U.S East Coast Community Resilience from a Community Capitals Perspective: Application of Indexing and Spatial Cluster Analysis

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U.S East Coast Community Resilience from a Community Capitals Perspective: Application of Indexing and Spatial Cluster Analysis

By

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B.S Environmental and Resource Economics, University of New Hampshire, 2019

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Taylor Daigle
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ABSTRACT

This thesis addresses regional, state, and county-level community resiliency to disasters along the United States East Coast. Research objectives include understanding the role of vulnerability and resiliency in disaster management, measuring community resilience in a new geographical area, and identifying strengths and weaknesses in community capitals, as related to disaster management. Community resilience in this study is measured by implementing an indexing method to fourteen states (129 counties) along the U.S. East Coast. The community disaster resilience index (CDRI) consists of measuring four community capitals (human, physical, social, and economic) according to the relevant disaster management activities identified in the original research (Mayunga, 2009), using 69 indicators. The CDRI consists of the four sub-indices (community capitals) averaged together for a composite score, reflecting a county’s community resilience capacity. Additionally, scores are evaluated spatially using ArcGIS for statistically significant hot and cold spots within the study area. Results of the index showed that counties in the northeast generally outscored those in the mid-Atlantic and southeast in both the composite index score as well as all four sub-index scores. Mid-Atlantic counties also generally ranked higher than the southeast. The highest performing state was Massachusetts with an average county CDRI score of 0.705 and the lowest performing state was Georgia with a county average CDRI score of -0.420. The spatial analysis found hot and cold spots for the composite CDRI as well as the sub-indices. Hot spots are generally located in the Greater Boston area as well as the New York City Metropolitan area, and occasionally extends north into New Hampshire and Maine. Cold spots are almost entirely located in the states of Virginia, North Carolina, and Georgia.
CHAPTER ONE: INTRODUCTION

The relation between climate change and weather patterns is of growing concern (Knutson, 2020; Seneviratne et al., 2012). In 2020 alone, the United States experienced twenty-two weather events that each cost over one billion dollars, seven of which were hurricanes along the Gulf and East coasts (Smith, 2021). This is particularly concerning for those who reside in coastal communities that are more vulnerable to the effects of hurricanes (Wong et al., 2014). Disaster management officials are tasked with building and utilizing community capitals for mitigation, preparation, response, and recovery of natural and manmade disasters. Understanding their community’s vulnerability and resiliency in relation to these community capitals is essential to properly handling the effects of future storms.

1.1 Background

The coastal areas of the United States are lively communities that contribute extensively to the nation’s economy – particularly within the tourism, transportation, and fishing industries. With global warming and rising sea levels, these communities are struck with threats of higher tides, flooding, erosion, saltwater intrusion into aquifers, rainfall, and rising temperatures, amongst other negative impacts (Fleming et al., 2018). These effects, coupled with growing coastal populations, put communities in a position where they will benefit from climate and natural disaster research. Understanding the role that rising sea levels and global temperatures have on the United States’ hurricane season is crucial to preparing and protecting the people and property within these communities.

The role of global climate change on natural disasters is of significant concern for researchers across the world. Lack of historical records for natural disasters are a limitation to understanding
the impacts that human activity has had on weather patterns. Most models agree that warming of average global temperatures will increase rainfall and storm surge during hurricanes and therefore general intensity, however, they tend to disagree about whether or not there is a link to the number of hurricanes in a season (National Climate Assessment, 2019). The Intergovernmental Panel on Climate Change (IPCC) stands by the stance that there will likely be no increase in the frequency of tropical cyclone/hurricane events, but that there is a likely increase expected in maximum wind speeds and heavy rainfall in association with these storms (Seneviratne et al., 2012). The IPCC’s research indicates that there are generally 90 tropical cyclones worldwide annually. While global rates of these storms are steady, there is significant frequency variability within different ocean basins, including the North Atlantic basin (Seneviratne et al., 2012). Research regarding the effects of climate change on hurricane season and the growing pressures it puts on the environment is especially important for communities with significant human development (Seneviratne et al., 2012). Additional research can provide more resources for these communities to evaluate their disaster management and update their practices to best meet the demands of future storms.

The effects a hurricane has on any given community depends on a variety of factors, including wind speeds, rainfall, storm surge, natural and manmade protection, and storm path, and includes both direct and indirect damages. Direct damages, such as loss of life and property, are immediately felt by the community, with the IPCC indicating that there are most acutely experienced at the local level, as opposed to regional and national levels (S. Cutter et al., 2012). Indirect damages typically occur in the response to and recovery from a hurricane. These damages include loss of businesses and income and additional costs associated with the direct effects. Indirect damages can occur in both the short and long run and extend far past the directly
impacted communities. Industries such as transportation, utilities, fisheries, agriculture, and
tourism and recreation are particularly vulnerable to the growing effects of these extreme
weather events (locally, regionally, and nationally) (Wong et al., 2014). Understanding the key
concepts discussed in this thesis (community resiliency, community capitals, and the disaster
management cycle) are imperative to developing policies and practices that minimize the impact
hurricanes have on a community and prepare them for efficient management for future storms.

1.2 Key Concepts

Key concepts to be discussed and analyzed in this research include vulnerability and
resiliency, the four community capitals, and the four phases of the disaster management cycle.

The concept of vulnerability has long been a focus of hurricane research. While definitions
vary based on the goals of the research being conducted, it is generally described as the
cumulative effect of exposure, sensitivity, and adaptive capacity (Yarnal, 2007). The IPCC
specifically defines vulnerability as “the degree to which a system is susceptible to, or unable to
cope with, adverse effects of climate change, including climate variability and extremes”
(Marshall et al., 2009). For hurricane events, exposure is determined by the magnitude,
frequency, duration, and spatial extent of the event. Sensitivity is the degree that a system is
affected by a storm – which can be reviewed based on ecological, social, and economic
sensitivities. Finally, adaptive capacity is the community’s ability to respond to the challenges
they face following a hurricane (Marshall et al., 2009). Increasing exposure and sensitivity to
hurricanes will make a community more vulnerable, while increasing its adaptive capacity can
reduce this vulnerability and increase resiliency. It is therefore generally understood that
vulnerability is an indication of a community’s resiliency against natural disasters.
In contrast with the vulnerability of a community, resiliency is a more recent concept in disaster management research. Kais and Islam (2016) define community resiliency as “a combination of resistance to frequent and severe disturbances, capacity for recovery and self-organization, and the ability to adapt to new conditions” (Kais & Islam, 2016). Like vulnerability, resiliency is defined and measured in different ways, relative to the objectives and goals of a research project. Despite the variety in definitions, there are common elements across the literature. Patel et al. (2017) conducted a literature review of the definitions of community resiliency across disaster literature and found nine consistent elements across most definitions: local knowledge, networks and relationships, communication, health, leadership, resources, economic investment, preparedness, and mental outlook (Patel et al., 2017). Each element included sub-elements that contribute to the main indicators. All nine elements and sub-elements can be attributed to one of the four community capitals or disaster management phases to be analyzed in this thesis.

One of the major contributing factors to a community’s resiliency against hurricanes is their composition of community capital. The Community Capitals Framework (CCF) is one of the most common approaches to analyzing capital within a community as it serves as a broad enough foundation to be applied to a multitude of different disciplines. The CCF identifies seven forms of community capital: natural, cultural, human, social, political, financial, and built (Emery & Flora, 2006). The CCF is a means of analyzing capital stock, flow, interactions, and resulting impacts (Emery & Flora, 2006). The framework defines each of these capitals as denoted in table 1. A resilient community will have well-balanced capitals across their community, contributing to their ability to cope with the effects of a disaster, within all phases of the disaster management process. There are a number of disaster risk reduction and resilience indices that address all, or
most, of the capitals identified in the CCF (S. L. Cutter et al., 2010; S. L. Cutter & Derakhshan, 2020; Rifat & Liu, 2020). The specific components of each capital to be used in this research will be discussed further in the methods chapter.

<table>
<thead>
<tr>
<th>Types of Capital</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>Environment, rivers, lakes, forests, wildlife, soil, weather, and natural beauty</td>
</tr>
<tr>
<td>Cultural</td>
<td>Traditions, heritage, work ethic, ethnic festivals. Influences what voices are heard and listened to and how creativity, innovation, and influence are nurtured</td>
</tr>
<tr>
<td>Human</td>
<td>Skills and abilities of residents and the capacity to access resources/knowledge to increase understanding and identify promising practices, including leadership</td>
</tr>
<tr>
<td>Social</td>
<td>Networks and connections among a community; the social glue that makes things happen; includes bonding (within the community) and bridging (across communities) capital</td>
</tr>
<tr>
<td>Political</td>
<td>Ability to influence standards, rules, regulations, and their enforcement</td>
</tr>
<tr>
<td>Built</td>
<td>Infrastructure that supports the community (utilities, buildings, public works, etc.)</td>
</tr>
<tr>
<td>Financial</td>
<td>Financial resources available to invest in community capacity building</td>
</tr>
</tbody>
</table>

Each indicator for a community capital influences at least one, but up to all four, of the disaster management phases. Understanding their role in terms of these phases is necessary for a full evaluation of the community’s ability to cope with a disaster. The four phases of the disaster management process include (1) mitigation, (2) preparedness, (3) response, and (4) recovery. These four phases can be categorized as pre-disaster (mitigation and preparedness), during disaster (response), and post-disaster (recovery) (Khan, 2008). Pre-disaster phases include minimizing the effects of a disaster and planning the appropriate response according to the
knowledge at hand. Response during a disaster includes all efforts to further protect life and property. Finally, the recovery phase is the community’s attempts to return to normal. Each of the four phases are addressed differently by communities using their unique skills, knowledge, and management systems. All phases consist of specific activities that contribute to well-thought-out management practices, including population movements in the response phase and reconstruction in the recovery phase (S. Cutter et al., 2012). A thorough look at the disaster phases’ activities that will be addressed through this research will be discussed in the methods chapter.

Figure 1: Disaster Management Process (Crisis Management and Disaster Response Center of Excellence, 2020)

1.3 Literature Review

National organizations, such as the Federal Emergency Management Agency (FEMA), the American Red Cross, and the Salvation Army, are well known for their coordinated efforts to help disaster-affected areas prepare, respond, and recover to hurricanes. Despite the assistance from these public and private organizations, resources for preparing for, responding to, and
recovering from a hurricane are often still limited. Communities must rely on their own people and resources to manage the effects of the storm. Efforts to better understand a community’s ability to do so have resulted in a shift in focus from assessing the vulnerability of an area to assessing its resiliency as a community. This can include evaluating the community’s capitals, management and planning processes, and natural protections, rather than focusing on common vulnerability measures like socioeconomic and demographic information.

Patel et al. (2017) discusses that this shift in focus to resiliency is perceived as a “more proactive and positive expression of community engagement” and more likely to create positive changes within a community (Patel et al., 2017). While the overall shift to resiliency assessments seems to be more beneficial to communities, there is still a wide range of metrics and no clear consensus as to what makes up a community’s resiliency. Resiliency studies are plagued with inconsistencies ranging from the defining and measuring of key terminology and general methodology resulting in different understandings, interpretations, and applications of the content. While this variety is not inherently bad, it does create difficulty in comparing one piece of literature to another. The following literature review synthesizes previous literature reviews and their findings and highlights some influential frameworks/indices.

**Previous Reviews & Conclusions**

There have been a number of cohesive literature reviews summarizing the approaches, models, and tools used in community disaster resilience. These reviews offer a variety of insights and conclusions that have aided in the development of the disaster risk management field. One review focused on the issues of needing a more systematic and comprehensive approach after identifying that there were more studies focused on post-disaster resiliency rather than pre-disaster or the combination of the two (Ostadtaghizadeh et al., 2015). Additionally, Cai et al.
found that of their nearly 200 studied articles, about 40% used qualitative methods, 40% used quantitative methods, and only 13% used both (Cai et al., 2018). This supplies a variety of data and methods for disaster and emergency managers to review but requires that they be aware of all unique differences, such as assumptions and definitions used in the research.

A common indication in these reviews was that the definition of community resilience ranges vastly depending on the hazard, location, and field, making comparability difficult from study to study (Cai et al., 2018; Ostadtaghizadeh et al., 2015). An additional factor influencing the lack of uniformity across research is the range of what is included in the variables and processes that influence resilience, in which some studies include 2-10 domains with 5-35 indicators per domain. This variety in indicators/factors that influences resiliency yields very different results that are difficult to compare across studies and apply to various locations.

There is also an indication that of those articles reviewed, very few of them provide validation for their methods and data (particularly those with the creation of indices) (Bakkensen et al., 2017). Bakkensen et al. (2017) conducted a validation study for multiple vulnerability and resiliency index studies in the disaster management field. This review was an attempt to ensure that the studied indices were empirically valid and used meaningful metrics for each domain of interest to better understand their ability to explain their desired objectives.

**Research Frameworks of Interests**

There is a large range in research frameworks and methodology within disaster resiliency and management research. General frameworks that are often adapted include place-based and capital-based approaches that use indices to rank communities based on their ability to resist the negative effects of a natural disaster. A place-based model is uniquely focused on one storm and
location, and uses spatial interactions among social, natural, and built systems (S. L. Cutter et al.,
2008). A capital-based approach, on the other hand, focuses on at least one (but usually multiple)
forms of capital within the community(s) to evaluate resiliency. Each index is based on a range
of domains (the specific categories that an index will be evaluated through – for instance,
ecologically, socially, economically, etc.) and indicators (measurable factors/data that can be
used to score the subjects within each domain) that correlate to the specific research questions of
the study. Each index contributes to the field of study and allows for decision makers to choose
from a variety of tools to apply and evaluate their strengths and weaknesses in resiliency.

Across the wide range of disaster management journals and articles published to date some
stand out more than others. The following four studies offered unique perspectives on disaster
management and brought significant contributions to the literature – ranging from methods
focused on specific locations to full regions and different defining factors for resiliency and
vulnerability.

**Baseline Resilience Index for Communities (BRIC):** One of the earliest and most cited
indices in the disaster resiliency literature is Cutter et al. (2010) “Baseline Resilience Index for
Communities” (BRIC). This study is modeled after previous research authored by Cutter, a
place-based framework known as the Disaster Resilience of Place (DROP). It identifies that the
total impact a natural disaster has on a community is the culmination of pre-existing conditions
of the community, the event characteristics, and the coping responses of the community and uses
six dimensions to measure such vulnerability and resilience (ecological, social, economic,
institutional, infrastructure, and community competence) (S. L. Cutter et al., 2008). The BRIC is
composed of 36 variables spread across five subcomponents to the index (S. L. Cutter et al.,
2010). This index was one of the first of its kind, allowing planners and policy makers to review
a county, region, or state by its overall resiliency ranking and identify the categories (subcomponents) in which an area needs to improve on most to increase its overall score.

**Social Vulnerability Index (SVI):** Flanagan et al.’s (2011) Social Vulnerability Index (SVI) is an approach focused on social vulnerability to disasters. Four major domains are used to for this index: socioeconomic status, household composition and disability, minority status and language, and housing and transportation (Flanagan et al., 2011). This approach differs from Cutter’s resiliency measurements in that it is far more focused on vulnerable populations. This index allows planners better insight on how to identify and support their socially vulnerable communities, using Hurricane Katrina and Louisiana as a case study (Flanagan et al., 2011).

**Rural Resilience Index (RRI):** Cox and Hamlen (2015) use a community-centered approach to measuring resilience in rural and remote areas in Canada, entitled the Rural Resilience Index (RRI). The RRI varies from previously discussed studies in that it is both qualitative and quantitative, built upon a number of indicators drawn from the community disaster resilience literature, expert opinions, and analysis of local stories and comments regarding resiliency (Cox & Hamlen, 2015). It is also built to be adaptable to an area based upon their own resources, priorities, and capabilities. The RRI uses eight domains for measuring resiliency with 5-6 indicators each: human, social, built, economic, and natural capitals, as well as governance and disaster preparedness. Additionally, this index was formatted into an interactive web application with reduced measurements to allow for easy use in non-studied areas. This approach is far more intensive and localized with the inclusion of local surveys and experts, but provides flexibility, empowerment, and community integration (Cox & Hamlen, 2015).

**emBRACE:** The final framework to be discussed in this literature review is that of Kruse et al. (2017), emBRACE. The emBRACE framework defined resilience across three core domains,
resources and capacities, actions, and learning (Kruse et al., 2017). While the previously described indices incorporate the concepts of resources and capacities and actions into their measurements, emBRACE is unique in that it adds an aspect of learning, such as critical reflection, experimentation and innovation, and risk/loss perception. This approach was created in these three broader domains in order to be applicable to multiple disciplines and aid primarily in communication and understanding of community resilience (Kruse et al., 2017).

1.4 Basis of Research

The general idea for this thesis came from a 2009 dissertation by a PhD student at Texas A&M University (Mayunga, 2009). The author, Joseph Mayunga, created a multi-dimensional index model for measuring community disaster resilience and applied his index to the U.S Gulf Coast region, entitled the Community Disaster Resiliency Index (CDRI). His research drew upon two major insights from the literature: an effective framework must address all four disaster management phases as well as five forms of capital (Peacock, 2010). It draws its community disaster resilience measurements from the intersection between the activities necessary in all four disaster management phases (mitigation, preparation, response, and recovery) and the community capitals necessary for completing those activities (Mayunga, 2009; Peacock, 2010). Mayunga successfully created 3 different community disaster resiliency indices (CDRI-1, -2, and -3). For this thesis, I will be evaluating the eastern seaboard using the CDRI-1. The index itself is a measure of a place’s resiliency capacity, offering a complementary analysis to studies that focus on resiliency based upon a moment in time or a particular response to a storm. The creation of this index followed these general steps:

1. Identifying and selecting a list of indicators and identifying which disaster management phases they are relevant to
2. Standardizing, weighing, and testing the indicators
3. Creating 4 sub-indices based on the four capitals and calculating each county’s score for each sub-index
4. Calculating the overall Community Disaster Resilience Index-1 (CDRI-1) score for each county

Additionally, Mayunga validated his methods with multiple tests to ensure reliability (Cronbach’s alpha coefficients and inter-item correlations) and predictability (correlation and multiple regression analyses). The reliability test indicated that each sub-indices was fairly reliable, the inter-item correlations of the indicators were mostly significant and positive, and the community disaster resilience index 1 (CDRI-1) is a fairly reliable measure (Mayunga, 2009). The predictability assessment determined that the CDRI worked as anticipated and that it is theoretically and empirically valid (Mayunga, 2009). Mayunga also validates his index against relevant outcomes, such as observed damages, fatalities, vulnerability, and underlying physical risk (Bakkensen et al., 2017). This thesis will not go further into the validity of the methods, but rather apply them to evaluate the CDRI-1 within the eastern seaboard counties.

1.5 Study Area

The United States’ eastern seaboard ranges from Maine to Florida, encompassing 14 states and over 2,100 miles. Within those 14 states there are 129 counties that directly touch the Atlantic Ocean and are significantly impacted by hurricanes. This region will be the focus of this thesis and will add substantial understanding regarding the community resiliency of these counties and states. Figure 2 indicates the study area for this research.
According to the Insurance Information Institute, 9 of the 10 costliest hurricanes in the United States occurred from 2000-2020. Of these 10 costliest hurricanes, 8 impacted the east coast states being studied (Insurance Information Institute, 2020). Some of the most notable storms from this list include Hurricanes Katrina, Irma, Harvey, and Sandy – each of which had severe impacts on the communities it hit, ranging from loss of life, property, and livelihoods. The more southern states in this study, such as Florida, Georgia, and South Carolina, are often hit with a range of hurricanes each season varying in strength. The northern states in this study, including New England states, New York, and New Jersey, are typically hit by weaker
hurricanes and tropical storms. The large range in experiences across states attributes to each community’s response to storms and their overall community resiliency.

Coastal communities face a unique range of challenges based on their geography including, but not limited to, coastal erosion, rising sea levels, and increasing intensity of natural disasters. Research on climate change and its impacts on weather events indicates that these challenges will become more disruptive and dangerous to those living in coastal communities, with the National Oceanic and Atmospheric Administration (NOAA) stating that there is at least a 66% chance that the number of storms to reach category 4 and 5 will increase (Knutson, 2020).

Despite the knowledge that these coastal areas will continue to face destruction from hurricanes, coastal population and urbanization continues to grow. The IPCC expects that population growth, economic development, and urbanization of coastal areas will significantly increase the number of people and assets at risk to the impacts of extreme weather events and the declining coastal ecosystems (Wong et al., 2014). Based on 2010 population statistics, 39% of the U.S population lived in coastal shoreline counties, which make up less than 10% of the total land in the country (Crossett et al., 2013). Population density in these counties is expected to continue to grow well past 2020, already seeing an increase of nearly 150 people/square mile from 1970 to 2010 (Crossett et al., 2013).

The United States’ east coast is among the regions facing this increase in population density. While significant research has been put forth focusing on the Gulf of Mexico region, the eastern seaboard faces similar challenges to the Gulf, and further research into their ability as a region and as smaller communities to withstand the impacts of these disasters is imperative to the well-being of thousands of people, properties, and ecosystems. This research serves to add volume to the literature focused on community disaster resiliency in the United States’ east coast.
1.6 Research Objectives

The research put forth in this thesis has three main objectives:

(1) To better understand the role of vulnerability and resiliency in disaster management
(2) To apply a validated method of measuring community resiliency to a new geographical region
(3) To identify regional, state, and county specific strengths and weaknesses regarding the four studied community capitals through an assessment of their disaster resiliency capacity, as indicated by their CDRI scores

1.7 Research Questions

This thesis will address the following research questions and hypotheses related to these objectives:

(1) What is the relation between vulnerability and resilience in hurricane disaster management?
(2) Do regions, states, and counties show any clear patterns in strengths and weaknesses regarding community capitals and their impacts on resiliency scores?
(3) Does the eastern seaboard of the U.S show any spatial patterns related to county resiliency?

Through my analysis and answering of these questions, I expect to be testing these hypotheses:

(1) Coastal counties that experience hurricanes more frequently (ex: counties located in the Southeast and Mid-Atlantic states over the Northeast states) will have higher CDRI
scores than those counties that have historically experienced fewer hurricanes due to more frequent use and adjustments to their disaster management plans and operations.

(2) There will be spatially significant clusters of coastal counties within the overall and sub-indices being evaluated. This is based on the understanding that communities interact with each other and learn how to better manage disasters together by sharing resources and knowledge.

1.8 Significance of Research

The literature surrounding disaster resiliency indicates that there is still a need for more research on measurements of community resiliency against disasters (Bakkensen et al., 2017; Cai et al., 2018; Ostadtaghizadeh et al., 2015; Wong et al., 2014). This thesis will contribute to the literature by adding volume to a previous tested and tried index. By doing so, the index can be evaluated on multiple fronts - two different geographic regions on the United States. Beyond adding to the literature on disaster resiliency, this research can serve as insight for East Coast communities in disaster management and resource planning. The index will offer county-level breakdowns of their community capitals and overall resiliency, supporting the identification of successes and failures in their management of capitals. This research will provide evidence to disaster management departments for procedural and operational changes that better their community’s resiliency to natural disasters.
CHAPTER TWO: METHODS

This research is designed to evaluate the study area’s community resiliency, particularly against hurricanes and within the realm of disaster management. The overall approach mimics previous research conducted by Joseph Mayunga at Texas A&M University (Mayunga, 2009). The scope of this research is to evaluate the United States’ Eastern Seaboard for regional, state, and county level resiliency. The evaluation of this index will expose spatial patterns of community resilience and strengths and weaknesses for counties in the four community capitals being studied (human, physical, social, and economic).

The following chapter will be organized to review Mayunga’s previous research and creation of the modelled index, introduce the steps required for creating the index, present the planned analysis following completion of the index, and discuss the variations from the original research and contributions to the field.

2.1 The Original Research

Joseph Mayunga’s 2009 Dissertation titled “Measuring the Measure: A Multi-Dimensional Scale Model to Measure Community Disaster Resilience in the U.S Gulf Coast Region” is a well-cited index within the disaster management and resiliency literature. Mayunga has contributed to the disaster risk reduction field with other research concerned with organizational and flood resilience and vulnerability assessments (Sweya et al., 2019, 2020). His thesis work created three different indices for measuring community disaster resiliency (CDRI-1, CDRI-2, CDRI-3), using a combination of community capitals and the disaster management phases. CDRI-1 was focused on the capital domain (including human, physical, social, and economic capitals), CDRI-2 on capital and disaster phases (applying the four community capitals to the
disaster management phases in which they specifically impact), and CDRI-3 on the disaster phases. Each index involved a different amount of sub-indices – CDRI-1 having the most (16) (Mayunga, 2009).

His conceptual foundation for community capital differs from that of the Community Capitals Framework (CCF) discussed in chapter one. Mayunga’s choice of community capitals is based on the sustainable livelihood framework (SLF) (Chambers & Conway, 1992). This framework differs from the CCF in that it only includes five capitals: natural, human, physical, social, and economic. The SLF is more oriented towards a disaster management discipline rather than the wide ranging CCF. Each of the community capitals have the ability to support and enhance one another when applied properly to a disaster situation (Kais & Islam, 2016). The only exception to the SLF in these methods is that natural capital was not included in his research for two reason: (1) the focus of the index is centered around social systems and (2) standardized measurements of natural capital vary significantly from location to location and region to region (Mayunga, 2009).

The research conducted in my thesis focuses on the application of the CDRI-1 to the Eastern Seaboard counties (Florida to Maine), using Mayunga’s methods. The reason for this, is that the CDRI-2 and -3 face issues of double-counting indicators, as the community capitals each influence more than one disaster management phase – in which the capitals would not be evenly weighted across the index values (Mayunga, 2009). Additionally, Mayunga’s reliability assessments within his work indicate that each of the three indices are reliable measures, but the CDRI-1 is the only one that does not indicate significant bias from the double counting of indicators. Finally, the validity assessments conducted by Mayunga suggested that the CDRI-1 was “theoretically and empirically valid” (Mayunga, 2009).
2.2 Creating the Index: Activities, Indicators, and Procedures

The development of the CDRI-1 involved the following steps: (1) identify relevant activities to each disaster management phase and significant components for each community capital, (2) identify measurable community indicators that reflect the community capitals’ components within the disaster management phases, (3) collect indicator data for each county being studied, (4) standardize the indicators using Z-scores, and (5) create the 4 sub-indices and overall CDRI-1 scores using the averaging method.

There are a few important concepts to consider while applying an indexing method to research in general. The first is that there are inherently issues with using a single index value as measurement for a broad concept such as disaster management, ultimately simplifying a multidimensional, complex issue into a single value. It is possible that composite index values may mask valuable information from the indicators collected in generating the index. This may lead to misuse of the findings and result in policy adaptations that are not fit for the situation. In the case of this research, for instance, the composite index and sub-index scores can give general insight to a community’s capital stock, but these values should not be taken as the only interpretation of the data. Rather, the index can focus community efforts by highlighting potential strengths and weaknesses, in which local planners, managers, and community members can begin to dissect the indicators of each index for areas of improvement. The value of individual indicators and community capital sub-indices is likely just as valuable for planners and policy makers as the overall CDRI, and thus the index analysis should be supplemented with community knowledge of local strengths and weaknesses for practical application.
**Disaster Management Activities**

There are four major phases to disaster management: mitigation, preparedness, response, and recovery. Each phase involves key activities that increase a community’s ability to cope with the disaster at hand. These activities should enhance the community’s organization and communication and identify barriers and opportunities to better management practices. The four phases can be split into the following categories: Pre-disaster (mitigation and preparedness), Disaster occurrence (response), and post-disaster (recovery) (Khan, 2008).

Pre-disaster phases of mitigation and preparedness can both be characterized as attempting to reduce risks imposed on people and property from a disaster. Mitigation efforts are made in advance of any real threat and categorized as structural or nonstructural (Saravanan, 2016). Structural mitigation activities may include building protective structures (dams, levees, etc.) and enforcing building codes and zoning regulations (Mayunga, 2009; Saravanan, 2016). Nonstructural mitigation activities may include educational tools and communication services. Mitigation activities can also be considered attempts at eliminating long-term risks to people and property (Federal Emergency Management Agency, 2020). In contrast to mitigation efforts, preparedness activities surface when imminent concern for a threat occurs. These activities are specific to locality and include development and implementation of emergency operations plans (communication, resource allocation, staff training, etc.) (Federal Emergency Management Agency, 2020).

The disaster response phase begins within the preparation phase but extends throughout the duration of the event. The activities involved in this phase may include emergency assistance, evacuation, and securing critical infrastructure (Federal Emergency Management Agency, 2020).
The overall goal of effective disaster response is to stabilize the area and the affected people and to proceed smoothly to the recovery phase.

The final phase in the disaster management cycle is post-disaster recovery. Recovery efforts are a balancing game between the short-term goal of returning the affected area back to its functioning normalcy and the long-term goal of reducing future vulnerability to the same type of disaster (Baird, 2010). Recovery is also complex in that it involves all sectors and subcommunities within the affected area – housing, education, businesses, and the environment. The activities involved in recovery efforts are vast – but may include restoring and rebuilding housing, businesses, and critical infrastructure and establishing better practices for mitigation and preparedness stages.

Identifying relevant activities within each disaster management phase is the first step to developing the community disaster resiliency index. “Relevancy” in this sense refers to activities that can be measured by the components that make up the community capitals, as listed in table 2. Mayunga (2009) thoroughly evaluates each phase for such activities – identifying the activities found in table 3 as essential to each phase.

**Table 2: Measurable components of each community capital (Mayunga, 2009)**

<table>
<thead>
<tr>
<th>Community Capital</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Education attainment, health, labor force</td>
</tr>
<tr>
<td>Social</td>
<td>Participation in voluntary organizations, involvement in social groups, civic and political participation, religious participation, community attachment, connection to working places</td>
</tr>
<tr>
<td>Physical</td>
<td>Construction, environment, land and building regulations, land-use planning, property insurance, research, college, housing, critical infrastructure, transportation, communication, emergency shelter and relief services</td>
</tr>
</tbody>
</table>
Economic Income, employment, property value, business, health insurance

Table 3: Activities included in development of CDRI-1 (Mayunga, 2009)

<table>
<thead>
<tr>
<th>Disaster Management Phase</th>
<th>Relevant Activities</th>
</tr>
</thead>
</table>
| Mitigation                | 1. Building dams, levees, dikes, and floodwalls  
                            | 2. Land use planning to prevent development in hazardous areas  
                            | 3. Strengthening buildings through codes and standards  
                            | 4. Protecting the natural environment  |
| Preparedness              | 1. Developing response procedures  
                            | 2. Design and installation of warning systems  
                            | 3. Developing plans of evacuation  
                            | 4. Emergency operations exercises  
                            | 5. Trained emergency management personnel  
                            | 6. Stockpiling resources  |
| Response                  | 1. Securing impacted areas  
                            | 2. Warnings  
                            | 3. Evacuation  
                            | 4. Search and Rescue  
                            | 5. Provisional medical care and sheltering  |
| Recovery                  | 1. Reestablishing economic activity  
                            | 2. Provision of housing, clothing, and food  
                            | 3. Restoring critical facilities and community services  
                            | 4. Reconstruction of major infrastructure  |

**Indicators and Data**

After proper identification of activities relevant to the disaster management phases, indicators must be chosen to represent those activities. Each indicator chosen is designated to one of the four community capitals – human, physical, social, and economic. This designation allows for the creation of individual sub-indices as well as the overall CDRI-1. Mayunga’s creation of the CDRI-1 involved collecting data for 75 indicators, however current data availability has limited this thesis to 69 of the original 75 indicators. Table 4 lists the 69 indicators, as split by the relevant community capital.
<table>
<thead>
<tr>
<th>Community Capital</th>
<th>Indicators (69)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human (21)</td>
<td>- Population with more than high school education</td>
</tr>
<tr>
<td></td>
<td>- Physicians</td>
</tr>
<tr>
<td></td>
<td>- Health care support workers</td>
</tr>
<tr>
<td></td>
<td>- Building construction workers</td>
</tr>
<tr>
<td></td>
<td>- Heavy &amp; civil engineering construction workers</td>
</tr>
<tr>
<td></td>
<td>- Architecture &amp; engineering workers</td>
</tr>
<tr>
<td></td>
<td>- Highway, street, &amp; bridge construction workers</td>
</tr>
<tr>
<td></td>
<td>- Environmental consulting workers</td>
</tr>
<tr>
<td></td>
<td>- Environmental &amp; conservation workers</td>
</tr>
<tr>
<td></td>
<td>- Land subdivision workers</td>
</tr>
<tr>
<td></td>
<td>- Legal services workers</td>
</tr>
<tr>
<td></td>
<td>- Building inspectors</td>
</tr>
<tr>
<td></td>
<td>- Landscape architects &amp; planners</td>
</tr>
<tr>
<td></td>
<td>- Property &amp; casualty insurance workers</td>
</tr>
<tr>
<td></td>
<td>- FEMA approved mitigation plans</td>
</tr>
<tr>
<td></td>
<td>- Firefighters, prevention, &amp; law enforcement workers</td>
</tr>
<tr>
<td></td>
<td>- Scientific research &amp; development workers</td>
</tr>
<tr>
<td></td>
<td>- Population employed by colleges, universities, &amp; professional schools</td>
</tr>
<tr>
<td></td>
<td>- Population that speaks English “very well”</td>
</tr>
<tr>
<td></td>
<td>- Special needs transportation workers</td>
</tr>
<tr>
<td></td>
<td>- Community &amp; social workers</td>
</tr>
<tr>
<td>Physical (33)</td>
<td>- Building construction establishments (est.)</td>
</tr>
<tr>
<td></td>
<td>- Heavy &amp; civil engineering construction est.</td>
</tr>
<tr>
<td></td>
<td>- Highway, street, &amp; bridge construction est.</td>
</tr>
<tr>
<td></td>
<td>- Utility systems est.</td>
</tr>
<tr>
<td></td>
<td>- Architectural and engineering est.</td>
</tr>
<tr>
<td></td>
<td>- Environmental consulting est.</td>
</tr>
<tr>
<td></td>
<td>- Environmental &amp; conservation est.</td>
</tr>
<tr>
<td></td>
<td>- Land subdivision est.</td>
</tr>
<tr>
<td></td>
<td>- Legal services est.</td>
</tr>
<tr>
<td></td>
<td>- Building inspection est.</td>
</tr>
<tr>
<td></td>
<td>- Property &amp; Casualty insurance est.</td>
</tr>
<tr>
<td></td>
<td>- Scientific research &amp; development est.</td>
</tr>
<tr>
<td></td>
<td>- Colleges, universities, &amp; professional schools</td>
</tr>
<tr>
<td></td>
<td>- Housing units</td>
</tr>
<tr>
<td></td>
<td>- Vacant housing units</td>
</tr>
<tr>
<td></td>
<td>- Hospitals</td>
</tr>
<tr>
<td></td>
<td>- Hospital beds</td>
</tr>
</tbody>
</table>
Table 4: Modified List of Indicators for the CDRI-1 (continued)

<table>
<thead>
<tr>
<th>Community Capital</th>
<th>Indicators (69)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical (33)</td>
<td>- Occupied housing units with a vehicle</td>
</tr>
<tr>
<td></td>
<td>- Special needs transportation services</td>
</tr>
<tr>
<td></td>
<td>- School and employee buses</td>
</tr>
<tr>
<td></td>
<td>- Occupied housing units with telephone services</td>
</tr>
<tr>
<td></td>
<td>- Newspaper publishers</td>
</tr>
<tr>
<td></td>
<td>- Radio stations</td>
</tr>
<tr>
<td></td>
<td>- Television stations</td>
</tr>
<tr>
<td></td>
<td>- Temporary shelters</td>
</tr>
<tr>
<td></td>
<td>- Community housing</td>
</tr>
<tr>
<td></td>
<td>- Community food services Ambulances</td>
</tr>
<tr>
<td></td>
<td>- Fire stations</td>
</tr>
<tr>
<td></td>
<td>- Schools</td>
</tr>
<tr>
<td></td>
<td>- Nursing homes</td>
</tr>
<tr>
<td></td>
<td>- Hotels and motel</td>
</tr>
<tr>
<td>Social (9)</td>
<td>- Registered non-profit Orgs.</td>
</tr>
<tr>
<td></td>
<td>- Recreational centers &amp; sports Orgs.</td>
</tr>
<tr>
<td></td>
<td>- Registered Voters</td>
</tr>
<tr>
<td></td>
<td>- Civic &amp; Political Orgs.</td>
</tr>
<tr>
<td></td>
<td>- Census response rates</td>
</tr>
<tr>
<td></td>
<td>- Religious Orgs.</td>
</tr>
<tr>
<td></td>
<td>- Owner-Occupied Housing</td>
</tr>
<tr>
<td></td>
<td>- Professional Orgs.</td>
</tr>
<tr>
<td></td>
<td>- Business Orgs.</td>
</tr>
<tr>
<td>Economic (6)</td>
<td>- Per-capita income</td>
</tr>
<tr>
<td></td>
<td>- Median household income</td>
</tr>
<tr>
<td></td>
<td>- Population employed</td>
</tr>
<tr>
<td></td>
<td>- Median value of owner-occupied housing</td>
</tr>
<tr>
<td></td>
<td>- Business establishment</td>
</tr>
<tr>
<td></td>
<td>- Percent of population with health insurance</td>
</tr>
</tbody>
</table>

Data for each indicator must be collected for every county within the study area. Data sources for this research include: The U.S Census (2020), County Business Patterns (2018), The Associated Press, the American Community Survey (1- and 5- year estimates), the Department of Homeland Security, the Federal Emergency Management Agency, the United States Department of Education, and the Center for Medicare & Medicaid Services.
Procedures

After successful collection of each indicator for all counties being considered, the data (which is collected as a value per 1000 people or a percentage) must be normalized to create the index. The chosen method for normalizing each indicator is the standard Z-Score as follows:

$$ Z - Score = \frac{Actual\ Value - Mean\ Value}{Standard\ Deviation} $$

Once all indicators are standardized using this formula, the next step is to create the four sub-indices: human capital, physical capital, social capital, and economic capital. These four sub-indices can be evaluated individually and combined to make the overall community disaster resilience index. Sub-index scores are calculated as:

$$ Sub - Index\ Score = \frac{\sum_{i=1}^{N} Z}{N} $$

$N$ = the number of indicators in a sub-index and $Z$ = the standardized score of an indicator

Following the creation of each sub-index, the overall CDRI scores can be collected by averaging the four sub-indices scores:

$$ CDRI\ Score = \frac{SC + PC + HC + EC}{4} $$

$SC$ = social capital index score, $PC$ = physical capital index score, $HC$ = human capital index score, and $EC$ = economic capital index score

There are a number of different methods for composing this index aside from the use of the averaging method. Mayunga (2009) identifies three reasons for the use of averaging: (1) the number of indicators for each sub-index are not equal and therefore averaging them ensures that
no one form of capital is significantly outweighing another in the final composite score, (2) he saw no theoretical reason that one capital or disaster management phase in more important than another, and therefore held each sub-index in equal weight, and (3) the averaging method performed better with his external criteria while assessing the validity of the index (Mayunga, 2009). It is, however, worth mentioning that in using the averaging method for the creation of the overall and sub-indices, a major assumption is made that each indicator and each form of capital is weighted the same. In reality, each community will have a different composition of community capital based upon the history of the community and resources available to them. One community may be prominently built upon by their community attachment and social networks (social capital) while another may be geared towards significant built infrastructure and economic resources. By weighing all indicators and capitals as equal, this could mislead planners in interpreting the index results.

2.3 Planned Analyses

The CDRI-1 for the United States’ eastern seaboard counties will be evaluated by region, state, and county ranks to identify the most and least resilient areas, according to the collected data. Each region, state, and county (Table 5) will be analyzed for their overall CDRI-1 scores in addition to each individual sub-index. These ranks will indicate which areas are higher performing in community resiliency and allow them to key into which community capitals might be their strongest and weakest. Additionally, that information will offer insight into which disaster management phases may be lacking in support from their community capitals. Once ranks are assigned and evaluated, regional, state, and county differences will be discussed in terms of each community capital and its role in disaster management.
Following the initial evaluation of each county and state’s CDRI-1 score, spatial patterns will be evaluated using ArcGIS. First, a basic visualization of the CDRI scores will be presented as groups based on the four quartiles. Second, optimized hot spot analysis will be used for the overall CDRI score as well as the sub-indices scores to allow for identification of statistically significant clusters of high and low scores within the index values. Applying a cluster analysis to this index is an opportunity to identify patterns in geographical areas regarding their disaster resiliency capacity.

2.4 Variations from the Original Research and Contributions to the Field

As mentioned earlier, Mayunga (2009) originally evaluated three different indices (CDRI-1, -2, -3). The major variation from Mayunga’s work in 2009 is that this thesis is solely focused on applying his Community Disaster Resiliency Index – 1 to the United States eastern seaboard. This approach will allow for more simplified analysis of the strengths and weaknesses of the studied communities, however, the data collected here is sufficient to also evaluate these communities using CDRI-2 and -3 in the future.

Additionally, it was noted that this thesis will focus on 69 of the 75 original indicators. Indicators that were not evaluated include: internet providers, childcare facilities, the percent of population covered by the comprehensive plan, the percent of population covered by zoning regulations, the percent of population covered by building codes, and the community rating system. Exclusion of these indicators was determined based on lack of consistent data availability. These indicators influence the human capital index (4) and physical capital index (2). While some counties may score better or worse with the inclusion of these indicators, the value of the index is not lost by excluding them, as all components of the human and physical capital domains are still accounted for with at least one indicator.
The results from this research will contribute to the field of community resiliency studies and disaster management in a few ways. Primarily, this research will add to the existing literature and studies by applying a reliable and validated indexing method to a new geographical area – the United States’ eastern seaboard. This can increase the comparability of the index to other similar studies across regions. Indices are a good summarizing measure – it will evaluate the “big picture” of community resiliency along the east coast. In doing so, this research can also promote resiliency capacity building at community, state, and regional levels. Emergency planners at all levels can use the data and analysis to compare their progress overtime to communities around them. Strengths and weaknesses in the community capitals can be identified and used to reevaluate and adjust mitigation, preparedness, response, and recovery plans.
<table>
<thead>
<tr>
<th>Connecticut</th>
<th>Maryland</th>
<th>New York</th>
<th>Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairfield</td>
<td>Anne Arundel</td>
<td>Bronx</td>
<td>Accomack</td>
</tr>
<tr>
<td>Middlesex</td>
<td>Baltimore</td>
<td>Kings</td>
<td>Essex</td>
</tr>
<tr>
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<td>Baltimore City</td>
<td>Nassau</td>
<td>Fairfax</td>
</tr>
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<td>Calvert</td>
<td>New York</td>
<td>Gloucester</td>
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<td>Cecil</td>
<td>Queens</td>
<td>Hampton City</td>
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<tr>
<td>Kent</td>
<td>Charles</td>
<td>Richmond</td>
<td>Isle of Wight</td>
</tr>
<tr>
<td>New Castle</td>
<td>Dorchester</td>
<td>Suffolk</td>
<td>James City</td>
</tr>
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<td>Sussex</td>
<td>Harford</td>
<td>Westchester</td>
<td>King George</td>
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<td>Kent</td>
<td>North Carolina</td>
<td>Lancaster</td>
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<td>Queen Anne’s</td>
<td>Beaufort</td>
<td>Mathews</td>
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<td>Somerset</td>
<td>Bertie</td>
<td>Middlesex</td>
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<td>Duval</td>
<td>St. Mary’s</td>
<td>Brunswick</td>
<td>Newport News City</td>
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<td>Talbot</td>
<td>Camden</td>
<td>Norfolk</td>
</tr>
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<td>Indian River</td>
<td>Wicomico</td>
<td>Carteret</td>
<td>Northampton</td>
</tr>
<tr>
<td>Martin</td>
<td>Worcester</td>
<td>Chowan</td>
<td>Northumberland</td>
</tr>
<tr>
<td>Miami-Dade</td>
<td></td>
<td>Craven</td>
<td>Poquoson City</td>
</tr>
<tr>
<td>Nassau</td>
<td>Massachussetts</td>
<td>Currituck</td>
<td>Portsmouth City</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>Barnstable</td>
<td>Dare</td>
<td>Prince William</td>
</tr>
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<td>St. John’s</td>
<td>Bristol</td>
<td>Hyde</td>
<td>Richmond</td>
</tr>
<tr>
<td>St. Lucie</td>
<td>Dukes</td>
<td>New Hanover</td>
<td>Stafford</td>
</tr>
<tr>
<td>Volusia</td>
<td>Essex</td>
<td>Onslow</td>
<td>Surry</td>
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<td>Georgia</td>
<td>Nantucket</td>
<td>Pasquotank</td>
<td>Virginia Beach</td>
</tr>
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<td>Bryan</td>
<td>Norfolk</td>
<td>Pender</td>
<td>Westmoreland</td>
</tr>
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<td>Camden</td>
<td>Plymouth</td>
<td>Perquimans</td>
<td>York</td>
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<td>Chatham</td>
<td>Suffolk</td>
<td>Tyrrell</td>
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</tr>
<tr>
<td>Glynn</td>
<td>New Hampshire</td>
<td>Washington</td>
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<tr>
<td>Liberty</td>
<td>Rockingham</td>
<td></td>
<td></td>
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<tr>
<td>McIntosh</td>
<td>New Jersey</td>
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</tr>
<tr>
<td>Maine</td>
<td>Atlantic</td>
<td>Rhode Island</td>
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<td>Cape May</td>
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<tr>
<td>Hancock</td>
<td>Cumberland</td>
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<td>Knox</td>
<td>Essex</td>
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<td>Lincoln</td>
<td>Hudson</td>
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<td>Middlesex</td>
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<td>Washington</td>
<td>Ocean</td>
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<tr>
<td>York</td>
<td>Salem</td>
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<td></td>
<td>Union</td>
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</tr>
</tbody>
</table>
CHAPTER THREE: INDEX AND SPATIAL RESULTS

The following chapter will present the results of the index and spatial evaluation for both the overall index and the four sub-indices. The results presented in this chapter hold valuable information on disaster management at the regional, state, and county levels. Results can indicate strengths and weaknesses among a study area’s composition of community capitals that influence their resiliency capacity during a hurricane event. Implications from those results can be used as evidence to promote policies and procedures that strengthen the community’s weak points within disaster management.

3.1 Index Results

After collecting the data to conduct this analysis, each county and state studied has been ranked according to their CDRI-1 score or state mean CDRI-1 score, in addition to each sub-index rank. A brief review of the regional differences (northeast, mid-Atlantic, and southeast) among states is also considered. This evaluation is done using ranks, scores, and box plots to understand the distribution of community resilience. A full breakdown of county scores by overall index and sub-indices is available in Appendix A.

Regional and State Results

A regional evaluation of the community disaster resiliency index is useful in that it connects the counties studied by recognized geographical groups that influence the way they manage disasters. These regions face different experiences that shape the way they approach policy and procedures regarding disaster management. Influences on regional differences could include storm frequency and intensity, natural protections and variables, and social and economic programs, among many others.
This research has revealed that almost all Northeastern states have outranked the mid-Atlantic and Southeastern states studied. Northeastern states (5) include: Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island. Mid-Atlantic states (4) are: Delaware, Maryland, New Jersey, and New York. Southeastern states (5) are: Florida, Georgia, North Carolina, South Carolina, and Virginia. Mean scores for the three regions were determined by averaging the scores of each state within the region. Figure 3 shows the box plot for the CDRI-1 scores, as organized by geographical regions. The box plot based on regions indicates that the southeastern counties’ scores appear to be the most condensed, while the northeast counties’ scores are the most dispersed, however the southeastern states’ counties clearly score lower, on average, than those of the northeast and mid-Atlantic. These scores for each region according to the overall index are presented in table 6. The northeast scores much higher (0.38403) than the mid-Atlantic and southeast regions (0.09058 and -0.21976, respectively).

Figure 3: Regional box plot for CDRI-1
Table 6: Regional mean scores for CDRI-1

<table>
<thead>
<tr>
<th>Region</th>
<th>Mean Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>0.38403</td>
<td>1</td>
</tr>
<tr>
<td>Mid-Atlantic</td>
<td>0.09058</td>
<td>2</td>
</tr>
<tr>
<td>Southeast</td>
<td>-0.21976</td>
<td>3</td>
</tr>
</tbody>
</table>

In addition to the overall rank, each sub-index is evaluated for regional scores as well.

Table 7 indicates the mean score for each sub-index and rank by region. Northeast states score the highest in all four community capital indexes, significantly outperforming the other regions in economic, social, and physical capital. The southeast also consistently scores the lowest in all four sub-indices, with its lowest score in the economic capital index. All northeast sub-indices scores are positive, while mid-Atlantic scores are all positive except for social capital. All southeast sub-index scores are negative.

Table 7: Regional mean scores for the four sub-indices

<table>
<thead>
<tr>
<th>Region</th>
<th>Human Capital</th>
<th>Physical Capital</th>
<th>Social Capital</th>
<th>Economic Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Rank</td>
<td>Score</td>
<td>Rank</td>
</tr>
<tr>
<td>Northeast</td>
<td>0.17959</td>
<td>1</td>
<td>0.24981</td>
<td>1</td>
</tr>
<tr>
<td>Mid-Atlantic</td>
<td>0.12019</td>
<td>2</td>
<td>0.01029</td>
<td>2</td>
</tr>
<tr>
<td>Southeast</td>
<td>-0.12415</td>
<td>3</td>
<td>-0.10675</td>
<td>3</td>
</tr>
</tbody>
</table>

State results were calculated using the mean score of the counties’ scores in each state.

Counties were distributed as according: Connecticut (4), Delaware (3), Florida (12), Maine (8), Maryland (15), Massachusetts (8), New Hampshire (1), New Jersey (10), New York (8), North
Carolina (18), Rhode Island (5), South Carolina (6), and Virginia (25). Table 8 reports each state’s coastal counties’ mean score and rank for the overall CDRI-1.

Table 8: State Mean CRDI-1 Scores

<table>
<thead>
<tr>
<th>State</th>
<th>Mean Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>0.7059</td>
<td>1</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>0.5406</td>
<td>2</td>
</tr>
<tr>
<td>Maine</td>
<td>0.2382</td>
<td>3</td>
</tr>
<tr>
<td>Connecticut</td>
<td>0.2344</td>
<td>4</td>
</tr>
<tr>
<td>New York</td>
<td>0.2018</td>
<td>5</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>0.2008</td>
<td>6</td>
</tr>
<tr>
<td>Delaware</td>
<td>0.1089</td>
<td>7</td>
</tr>
<tr>
<td>New Jersey</td>
<td>0.0296</td>
<td>8</td>
</tr>
<tr>
<td>Maryland</td>
<td>0.0218</td>
<td>9</td>
</tr>
<tr>
<td>Florida</td>
<td>-0.0707</td>
<td>10</td>
</tr>
<tr>
<td>Virginia</td>
<td>-0.1228</td>
<td>11</td>
</tr>
<tr>
<td>South Carolina</td>
<td>-0.1588</td>
<td>12</td>
</tr>
<tr>
<td>North Carolina</td>
<td>-0.3261</td>
<td>13</td>
</tr>
<tr>
<td>Georgia</td>
<td>-0.4202</td>
<td>14</td>
</tr>
</tbody>
</table>

The top four ranks for states are held by Massachusetts, New Hampshire, Maine, and Connecticut, respectively. Massachusetts and New Hampshire out score the other states by a larger margin overall, however, New Hampshire did only have one coastal county and therefore only reflects the individual score of that county. The highest-ranking southeast state is Florida, ranked at 9th overall, meanwhile the highest-ranking mid-Atlantic state was New York, ranked at 5th overall. Additionally, all five southeast states scored below the mean. Southeastern states make up the bottom five ranks, while four of the five northeastern states are ranked in the top four. Mid-Atlantic states make up the difference, with ranks at 5th and 7th-9th. This indicates a clear pattern in which the northeast states outrank almost all other states, as discussed in the regional breakdown. Figure 4 shows that Maine, Massachusetts, and New York states have the most dispersal across their counties’ scores. Scores in Connecticut, Delaware, and Rhode Island
appear to be the most consistent. There are two outliers in the data: Somerset County, MD (126th overall) and Fairfax County, VA (7th overall).

Figure 4: State box plot of the CDRI-1

In addition to state mean scores for the overall CDRI-1, each state was ranked and evaluated according to the four sub-indices: human capital, physical capital, social capital, and economic capital (collectively referred to as community capitals). Table 9 shows the mean score and rank for each state in each community capital. Three states (Massachusetts, Connecticut, and New Hampshire) exhibit positive scores for all four capitals. The remaining ten states have scores in both the positive and negative ranges. States appear to generally perform better with physical capital, as nine states scored above the mean and five below. Human capital show eight states with scores above the mean and six below. Economic capital has six states above the mean and eight below, while finally, social capital has an equal distribution of states above and below the average, with seven each.
Table 9: Mean scores and ranks for each state in the four community capitals

<table>
<thead>
<tr>
<th>State</th>
<th>Human Capital</th>
<th>Physical Capital</th>
<th>Social Capital</th>
<th>Economic Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Rank</td>
<td>Score</td>
<td>Rank</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>0.4843</td>
<td>1</td>
<td>0.4393</td>
<td>1</td>
</tr>
<tr>
<td>New York</td>
<td>0.3278</td>
<td>2</td>
<td>0.0033</td>
<td>9</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>0.2437</td>
<td>3</td>
<td>0.3414</td>
<td>2</td>
</tr>
<tr>
<td>Maine</td>
<td>0.1374</td>
<td>4</td>
<td>0.3316</td>
<td>3</td>
</tr>
<tr>
<td>Delaware</td>
<td>0.1163</td>
<td>5</td>
<td>0.1682</td>
<td>4</td>
</tr>
<tr>
<td>Connecticut</td>
<td>0.0765</td>
<td>6</td>
<td>0.0857</td>
<td>5</td>
</tr>
<tr>
<td>New Jersey</td>
<td>0.0545</td>
<td>7</td>
<td>-0.0446</td>
<td>10</td>
</tr>
<tr>
<td>Florida</td>
<td>0.0416</td>
<td>8</td>
<td>0.0371</td>
<td>8</td>
</tr>
<tr>
<td>Maryland</td>
<td>-0.0179</td>
<td>9</td>
<td>-0.0857</td>
<td>11</td>
</tr>
<tr>
<td>South Carolina</td>
<td>-0.0419</td>
<td>10</td>
<td>0.0655</td>
<td>6</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>-0.0440</td>
<td>11</td>
<td>0.0508</td>
<td>7</td>
</tr>
<tr>
<td>Virginia</td>
<td>-0.1116</td>
<td>12</td>
<td>-0.1959</td>
<td>13</td>
</tr>
<tr>
<td>North Carolina</td>
<td>-0.2462</td>
<td>13</td>
<td>-0.1545</td>
<td>12</td>
</tr>
<tr>
<td>Georgia</td>
<td>-0.2625</td>
<td>14</td>
<td>-0.2859</td>
<td>14</td>
</tr>
</tbody>
</table>

The individual community capital mean scores and ranks are somewhat more variable than the overall CDRI-1 scores and ranks when referencing the regions (northeast, mid-Atlantic, and southeast). Rhode Island ranked the lowest among the northeast states in three of the four capitals (human, physical, and social), whereas Maine ranked lowest for economic capital. For northeast states, Massachusetts and New Hampshire consistently ranked 1<sup>st</sup> and 2<sup>nd</sup>, respectively. For mid-Atlantic states, Delaware ranked highest in physical (4<sup>th</sup>) and social (6<sup>th</sup>) capital and New York ranked highest in human (2<sup>nd</sup>) and economic (3<sup>rd</sup>) capital. The southeast states saw Florida ranking the highest in human (8<sup>th</sup>) and social (7<sup>th</sup>) capital, Virginia ranking highest in economic (10<sup>th</sup>) capital and South Carolina ranking the highest in physical capital, at 6<sup>th</sup> overall.
Overall, Massachusetts ranked 1st across all four community capitals and is most strongly influenced by its economic and social capital scores (1.2099 and 0.6901, respectively). New Hampshire consistently ranked 2nd or 3rd in all community capitals, scoring their highest in economic capital, followed by human capital. Georgia ranked last in three of the four capitals (human, physical, and social) and second to last in economic capital.

**County Results**

The basis of this research was to analyze the community capitals at the county level in a manner that would give comparable results to neighboring counties and create a baseline score for these communities to grow from. Following the regional and state discussion, it is important to review the individual counties that outperformed and underperformed, overall and within different capitals. This analysis can highlight those that implement policies and procedures that best serve the community in disaster management, as well as those that may not be focusing enough on community capitals as an approach to growing their resiliency. Each county received a rank (1-129) on the overall CDRI-1 and all four sub-indices. Overall CDRI scores range from 1.729 to -0.829. The top and bottom ten will be highlighted for review and considerations. Table 10 shows results for the top and bottom ten counties in their overall CDRI-1 ranks.

Perhaps one of the most notable takeaways from this ranking is that of the top ten scores, only three counties are from outside the northeast region: New York county, NY (2nd), Fairfax county, VA (7th), and Nassau County, NY (10th). As noted earlier, Fairfax county was considered outliers for the states’ box plots. The remaining seven top ranking counties are largely concentrated in Massachusetts (5) and Maine (2). On the other hand, all of the bottom ten ranking counties are in the southeast states (North Carolina holds six of these spots while Georgia holds the other four). Examining these counties can provide unique insight to what
capitals influence resiliency the most and what indicators other counties may want to focus on in their efforts to increase resiliency.

Table 10: Top 10 and Bottom 10 ranking counties by overall CDRI-1 Score

<table>
<thead>
<tr>
<th>County, State</th>
<th>Rank</th>
<th>County, State</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nantucket County, MA</td>
<td>1</td>
<td>Camden County, GA</td>
<td>120</td>
</tr>
<tr>
<td>New York County, NY</td>
<td>2</td>
<td>Perquimans County, NC</td>
<td>121</td>
</tr>
<tr>
<td>Dukes County, MA</td>
<td>3</td>
<td>Pamlico County, NC</td>
<td>122</td>
</tr>
<tr>
<td>Cumberland County, ME</td>
<td>4</td>
<td>Camden County, GA</td>
<td>123</td>
</tr>
<tr>
<td>Barnstable County, MA</td>
<td>5</td>
<td>Hyde County, NC</td>
<td>124</td>
</tr>
<tr>
<td>Suffolk County, MA</td>
<td>6</td>
<td>Washington County, NC</td>
<td>125</td>
</tr>
<tr>
<td>Fairfax County, VA</td>
<td>7</td>
<td>Onslow County, NC</td>
<td>126</td>
</tr>
<tr>
<td>Hancock County, ME</td>
<td>8</td>
<td>Tyrell County, NC</td>
<td>127</td>
</tr>
<tr>
<td>Norfolk County, MA</td>
<td>9</td>
<td>McIntosh County, GA</td>
<td>128</td>
</tr>
<tr>
<td>Nassau County, NY</td>
<td>10</td>
<td>Liberty County, GA</td>
<td>129</td>
</tr>
</tbody>
</table>

When presenting the top and bottom ten counties for each sub-index, there appears to be much more variation as to the states the perform above and below the mean. These results, analyzed as the components of the overall CDRI-1, can indicate which community capital a county performs best and worst in, in terms of the measurable indicators chosen for this study. This can therefore indicate where a community should focus their efforts in bettering their community capital to improve their community’s disaster resiliency. Below are the results for the top and bottom ten counties in the sub-indices present in tables 11-14.
Table 11: Top and Bottom 10 ranking counties in human capital

<table>
<thead>
<tr>
<th>County, State</th>
<th>Rank</th>
<th>County, State</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suffolk County, MA</td>
<td>1</td>
<td>Pamlico County, NC</td>
<td>120</td>
</tr>
<tr>
<td>New York County, NY</td>
<td>2</td>
<td>McIntosh County, GA</td>
<td>121</td>
</tr>
<tr>
<td>Nantucket County, MA</td>
<td>3</td>
<td>Hyde County, NC</td>
<td>122</td>
</tr>
<tr>
<td>Cumberland County, ME</td>
<td>4</td>
<td>Somerset County, MD</td>
<td>123</td>
</tr>
<tr>
<td>Fairfax County, VA</td>
<td>5</td>
<td>Flagler County, FL</td>
<td>124</td>
</tr>
<tr>
<td>Baltimore City County, MD</td>
<td>6</td>
<td>Kent County, MD</td>
<td>125</td>
</tr>
<tr>
<td>Norfolk County, MA</td>
<td>7</td>
<td>Camden County, NC</td>
<td>126</td>
</tr>
<tr>
<td>Nassau County, NY</td>
<td>8</td>
<td>Camden County, GA</td>
<td>127</td>
</tr>
<tr>
<td>Westchester County, NY</td>
<td>9</td>
<td>Washington County, NC</td>
<td>128</td>
</tr>
<tr>
<td>Barnstable County, MA</td>
<td>10</td>
<td>Mathews County, VA</td>
<td>129</td>
</tr>
</tbody>
</table>

Table 12: Top and Bottom 10 ranking counties in physical capital

<table>
<thead>
<tr>
<th>County, State</th>
<th>Rank</th>
<th>County, State</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nantucket County, MA</td>
<td>1</td>
<td>Somerset County, MD</td>
<td>120</td>
</tr>
<tr>
<td>Hancock County, ME</td>
<td>2</td>
<td>Flagler County, FL</td>
<td>121</td>
</tr>
<tr>
<td>Barnstable County, MA</td>
<td>3</td>
<td>Suffolk County, VA</td>
<td>122</td>
</tr>
<tr>
<td>New York County, NY</td>
<td>4</td>
<td>Perquimans County, NC</td>
<td>123</td>
</tr>
<tr>
<td>Cumberland County, ME</td>
<td>5</td>
<td>Camden County, GA</td>
<td>124</td>
</tr>
<tr>
<td>Cape May County, NJ</td>
<td>6</td>
<td>Poquoson City County, VA</td>
<td>125</td>
</tr>
<tr>
<td>Dukes County, MA</td>
<td>7</td>
<td>McIntosh County, VA</td>
<td>126</td>
</tr>
<tr>
<td>Washington County, ME</td>
<td>8</td>
<td>Surry County, VA</td>
<td>127</td>
</tr>
<tr>
<td>Richmond County, VA</td>
<td>9</td>
<td>Camden County, NC</td>
<td>128</td>
</tr>
<tr>
<td>New Hanover County, NC</td>
<td>10</td>
<td>Liberty County, GA</td>
<td>129</td>
</tr>
</tbody>
</table>

Table 13: Top and Bottom 10 ranking counties in social capital

<table>
<thead>
<tr>
<th>County, State</th>
<th>Rank</th>
<th>County, State</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dukes County, MA</td>
<td>1</td>
<td>Somerset County, MD</td>
<td>120</td>
</tr>
<tr>
<td>Nantucket County, MA</td>
<td>2</td>
<td>Hyde County, NC</td>
<td>121</td>
</tr>
<tr>
<td>Knox County, ME</td>
<td>3</td>
<td>Jasper County, SC</td>
<td>122</td>
</tr>
<tr>
<td>Hancock County, ME</td>
<td>4</td>
<td>Hudson County, NJ</td>
<td>123</td>
</tr>
<tr>
<td>New York County, NY</td>
<td>5</td>
<td>Onslow County, NC</td>
<td>124</td>
</tr>
<tr>
<td>Cumberland County, ME</td>
<td>6</td>
<td>McIntosh County, GA</td>
<td>125</td>
</tr>
<tr>
<td>Barnstable County, MA</td>
<td>7</td>
<td>Queens County, NY</td>
<td>126</td>
</tr>
<tr>
<td>Middlesex County, CT</td>
<td>8</td>
<td>Kings County, NY</td>
<td>127</td>
</tr>
<tr>
<td>Worcester County, MD</td>
<td>9</td>
<td>Liberty County, GA</td>
<td>128</td>
</tr>
<tr>
<td>Cape May County, NJ</td>
<td>10</td>
<td>Bronx County, NY</td>
<td>129</td>
</tr>
</tbody>
</table>
Table 14: Top and Bottom 10 ranking counties in economic capital

<table>
<thead>
<tr>
<th>County</th>
<th>Rank</th>
<th>County</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nantucket County, MA</td>
<td>1</td>
<td>Washington County, ME</td>
<td>120</td>
</tr>
<tr>
<td>New York County, NY</td>
<td>2</td>
<td>Liberty County, GA</td>
<td>121</td>
</tr>
<tr>
<td>Dukes County, MA</td>
<td>3</td>
<td>Colleton County, SC</td>
<td>122</td>
</tr>
<tr>
<td>Fairfax County, VA</td>
<td>4</td>
<td>Richmond County, VA</td>
<td>123</td>
</tr>
<tr>
<td>Nassau County, NY</td>
<td>5</td>
<td>McIntosh County, GA</td>
<td>124</td>
</tr>
<tr>
<td>Norfolk County, MA</td>
<td>6</td>
<td>Hyde County, NC</td>
<td>125</td>
</tr>
<tr>
<td>Fairfield County, CT</td>
<td>7</td>
<td>Somerset County, MD</td>
<td>126</td>
</tr>
<tr>
<td>Monmouth County, NJ</td>
<td>8</td>
<td>Bertie County, NC</td>
<td>127</td>
</tr>
<tr>
<td>Rockingham County, NH</td>
<td>9</td>
<td>Washington County, NC</td>
<td>128</td>
</tr>
<tr>
<td>Suffolk County, NY</td>
<td>10</td>
<td>Tyrell County, NC</td>
<td>129</td>
</tr>
</tbody>
</table>

The four-community capital sub-indices ranks indicate some additional variability in the top ten ranks. Each of the four indices show that the top ten positions are dominated by northeastern states’ counties, ranging from 50-70% of the top ten ranks. The remaining of the top ten ranks is distributed as 20-40% counties from the mid-Atlantic, and 0-20% counties from the southeast. There are only four cases where a southeast county ranks in the top ten of the sub-indices.

On the other hand, the bottom ten ranks for the capital sub-indices are much less variable, with 75% of the bottom ten ranks being southeast counties, 22.5% counties from the mid-Atlantic, and less than 2% from the northeast. Virginia, North Carolina, and Georgia counties have the most consistent presence in the bottom ten ranks for each community capital, with some additions from Maryland, Florida, South Carolina, New York, New Jersey, and Maine.

It may also be interesting to note the distribution of scores above and below the mean, according to the regional grouping of the counties. Of the counties ranking above the mean for the overall CDRI, only 25% are counties from the southeast, 37% are from the mid-Atlantic, and 38% from the northeast. For counties below the mean of the overall CDRI, 77% are southeast
counties, 20% are mid-Atlantic, 3% are from the northeast. Additional breakdowns for the sub-
indices are presented below in Table 15.

Table 15: Percent of regional counties that have scores above (+) and below (-) the mean in
the sub-indices

<table>
<thead>
<tr>
<th>Countries by Region</th>
<th>Human Capital</th>
<th>Physical Capital</th>
<th>Social Capital</th>
<th>Economic Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(+)</td>
<td>(-)</td>
<td>(+)</td>
<td>(-)</td>
</tr>
<tr>
<td>Northeast</td>
<td>87%</td>
<td>13%</td>
<td>88%</td>
<td>12%</td>
</tr>
<tr>
<td>Mid-Atlantic</td>
<td>81%</td>
<td>19%</td>
<td>42%</td>
<td>58%</td>
</tr>
<tr>
<td>Southeast</td>
<td>34%</td>
<td>66%</td>
<td>33%</td>
<td>57%</td>
</tr>
</tbody>
</table>

Table 15 highlights the differences in counties across the three regions. When comparing
economic capital scores, 88% of northeast counties scored above the mean, while just 19% of
southeast counties did so. Similar patterns extend with the remaining three capitals. Southeast
counties only have positive scores 33-34% of the time in human, physical, and social capital
indices, as compared to northeast counties, which had over 85% of counties above the mean in
the remaining three capitals. Mid-Atlantic counties consistently have more positive scoring
counties in all four capitals as compared to the southeast, and less as compared to the northeast.
This breakdown signals that southeast counties have far more ground to make in promoting their
community capitals than the northeast and mid-Atlantic.

**Index Results and Hypothesis 1**

The analysis of these study areas addresses hypothesis one: coastal counties located in states
that experience more hurricanes annually (Southeastern and mid-Atlantic states) will score
higher, on average, than states that experience hurricanes less often (Northeast states). This hypothesis came from the idea that states and communities that experience hurricanes more often are better positioned to have evaluated and reevaluated their mitigation, preparedness, response, and recovery plans than those that do not experience hurricanes as often. In addition, it could be assumed that these more experienced communities and states would have plans that have encouraged the development of their community capitals in a way that would better serve them for a future storm, and therefore would present as higher ranking in the CDRI.

3.2 Spatial Results

In addition to the above evaluation, a spatial analysis was conducting using ArcGIS to both visually present the index results as well as identify spatial clusters among the data of high and low scoring counties. The optimized hot spot tool was used for this evaluation which uses the Getis-Ord Gi* statistic to identify hot (high scores) and cold (low scores) spots of significance within the data. Figure 5 shows spatial distribution of CDRI scores for the United States’ eastern seaboard according to four quartiles. Northeast states are more resilient than states in the mid-Atlantic and Southeast, according to the map.

**Overall CDRI-1**

Spatial analysis of the overall community disaster resilience index scores for each county indicates a few statistically significant hot (referred to as “high spots” moving forward) and cold (referred to as “low spots” moving forward) spots. Figure 6 shows such clusters. The analysis shows only one region with hotspots – primarily consisting of counties in Rhode Island, Massachusetts, and New Hampshire, as well as a smaller grouping of Connecticut and New York counties. There are two statistically significant low spots, the first clustered across the North Carolina and Virginia border, and the second includes counties in Georgia and South Carolina.
Figure 5: Study area map showing counties of low to high resilience
In comparison to the index evaluation in section 3.1, these high and low spots appear to align well with the top and bottom 10 ranking county patterns, in which the top ten is dominated by Massachusetts counties and the bottom ten by Georgia and North Carolina counties. It is important to note here that a county included within a high or low spot does not necessarily have a high or low index score. Each county is compared to its neighbor features in which it is then decided if it is statistically significant. For instance, Dare County, North Carolina ranks 22\textsuperscript{nd} overall and falls within the fourth percentile, indicating high resiliency, however it is a part of the larger low spot that is seen in North Carolina and along the Virginia border. While Dare County
scores higher separately, it is surrounded by lower scoring counties and therefore falls into a low spot, despite its high rank.

**Sub-indices of CDRI-1**

In addition to reviewing high and low spots of the overall CDRI scores, it is also beneficial to review that of the four capital sub-indices: human, physical, social, and economic. This analysis can identify regions in which one counties’ resilience capacity likely influences those around it. For instance, a high spot of physical capital would indicate that that area likely shares in the benefits of such resources with its neighbors. These high spots are influential in analyzing the strengths and weaknesses of an area in their disaster resiliency.

The first sub-index to be reviewed is the human capital index. Figure 7 shows the high and low spots according to their human capital resiliency index score. It is notable, and perhaps not surprising, that the two high spots found in the human capital index are located in both the Greater Boston Area as well as the New York City Metropolitan Area. These two areas feature much higher population densities than many others within the study area. Such higher population densities indicate a larger workforce, including those fields that are included in the human capital index as related to disaster management activities.

There are two low spots from the human capital spatial analysis. These low spots are nearly identical to the low spots identified in the overall CDRI scores in Figure 6, one focused in North Carolina and extending into Virginia, and another in Georgia.
The second sub-index hotspot analysis is that of the physical capital index. Of the four sub-indices, the physical capital index has the largest clusters of significance. Figure 8 details the spatial distribution of high and low spots for this sub-index. With the exception of a few New York counties, all northeast counties are considered to be a part of a high spot, most of which are with 99% confidence. Meanwhile the large low spot identified in this sub-index covers counties from southern New Jersey, Delaware, Maryland, Virginia, and North Carolina. This low spot is also largely made of counties within 99% confidence.
The third sub-index evaluated is the social capital index. Figure 9 shows the spatial distribution of high and low spots for social capital within the study area. A significant high spot ranges from Maine to Connecticut, in which all but two counties (Fairfield and New Haven) in Connecticut are a part of the cluster. There are also two low spot clusters for social capital. One is, again, located in the northern counties of North Carolina and includes one county in Virginia (Suffolk county). The second low spot includes all the studied Georgia counties as well as three South Carolina counties (Jasper, Beaufort, and Colleton).
Finally, the economic capital sub-index is the fourth to be spatially analyzed. Economic capital high spots appear to be more variable than those of the other three sub-indices. Figure 10 shows the distribution of significant clusters. High spots include: Rhode Island and Massachusetts counties; New York, New Jersey, and Connecticut counties; and Prince William county, Virginia. There is one economic capital low spot within this analysis, which consists of only counties located in North Carolina.
The spatial analysis for this research employs ArcGIS to identify significant spatial clusters within the data to address hypothesis two: there will be spatially significant clusters of coastal counties within the overall and sub-indices, based on the understanding that communities interact and share knowledge and resources with neighboring municipalities. In times of disaster, response largely fall on local governments rather than metropolitan, state, or regional entities. The pressure to secure valuable resources in disaster management efforts garners collaboration between communities (in this case, counties) in order to ensure they are well
prepared for what is to come. This may present in spatial clusters of significant resource benefits (or lack thereof) in human, physical, social, and economic capital domains. The spatial analysis conducted confirms the suspicion of these statistically significant clusters within the overall index as well as the sub-indices. Additionally, the high and low spot clusters across all five levels of spatial analysis (overall, human, physical, social, and economic) are generally consistent, with high spots concentrated in the northeast, and some in the mid-Atlantic, and low spots concentrated in the southeast and mid-Atlantic.
CHAPTER FOUR: DISCUSSIONS & CONCLUSIONS

Chapter four of this thesis will discuss the results found in chapter three by considering the index and spatial analyses within the context of each community capital. A brief summary of the results will be shared, and the remainder of the chapter will address each capital individually, compare the results of this thesis with previous research, and provide recommendations for building community capital to enhance community resiliency. These discussions will recognize the diversity in circumstances and strategies for approaching community resiliency through a capitals-based framework.

The index results presented in chapter three indicate that counties in the northeast are generally more disaster resilient than those of the mid-Atlantic and southeast. When averaging the scores within each state, Massachusetts ranked first and Georgia last. Individual county CDRI scores ranged from -0.829 to +1.729, with only 25% of counties from the southeast, 37% from the mid-Atlantic, and 38% from the northeast scoring above the mean. Finally, northeast counties performed their best in physical and economic capitals, mid-Atlantic counties scored their best in human and economic capitals, and the southeast counties scored their best in human capital. This suggests that each region, state, and county will have specific concerns related to their community’s resilience and may use the following discussions to provoke innovation and conversations within their community’s policy planning activities.

These findings contradict the original hypothesis of this research. Initial indications were that regions/states/counties that experienced hurricanes more frequently would have better adapted policies and procedures that focus on building community capital in a manner that increases their resiliency. In addition, it was found in the original research that Florida outperformed the other
Gulf of Mexico states, providing the basis that Florida is potentially more resilient that the other states in this study (Mayunga, 2009). This would imply the opposite of the results, in which it was expected that the southeast region would outscore both the mid-Atlantic and northeast due to the frequency and intensity in which they face storms.

These unanticipated results are documented in other research of similar interests. Rifat and Liu (2020) demonstrated through their own composite community disaster resilience index (CCDRI) that northeastern communities are comparatively more resilient than southeastern communities (Rifat & Liu, 2020). This CCDRI studied all coastal communities in the United States (397) and included five environmental resilience indicators in addition to indicators that align with this study. Summer et al.’s (2018) also indicated that their study showed higher resiliency in northeast states as compared to regions such as mid-Atlantic and South Atlantic. This study, however, measures resiliency considerably differently (using the domains of built environment, governance, natural environment, risk, and society), and indicated that level of risk significantly influenced their results (Summers et al., 2018). Finally, a 2015 reapplication of Cutter et al.’s (2008) baseline resilience index for communities (BRIC) shows evidence that the northeast and mid-Atlantic regions largely show “high” resilience as opposed to the southeast region ranking at “medium” to “low” resilience (S. L. Cutter & Derakhshan, 2020).

Hypothesis two for this thesis addressed the presence of spatially significant clusters of high and low scoring counties. The variety in defining the domains and indicators used to evaluate community resiliency limits the ability to compare spatially significant clusters across studies. Overall spatial distribution of sub-indices generally follows what is found in this research. Cutter and Derakhshan (2020) found that spatial distribution of social, economic, and physical capitals
align with the idea that communities within the northeast appear to be more resilient than in the southeast (S. L. Cutter & Derakhshan, 2020).

4.1 Community Capitals and their Relation to Disaster Resiliency

When disaster strikes a community, officials are tasked with choosing to stabilize the community by returning it to its previous conditions or by breaking the status quo and establishing new policy that will better serve them in the future. Doing so requires extensive finances, human resources, and time (National Research Council, 2012) but can greatly improve the community’s ability to mitigate and prepare for future disasters as well as respond and recover quicker.

The following sections will examine the role of each of the four community capitals focused on within this research (physical, economic, social, and human) within the realm of disaster management and the results of this thesis. Each section will discuss the significance of the capital, indicators, results, and strategies for improving a community’s stock of that capital. While the content presented here is intended to highlight the significance of the capitals and ways to improve upon them, it is not an exhaustive effort. Any community that uses the insight from this research should supplement it with local knowledge and expert opinions to address capital issues that are of top importance and feasible within the community’s structure.

**Physical Capital**

Physical capital includes the critical infrastructure, establishments, and transportation and communication services that supports the activities of economic, social, and human capital (Anglin, 2015). This index accounts for physical capital in a wide range of indicators that address the built capital stock in the community.
Physical capital index scores ranged from 0.439 (Massachusetts) to -0.285 (Georgia). The county breakdown of this sub-index showed that 88% of northeast counties, 42% of mid-Atlantic counties, and 33% of southeast counties scored above the mean. Nantucket county, MA, Hancock county, ME, and Barnstable county, MA ranked as the top three for this sub-index. Meanwhile, the spatial results for the physical capital sub-index showed extensive high and low spots. One high spot includes all counties from Maine, south to New York state. The low spot consists of counties from New Jersey, Delaware, Maryland, Virginia, and North Carolina.

Poor physical capital stock and overall quality can have negative effects on a community’s resilience and increase their vulnerability to disasters (National Research Council, 2012). Research conducted comparing community resiliency at the county-level from 2010 to 2015 shows that infrastructural resiliency has slightly decreased over that time frame (S. L. Cutter & Derakhshan, 2020). The study also confirms high physical capital resiliency in the northeast and mid-Atlantic regions and scattered, lower physical resiliency in the southeast, as aligned with the results from chapter three.

General recommendations for increasing a community’s physical capital stock includes addressing weak physical infrastructure through retrofitting, improving upon required building codes, and controlling land-use management practices to reduce vulnerability (National Research Council, 2012). These practices can better prepare the physical capital stock to withstand the impacts of a disaster, ultimately reducing the need for substantial response and recovery efforts. Physical capital indicators that this may include are housing infrastructure, health facilities like nursing homes and hospitals, and emergency response facilities (police, fire, ambulances), among many others. These practices can be implemented through subsidies for building improvements and incentives for increasing insurance coverage of properties. Policy that
addresses the bettering of these infrastructures, and others, creates a stronger foundation for a community’ resiliency.

**Economic Capital**

Economic capital refers to the financial resources available to support a community’s (or household’s) livelihood. Hancock (2001) indicates that economic capital is the means by which we can support and attain many of our human and social goals (Hancock, 2001). The economic indicators in this research addressed the socioeconomic status of a community through measurements like per capita income, household values, median income, employment rates, business establishments, and healthcare coverage.

Results from chapter three highlighted the variability in state mean economic scores, with ranges from 1.209 (Massachusetts) to -0.708 (North Carolina). A county breakdown of scores showed that 88% of northeast counties, 73% of mid-Atlantic counties, and only 19% of southeast counties scored above the mean in the economic index. Counties that scored exceptionally well in the economic index included Nantucket county, MA, New York County, NY, and Dukes county, MA. The spatial results for the economic index indicated significant high spots in the Greater Boston area, the New York City metropolitan area, and Prince William county, VA. Low spots for the sub-index were entirely located in North Carolina.

Toya and Skidmore (2007) claim that as an area develops it will begin to allocate greater resources to safety measures including those associated with disaster management, resulting in less damages to life and gross domestic product (Toya & Skidmore, 2007). This correlates to the concept that higher economic capital sets a community up well for better resistance and response to a disaster at its beginning (Cui & Li, 2019) and acts as a primary driver for recovery efforts (S.
L. Cutter & Derakhshan, 2020). Research has suggested that communities of lower socioeconomic status are often times less prepared for a disaster and do not have the access to resources that allow them to respond and recover as quickly as communities of higher socioeconomic status, increasing their vulnerability to the effects of disasters (SAMSA, 2017; Toya & Skidmore, 2007). Additionally, SAMSA (2017) makes note that poor people are far more impacted by natural disasters on the basis that their savings are “concentrated in their homes and livestock, both of which may be damaged, injured, or lost in disasters” making disasters particularly crippling (SAMSA, 2017). The findings from this research generally align with existing research on economic capital in community resilience. Cutter and Derakhshan (2020) found that the northeast region performed better than most in economic capital and confirm the clustering of economic capital with high scores in the Greater Boston area and the New York City metropolitan area (S. L. Cutter & Derakhshan, 2020). They further mention that high scoring communities in economic capital are the most resilient communities (S. L. Cutter & Derakhshan, 2020).

The economic resources of a community are an essential component to being able to adapt well and grow past a disaster. Policy in disaster management is often oriented towards reducing the physical vulnerability of low socioeconomic communities, however, this does not address the root causes of low socioeconomic status. Policy that addresses the root causes will benefit a community in the long run by directing their people to the assets that improve their living situations and ability to mitigate, prepare, respond, and recover from disasters. Therefore, economic capital development policy should be oriented around reducing poverty levels and increasing access to financial resources for individual aid during and after a disaster.
Masozera et al. (2007) conducted research on the effects of disasters on low-income communities in the aftermath of Hurricane Katrina in New Orleans, Louisiana. One of their primary policy recommendations was aimed at reducing the socioeconomic conditions that leave communities more vulnerable (Masozera et al., 2007). In particular, the authors suggest that addressing low wages in many areas will increase the community’s resiliency as a whole, providing people access to resources they previously did not have access to. This can manifest in increasing local minimum wages, so that employees are comfortably living with one full-time income job.

The concept of financial inclusion can increase resiliency through programs that support the development of savings instruments and increasing access to borrowing and insurance opportunities (Hallegatte et al., 2017). Addressing economic capital through resiliency policy should include considerations for improving access to financial resources aimed at aiding in recovery and reconstruction efforts for low-income and economically vulnerable communities. Access to borrowing and insurance institutions can reduce asset losses and increase the speed in which households and communities can recover and rebuild after disaster, thereby reducing future vulnerability and increasing resiliency.

Social Capital

Social capital has evolved since its mainstream conception in the 1970’s and 80’s (Rogers & Jarema, 2015). Social capital, as defined by Putnam (1994) includes the features of social organization, such as networks, norms, and trust, that facilitate coordination and cooperation for mutual benefit (Putnam, 1994). It may also be referred to as the connections within a community’s people and organizations that bring them together to make changes, consisting of bonding and bridging subgroups (Emery & Flora, 2006). It serves a critical role as the “glue” that
holds a community together, making it cohesive and productive for all. Social capital indicators used in this research addressed measurements for volunteerism, civic engagement, and community attachment, among others.

Social capital index results indicated that northeast states took the top five ranks for mean scores, followed by a mix of mid-Atlantic and southeast states. Scores ranged from 0.690 (Massachusetts) to -0.512 (Georgia). The county breakdown showed that 85% of northeast counties, 39% of mid-Atlantic counties, and 33% of southeast counties scored above the mean for the sub-index. Dukes and Nantucket counties from Massachusetts and Knox county, Maine took the top three ranks for this category. Spatial results for this sub-index revealed a high spot that encompasses counties from Maine to Connecticut. Low spots were centered around northern North Carolina and the Georgia/South Carolina coast.

Literature surrounding social capital and its development highlights the critical influence that social capital has on the stock and flow of other community capitals. Emery and Flora (2006) discuss the significance of social capital as the catalyst for communities to “spiral up”, in which they argue that the development of social capital assets leads to increases in economic, political, and cultural capital assets (Emery & Flora, 2006). The literature also highlights the significance of social capital within the realm of disaster management as an essential consideration for managers and policy makers (Sadri et al., 2018) and indicates that a community’s stock of social capital can increase their ability to recover and reconstruct after a disaster (Aldrich, 2010; Cui & Li, 2019). This is further supported by findings that show less resilient regions will often score worse in social capital indices (S. L. Cutter & Derakhshan, 2020). These concepts are illustrated in the results of this analysis, in which only 18% of counties that scored below the mean CDRI index score had positive scores for the social capital sub-index, making social capital scores
influential on overall resiliency scores. Spatial results that indicate greater social capital in the northeast are also confirmed through the Joint Economic Committee’s (2018) social capital index of America, in which the northeast region states rank in the top 40%, with the exception of Rhode Island, and southeastern states rank in the bottom 40%, with the exception of Virginia (Social Capital Project, 2018).

The connections within a community are vital to the overall health and resiliency of that community. A community that wishes to address shortcomings in their social capital stock and index score should consider policy that builds capital through community and civic engagement, volunteerism, and general social connections. General recommendations for doing so from the literature include addressing inequities in communication (National Research Council, 2012), enhancing community leadership through political engagement (Emery & Flora, 2006), and utilizing community organizations, such as religious and civic ones, to increase collective responsibility in times of disaster (Dynes, 2005). Two specific social capital building programs that address social capital building well include the “Seattle Neighborhoods Actively Prepare” (SNAP) and San Francisco’s “Empowered Communities Program” (ECP).

The Seattle Neighborhoods Actively Prepare (SNAP) program is disaster preparedness program designed to bring together communities to ensure the safety of one another, created by the Seattle office of Emergency Management. SNAP includes training and organizational content for community members to coordinate responsibilities and priorities within times of disasters (Seattle Office of Emergency Management, 2020). San Francisco’s Empowered Communities Program (ECP) also approaches social capital development as a means towards total community development and disaster resilience. The mission of ECP is to align expertise, resources, and
community partnerships to develop tools and programs that create stronger and more connected communities (Neighborhood Empowerment Network, 2020).

These programs align with literature that encourages adaptability, responsibility, and initiative within communities as a means to growing their social capital stock (Anglin, 2015). Adoption of similar programs in communities that struggle with low social capital scores is an opportunity for improving social and political engagement, volunteerism, and community attachment.

**Human Capital**

Human capital generally refers to the knowledge and skills of a community’s population, consisting of their health, education, skills, innovation, and creativity (Hancock, 2001). It can also broadly be addressed as the “attributes of community members that can be used to develop and increase resources both within and outside the community” (Anglin, 2015). Indicators used to measure human capital in this research include education attainment, access to health services, and employment numbers in disaster related industries, among others.

Index results for human capital ranged in scores from 0.484 (Massachusetts) to -0.262 (Georgia). The county breakdown shows that 87% of northeast counties and 81% of mid-Atlantic counties scored above the mean, while only 34% of southeast counties did so. Suffolk county, MA, New York county, NY, and Nantucket county, MA made up the top three ranks for this sub-index. The two spatial high spots for human capital were the Greater Boston area and the New York City metropolitan area. Low spots spread from Virginia to North Carolina, plus most counties along the Georgia coast.
Much of the research reviewed highlighted human capital development as the center of community development as a whole (Abel & Gabe, 2010; Anglin, 2015; National Research Council, 2012). Human capital has significant ties to social, economic, and ecological capitals within a community. Hancock (2001) goes as far as putting human capital at the center of development, where he discusses that the ability to expand on our human capital comes with the condition of conserving social, economic, and ecological capitals (Hancock, 2001). Human capital can be seen as an option to create value in output and income (Abel & Gabe, 2010) and the product of increasing the community’s stock in other capitals (Hancock, 2001).

The Federal Reserve Bank of New York’s report number 332 examined the relationship between economic activity in metropolitan areas and their stock of human capital (Abel & Gabe, 2010). While this research was limited by measuring human capital only as a function of educational attainment, it found similar results to this thesis. The study focused on the gross domestic product (GDP) per capita for metropolitan areas in the United States and found that educational levels in a community and the type of knowledge possessed by workers greatly influences the economic activity of a region (Abel & Gabe, 2010). Results from Abel and Gabe’s study also suggests that metropolitan areas like the Greater Boston area and the Fairfield county, CT regions show significant human capital stock (Abel & Gabe, 2010). The overlap of the spatial hot spot results for human and economic capital sub-indices in this thesis agrees that there appears to be a correlation between the capital stock levels in a community, as well as confirming the higher levels of human capital in regions like the Greater Boston area and the New York City metropolitan area, which includes Fairfield county, CT.

This research, as supported by the literature, would suggest that addressing human capital stock within a community is a fundamental opportunity for increasing community resilience to
disasters. It is recommended that communities facing low human capital index scores examine their workforce policies to help their community obtain the skills needed to succeed in their local economy, adapt to continually learning new skills, and build a system of life-long learning (Ratliff et al., 2020). The Shared Prosperity Partnership discussed that current workforce policy is often times complex, fragmented, and decentralized, making productive policy that much more challenging (Ratliff et al., 2020). Human capital policy for effectively building community resilience can include broad policy that crosses jurisdictions – orienting incentives and services towards talent development in fields that would serve a community well in times of disaster (Ratliff et al., 2020). Industries might include building and construction, property and casualty insurance, landscaping and land subdivision, and environmental research and consulting.

Sample policy programs for human capital development of this type include the P-20 Leadership Council of Maryland and Real Jobs Rhode Island (RJRI). The P-20 Leadership Council of Maryland is a partnership between the state and business communities that addresses human capital development through education, workforce, and economic development (Maryland Department of Labor, 2017). The development of this council has brought together public and private stakeholders to create effective resource allocation that supports a number of pathways to job/career education and training. Other states, such as Delaware and Illinois, have followed in their own creation of a P-20 council to address similar issues.

Real Jobs Rhode Island (RJRI) was developed in 2015 as a means to develop Rhode Island’s skilled workforce through business partnerships and state investment. RJRI is one of the leading examples of state investment in human capital development for its substantial scale and investing (Ratliff et al., 2020). The programing assesses sectoral needs, develops training and educational programs, and recruits new talent to meet the needs expressed. The program has seen significant
impacts – their March 2021 report indicates that they invest with 16 industries, over 2000 businesses, and has served over 12,000 people in their educational and training goals (Department of Labor and Training, 2021). This program demonstrates the benefits inherent in state investment in the local workforce.

The Connections between Community Capitals

Following the discussion surrounding each of the four studied capitals it is necessary to highlight the interlinkages between the community capitals. Community capitals are not isolated assets and do hold the ability to enhance or detract from one another (Flora et al., 2004). Samples of the connections between the capitals include:

- Built capital serves as a foundation for housing the activities of other community capitals
- Development of built capital may influence the development of social capital (Leyden & Goldberg, 2015)
- Social capital may influence economic development by encouraging entrepreneurship and small business development and increasing worker productivity (Markeson & Deller, 2015)
- Social capital has a spiraling-up effect on other community capitals (Emery & Flora, 2006)
- Human and economic capital are interconnected, where economic activity is often determined by the types of knowledge possessed by community members (Abel & Gabe, 2010)
These connections between community capitals, among many others not depicted here, must be understood to successfully implement policy actions that addresses the cohesiveness of capital stock and flows within in a community.

4.2 Summary of Discussions

A resilient community is an organized one that takes intentional action to enhance the capabilities and capacities of its members and institutes, adapts to constant changes, and builds resilience through cumulative pathways (Kais & Islam, 2016). Efforts at advancing community resilience must be met with strong leadership and long-term approaches. Coordination between bottom-up and top-down efforts that incorporate varying levels of government support are imperative for effective development that serves to reduce vulnerability and increase resiliency. Physical and cultural shifts should be utilized to advance resiliency by strengthening the built environment, increasing socioeconomic health, and developing community connections that enhance the community and its members to improve on itself (National Research Council, 2012). While policy that reflects the balance between these four capitals may prove to be financially challenging, communities must consider the economic, social, public health, and environmental values that can be gained from such action (National Research Council, 2012).

The nature of disaster management policy requires flexibility and adaptability (National Research Council, 2012). The discussions provided in this chapter recognize the significant interlinkages between the four community capitals; human and economic capital are closely tied to one another (Abel & Gabe, 2010), social and economic systems are increasingly interdependent (National Research Council, 2012), and physical capital serves as a foundation for the development and activities of the other three community capitals. Management and policy practices are recommended to address shortcomings in capital stock and flow through cohesive
policy actions that incorporate those linkages. Doing so can increase overall development for a community and induce a spiraling up effect, in which growth across capitals is concurrent more sustainable.

Such policy action is well-documented with one of the studied states in this thesis – Massachusetts. The Commonwealth of Massachusetts has been shown to approach the issue of capital development as a component of community resiliency to climate change through a variety of programs – one of which is titled the “Municipal Vulnerability Preparedness (MVP) Program” (Gilvarg, 2020). The MVP program, launched in 2017, has provided 89% of Massachusetts communities with over $44 million in grant money for the development of community resilience (Gilvarg, 2020). These grants are aimed at addressing community vulnerabilities and creating action plans. While many of the approved grants are directed towards environmental-based concerns, there is a significant focus on the social and economic aspects of community resiliency. The program notes that their efforts help to increase employment, contribute to the economy, and build upon social networks within the communities (Gilvarg, 2020; State of Massachusetts, 2017). Programs as such have an influence on a states’ CDRI score by addressing the root of resiliency as community capitals. By focusing climate adaptation efforts through development and use of these capitals, we find that states such as Massachusetts excel at capital production in economic, social, human, and physical terms and serves as a national model in a number of aspects related to community resilience and climate adaptation. The adoption of a similar state or region backed program would serve many of the communities researched well in their development of their community capitals.
4.3 Concluding Remarks

The results of this research can be used by local governments and planning agencies to address areas of weakness in their community’s resilience to disasters. Index scores and individual county data can be considered as evidence to these weaknesses to support the implementation of policies and practices that promote the growth and development of the community, by addressing individual community capitals. Indicator, sub-indices, and overall CDRI scores should not, however, be the only interpretation of the data. Local knowledge of and experience with community strengths and weaknesses should supplement the findings of this research in all applications for policy decision-making. The contribution of this local knowledge is crucial to creating effective management plans, as community experience and history will influence their capacity for change. In addition, the results may act as a baseline for comparing communities across time. Future updates to this research would be able to show growth and decay in community capitals across time and highlight areas for further adjustment and fine tuning.

Future research regarding the use and/or enhancement of these methods and the index could be broadened by incorporating the three other capitals (natural, political, and cultural) identified in the Community Capitals Framework. First, the inclusion of the other three capitals will give a more exhaustive review of a community’s capital stock and add additional dimensions to the index’s ability to guide planners in implementing effective policies. Natural capital is an essential component to how well a community can preemptively manage a disaster situation. Including this as an additional sub-index in this research could significantly influence areas where natural capital supports their disaster management activities regularly. Political capital would be a beneficial addition to this index because it may be able to capture how the
community’s political structure may influence the development of policy addressing capital
deficiencies related to community resilience. Finally, the inclusion of cultural capital in the index
would allow us to measure community perspectives on developing climate and community
resilience. The attitudes and perceptions likely work with the political capital of a community to
direct the allocation of resources to developing capitals.

In addition, future research would be suited to include a complementary model that focuses
on the equity issues involved in resiliency and vulnerability studies. As this index highlights
communities with deficiencies in community capitals, it would be wise to investigate how equity
issues and environmental justice may influence these values. This addition could broaden the
value of the index and highlight environmentally vulnerable communities who do not have equal
access to knowledge and finances that would support resiliency efforts. This would significantly
contribute to the work being done in resiliency and vulnerability assessments nationwide.

Finally, future use of this index and research in community resiliency overall, would be
benefited by conversations that address a community’s ability to learn from their past.
Incorporation of past experiences with disaster management and the state of the community
following a disaster could be collected through community-based surveys and interviews that
would provide a more localized context for how they are able to address the challenges presented
to them. This would continue to develop the conversation surrounding how important local
context is to each community’s approach towards developing their community capital stock.

This research had three primary objectives stated in chapter one: to better understand the role
of vulnerability and resiliency in disaster management, to apply a validated method of measuring
community resilience to a new geographical region, and to identify specific strengths and
weaknesses in community capitals at regional, state, and county levels using the CDRI. The first
objective was met through the discussion on key concepts and the literature review conducted. Objectives two and three were addressed through the methods and results and analysis chapters.

This thesis serves as a compliment to the original work of Mayunga (2009) by advancing the application of his methods to an additional study area. Doing so offers communities previously not evaluated by his work to understand where they stand on community resiliency within the community capital framework. Mayunga’s methodology bridges theory and practical application in community resiliency and disaster response together through validation. Further implementation of the methods adds volume to the validated literature in measuring community resiliency.
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APPENDIX A

COUNTY SCORES OF CDRI INDEX AND SUB-INDICES
Table A-1: All counties and their CDRI scores

<table>
<thead>
<tr>
<th>Rank</th>
<th>County</th>
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Table A-5: All counties and their economic capital score

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