FLOOD EXPERIENCE ALONG THE U.S. MISSISSIPPI RIVER

Abstract

In this research, I investigate the principles of social and economic resilience to natural disasters considering areas of the Mississippi River basin affected by flooding over the last 20 years. In an effort to address the challenges and opportunities faced by communities in response to natural hazards, I followed Beatley's (2009), Masterson et al' (2014), and Daniel's (2014) best practices in planning for community resilience and employed integrated spatio-temporal variations in disaster vulnerability. Through bringing together empirical evidence and comparative case studies within the context of rural community resilience, Results suggest that disaster-prone rural communities need to implement new social and environmental planning strategies to potentially mitigate negative effects of natural disasters that incorporate long-term planning and implementation, land use, and structural and non-structural mitigation designs.

Keywords: Flood, Planning, Resilience, Rural communities, Vulnerability

5.1 Introduction

Waugh (2013, p. 291) noted that

> "…Rural communities are particularly vulnerable because they lack the resources of urban areas and have populations that require greater support. …the impact of low management capacity on rural community resilience, in particular the lack of capacity for planning and program management necessary to manage hazards, prepare for disasters, respond to disasters, and recover quickly…."

This passage underscores the role of rural communities' capacity in reducing vulnerability and increasing resilience and also that rural communities tend to be more vulnerable to natural disaster damage than their urban counterparts. Rural communities, in general, have a lack of social and planning policy resources in the face of natural disasters and climate change impacts (Caldwell, 2015). In a broad sense, to further improve the resilience and effectively respond to natural disasters, it is essential for rural communities to have appropriate hazard management capacity and planning or policy efforts. In this regard, rural communities need to implement disaster resilience plans so that they can recognize the individual principles of community resilience and pursue specific tools and techniques for enhancing and strengthening responses to natural disasters.

Even though numerous studies conceptually addressed community disaster resilience through the comparison of urban and rural characteristics based on previous literature review and case studies (e.g., Shaw, 2013; Waugh, 2013) and empirically examined the urban and rural difference on community resilience by applying quantitative method (e.g., Brody and Gunn, 2013; Ganapati et al., 2013), few studies have been conducted using qualitative and quantitative measures on the role of community capacity and planning effort in enhancing resilience to natural disasters with a focus on rural communities and planning practices for community resilience.

The purpose of this Chapter is to investigate the principles of social and economic resilience to natural disasters employing a case study approach for two rural communities— Hancock County in Illinois and Crawford County in Wisconsin that sit in the center of one of the most disaster-prone areas of the United States. More specifically, in this paper I explore the socio-economic components of resilience that can contribute to improved disaster recovery. Together with the application of socio-economic resilience principles to the study areas, this study attempts to accomplish the following research objectives:

- To select socio-economic factors contributing to community resilience along the Mississippi River counties affected by flood events by using socio-economic census data
- To identify how community responds to short-term impacts of natural disasters with a focus on economic capacity by using longitudinal data analysis
- To examine whether the disaster response plan is effective in reducing disaster losses by surveying two rural communities' local hazard mitigation plans and comprehensive plans

Following this introduction, this chapter is organized into four subsequent sections. First, I attempt to integrate disaster resilience and rural communities with an overview of the recent resilience literature on socio-economic resilience factors. This is then followed by a proposed analytical framework for selecting community resilience factors and case studies within planning effort and rural context. This includes both an acknowledgment and discussion of existing knowledge that significantly contributes to the formation of rural community resilience. The next section empirically investigates the role of community capacity in enhancing resilience to natural disasters with comparison of urban and rural characteristics and assesses the resilience of selected rural communities within disaster prone areas. The final section provides conclusions and relevant policy implications.

5.2 Disaster Resilience and Rural Communities

Over time, the concept of resilience has been applied to diverse social-economic systems in accordance with thematic domains like social and economic change, ecosystems, and environmental change; and individual, community, region, national, and international spatial domains. If resilience is addressed in relation to social and environmental situations (or change), it can be represented as the capacity of individuals or communities to deal with external perturbations (i.e., disturbances, stresses) as a consequence of social, political, and ecological change (Berkes, 2007; Nelson et al., 2007; Norris et al., 2008; Peacock et al., 2012). In addition to this definition, social and environmental resilience persists with the same controls on the function and structure of diverse changes (Berkes, 2007; Cutter et al., 2008) and recovers or bounces back from the change (e.g., lack of water resources, biodiversity loss or extinction, population displacement) (Beatley, 2009; Perrings, 2006). For instance, in light of ecological systems, conserving, diversifying, and nurturing biodiversity can be helpful in increasing environmental resilience, stability, and its function (Adger, 2000; Berkes, 2007).

Given the dynamic association between social resilience and dependence on natural resources, resilience can be determined by institutional change, economic structure, and demographic change (Adger, 2000). As a detailed indicator for this resilience measurement, both institutional change and economic structural factors include economic growth, income stability and distribution, and environmental variability (Adger, 2000). At the local or community level, the resilience factor encompasses formal sector employment, crime rates, and demographic change factors (e.g., mobility, migration). Regarding demographic change, in particular, significant population movement can be evidence of instability or it could be a component of enhanced stability and resilience. In particular, in terms of economic vulnerability in rural areas, numerous studies (e.g., Kacupu et al., 2013; Saenz and Peacock, 2006; Shaw, 2013; Wilson, 2010) claim that rural areas are more vulnerable to natural disasters since they are primarily less diverse; dependent on a limited set of economic sectors such as agricultural or fishing without other adequate alternative employment sources. These represent the "tendency for rural communities to have higher levels of social vulnerability – less education, lower income, and higher unemployment" (Ross, 2014, p. 83).

The measurement or indicator of social resilience can be more specifically observed in the work of Cutter et al. (2008). Based on community resilience to natural disasters from a variety of research perspectives, variables for measuring resilience were described in combination with the competence of ecological, social, economic, institutional, infrastructure, and community systems (Cutter et al., 2008; Kapucu et al., 2013; Peacock et al., 2012). In particular, under the attributes of natural disasters and disaster risk reduction (Cutter et al., 2008; Mercer et al., 2007), ecological and institutional systems are determined by factors like floodplain area, soil permeability, wetlands acreage and loss, erosion rates, impervious surfaces, precipitation, biodiversity (Brody and Gunn, 2013; Brody et al., 2014), participation in hazard reduction programs, hazard mitigation plans, emergency services, zoning and building standards, emergency response plans, and continuity of operations plans (Cutter et al., 2008). Most notably, local governments with poor economic status have difficulty in preparing for emergency management. These constraints can be associated with rural communities' challenges in engaging planning with disaster resilience (Kacupu et al., 2013). Due to the lack of planning capacity to manage hazards, rural communities' responses to emergencies are less certain (Kacupu et al., 2013; Waugh, 2013).

Community resilience (urban or rural) components include social and economic factors, infrastructure, and community competence factors (Adger, 2000; Cutter et al., 2008; Cutter et al., 2014; Peacock et al., 2012). Social and economic resilience indicators can be addressed by demographics, social networks and embeddedness (i.e., social capital), community value-cohesion, faith-based organizations, employment, values of property, wealth generation, and municipal finance or revenues (Aldrich, 2012; Ersing and Kost, 2012; Nowell and Steelman, 2013). In particular, as components of community resilience in rural systems, Bryant (2015) suggested the situation regarding preparedness and training, family and business finances, dynamics of communities, the ability of different actors and citizens to work together for a more sustainable system, and local and regional initiatives.

With a focus on rural communities and economic and social resilience, Hofferth and Iceland (1998), Lannoo et al. (2012), and Ross (2014) argued that rural communities have a stronger tie with neighborhoods than do their urban counterparts. Conversely, Whitman et al. (2013) assumed that since rural communities are declining in population funding for public space (as a place for social engagement) can be reduced. As expected, in rural context, "population is dispersed and the decline in some economic facilities may lead to reduced resilience" (McManus et al., 2012, p. 22). In this regard, I hypothesized that rural characteristics with higher social capital or social network and lower population and economic status can play a positive or negative role in enhancing community resilience to natural disasters.

In addition, infrastructure resilience factors in the context of environmental hazards include lifelines and critical infrastructure, transportation networks, residential housing stock and age, and commercial and manufacturing establishments (Cutter et al., 2008). These resilience indicators address physical systems and have a dependence or interdependence on other infrastructures. Based on community attributes, indicators of community competence resilience involve health and wellness, quality of life, and absence of psychopathologies (Deshkar et al., 2011). A resilient system is forgiving of external shocks (i.e., disturbances). Resilience shifts attention from purely being aimed at growth and efficiency to including recovery and flexibility (Pine, 2009; Walker and Salt, 2006). In terms of rural community resilience, Skerratt (2013, p. 36) claimed that the following six characteristics can be included as resilience factors: 1) outcome source, 2) resources and vulnerabilities, 3) cumulatively built mechanisms and pathways, 4) multi-scale, 5) constant change, and 6) implicit normative associations.

In this regard, resilience can be defined as the capacity of a system to absorb disturbances and reorganize while undergoing changes so as to still retain essentially the same function, structure and feedbacks—and therefore the same identity. Drawing upon the wider review of the resilience literature, in an attempt to address the challenges and opportunities faced by communities (in particular rural communities) in response to natural hazards, in this Chapter, I focus more on investigating the principles of social and ecological resilience to natural disasters than those of disaster vulnerability.

5.3 Research Design and Methods

5.3.1 Analytical framework and data collection

Based on the literature review concerning indicators of socio-ecological resilience and as illustrated in Figure 5-1, an analytical framework was devised to address the empirical as well as theoretical approach for the case study. First, I examined social-economic factors contributing to community resilience within the selected flood-prone counties along the U.S. Mississippi River over the last 10 years (*Phase I*). Second, among the flood vulnerable counties, I applied diverse disaster resilience principles and evaluated rural communities' response to flood events (*Phase II*).

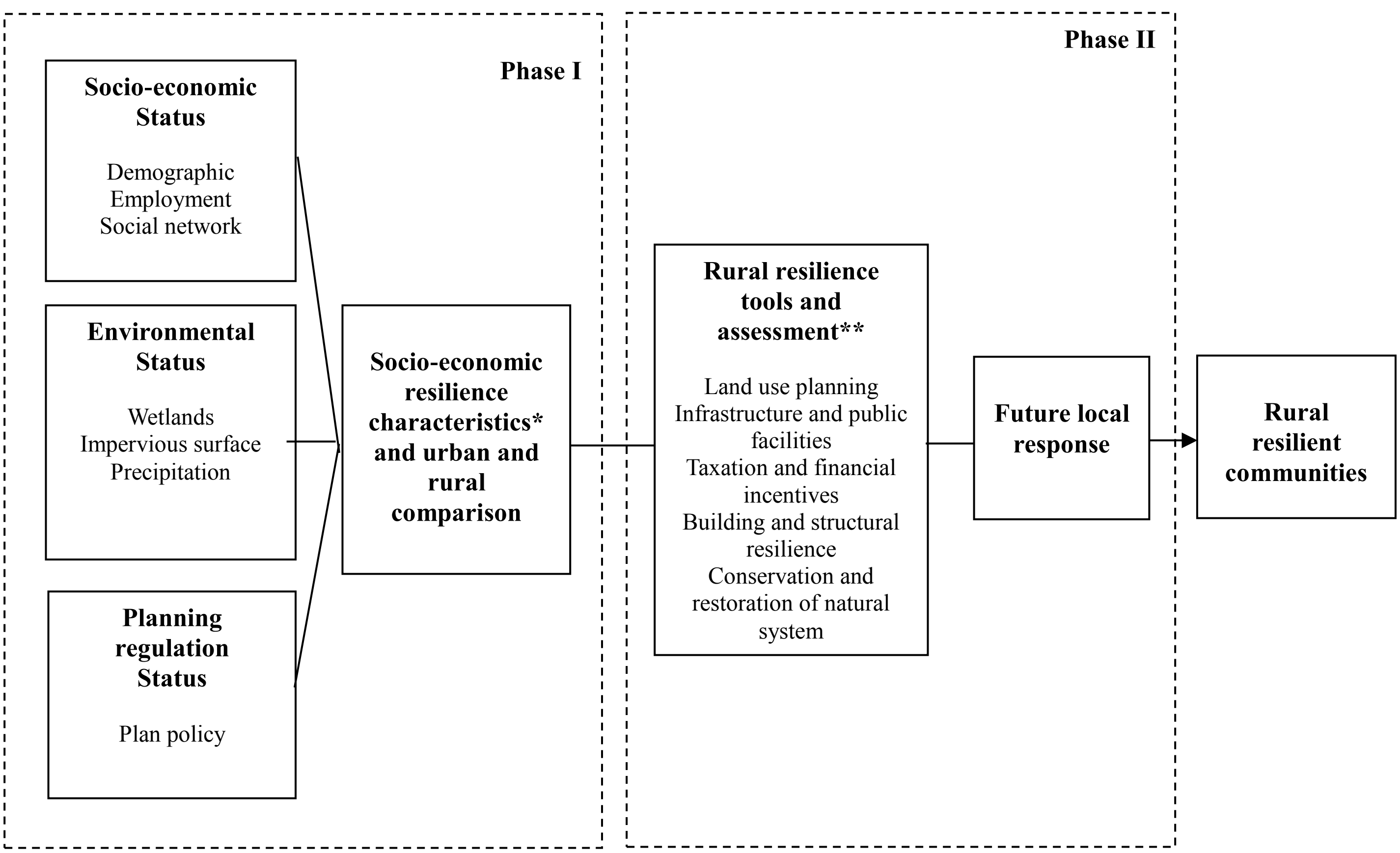

Figure 5-1. Analytical Framework
Note: *: secondary data based analysis, **: document based analysis

With respect to *Phase I,* socio-economic resilience characteristics that include various social, economic, environmental, and institutional situations can be determined in line with thematic domains like social and economic change, environmental change, and planning regulations associated with natural disasters. I analyzed 85 counties affected by floods in an effort to determine socio-ecological resilience indicators and compared the disaster resilience between urban and rural communities.

From the results of the flood risk index level and spatial clustering of the index during the last decades (see Appendix 5-1), I selected the study areas among flood vulnerable counties within the Mississippi River basin areas. This phase is based on the available data collected from several official research sources that include the U.S. Census Bureau, the Federal Emergency Management Agency (FEMA), the U.S. Census Bureau (USCB), PRISM Climate Group at the U.S. Northwest Alliance for Computational Science and Engineering (PRISM), Dave Leip's Atlas of Presidential Election (DLAPE), NASA's MODIS classification (MODIS), and the Spatial Hazard Events and Losses Database for the United States (SHELDUS) at the Hazard Research Lab at the University of South Carolina.

In addition, in order to estimate the economic disaster resilience of 85 counties with the flood prone areas before and after flooding events, a time series analysis with an autoregressive integrated moving average (ARIMA) intervention model was used. In the case of representing a non-stationary in a time series, the non-stationary can be minimized through a proper differencing; in the end it can be viewed as stationary (Ismail et al., 2009). The ARIMA is useful in employing a non-stationary in a time series model. Furthermore, an extreme change in the mean of a time series is known as a structural change (Ismail et al., 2009). This change is caused by an intervention coming from both external and internal factors such as environmental law or regulation, stock stabilization, oil embargo, the bombing of the World Trade Center, or natural disasters. An ARIMA with an intervention model was used to estimate resiliency change before and after natural disasters following similar work conducted by Worthington and Valadkhani (2004) and Woosnam and Kim (2014).

The model simulates a variable's time series as the following stochastic process:

$$y_t = N_t \tag{5-1}$$

Where y_t is the variable and N_t is stochastic noise that can be modeled by a mixed autoregressive moving average process:

$$N_t = \frac{\mu(L)}{\sigma(L)} \partial_t \ ,$$

$$\begin{aligned} \mu(L) &= 1 - \mu_1 L_1 - \mu_2 L_2 - \mu_3 L_3 - \ldots\ldots - \mu_q L_q, \\ \sigma(L) &= 1 - \sigma_1 L_1 - \sigma_2 L_2 - \sigma_3 L_3 - \ldots\ldots - \sigma_p L_p \end{aligned} \tag{5-2}$$

Where L is a time lag and $\ldots\ldots \partial_{t-1}, \partial_t, \partial_{t+1} \ldots\ldots$ is a sequence of white noise. In order to test short-and long-term shifts caused by a distinct flood event, the time span S_t (T) is divided by the intervention time (span). The intervention variable is equivalent to 1 during intervention time (in this study, both 2002 and 2008 were used as the time the flooding occurred) and 0 otherwise. By doing so, the impact of flood occurring at any time was estimated as if the assessment was made after the flood events. In this study, I used an ARIMA model to examine how communities respond to short-term impacts of flooding with an emphasis on economic capacity.

Such selected disaster resilience indicators are also closely associated with resilience principles. For the case studies on rural disaster resilience (*Phase II*), I used five different documents from various printed and online sources (e.g., Hancock County Journal-Pilot) relevant to planning for local resilience, environmental planning, rural community capacity, each local hazard mitigation plan and comprehensive plan, each county's soil and lake survey document, and each county's online news. Particularly, the relevant academic literature includes Beatley (2009) on the "tools and techniques for enhancing and strengthening coastal resilience," Masterson et al. (2014) on the "planning for community resilience," Daniels (2014) on "environmental planning," Brown and Schafft (2011) and Wilkinson (1999) on "rural community characteristics and resilience."

Applying a close documentary case study approach, I attempted to address the application of resilience and the evaluation of two rural communities' responses to the flood events. Relying on multiple resources, this case study could be contextually based and triangulated. In order to investigate the effectiveness of disaster resilience and compare the resilience in rural communities, I selected Hancock County in Illinois and Crawford County in Wisconsin, based on similar levels of severe and high flood risk index and differing vulnerability indices (see Appendix 5-2) while controlling for comparable levels of socio-economic characteristics (see Appendix 5-3). Such analytical processes will be useful in providing important insights on how to make rural communities more resilient to the adverse impacts of natural disasters, in understanding the influence of community capacity on flood-resilient communities, and in underscoring the critical importance of a local hazard mitigation plan or comprehensive plan in contributing to resilience.

5.3.2 Descriptive analysis

Relying on a variety of data sources, descriptive analysis for *Phase I* focused on three characteristics of indicators associated with natural disaster losses within affected counties:

socio-economic characteristics, environmental characteristics, and disaster planning regulation characteristics. Based on the literature review, the numerous variables are presented in Table 5-1, together with the hypothesized effect of property damage (one of the main disaster losses) caused by natural disasters. First, as a dependent variable, the per capita dollar value of property losses from flood events (adjusted for inflation in 2010) aggregated to the county level was log transformed in order to better approximate a normal distribution. The socio-economic characteristic variables (from 2000 to 2009) included age (percent of population over 65), income (median household income), race (percent of white population), educational attainment (percent of population with a bachelor's degree), income inequality (Gini coefficient), and housing characteristics (percent of housing units built after 2000, percent of mobile housing units). As a proxy for social capital characteristic variables, the percentage of voter turnout was selected.

In terms of higher homeownership and a small number of elderly, urban counties in the study areas tend to exhibit better socio-economic characteristics that can play an important role in minimizing disaster vulnerability and have a positive influence on disaster resilience. As supported by Shaw (2013), since rural communities in this study have generally lower socio-economic characteristics including educational attainment, health accessibility, and income level, it is expected that rural jurisdictions can less effectively lead community resilience in flood hazards.

Table 5-1. Descriptive Statistics

Variable name	Definition/measurement	All counties (n=85)		Urban (n=50)		Rural (n=35)	
		Mean	SD	Mean	SD	Mean	SD
Disaster damage characteristics*:* Respondent variable							
*Flood losses**	Average flood damage (1,000,000 $)	15.34	42.67	17.95	44.05	11.84	41.06
Explanatory variables							
Socio-economic characteristics							
White[b]	White population/ total population (%)	91.11	12.04	90.26	13.77	92.33	9.05
Bachelor[b]	Bachelor degree or higher/ total population (%)	17.08	8.05	17.52	8.40	16.76	7.86
Female[b]	Female householder/total population (%)	9.20	3.07	9.51	3.51	8.78	2.27
GINI[b]	Income inequality	0.42	0.02	0.43	0.03	0.42	0.02
Health access[b]	Total physicians per 10,000 population	17.26	20.53	19.14	27.78	15.94	14.86
Income[b]	Median household income ($)	36,542	8,735	36,819	7,581	36,348	9,531
Economic diversity[b]	Farming, fishing, and forestry industry (%)	13.94	3.22	0.86	2.19	0.95	1.93
Employment[b]	Employment rate (%)	60.66	7.02	60.66	7.50	60.66	6.39
Housing age[b]	Built housing 2000 later / total housing units (%)	12.60	6.35	13.37	6.10	11.51	6.61
Mobile housing[b]	Mobile housing/total housing units (%)	9.44	6.69	10.28	7.53	8.24	5.15
Housing tenure[b]	Owner occupied / total housing units (%)	73.84	5.66	74.30	5.81	73.18	5.46
Age[b]	65 years and over /total population (%)	14.92	3.33	14.50	3.01	15.52	3.71
Voter[c]	Voter turnout (%)	45.83	6.21	45.40	6.21	46.46	6.26
Environmental characteristics							
Residential[d]	Residential area/ total area (%)	17.47	16.50	20.03	16.34	13.82	16.27
Precipitation[e]	Number of times precipitation exceeded the 75 percentile	8.35	3.52	9.06	3.09	7.34	3.88
Planning regulation characteristics							
Flood program[a]	Dummy-coded, whether or not a county participate in national flood program (yes=1, no=0)	0.05	0.23	0.06	0.23	0.05	0.23
Approved mitigation plan[a]	Dummy-coded, whether or not a county has an approved hazard mitigation plan from FEMA (yes=1, no=0)	0.69	0.46	0.62	0.49	0.80	0.40
Mandatory mitigation plan[a]	Dummy-coded, whether or not a county where state require mandatory hazard mitigation plan (yes=1, no=0)	0.10	0.30	0.06	0.23	0.17	0.38

Note: *: inflation adjusted in 2010, Units in parentheses, a: collected from FEMA, b: collected from USCB and USCBP, c: collected from DLAPE, d: collected from MODIS, e: collected from PRISM

As explanatory variables for environmental characteristics, the percent of residential areas in each county and the number of times precipitation exceeded the 75 percentile over the last 10 years were selected to represent the urban influence as proxies for impervious surfaces and flood exposure (Brody and Gunn, 2013; Brody et al., 2014). As expected, urban counties that exhibit higher population concentrations and dominated by residential areas as compared to their rural counterparts tend to be more vulnerable to flood events. As representatives for non-structural hazard mitigation measures, three planning characteristics that involve a flood program (dummy-coded, whether or not a county participate in the national flood program), an approved mitigation plan (dummy-coded, whether or not a county has a FEMA approved mitigation plan), and a mandatory mitigation plan (dummy-coded, whether or not a county is in a state that requires a mandatory hazard mitigation plan) were selected. Surprisingly and inconsistent with the claims of Waugh (2013), rural communities in the study areas are involved in more planning effort in disaster risk reduction than urban counties.

5.3.3 Study area and flood experience

With a focus on the two rural communities located adjacent to the Mississippi River (see Figure 5-2) selected for a case study on local disaster resilience, both Hancock County in Illinois and Crawford County in Wisconsin were agricultural regions that had a population of 19,104 and 16,644 in 2010, respectively (see Appendix 5-3). Since 1990, both counties' population has declined by about 4.4 to 10.6 percent. The rural nature of Hancock County and Crawford County exhibited employment rates in agricultural, forestry, fishing, and hunting industries of 32.8 and 41.5 percent, respectively.

The proximity to the Mississippi River makes both rural counties vulnerable to flood events. According to data provided by SHELDUS supported by the National Climate Data Center, Hancock County and Crawford County had severe flood losses during the last 10 years, from 2000 through 2009 (Crawford county had over US$ 12 million and Hancock County had about US$ 43million). These economic losses were significantly above the average damage costs for counties along the Mississippi River and within the Mississippi River basin areas (see also Appendix 5-3).

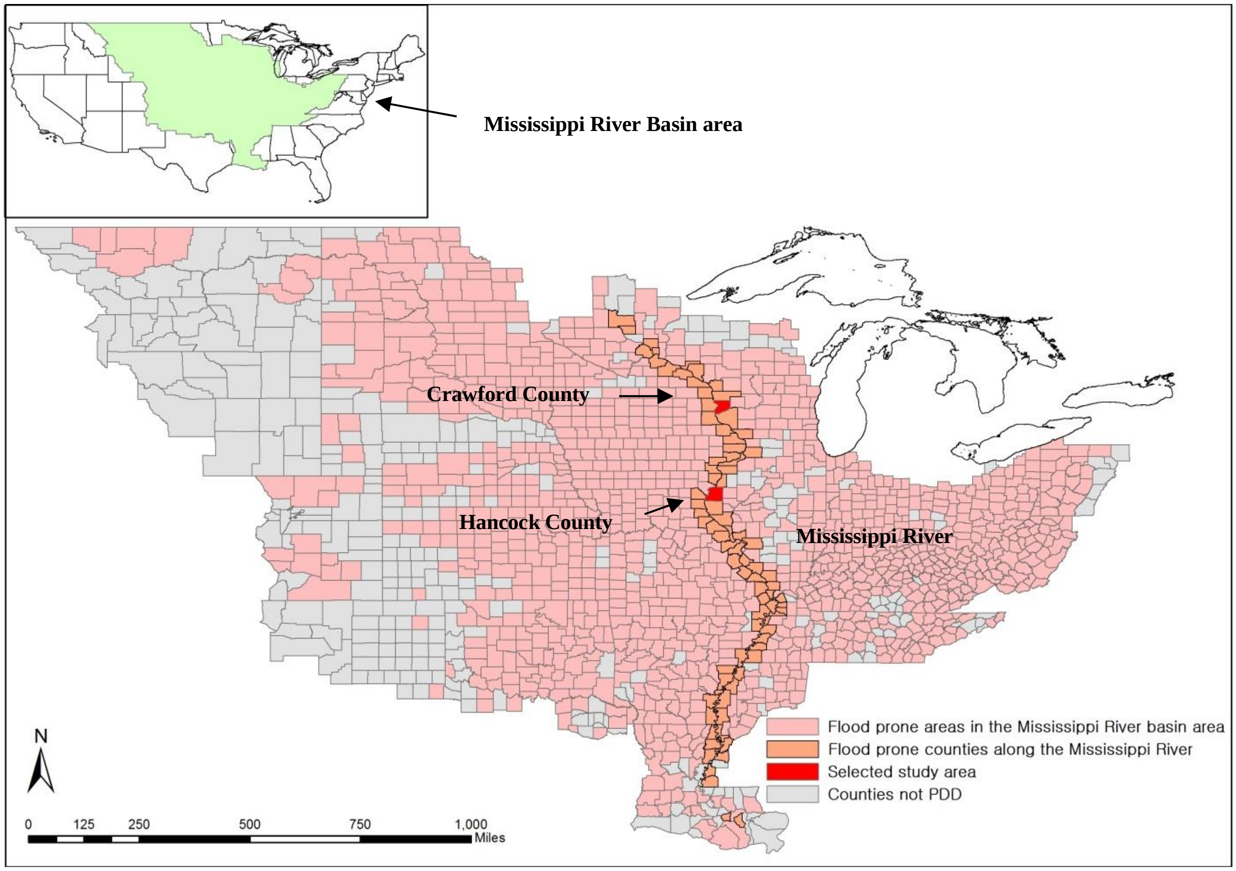

Figure 5-2. Study Area

According to the Hancock County's comprehensive plan (2014), the impacts of the 2008 flood of the Mississippi River and its tributaries was significant in Hancock County, especially due to the lack of a levee system and social and economic vulnerability. As flood-prone counties, both have diverse socio-economic characteristics compared to rural counties or all counties along the Mississippi River. For instance, both counties have lower or slightly equivalent values in bachelor degrees, per capita income, population, income inequality, and poverty rate. This fact reflects that overall, both counties have a lower potential to enhance economic development.

5.4 Results

5.4.1 Socio-economic factors contributing to community resilience

A regression model was used to isolate the impacts of selected socio-economic resiliency components of flood losses throughout the study areas. As illustrated in Table 5-2, several factors played an important role in modifying the amount of physical loss caused by flood event over the past 10 years. As supported by the research of Kellenberg and Mobarak (2008) and the variables such as employment rate, health access, voter turnout, and an approved hazard mitigation plan significantly decrease physical damage in all models. Unexpectedly, rural counties along the Mississippi River vulnerable to natural disasters had a discernible influence on mitigating the amount of flood damage. The percentage of residents with a higher income level, bachelor's degrees, and white population were negatively correlated with flood losses in the rural counties (see Model 3).

Among disaster planning regulation characteristics, an approved natural hazard mitigation plan from FEMA played a critical role in reducing disaster losses in rural and urban counties. In keeping with the claim of Bryant (2015, p. 160) that " community resilience must become part of the overall strategic reflection and planning approach both in relation to community development and in the planning," these findings suggest that a greater socio-economic condition and hazard mitigation planning effort contributed to lower disaster losses. Counties with strong economic status and planning regulation associated with disaster risk reduction should experience lower disaster losses when compared to counties exhibiting weaker economic conditions and planning effort.

Table 5-2. Log-linear Model of Socio-economic Resilience Factors

	Model 1	Model 2	Model 3
Intercept	10.840** (5.991)	20.308** (8.680)	20.556 (12.139)
Socio-economic characteristics			
White	-0.009 (0.015)	-0.001 (0.031)	-0.066* (0.047)
Bachelor	-0.045* (0.030)	-0.060 (0.051)	-0.110** (0.060)
Female	0.102 (0.081)	0.034 (0.146)	0.128 (0.185)
GINI	13.542** (6.579)	23.671** (8.627)	32.433** (14.198)
Health access	-0.033*** (0.008)	-0.061*** (0.021)	-0.038*** (0.014)
Income	-0.0002 (0.0003)	-0.003 (0.0006)	-0.007* (0.005)
Economic diversity	0.253* (0.248)	0.221 (0.251)	0.233* (0.865)
Employment	-0.025* (0.038)	-0.015* (0.061)	-0.034* (0.052)
Housing age	0.034 (0.031)	0.070* (0.049)	0.044 (0.049)
Mobile housing	0.030 (0.031)	0.021 (0.045)	0.094** (0.048)
Housing tenure	-0.019 (0.040)	-0.021* (0.052)	-0.052 (0.068)
Age	0.008 (0.060)	0.008 (0.107)	0.043* (0.109)
Voter	-0.024* (0.026)	-0.069* (0.052)	-0.015 (0,032)
Environmental characteristics			
Residential	0.006 (0.009)	0.007 (0.018)	0.010 (0.014)
Precipitation	0.023 (0.043)	0.021 (0.081)	0.146** (0.056)
Planning regulation characteristics			
Flood program	-0.251 (0.265)	-0.079 (0.776)	-0.247 (0.906)
Approved mitigation plan	-0.503** (0.248)	-0.883* (0.367)	-0.088** (0.341)
Mandatory mitigation plan	-0.447 (0.478)	-0.107 (0.754)	-0.100 (0.463)
Number of observations	85	50	35
F value	2.08**	1.42**	9.00***
R-squared	0.3371	0.4294	0.6643

Note: *: p<0.1, **:p<0.05, ***: p<0.001, dependent variable : log per capita flood losses, Robust standard errors in parentheses, Model 1 is for entire study area, Mode1 2 is for urban counties, Model 3 is for rural counties

As a second estimation procedure, ARIMA can be employed to predict county economic characteristics such as employment rate and household income influenced by natural disasters (Elsner et al., 2008). Empirical findings for the resilience determinants of employment rate and household income are presented in Table 5-3. The study area (total 85 counties) was divided into two groups according to urban and rural classification during the study period. One group included 50 urban counties damaged by flood events, whereas the other was comprised of 35 rural counterparts influenced by the flooding during the past 10 years, from 2000 through 2009.

As shown in Table 5-3, it is noted that economic losses (i.e., *Property, Crop*) from flood events did significantly affect the employment rate as one of the indicators for the economic situation in all of the counties. As expected, the coefficient of the flood intervention variables (*YR 2002* and *YR2008*, indicating each year, 2002 and 2008, severe flood event occurred in the study areas) was negative for the independent variable employment rate and household income in all counties. Overall, the urban counties damaged by the flood events experienced a lower employment rate and household income (low economic condition). On the other hand, the result of AR (1) indicates that, flooding shock appeared to be most persistent in the rural communities damaged by the flood events as shown by an AR (1) coefficient of -0.752 and -0.891. This finding shows that in terms of economic situations, these counties have taken the longest time to return to the usual level among the counties in the disaster-prone areas.

Table 5-3. Autoregressive Moving Average Analysis

	Urban				Rural			
	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model10	Model11
Intercept	5.718	5.698***	10.389***	10.388***	4.728***	4.779***	10.462***	10.448***
Duration	-0.028	0.051	0.002	0.0004	-0.654	-0.591	-0.078*	-0.062***
Property	-0.245*		-0.013*		-0.282*		-0.005*	
Crop	-0.228*		-0.011*		-0.463**		-0.267**	
Yr2002[a]	-1.024*	-0.964*	-0.052*	-0.047*	-0.687*	-0.564*	-0.032*	-0.089*
Yr2008[b]	-4.079***	-3.951***	-0.299***	-0.369***	-2.002***	-1.289***	-0.167***	-0.510***
AR(1)	-0.703***	-0.699***	-0.843***	-0.842***	-0.755***	-0.752***	-0.891***	-0.855***
MA(1)					0.364***	0.355***		
Number of observations	500[c]				350[d]			
Log likelihood	-241.045	-241.479	91.505	91.275	-672.670	-675.280	363.250	408.330
Wald Chi-square	329.18***	321.33***	166.80***	168.65**	453.25***	438.02***	273.18***	322.31***

Note *: p<0.1, **:p<0.05, ***: p<0.001* significant at 10%, a : year dummy and intervention variable in flooding 2002, b: year dummy and intervention variable in flooding of 2008, c: 50 urban counties affected by flooding during 10 years (2000-2009), d: 35 rural counties affected by flood during 10 years (2000-2009), Dependent variables in Models (4),(5), (8), and (9) are *employment* and in Models (6), (7), (17) and (18) are log *Income*, AR is Auto Regressive and MA is Moving Average

5.4.2 Resilience tools and assessment of disaster responses : Comparative case studies

Among the 35 rural counties along the Mississippi River, Hancock County in Illinois and Crawford County in Wisconsin were classified as counties with a high flood risk level[16] (also see Appendix 5-4). Based on the similar level of flood risk index,[17] both rural counties were selected for assessing rural community resilience to natural disasters. Such comparative case study can be useful in illustrating important insights on how to make rural communities more resilient to the adverse impacts of natural disasters within an evaluation questions.

[16] Among the 10 high flood risk counties selected from the spatial clustering of risk index, Allamakee County in Iowa, Jackson County in Iowa, Clark County in Missouri, Crawford County in Wisconsin, and Vernon County in Wisconsin are included in the high vulnerability index level and high risk index level. While counties such as Clayton County in Iowa, Hancock County in Illinois, Lewis County in Missouri, and Grant County in Wisconsin had high risk index and low vulnerability index level, Dubuque County in Iowa had high vulnerability and low risk index level.

[17] As discussed in Chapter 3, in order to measure flood risk index in this study, first, I measured the vulnerability index using equal weighted and normalized scaling methods that include min-max transformation, Z score, and maximum value transformation, based on the various factors such as environmental and geographical, human and social capital, economic and housing, and planning effort. Coupled with the result of vulnerability index, to measure the risk index, I used the equation risk is vulnerability plus exposure. For exposure, I reclassified severity by the level of flood damage and calculated flood duration.

In examining Hancock and Crawford counties' structural and non-structural hazard mitigation plans as well as their comprehensive plans, an assessment of the two rural communities' response to flood events was undertaken by adapting theoretical perspectives of Beatley (2009), Daniels (2014), Masterson et al. (2014), Brown and Schafft (2011), Wilkinson (1999), and Sargent et al. (1991). Following these works, specific tools and techniques for enhancing and strengthening resilience to natural disasters were selected and analyzed based on each local hazard mitigation plan and comprehensive plan (see Appendix 5-5). As depicted in Figure 5-3, such resilience tools and techniques included: 1) land use planning, 2) local infrastructure and public facilities, 3) taxation and financial incentives, 4) conservation and restoration of natural systems, and 5) building and structural resilience.

As suggested by previous studies (Godschalk et al., 1998; Gruntfest, 2000; Masterson et al., 2014; Sargent et al., 1991), local land use planning techniques, as one of the non-structural flood mitigation approaches, allows rural communities to be more resilient to flooding. Consistent with the emphasis on the positive role of land use planning in mitigating natural disaster damage (Berke and Smith, 2009), Hancock and Crawford Counties, similar to other local jurisdictions (e.g., Worcester County in Maryland, Palm Beach County in Florida), have adopted a land use plan that has fostered greater resilience to and incorporated responses to natural disasters like flooding.

Both rural communities have reviewed zoning standards and subdivision regulations. For instance, according to the Crawford County's local comprehensive plan (2010), the rural county has several land use ordinances (e.g., shoreland-wetland zoning, floodplain-zoning ordinance) that should be useful in mitigating flood losses through coordination among federal, state, and local agencies in the context of managing what has been referred to as a "transboundary ecosystem" (Johnson and Becker, 2015; Shrestha et al., 2015). The counties attempted to respond to the multipurpose use of floodplains, including "a variety of outdoor recreational and economic activities as well as provide access to public waters" and "flood damage mitigation" (Beatley, 2009; Sargent et al., 1991, p.123). In terms of the positive role of wetlands or natural resources in mitigating flood losses (American Planning Association, December 2014, p. 50), a local news website of Warsaw city within Hancock County pointed out that the sanitary sewer lagoon needed to be repaired after flood events in 2008 (Hancock County Journal-Pilot, October 6, 2009) as follows:

> "…Coming up with the funds to repair the city' [Warsaw's] s sanitary sewer lagoon is the focal point of Warsaw's post-Flood of 2008 attention…As Mississippi River flood waters receded in the summer of 2008, they left behind a heavy deposit of silt in the lagoon, which reduced the lagoon's volume and efficiency. The lagoon operated successfully through last winter, spring and summer, and the council hopes it will make it through the next year…"

One possible consideration may include the use of cluster zoning or other land use conservation measures for future development in accordance with the hazard mitigation strategy incorporating natural resources (e.g., wetlands) (Beatley, 2009; Bonnieux and Guyomard, 1999; Brody and Highfield, 2013).

Resilience tools and current assessment	Hancock county	Crawford county	Future local response: Hancock county	Future local response: Crawford county
Land use planning (S+N+C)			• Cluster zoning or land use conservation (e.g., wetlands) • Evaluating and updating watershed/drainage system • Insurance for residents and business (e.g., CRS)	• Continuing enforcement of floodplain shoreland and wetland ordinance • Maintaining watercourse • Maintaining NFIP participation
Cluster zoning	*Weak*	*Weak*		
Hard mitigation strategy	*Weak*	*Moderate*		
Complex wetland system	*Weak*	*Moderate*		
Infrastructure and Public Facilities (S+C)			• Retrofitting for wind resistance • Elevating buildings (i.e., structural design) • Construction of an elevated emergency center	
Retrofit for wind resistance	*Weak*	*Weak*		
Elevating building	*Moderate*	*Moderate*		
Emergency operation	*Weak*	*Weak*		
Taxation and financial incentives (N+C)			• Adequate supply of affordable housing • Extending tax exemption along with tax credits or abatement	
Infill rehabilitation	*Weak*	*Weak*		
Tax exemption program	*Weak*	*Weak*		
Conservation and restoration of natural system (S+N+C)			• Natural resources protection ordinance • Preservation of established native vegetation	
Natural system preservation	*Weak*	*Moderate*		
Defense against river erosion	*Weak*	*Weak*		
Building and structural resilience (S+C)			• Newly cleaned storm sewers • Improved storm water retention system	
Strom security system	*Weak*	*Weak*		
Structural mitigation strategy	*Weak*	*Weak*		

Figure 5-3. Evaluating Rural Community Resilience to Natural Disasters

Note : S: Structural Hazard Mitigation Plan, N: Non-structural Hazard Mitigation Plan, C: Comprehensive Plan, Resilience tools in boldface

In addition to cluster zoning, it is necessary that both communities analyze environmental erosion issues as well as develop a response plan to cope with erosion. Furthermore, protecting wetlands should be deemed a priority in the rural development ordinance in line with both rural counties' desire to reduce flood insurance rates. To acquire lower rates, it is necessary that the communities become involved in the voluntary Community Rating System (CRS) of the National Flood Insurance Program (NFIP) (Beatley, 2009; National Research Council, 2015). This insurance is designed to provide an insurance alternative to disaster assistance in meeting the escalating costs of repairing damage to buildings and their contents caused by floods (Brody, 2012; Brody and Highfield, 2013). Although both communities have adopted a flood damage prevention ordinance, including provisions for building codes, both should also consider joining the CRS.

A second tool is to design local infrastructure and public facilities for community resilience. The infrastructure element in the comprehensive plan and hazard mitigation plan provides resilient and adequate infrastructure linked with a hazard mitigation strategy to protect infrastructure in flood events and ensure quick recovery and use during emergency situations. According to the comprehensive plan of Hancock County (2014) and Crawford County (2010), this element calls for the alignment of land use decisions with public facilities and infrastructure investments determined by the rural community carrying capacity, anticipated demands, and financial feasibility.

Over time, many facilities in both communities have received repetitive damages from flooding. For more resilient facilities, it is necessary that the communities assess all municipal facilities to determine if the structures can be strengthened or made more resistant to damage from catastrophic events. Similar to the case of Worcester County in Maryland (Beatley, 2009), this would include retrofitting for wind resistance, elevating buildings or raising critical mechanical systems above flood levels similar to other disaster-prone communities (Emmer et al., 2008). In addition to structural design for resilience, it is necessary that both counties consider the construction of an elevated emergency operation center to provide a protected location for critical personnel and equipment as suggested by the comprehensive plan and hazard mitigation plan. The communities should establish a system to secure the municipal transportation system so that there is not a complete loss of the transit system in a disaster event.

With regard to taxation and financial incentives, both communities have tried to encourage small subdivisions on larger properties comprising a block or more of land. Encompassing an expedited development review, waivers of permit fees, short-term abatement of property taxes for new homeowners and developers in these areas, and capital improvements to infrastructure systems and neighborhood amenities such financial incentives may be relatively passive in nature. Since infill development reinforces existing neighborhoods and supports existing commercial uses, it can be a particularly sustainable form of development and rural reinvestment (Porter, 2000). In reality, in the aftermath of repetitive flood events, both communities have seen an increase in the number of demolitions and new vacant lots. For this reason, it is necessary that the communities create incentives for the introduction of new single-family houses into these neighborhoods that include older residential areas as noted in the comprehensive plan.

Furthermore, the present tax exemption program in both communities encourages rehabilitation of commercial structures within designated historic districts. In an effort to apply the exemption to historic residential properties, it is necessary that the city consider extending this exemption along with tax credits or tax abatements as in the case of Portland, Oregon

(Beatley, 2009). According to Hancock's comprehensive plan (2014), similar to the localities such as Collier County in Florida and Montgomery County in Maryland (Beatley, 2009), other financial tools and incentives that the counties could consider include: tax relief for qualified rehabilitation and infill residential development (including property tax abatements, property tax credits, transfer of development, and property tax exemptions), tax reinvestment / tax increment financing, expansion of the community's receivership program, and revolving/low-interest loan programs.

The fourth tool for meaningful responses to natural disasters is related to conservation and restoration of natural systems for community resilience. Intact and contiguous forest cover—as a natural system—can act to improve air quality, provide shade, protect against erosion, lessen the impact of storm water, and serve as wildlife habitat (Porter, 2000). For this reason, both communities should continue to update landscaping and forestry requirements to emphasize the protection of established native vegetation and the use of locally native or naturalized and non-invasive plants. The counties should maintain and, where needed, restore and protect river and watershed systems. By maintaining these natural systems, there will be a greater opportunity for marshes and wetlands to provide a buffer from the wave action of the river.

With an emphasis on environmental planning and green infrastructure to mitigate disaster risk in rural communities, Kraehling and Caldwell (2015, p. 74) and Tidball and Krasny (2014) claimed that "additional buffers [such as wetlands, floodplain lakes] will be required along waterways and shorelines for anticipated floods in the future." The survey of Crawford County floodplain lakes conducted by Crawford County Land Conservation Department (2009) revealed that floodplain lakes (consisting of State Riverway upland forest and wetlands) within the county can play an important role in protecting upland groundwater and reducing surface runoff.

Another option for both communities would be to include open space acquisition as an expense item in the annual budget although this option requires annual reauthorization and does not constitute a clear commitment to the program. Another alternative action could be the purchase of development rights (i.e., conservation easement). Generally, a land trust, or another organization linked to the local government (Beatley, 2009), offers to buy development rights to a parcel. Since these programs are voluntary, the property owner may choose to accept, refuse, or negotiate the price. If an agreement is made, a permanent deed restriction is placed on the property in perpetuity that restricts the types of activities that may take place on the land.

A final tool is related to building and structural resilience. As a result of natural hazards like flooding, significant deposits can be and were left in the storm sewer system. This causes a reduction in the capacity of the pipes and exacerbates the flooding problems. For this reason, it is necessary that both communities ensure that the newly cleaned storm sewers are maintained and regularly cleaned in the future. If additional cleaning is desired, the counties must be willing to fund this type of work in the future. Any new or replacement storm sewers should be designed to facilitate ease of maintenance.

Similar to the example of Worcester County in Maryland (Beatley, 2009), both communities should consider new regulations to require storm water retention systems and levee and address the impact of fill on surrounding properties. Storm water retention systems can reduce the demand on the storm sewer system during rain events (Emmer et al., 2008; Porter, 2000). Thus, the communities should encourage the use of rain gardens—landscaped areas that hold water until it can be absorbed into the ground—and rainwater harvesting systems (Kim et al., in press). It is necessary that both counties participate in all regional discussions regarding structural mitigation strategies to ensure that the interests of the counties are represented and that the best solutions for the area are determined.

As illustrated in Figure 5-3, overall, these two counties have little differences with respect to resiliency to natural disasters. Both rural counties had a lower resilience to natural disasters in accordance with the five resilience assessment tools. Even though both communities had a high flood risk level, they had a limited resilience or community capacity in reducing disaster risk and preparing for future disaster response. Specifically, in terms of land use planning, even if Crawford had better appropriate hazard mitigation strategies such as ordinance of floodplain and wetlands and NFIP participation than Hancock County, both rural counties had a weak or moderate level in clustering zone, wetland and flood plain system, and flood insurance. With respect to the infrastructure and public facilities as well as building and structural resilience, both counties need more efforts in retrofitting buildings, establishing newly located emergency centers, constructing newly cleaned storm sewers, and improving storm water retention systems. In addition, both rural communities need more affordable housing and appropriate natural system preservation and restoration to reduce vulnerability and promote resilience to flood events.

5.5 Conclusions and Discussion

The case examples discussed in this study represent rural community-based sustainable development strategies in a variety of rural settings and natural disaster impacts. Rural communities, Hancock County and Crawford County, located in areas adjacent to the Mississippi River, have experienced rapid social and ecological changes due to increasing surrounding urban development combined with an increase in natural disasters resulting from flood events. Their social and ecological deterioration has reached an alarming level and therefore has led to negative effects. In an attempt to solve these social and ecological problems, promote a healthy and sustainable rural community for the future, and open new "windows of opportunity" through social flexibility and resilience of livelihood (Titus, 2008) in the face of natural disaster impacts, the communities need a resilient disaster approach along with effective hazard mitigation plans as part of comprehensive plans.

As an empirical result of socio-economic factors contributing to resilience, greater economic conditions before the disaster leads to lower disaster losses than those suffered by other high flood risk counties along the Mississippi River with higher unemployment. In other words, if a region has a stronger economic status before a disaster, it will experience fewer disaster losses. In this regard, this study will be helpful in responding to Gwimbi' (2009, p. 77) on liking rural community livelihoods to resilience building in flood risk reduction:

> "…central to the rural livelihoods resilience building debate are livelihood assets. While flood risks are not the only threat to natural resources and livelihoods the changes they induce in resource flows will affect the viability of livelihoods unless effective measures are taken to protect them through adaptation and other strategies…"

The social and economic resilience plans, comprising diverse principles, scientific analysis, education, and institutional learning to manage environmental resources sustainably can be implemented through low impact development, a diverse local economy, long-term planning, a compelling vision of the future, preparation and advance planning, and preservation and restoration of ecosystems and ecological infrastructure. Particularly, in integrating social and ecological planning (or environmental planning) to alleviate the negative effects on the rural disaster-prone social or ecological conditions, new strategies encompassing these principles that incorporate long-term planning and implementation, rural economic development and diversification, rural tourism development, environmental conservation, land use, and structural and non-structural designs are necessary (Caldwell, 2015).

It goes without saying that the process a community must engage in to become resilient involves numerous barriers. Such barriers are due to geographical location, political climate, and economic condition. In particular, since river basin is usually "not defined by political boundaries" (Sargent et al., 1991, p.122), with widespread natural disasters impacting multiple communities, inter-community and transboundary coordination among federal, state, and local agencies is crucial before and after a disaster.

In addition, those local communities with traditional top-down decision-making will be at a disadvantage and need to embrace a bottom-up approach through participation of residents—especially those having prior experience with natural disasters. Furthermore, communities with minimal economic reserves may have difficulty implementing structural hazard mitigation plans. In line with the "importance of taking a holistic perspective on reducing vulnerability and building adaptive capacity [community capacity] to ensure community resilience" (Bryant, 2015, p.160), the key lesson to be learned here is that crucial disaster resilience practice—in collaboration with local responses to natural hazards, sharing hazard mitigation plans and comprehensive plans with regard to social and ecological issues—can improve local responses to natural disasters in the future and promote tools for resilience.

These conclusions and policy implications should be interpreted with some degree of caution due to data-quality concerns and limitation of results. In utilizing such secondary data, estimates such as those provided by SHELDUS may be slightly over or under true losses experienced in counties under consideration. As Babbie (2012) claims, such potential for error exists when using data collected and compiled by others. Additionally, such data are limited in that household or individual-level perceptions of local economic status (e.g., quality of life, or degree of satisfaction about government assistance programs) altered by natural disasters are not considered. Therefore, in addition to utilizing secondary data, as suggested by Park and Reisinger (2010), future research should include primary data measuring local residents' perceptions at multiple points in time as in longitudinal data collected through questionnaires and interviews.

Furthermore, since this study includes only the North American mid-continent damaged by natural disasters during the study period (and considered such sites to be homogeneous), there is a limitation in generalizing the empirical results. For example, the economic losses from Hurricane Katrina in 2005 were among the largest the world has ever seen, and some areas were impacted more than others, most notably the Lower Ninth Ward of New Orleans (Rich, 2012). The data used in this study treated all areas impacted by a disaster as equally impacted.

To remedy this, future studies should involve additional study areas impacted by natural disasters and compare them with non-damaged areas in the context of longitudinal spatial econometric analysis (e.g., quasi-experimental control group methodology). In addition, once secondary data is available from necessary sources, subsequent research should be undertaken that encompasses more recent years of natural disasters making landfall adjacent to disaster prone areas, along with the possibility of "link [ing] demographic and socio-economic census data to environmental data" in the context of environmental and climate change research (Guzmán, 2009, p. 199).

In addition, given the limited research area based exclusively on counties within the Mississippi River basin area and flood events, some would assert that generalizing the empirical findings to other locations and natural hazards. For this reason, future research should include additional study areas, including coastal disaster-prone along the Gulf of Mexico and Atlantic coast and reflect the impacts of multi-hazards. Furthermore, these broad viewpoints can help to compare the results of previous disaster studies primarily focusing on coastal prone areas and contribute to multi-hazard cross-national comparisons (Peacock, 2002).

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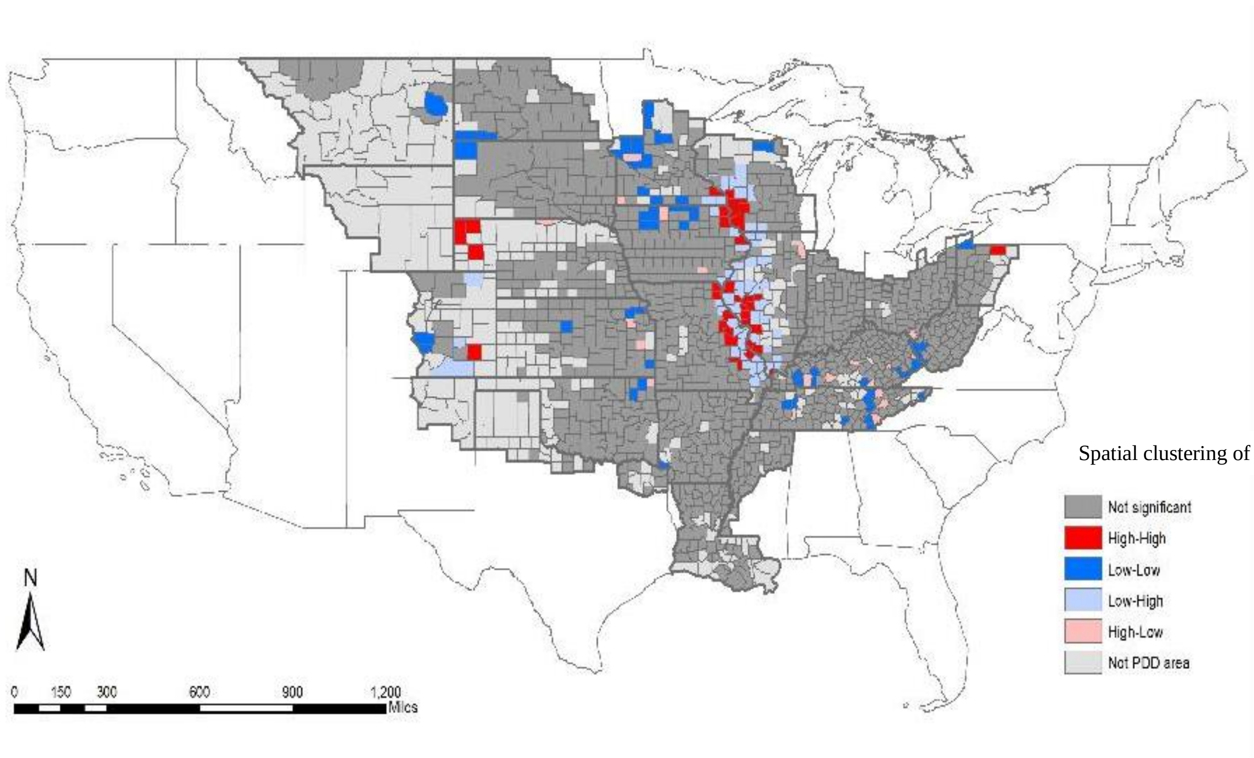


Appendix 5-1. Spatial Clustering of Risk (2000-2009)

Appendix 5-2. Spatial Comparison of Vulnerability Index and Risk Index among 85 Counties

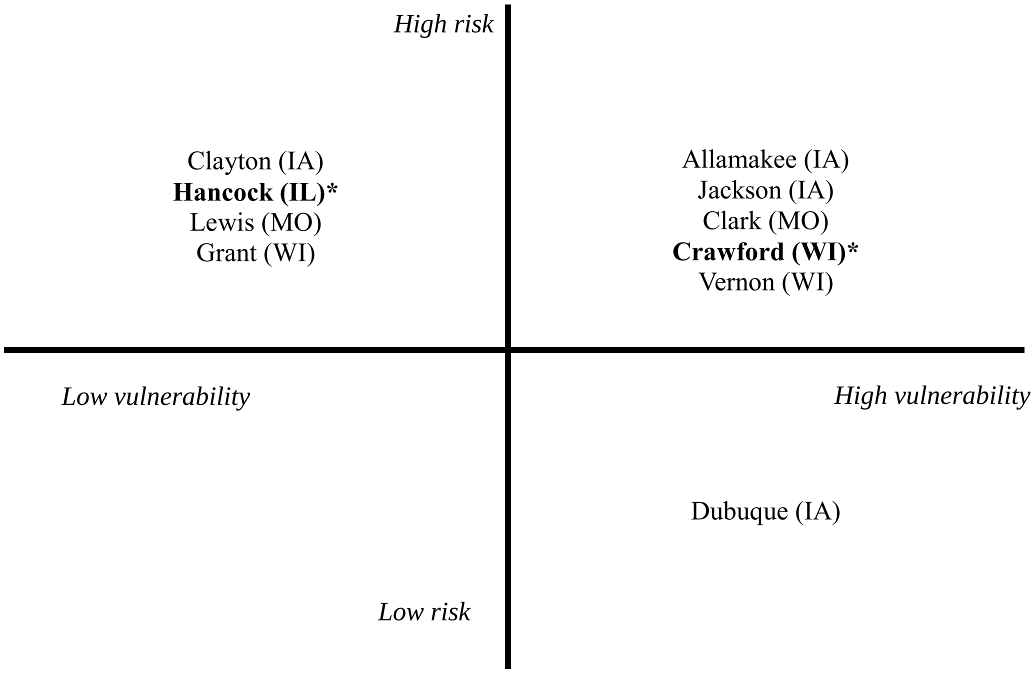
		Vulnerability			Risk		
	Rank	Counties	Index*	Urban and rural classification	Counties	Index**	Urban and rural classification
Top 10 vulnerable and risk communities	1	Scott, IA	0.7026	Urban	Hancock, IL	663.04	Rural
	2	St. James, LA	0.4498	Suburban-exurban	La Crosse, WI	616.03	Urban
	3	Jackson, IA	0.2405	Suburban-exurban	Randolph, IL	594.06	Suburban-exurban
	4	Buffalo, WI	0.2132	Suburban-exurban	Jersey, IL	570.09	Urban
	5	Perry, MO	0.2086	Rural	Whiteside, IL	548.20	Suburban-exurban
	6	St. Charles, LA	0.2048	Urban	Mississippi, MO	363.11	Rural
	7	Whiteside, IL	0.2046	Suburban-exurban	Ramsey, MN	355.01	Urban
	8	Tensas, LA	0.1198	Rural	Jackson, IA	285.24	Suburban-exurban
	9	Morrison, MN	0.1162	Suburban-exurban	Vernon, WI	275.08	Suburban-exurban
	10	Ralls, MO	0.1126	Rural	Jackson, IL	266.09	Rural
Bottom 10 vulnerable and risk communities	1	Rock Island, IL	0.0095	Urban	Alexander, IL	1.0394	Rural
	2	Ramsey, MN	0.0119	Urban	Ralls, MO	1.1126	Rural
	3	Phillips, AR	0.0148	Rural	Jo Daviess, IL	2.0255	Suburban-exurban
	4	Crittenden, AR	0.0152	Urban	Carlisle, KY	2.0362	Rural
	5	Wilkinson, MS	0.0211	Suburban-exurban	Goodhue, MN	2.0532	Suburban-exurban
	6	Anoka, MN	0.0214	Urban	Ballard, KY	3.0226	Rural
	7	Shelby, TN	0.0222	Urban	Tunica, MS	3.0232	Urban
	8	Coahoma, MS	0.0222	Rural	Lake, TN	3.0343	Rural
	9	Cape Girardeau, MO	0.0224	Rural	Cape Girardeau, MO	4.0224	Rural
	10	Ballard, KY	0.0226	Rural	Mercer, IL	4.0231	Urban

Note: * : Min-max transformation method, **: Vulnerability index+ Exposure (flood severity*flooding duration)

Appendix 5-3. Selected Socio-economic Characteristics and Disaster Losses (2000-2009)

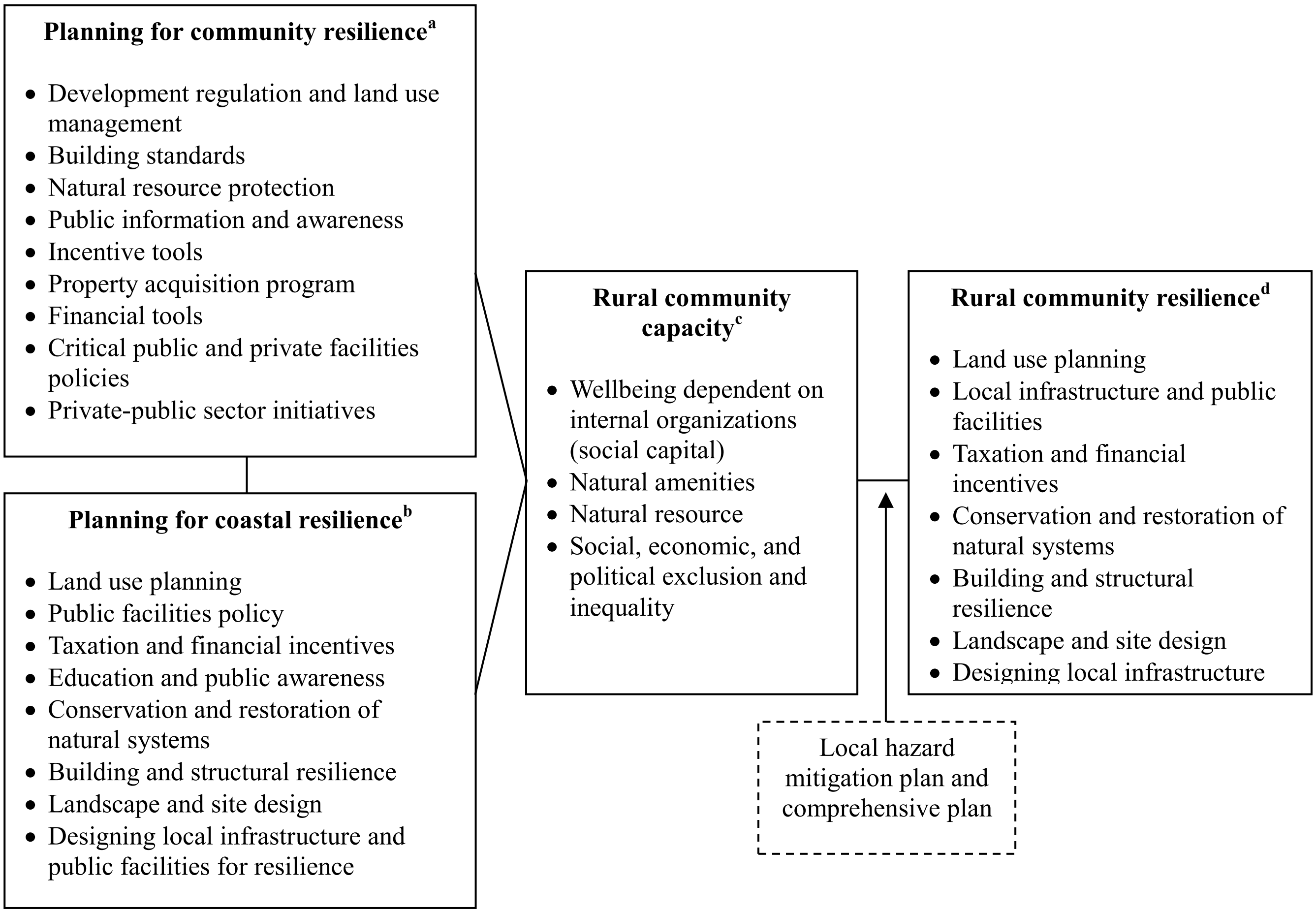
	Surrounding areas		Selected rural communities	
	Counties average along the Mississippi River	Rural counties average along the Mississippi River	Hancock county (IL)	Crawford county (WI)
Disaster damage characteristics				
Flood losses (1,000$), 2000-2009	21,507	16,380	43,212	12,414
Socio-economic characteristics				
Population	61,918	50,822	19,104	16,644
% Bachelor degree and beyond	17.08	17.52	13.20	16.70
% White	91.11	92.33	97.30	91.00
% above 65	14.92	15.52	16.00	12.70
% Female headed households	9.20	8.78	8.40	10.90
Income inequality	0.426	0.421	0.417	0.402
Poverty rate	12.06	11.04	10.20	7.30
% Homeownership	73.84	73.18	76.80	71.10
Per capita income ($)	29,857	30,385	26,939	30,007
Employment rate	60.66	60.66	61.60	65.40
Industries providing employment (%)				
Agricultural, forestry, fishing, and hunting			32.8	41.5
Educational, health, and social service			14.9	19.2

Source: U.S. census bureau, USDA ERS



Appendix 5-4. Sample Case Study Selection for Evaluating Rural Community Resilience

Note: *: selected study areas for case study, center value is based on the median value among vulnerability index and risk index level



Appendix 5-5. Rural Community Resilience Assessment

Note: a: derived from Masterson et al. (2014), b: derived from Beatley (2009), c: derived from Brown and Schafft (2011), d: used in this study

CHAPTER 6

SUMMARY AND POLICY IMPLICATIONS

6.1 Summary

In the second chapter, I addressed the links between disaster risk, community capacity, and planning effort within the context of previous theoretical and empirical literature. By identifying the shortcomings of the dominant disaster management paradigm, I developed a spatio-temporal conceptual model for disaster risk reduction that involves local vulnerability and resiliency. Three theoretical hypotheses are proposed. First, disaster effects will have a negative association with social and economic development metrics; second, the higher the levels of a community's social and economic conditions the lower the disaster losses; and third, better planning efforts (including plan quality), greater social capital, and higher social justice in place before a natural disaster will lead to lower disaster losses. Findings suggest that sustainable and resilient communities should be able to recover rapidly from disasters whenever they occur. Sustainable development and resilience are contingent on careful planning and organization by society, both to ameliorate disaster impacts and to facilitate the recovery processes.

In the third chapter, I examined the association between community capacity and community resilience with specific reference to social, economic, environmental, and planning related characteristics at the county-level within the U.S. Mississippi river basin over the past 20 years. Using the basic premise that natural disaster effects are social frameworks that require pro-active planning, I developed a spatio-temporal conceptual model for disaster risk reduction, climate change adaptation, and environmental change that involves local vulnerability, risk, and resiliency processes. Based on socio-ecological resilience and community capacity characteristics, I temporally and spatially analyzed community vulnerability using an integrative index and spatial clustering. In addition, I estimated the role of community capacity and planning effort in disaster risk reduction and environmental sustainability using spatial lag models. Results suggest that disaster losses have inverse associations with community social and economic structures, and that engaged social capital and social justice characteristics combined with local proactive planning in place before a disaster results in lower disaster losses and enhancements to community resilience and environmental sustainability. Further, disaster planning that involves social, economic, and cultural attributes for community resiliency is the best approach from multi-disciplinary perspectives.

In the fourth chapter, looking over the severe disaster losses within the U.S. Mississippi River Basin areas over the past 20 years, I addressed the effect of local hazard mitigation plan quality on mitigating disaster risk and the relationship between the plan quality and community resilience. Using content analysis and previous identified attributes for measuring plan quality, I evaluated local hazard mitigation plans to determine how well they support disaster risk reduction. Incorporating the results of local hazard mitigation plan quality evaluations and selected community resilience factors, I assessed the role of plan quality and community resilience in flood risk reduction using a log-linear modeling and a quantile regression modeling. Findings suggest that better plan quality and high community resilience play a positive role in reducing disaster losses.

In the last chapter, I investigated the principles of social and ecological resilience to natural disasters considering areas of the Mississippi River Basin affected by flooding over the last 20 years. In an effort to address the challenges and opportunities faced by communities in response to natural hazards, I employed best practices in planning for community resilience and integrated spatio-temporal variations in disaster vulnerability. As a result of bringing together empirical evidence with a review of rural community resilience, I concluded that disaster-prone rural communities need to implement new social and environmental planning strategies to potentially mitigate negative effects of natural disasters that incorporate long-term planning and implementation, land use, and structural and non-structural mitigation designs.

6.2 Research Limitations and Future Research Direction

Although this research offers empirical insights into community resilience to natural disasters, it is still quite preliminary and contains important limitations. As with many studies utilizing standardized secondary data, I was constrained by the limited number of analytical variables. It is difficult to use existing data to address individual-level perceptions or behavioral responses reflective of diverse economic and social variables affected by natural disasters. Future research needs to include data on resident or community risk perceptions. Examples of which include the extent to which natural disasters affect perceptions of social and economic inequality and social capital (or social networks). This could be done through a variety of primary data collection mechanisms within affected study areas (e.g. surveys, structured interviews, focus groups, Delphi, etc.).

In addition, given that there are spatial and temporal attributes of social and economic status influenced by unexpected natural disasters, I was limited by nonlinear causality and spatial heterogeneity in addressing disaster resilience due to the lack of efficiently scaled geographic datasets. In order to overcome this limitation and conduct truly meaningful spatial and temporal analysis, future research needs to utilize spatial data at more micro-levels (e.g. sub-county geographic units) across broader time frames.

From the perspective of statistical analysis, while I took care to appropriately specify our models, heteroscedasticity could remain problematic. This research tested the assumption that the poorer a community is, the more likely it is that a community suffers higher levels of natural disaster loss. Possible solutions to these analytical problems could specify empirical models using dummy variables that divide communities into high and low damage to test income and other economic conditions in explaining disaster loss. Despite these limitations, these findings can be useful for reflection on disaster resilience. Theoretically sound empirical approaches can assist public policymakers in better understanding natural disaster planning. This, in turn, will allow for improved social and economic resilience leading to higher levels of rural community sustainability. In this way, planners can more effectively implement policies to ameliorate future negative impacts to rural communities.

6.3 Policy Implications

Drawing upon socio-economic resilience and community capacity characteristics, I temporally and spatially analyzed community vulnerability using an integrative index and spatial clustering. In addition, I estimated the role of community capacity and planning efforts in disaster risk reduction and environmental sustainability using spatial lag models. Results suggest that disaster losses have inverse associations with community social and economic structures, and that engaged social capital and social justice combined with local proactive planning in place before a disaster results in lower disaster losses and enhancements to community resilience and environmental sustainability.

As discussed earlier, findings suggest that better community capacity and planning efforts prior to the occurrence of natural disasters leads to smaller disaster losses. To mitigate vulnerability, communities should set aside resources to make residents safer. For this, policy makers or planners at the local level need to work with residents planning for disaster mitigation or resiliency activities. Moreover, effective and proactive local policy making and planning can help minimize disaster loss while helping to make disaster-prone communities more resilient to future events.

Results suggest that disaster damage has a negative association with social and economic conditions and that engaged social capital, more equitable distributional characteristics, and local proactive planning in place before the disaster lead to lower disaster losses. Ultimately, community resiliency to natural disasters leads to sustainable development at the community level. Furthermore, sustainable development increases the opportunity for achieving disaster resiliency in a community. Lessons learned from past natural disasters impacts in disaster-prone areas can help planners and policy makers predict problems, prepare for future disasters occurs and provide an opportunity to influence public policy focused on disaster risk. In addition, lessons to be learned here are that with crucial disaster resilience practice—in collaboration with local responses to natural hazards, sharing hazard mitigation plans and comprehensive plans with regard to social and ecological issues—can improve local responses to natural disasters in the future and promote tools for resilience. Therefore, it is necessary that local communities implementing disaster resilience plans recognize the principles of social and ecological resilience and pursue specific tools and techniques for enhancing and strengthening responses to natural disasters in accordance with the characteristics of the community.

Natural disasters become crises when unambiguous failures of public and private decision-making create outcomes that interrupt local activity. Whereas disaster vulnerability reflects the frequency and intensity of naturally occurring large-scale materialized risks, disaster resilience refers to the capacity of people and organizations to develop adaptive responses to perturbations that protect communities from potential loss. Together with the basic premise that disaster effects are fundamental social process responses that require pro-active planning, a conceptual model of disaster loss factors involves hazard exposure, shock, and loss within the context of inherent social system vulnerability and resiliency. Specific research questions involve alternative levels of community development, social system status, and their influence on disaster resilience.

In integrating socio-economic with environmental planning to alleviate negative effects on the disaster-prone social or ecological conditions, new strategies encompassing these principles that incorporate long-term planning and implementation, land use, and structural and non-structural designs are necessary. The key lesson to be learned here is that crucial disaster resilience practice—in collaboration with local responses to natural hazards, sharing hazard mitigation plans and comprehensive plans with regard to social and ecological issues—can improve local responses to natural disasters in the future and promote tools for resilience. Therefore, it is necessary that local communities implementing disaster resilience plans recognize the principles of community resilience and pursue specific tools and techniques for enhancing and strengthening responses to natural disasters. In addition, in order to engage communities in building capacity, it is essential for foundation knowledge in decision making to include community characteristics, specifically hazard exposures, physical vulnerability (or risk), and social vulnerabilities.

This study takes on both planning and decision-making frameworks that act to simultaneously minimize vulnerability elements of a community while maximizing resiliency elements. Based upon a review of the extant literature, two central theoretical hypotheses are proposed. First, higher levels of community capacity will result in lower disaster-related losses; and second, establishing better planning efforts, social capital, and social justice systems prior to an occurrence of a natural disaster will lead to reduced disaster losses. This approach improves on previous work by incorporating tacit stages of development, social capital, social justice, and distributional elements that speak to social and economic inequity. Results from this review of extant knowledge suggest that disaster damage likely has an association with social and economic structure, and that engaged social capital, more equitable distributional characteristics, and local pro-active planning in-place before a disaster results in lower disaster losses.

Rural communities have experienced rapid social and ecological changes due to increasing surrounding urban development combined with an increase in natural disasters resulting from flood events. Their social and ecological deterioration has reached an alarming level and therefore has led to negative effects. In an attempt to solve these social and ecological problems and promote a healthy and sustainable rural community for the future, the communities need a resilient disaster approach along with effective hazard mitigation plans as part of comprehensive planning. As an empirical result of socio-economic factors contributing to resilience, greater economic conditions before the disaster leads to lower disaster losses than those suffered by other high flood risk counties along the Mississippi River with higher unemployment. In other words, if a region has a stronger economic status before a disaster, it will experience fewer disaster losses.

The process a community must engage in to become resilient involves numerous barriers. Such barriers are due to geographical location, political climate, and economic condition. With widespread natural disasters impacting multiple communities, inter-community and transboundary cooperation is crucial before and after a disaster occurs. In addition, those local communities with traditional top-down decision-making will be at a disadvantage and need to embrace a bottom-up approach through participation of residents—especially those having prior experience with natural disasters. Furthermore, communities with minimal economic reserves may have difficulty implementing structural hazard mitigation plans.