Spring 4-20-2017

EVALUATING CLIMATE CHANGE MITIGATION AND ADAPTATION POLICIES ON THE U.S. 50 STATES' HAZARD MITIGATION PLANS

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by

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A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the degree of Master of Community and Regional Planning

Major: Community and Regional Planning

Under the Supervision of Professor: Zhenghong Tang

Lincoln, Nebraska

April 2017

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University of Nebraska, 2015

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Climate change brings uncertain risks of climate-related natural hazards. The U.S. Federal Emergency Management Agency (FEMA 2011) has issued a policy directive to integrate climate change adaptation actions into hazard mitigation programs, policies, and plans. However, to date there has been no comprehensive empirical study to examine the extent to which climate change issues are integrated into State Hazard Mitigation Plans (SHMPs). This study develops 18 indicators to examine the extent of climate change considerations in the 50 SHMPs. The results demonstrate that these SHMPs treat climate change issues in an uneven fashion, with large variations present among the 50 states. The overall plan quality for climate change considerations was sustained at an intermediate level with regard to climate change-related awareness, analysis, and actions. The findings confirm that climate change concepts and historical extreme events have been well recognized by the majority of SHMPs. Even though they are not specific to climate change, mitigation and adaptation strategies that can help reduce climate change risks have been adopted in these plans. However, the plans still lack a detailed assessment of climate change and more incentives for collaboration strategies beyond working with emergency management agencies.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Tang, with the greatest gratitude. During the two-year graduate study, Dr. Zhenghong Tang consumed a plenty of energy, time, and resources to support my study, selflessly and constantly. He is the kindest person who offered me the valuable research program and funding, which broadens my horizon and advances my career largely. Both his wisdom and kindness will influence my whole career and life continuously. Also, I would like to show my gratitude to my other two committee members: Dr. Dan Piatkowski and Dr. Mark Burbach, who contribute to my thesis a lot with their constructive and informative suggestions to my thesis. Without their generous and persistent help and aid, I can not imagine how long this work will last.

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CHAPTER 1 INTRODUCTION

Climate change brings uncertain challenges for natural ecosystems, the built environment, and human health, and thus may cause significant human and economic losses. The magnitude and frequency of natural hazards such as intense storms, heavy precipitation, heat waves, severe droughts, and extreme flooding can be further accelerated by climate change (Field 2012; Melillo et al. 2014). The resiliency of critical infrastructure and emergency assets is potentially threatened by climate change. Planning for disasters has been widely recognized as a necessary step to reduce vulnerabilities and increase community resiliency in the disaster risk management cycle: mitigation, preparation, response, and recovery. Hazard mitigation planning serves as a process to identify and analyze potential hazards, then put proper actions into place to reduce or even eliminate long-term risks (FEMA 2015). Therefore, incorporating climate change threats into hazard mitigation planning processes is a feasible option for hazard managers to appropriately address these risks.

The Disaster Mitigation Act of 2000 (42 U.S.C. §5165) requires that all states must have an approved statewide hazard mitigation plan to be eligible to receive the relevant federal disaster mitigation funds. The Act was a milestone in the effort to address hazard loss in the United States, enhance the efficiency of arranging for hazard mitigation funding, and strengthen the capabilities of states to reduce natural hazard damage (Godschalk et al. 2009; Berke et al. 2012). Hazard management agencies have recently paid more attention to climate change and its impacts. In 2011, the U.S. Federal Emergency Management Agency (FEMA) issued a climate change adaptation policy statement to promote the incorporation of climate change adaptation and emergency management activities to reduce long-term climate risks (FEMA 2012). The policy statement is a critical step to urge climate change adaptation planning and prioritize corresponding mitigation strategies.

Over the last two decades, researchers and planners have conducted numerous plan evaluation studies targeting hazard mitigation elements in various planning domains, including comprehensive planning, natural hazard mitigation, sustainable development, and transportation. Berke et al. (1996) assessed the quality of natural hazard elements in 139 community comprehensive plans to examine whether state mandates could promote better local plans. They found that plans developed under state mandates were of higher quality than plans that were voluntarily created. Nelson and French (2002) evaluated the hazard mitigation policies of comprehensive plans of different areas against seismic hazard events in the Los Angeles region of California in the 1994 Northridge earthquake. Their findings confirmed that the regions with higher quality of hazard mitigation components in their comprehensive plans had better hazard resilience to seismic events. Brody (2003) examined the quality of plans associated with hazard mitigation developed in comprehensive planning processes between 1991 and 1999 in Florida and Washington with a random sample of 60 local governments in those states. Their results suggested that hazard mitigation ability in comprehensive plans was enhanced in different areas. Srivastava and Laurian (2006) studied the natural hazard mitigation in local comprehensive plans in the six largest cities in Arizona. They concluded that droughts received more attention than other hazards and the hazard information needs to be further improved to advance hazard mitigation. Tang et al. (2008) examined the tsunami preparedness capacity in local comprehensive plans in three Pacific States in the United

States. They found that these coastal comprehensive plans did not fully consider the risks of tsunami hazards. Berke et al. (2012) studied 30 coastal state hazard mitigation plans and found that although the plans had a medium level of support for general mitigation principles, the general condition of the plans was slightly enhanced over the last decade. Fu et al. (2013) evaluated 44 state drought mitigation plans in the United States and concluded that the majority focused more on immediate emergency responses rather than risk management. Fu et al. (2017) also evaluated sea level rise adaptation in 36 local comprehensive and hazard mitigation plans from 15 coastal cities, and found that although rising sea levels were extensively considered in these plans, they were limited to establishing a specific agenda and adaptation toolkit to assure implementation. Horney et al. (2016) researched local hazard mitigation plans in 379 rural counties of the Southeastern United States and found that both rural and urban hazard mitigation plans failed to achieve high plan quality but achieved relatively high scores for different principles outlined in these plans. All of those studies provide valuable academic insights for scholars and planners to establish a systematic methodology and mechanism for plan evaluation.

Because climate change has been increasingly acknowledged as an ongoing threat for natural and human systems, numerous studies have also been conducted to examine climate change considerations in different planning fields. Wheeler (2008) evaluated planning documents from 18 U.S. municipalities and 17 smaller jurisdictions to assess climate change adaptation issues in the first generation of climate change plans, and found that most plans had set emission-related goals, inventories, and operations but barely addressed climate change adaptation. Tang et al. (2010) analyzed 40 local climate change plans in the U.S. to examine how well climate change considerations were incorporated into local planning processes, and found that local plans were good at climate change awareness but poor at climate change analysis and actions. Preston et al. (2011) evaluated 57 adaptation plans to examine how planners and state governors framed climate change adaptation issues and related responses, finding that most of the adaptation plans were under-developed. Stone et al. (2012) reviewed 50 climate change action plans in the most populous metropolitan regions in the U.S., and suggested that urban scale and land use-based climate change policies were minimally considered in large U.S. cities, which is not enough to build strong disaster resilience at local or state levels. Babcock (2013) assessed 50 state-level hazard mitigation plans in the U.S. to examine how well climate change is addressed at the state level; the results showed that coastal states were more likely to include climate change. Tang et al. (2013) evaluated 24 coastal states' climate action plans. They found that the states have a medium planning capacity in managing the risks of extreme climate events, and only a few connections could be identified between climate change and coastal disaster management. Woodruff and Stults (2016) evaluated 44 local climate change adaptation plans in the U.S. and concluded that while a lot of climate change-related policies were included in local plans, details on implementation of these policies were barely offered. All of these studies offer significant insights for practitioners who desire to exploit and advance climate change adaptation policies and practices in politics or in academia.

A hazard mitigation plan is usually regarded as the most straightforward way to evaluate hazard risks and suggest mitigation strategies. State Hazard Mitigation Plans (SHMPs) provide an engagement platform to foster intergovernmental coordination

(Burby and May 1997), encourage public participation in hazard reduction, and build broader resiliency capacity. State-level mandates and policies in SHMPs are crucial for climate change mitigation and adaptation, and they often bridge federal and local governments. However, no research exists that examines climate change considerations in state hazard mitigation plans. In particular, there have been no efforts to evaluate the current working status of the SHMPs after FEMA's 2011 climate change adaptation policy statement. Evaluating the quality of SHMPs can provide a strong foundation for proactive climate mitigation and adaptation strategies to reduce loss and build resiliency.

In addressing the current research gap, three research questions are posited in this study:

1) How well do the 50 SHMPs reflect an understanding of climate-related hazards, analyze these hazards, and propose actions to address the potential risks of climate-related hazards?
2) What are the relative strengths and weaknesses of each state's hazard mitigation plan?
3) How should the integration of climate change with hazard mitigation plans be facilitated?

CHAPTER 2 FRAMEWORK

This study employs the "AAA" model which analyzes the plan content through three dimensions: Awareness, Assessment, Actions. The awareness component measures how well a state understands climate change concepts and relevance to climate-related hazards (Moser and Luers 2008; Tang et al. 2013). Climate change awareness is the most fundamental and preliminary step to establish the linkage between climate change and natural hazards. FEMA has documented different initiatives and statements to direct additional climate change issues and considerations into all agency programs (FEMA 2011, 2012, 2013). Uncertainties about climate change are believed to be an important aspect of climate change, which increases the difficulty of anticipating, assessing, and communicating hazard risks and vulnerability (Field 2012). The deep uncertainty rooted in the hazards, exposure, and vulnerability associated with climate change often motivates the necessity to better understand patterns of human vulnerability responses to future climatic events (Lempert and Collins 2007; Field 2012). Referring to published national or international research or reports on how climate is expected to change and affect individual behaviors or mitigation policies in targeted regions is a fundamental and ongoing processes to prepare for climate change and rational steps to address climate change impacts (Snover et al. 2007). Incorporating a hazard mitigation team within a climate change leadership team at the state level is a crucial measurement of the awareness level of climate change. A well-designed and organized preparedness response to climate change-related disasters relies on numerous, cumulative efforts, actions and programs of multiple departments and agencies (Snover et al. 2007). Therefore, incorporating or forming a climate change preparedness team across diverse organizations, institutes, and sectors is a significant step in the oversight, coordination, and advocacy for climate change adaptation efforts and preparedness.

The assessment component measures the impacts of climate change on hazards, vulnerability, risks, and costs of disasters from environment, social, and economic perspectives (Moser and Luers 2008; Baker et al. 2012; Tang et al. 2013). Climate change poses a variety of risks to human communities and the built environment (Melillo et al. 2014). It has direct and cascading effects by altering environmental conditions, energy, water, materials, food, transportation, health, and ecological systems on which people and communities depend (Gasper et al. 2011). Integrated and comprehensive scientific assessments of the consequences of historical climate change impacts on specific places or systems have been undertaken to support climate change adaptation planning activities and risk management. These assessments provide insights into the potential impacts and vulnerability human systems may experience (Hansen et al. 2015). The most vulnerable populations and the most vulnerable communities and infrastructures represent major concerns for climate mitigation and adaptation (Bierbaum et al. 2013), and the severity of the impacts of climate extremes is strongly correlated with the level of human communities' exposure and vulnerability to these extremes (Lavell et al. 2012). Considerations of climate change adaptation strategies in national development and community plans, and translating these plans and strategies into practices that target vulnerable areas and groups or infrastructure, is critical to systematically and successfully managing current and future disaster risks of the most vulnerable populations and systems (Hansen et al. 2015).

The action component evaluates strategies for building adaptive capacity to reduce climate risks (Moser and Luers 2008; Baker et al. 2012; Tang et al. 2013). Once climate-related risks and vulnerabilities are recognized, the next stage typically involves taking actions to respond to existing and future changes in climate (Bierbaum et al. 2013). Mitigation and adaptation strategies include the adoption of resilience standards in the siting and design of buildings; smart growth and development practices; green and natural infrastructure; clean energy programs; restoration and conservation of ecosystems; promotion of integrated watershed-based water resources management; building a stronger culture of partnership/collaboration (Renn et al. 2011); strengthening the National Flood Insurance Program; providing climate-related data, tools, and guidance for policy makers (Kareiva et al. 2008); and improving climate literacy and public awareness. Creating new building codes and standards, undertaking smart development, and promoting green infrastructure and renewable energy allows communities to increase their resiliency to the effects of climate change by modifying development patterns to protect people and property on limited urban lands (Schwab et al. 2010). Sustainable development can meet the growing needs for more reliable, affordable, and accessible development (Clarke et al. 2007). Ecosystem management and watershed management are essential to mitigating deteriorating environmental and water conditions and protecting and sustaining people facing climate threats to clean water, agro-ecology, and forest recovery (Ellis and Allison 2004). Providing climate-related data, tools, and guidance; building a stronger culture of partnership/collaboration; and increasing climate literacy and public awareness are vital to planning teams to exchange, share, and integrate knowledge about climate-related risks among all stakeholder groups (Lavell et al. 2012); and adjust plans, policies, and approaches according to real-time conditions and changes (Hansen et al. 2015).

CHAPTER 3 METHODS

3.1 Study samples and data sources

The samples in this study comprise the hazard mitigation plans of all 50 states in the United States. An internet-based search was performed to collect these SHMPs from state-level emergency management agency websites. Every plan was assumed to be the latest version available on the internet. A total of 46 out of 50 states' hazard mitigation plans were collected through the internet. The states of Montana, Tennessee, Iowa, and Delaware had hazard mitigation plans that were either outdated or unavailable online. These four states' plans were eventually obtained by written request. Details of the plans are shown in Table 3.1. The dates of these plans ranged from 2010 to 2015. Only one plan, from Oregon, was issued in 2015; 41 plans were published from 2013 to 2014; and 8 were developed from 2010 to 2011. All of the plans represent the latest versions in those states.

Table 3.1 List of the state hazard mitigation plans

State	Year	Plan name	Plan maker
Oregon	2015	The Oregon Military Department's Office of Emergency Management facilitates	Oregon Natural Hazards Mitigation Plan
Georgia	2014	Georgia Emergency Management Agency	State of Georgia Hazard Mitigation Strategy
Indiana	2014	Indiana Department of Homeland Security	State of Indiana Standard Multi-Hazard Mitigation Plan
Louisiana	2014	Governor's Office of Homeland Security and Emergency Preparedness	Louisiana's Hazard Mitigation Plan
Michigan	2014	Emergency Management and Homeland Security Division	Michigan Hazard Mitigation Plan
Minnesota	2014	Minnesota Department of Public Safety; Division of Homeland Security and Emergency Management	Minnesota State Hazard Mitigation Plan
Nebraska	2014	Nebraska Emergency Management Agency	Nebraska State Hazard Mitigation Plan
New Jersey	2014	New Jersey Office of Emergency Management	State of New Jersey 2014 State Hazard Mitigation Plan

New York	2014	New York State Division of Homeland Security and Emergency Services	New York State Hazard Mitigation
North Dakota	2014	NDDES Homeland Security State Radio	State of North Dakota Multi-Hazard Mitigation Plan
Oklahoma	2014	Oklahoma Department of Emergency Management	Oklahoma State Standard Hazard Mitigation Plan
Rhode Island	2014	State of Rhode Island Emergency Management Agency	Rhode Island Hazard Mitigation Plan
Utah	2014	Department of Public Safety; Division of Emergency Management	State of Utah Hazard Mitigation Plan
Wyoming	2014	Wyoming Office of Homeland Security	Wyoming State Mitigation Plan
Ohio	2014	Department of Pubic Safety	State of Ohio Hazard Mitigation Plan
Delaware	2013	Delaware Emergency Management Agency	State of Delaware Hazard Mitigation Plan
Alabama	2013	Alabama Emergency Management Agency	Alabama State Hazard Mitigation Plan
Alaska	2013	Division of Homeland Security and Emergency Management	State of Alaska Hazard Mitigation Plan
Arizona	2013	Arizona Department of Emergency and Military Affairs	Arizona State Hazard Mitigation Plan
California	2013	California Governor's Office of Emergency Services	State of California Multi-hazard Mitigation Plan
Colorado	2013	Division of Homeland Security and Emergency Management	Colorado Natural Hazards Mitigation Plan
Connecticut	2013	Department of Energy and Environmental Protection	Connecticut Natural Hazards Mitigation
Florida	2013	Florida's Local Mitigation Strategy Working Group	State of Florida Enhanced Hazard Mitigation Plan
Hawaii	2013	Hawaii Emergency Management Agency	State of Hawaii Multi-Hazard Mitigation Plan
Illinois	2013	Department of Defense Civil Defense Division	State of Hawaii Multi-Hazard Mitigation Plan
Kentucky	2013	Kentucky Emergency Management	Commonwealth of Kentucky Enhanced Hazard Mitigation Plan
Maine	2013	Maine Emergency Management Agency; Department of Defense,	Maine State Hazard Mitigation Plan

		Veterans and Emergency Management	
Massachusetts	2013	Massachusetts Emergency Management Agency	Commonwealth of Massachusetts State Hazard Mitigation Plan
Mississippi	2013	Mississippi Emergency Management Agency	Mississippi State Hazard Mitigation Plan
Missouri	2013	State of Missouri Emergency Management Agency; Department of Public Safety	Missouri State Hazard Mitigation Plan
Nevada	2013	Nevada Department of Public Safety	The State of Nevada Enhanced Hazard Mitigation Plan
New Hampshire	2013	New Hampshire Department of Safety; Homeland Security and Emergency Management	State of New Hampshire Multi-Hazard Mitigation Plan
New Mexico	2013	New Mexico Department of Homeland Security and Emergency Management	New Mexico State Hazard Mitigation Plan
North Carolina	2013	North Carolina Department of Public Safety	State of North Carolina Hazard Mitigation Plan
Pennsylvania	2013	Pennsylvania Emergency Management Agency	Commonwealth of Pennsylvania State Standard All-Hazard Mitigation Plan
South Carolina	2013	South Carolina Emergency Management Division	South Carolina Hazard Mitigation Plan
South Dakota	2013	South Dakota Department of Public Safety	State of South Dakota Hazard Mitigation Plan
Texas	2013	Texas Department of Public Safety	State of Texas Hazard Mitigation Plan
Vermont	2013	Division of Emergency Management and Homeland Security; Vermont Department of Public Safety	State of Vermont Hazard Mitigation Plan
Virginia	2013	Virginia Department of Emergency Management	Commonwealth of Virginia Hazard Mitigation Plan
Washington	2013	Washington Military Department’s Emergency Management Division	Washington State Hazard Mitigation Plan
West Virginia	2013	West Virginia Division of Homeland Security and Emergency Management	West Virginia State Hazard Mitigation Plan

Iowa	2013	Iowa Homeland Security Emergency Management Division	Iowa Hazard Mitigation Plan
Tennessee	2013	Tennessee Emergency Management Agency	State of Tennessee Hazard Mitigation Plan
Montana	2013	The State of Montana Department of Military Affairs; Disaster and Emergency Services	Montana State Hazard Mitigation
Arkansas	2013	Arkansas Department of Emergency Management	All Hazard Mitigation Plan State of Arkansas
Idaho	2013	Idaho Bureau of Homeland Security	State of Idaho Hazard Mitigation Plan
Kansas	2013	Adjutant General's Department; Kansas Division of Emergency Management	Kansas Hazard Mitigation Plan
Maryland	2011	Emergency Management Agency	Maryland Hazard Mitigation Plan
Wisconsin	2011	Wisconsin Department of Military Affairs; Division of Emergency Management	State of Wisconsin Hazard Mitigation Plan

3.2 Coding protocol

A three-point coding protocol was developed to evaluate the quality of the plans in this study. This coding protocol is based on several indicators, which represent several specific parts of the content in the SHMPs. Eighteen indicators were developed for evaluation purposes. Three categories were developed based on the 18 indicators to match FEMA's guidelines (FEMA 2012), which aid states to develop hazard mitigation plans. Table 3.2 displays how these categories relate to the FEMA guidelines.

Table 3.2 Relation between plan quality categories and FEMA guidelines

Categories	**Structures**
Awareness	Planning Process
	Hazard Identification and Risk Assessment
Assessment	Planning Process
	Hazard Identification and Risk Assessment
Action	Mitigation Strategy
	State Mitigation Capabilities
	Local Coordination and Mitigation Capabilities
	Plan Review, Evaluation, and Implementation

	Adoption and Assurances
	Repetitive Loss Strategy

3.2.1 Coding for indicators

Generally, each indicator is scaled with an ordinal scale, in other words, a 0-2 scale. The point "0" indicates that the indicator is not identified or mentioned totally in a particular plan, the point "1" indicates that the indicator is minimally mentioned without specific details, and the point "2" indicates that the indicator is thoroughly discussed with detailed descriptions. As for indicators related to visualized features such as maps and tables, "0" indicates that the indicator is not visualized in any format, "1" indicates that the indicator is visualized with table-related features, and "2" indicates that the indicator is visualized with map-related features. As for indicators relating to a state's awareness and willingness to include recognized beneficial policies and strategies into its plan, "0" indicates that the indicator can't be identified; "1" indicates that the indicator is described with an uncertain tone, such as "should," "may," "need," "would;" "2" indicates that the indicator is described with a certain tone, such as "must," "shall," or "has been implemented."

3.2.2 Plan quality measurement

A statistical analysis was applied in this study to explain the results. Within a specific plan, first, all indicators' scores are summed together in each individual category. Secondly, the sum of each category is divided by the theoretically full point of their corresponding categories, respectively. Finally, those values are multiplied by 100 to make them fit a 0-100 scale. By doing this, every category is scaled into a 0-100 scale so that the study can compare the performance between different categories. By summing all of the three categories' quality scores, the study divides their sum by the theoretically full point of all categories and then multiplies the results by 100 to make them fit a 0-100 scale.

3.2.3 Indicator quality measurement

This study also uses the indicator breadth and indicator depth to measure each indicator's performance. The "breadth" indicates how extensive an indicator is expressed across all plans. It is calculated by using the number of plans that address a specific indicator and then dividing the result by the theoretically full number of the subjects (N=50). In this case, an indicator is qualified to be taken into account with either "1" point or "2" points. The "depth" indicates how profound an indicator is expressed across all plans. It is calculated by using the average of an indicator's point across all states and then dividing the result by an indicator's theoretically full score at 2 points. The "breadth index" represents an indicator's coverage in the plans. The "depth index" represents the important degree of an indicator in the plans. With the measures of "breadth" and "depth," the study is able to compare the advantages and disadvantages among distinctive indicators and explore more in-depth the existing variations across different indicators.

3.3 Coding procedures and statistical reliability

In this research, every state's hazard mitigation plan was evaluated by a coding team consisting of two research assistants who worked independently at the same time. In order to guarantee the reliability of the coding results, a uniform coding criteria index was developed to regulate every individual's coding procedure into the same standard consistently. An inter-coder reliability test was employed to examine the acceptability of the final coding results. The intercoder reliability represents the percentage of the indicators that received the same coding points from both coders. Finally, reconciliations against indicators' coding points were made when there were coding disagreements. After three rounds of inter-coder assessment, interceder reliability was achieved above the acceptable level of 70-97% (Berke and Godschalk 2009). This process eliminates the potential coding dynamics between different plan coders.

CHAPTER 4 RESULTS

4.1 Scores for the quality of SHMPs

The study results show that state hazard mitigation plans had a moderate level of consideration in climate change-related awareness, assessment, and action. Large variations were seen among the 50 states. According to the results, most of the states that received high scores are located in the western coastal and Great Lakes areas. Table 4.1 and Figure 4.1 illustrate the quality indices for the state hazard mitigation plans. They display scores for every state and their different categories. The indices indicate that large variations exist among the 50 states. Three states received plan quality scores below 40 points; 17 states received plan quality scores between 40 to 60 points; and 23 states received plan quality scores between 60 to 80 points. Only seven states were scored above 80 points. Some states, such as Indiana, Kentucky, and Oklahoma, did not mention climate change at all in their SHMPs. A few states (Alabama, Arkansas, Colorado, Georgia, Illinois, Iowa, Kansas, Louisiana, Mississippi, Nevada, New Mexico, North

Dakota, South Carolina, Tennessee, Texas, Utah, Virginia, and Wyoming) minimally referenced climate change in their plans with only one or two sentences.

Further insights can be achieved by analyzing the results for different categories, including region, page, and year (see Figure 4.2). The results also show that climate change issues are more likely to be addressed in coastal areas. A total of 16 states (New York, Hawaii, California, Oregon, Massachusetts, Wisconsin, Pennsylvania, Colorado, Florida, Minnesota, Delaware, Maine, New Jersey, Washington, Connecticut, and Vermont) had higher than mean scores (M=62.3) for each category. Generally, these states are concentrated in western and northeastern U.S. coastal areas. A total of 21 states (Iowa, North Dakota, Arkansas, Kansas, Alaska, New Hampshire, Arizona, Tennessee, Nevada, Oklahoma, Alabama, Texas, Illinois, North Carolina, Utah, Wyoming, Kentucky, New Mexico, Virginia, Louisiana, and Indiana) had below average scores. An obvious trend is that coastal states have slightly higher scores than inland states, indicating that the closer to the ocean a state is, the more detailed the hazard mitigation plan is. To some extent, "crisis vigilance" comes into play here, whereby the closer to the ocean a state is, the easier it is to have hazards occur in that state. As expected, plans with more pages tended to have higher scores than shorter plans, consistent with the common assumption that the longer a plan is, the more potential it is to cover more comprehensive details and information. Astonishingly, plans developed in later years had a lower mean score than earlier-developed plans, but earlier plans had a lower maximum score and higher minimum score than later plans.

Table 4.1 Plan category scores and total scores

State	Awareness	Assessment	Action	Whole Score
New York	100.0	100	85	95.0

Hawaii	100.0	87.5	85	90.8
California	87.5	87.5	95	90.0
Oregon	100.0	87.5	80	89.2
Massachusetts	87.5	87.5	80	85.0
Wisconsin	100.0	75	75	83.3
Pennsylvania	62.5	87.5	90	80.0
Colorado	62.5	100	75	79.2
Florida	100.0	62.5	75	79.2
Minnesota	87.5	75	75	79.2
Idaho	100.0	75	60	78.3
Delaware	75.0	87.5	70	77.5
Maine	75.0	75	80	76.7
New Jersey	75.0	75	75	75.0
Ohio	100.0	75	50	75.0
Washington	62.5	87.5	75	75.0
Connecticut	75.0	75	70	73.3
Vermont	75.0	75	70	73.3
Maryland	50.0	75	80	68.3
Rhode Island	50.0	75	80	68.3
West Virginia	50.0	87.5	65	67.5
Georgia	50.0	75	70	65.0
South Dakota	50.0	75	70	65.0
Michigan	50.0	62.5	80	64.2
Mississippi	37.5	75	80	64.2
Missouri	62.5	75	55	64.2
Montana	50.0	87.5	55	64.2
Nebraska	62.5	75	55	64.2
South Carolina	37.5	87.5	65	63.3
Iowa	37.5	75	70	60.8
North Dakota	37.5	87.5	55	60.0
Arkansas	37.5	87.5	50	58.3
Kansas	37.5	87.5	50	58.3
Alaska	50.0	62.5	60	57.5
New Hampshire	50.0	62.5	60	57.5
Arizona	62.5	62.5	45	56.7
Tennessee	37.5	75	55	55.8
Nevada	50.0	50	65	55.0
Oklahoma	37.5	62.5	60	53.3
Alabama	37.5	50	70	52.5
Texas	25.0	87.5	45	52.5
Illinois	12.5	62.5	70	48.3
North Carolina	50.0	50	45	48.3
Utah	37.5	62.5	40	46.7
Wyoming	12.5	75	50	45.8
Kentucky	12.5	50	65	42.5

New Mexico	25.0	37.5	60	40.8
Virginia	37.5	50	30	39.2
Louisiana	25.0	50	35	36.7
Indiana	0.0	25	55	26.7

Figure 4.1 Score indices of hazard mitigation plan

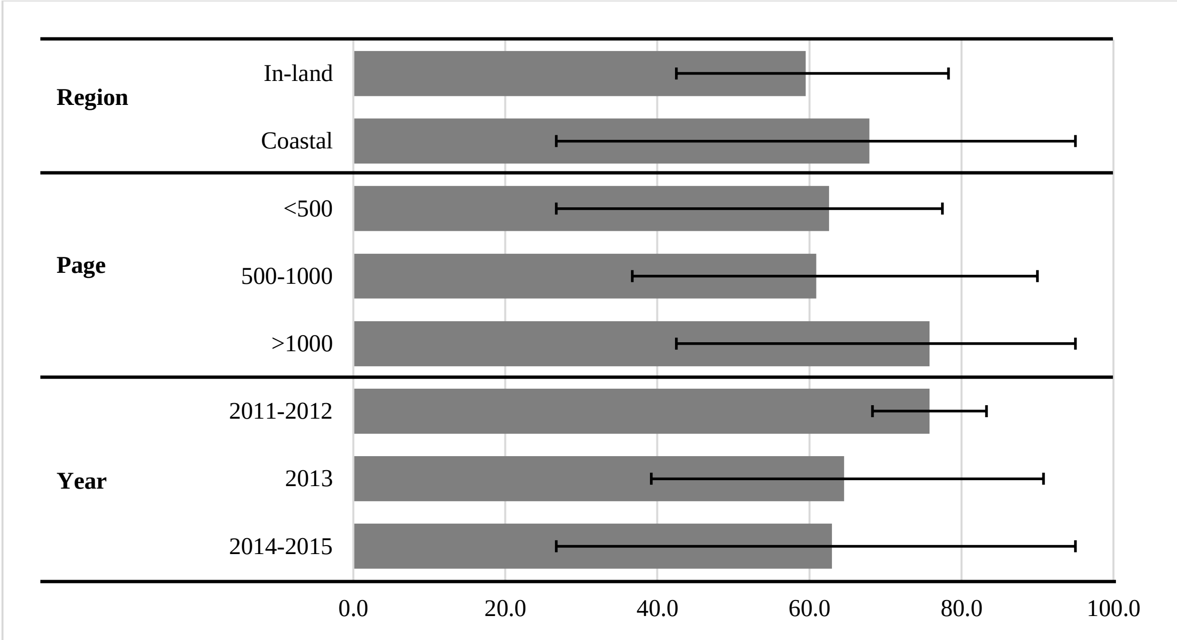

Figure 4.2 Score Analyses by geographical region, page, year

4.2 Indicator performance

Table 4.2 The indexes for all indicators' performance

Categories	Indicators	Breadth	Depth
Awareness	1.1 Identify/define climate change	0.94	0.76
	1.2 Recognize the uncertainty and scenarios of climate change	0.34	0.27
	1.3 Cite climate change assessment reports/evidence	0.94	0.83
	1.4 Incorporate with climate change leadership team	0.46	0.37
Assessment	2.1 Identify/analyze historic events and climate hazard	1.00	1.00
	2.2 Assess the impacts of climate change	0.72	0.61
	2.3 Identify the most vulnerable populations with climatic hazards	0.50	0.38
	2.4 Identify the most vulnerable communities and infrastructures	0.98	0.92
Action	3.1 Develop and encourage adoption of resilience standards in the siting and design of buildings	1.00	0.96
	3.2 Encourage and reward smart growth management and development practices	0.46	0.38

	3.3 Promote and prioritize the use of green and natural infrastructure	0.36	0.31
	3.4 Support development of clean energy programs/solutions/initiatives	0.18	0.14
	3.5 Restore and conserve ecosystems and lands to build resilience in a changing climate	0.82	0.60
	3.6 Promote integrated watershed-based water resources management	0.96	0.93
	3.7 Build a stronger culture of partnership/collaboration	1.00	0.96
	3.8 Strengthen the National Flood Insurance Program	1.00	0.91
	3.9 Provide climate-related data, tool, and guidance	0.98	0.85
	3.10 Increase climate literacy and public awareness	0.52	0.47

Awareness: In the indicator performance index, large variations were identified between different indicators (see Table 4.2). Almost 94% of plans defined climate change in their state hazard mitigation plans with a relative medium-high depth (Depth= 76%). However, only 34% states admitted or recognized that climate change is uncertain, and the much lower depth (Depth=27%) is further evidence of states' superficial recognitions of climate change uncertainty. The index also suggests that almost 94% of states cited evidence or reports from climate change assessments as references in their plans, achieving a relatively high depth score (Depth=83%). However, the low breadth score (Breadth=42%) and low depth score (Depth=34%) regarding the participation of a climate change team indicates minimal involvement of climate change organizations during the state hazard mitigation planning processes.

Assessment: The index indicates that 100% of states recognized historic events and hazards in their local areas (see Table 4.2). A 100% depth score was achieved. These plans specified meteorology-related hazards including storms, floods, drought, heat waves, and rising sea levels. However, only 72% states assessed the impacts of climate change in their state hazard mitigation plans. In addition, a medium-low depth score was achieved (Depth=61%). This indicates that although every state displayed an excellent knowledge of historic events and hazards in their local areas, only about half of them emphasized the impacts of climate change on climate-related hazards. As for vulnerable communities and infrastructures, the index shows a 98% breadth score along with a 92% depth score. However, the identification of vulnerable populations received a low breadth score (Breath=50%) and low depth score (Depth=38%). This indicates that almost every state's plan had very detailed tables, graphs and visualized maps showing vulnerable communities and/or infrastructures, but less than half of the state plans had detailed tables, graphs, and visualized maps showing vulnerable population locations. Most states' plans reflect a macroscopic level of analyzing potential risk locations instead of a more detailed level specific enough to identify vulnerable groups, such as the disabled, the elderly, and children.

Action: Large variations can also be seen in the adaptation category (see Table 4.2). The index shows that plans generally reflect an excellent knowledge of the following indicators: developing and encouraging adoption of resilience standards in the siting and design of buildings (Breath=100%, Depth=96%); promoting integrated watershed-based water resources management (Breath=96%, Depth=93%); building a stronger culture of partnership (Breath=100%, Depth=96%); strengthening the National Flood Insurance Program (Breath=100%, Depth= 91%); and providing climate-related data, tools, and guidance (Breath=98%, Depth=85%). Indicators like the National Flood Insurance Program are strongly encouraged in many states. It does make sense that these indicators have a very high indicator performance, both in breadth and depth.

Meanwhile, the indicator of restoring ecosystems and land to build resilience in a changing climate only achieved a high breadth score (Breadth=82%) and medium depth score (Depth=60%). In fact, most states are successful with regard to the "environment," but fail to mention the term "ecosystem."

Medium-low or low indicator performance was measured in the following indicators: increasing climate literacy and public awareness (Breadth=52%, Depth=47%); encouraging and rewarding climate-smart land use management and development practices (Breadth=46%, Depth=38%); promoting and prioritizing the use of green and natural infrastructures (Breadth=36%, Depth=31%); and supporting the development of clean energy programs (Breadth=18%, Depth=14%). These indicators are either difficult to achieve in the short term or focus on future benefits. This may suggest that the strategies and policies in current hazard mitigation plans are not proactive enough.

CHAPTER 5 DISCUSSION

There are several possible reasons for the large variations shown among the plan quality of different states. First, even though FEMA's climate change adaptation policy (2011-OPPA-01) directed FEMA programs and policies to integrate considerations of climate change adaptation into all agency activities, detailed climate guidelines are still absent (Babcock 2013). Secondly, the uneven ability to access and utilize existing information for planning and implementation also affects states' adaptive capacity significantly (Burch 2010). Even among planners, knowledge and prioritization of climate change adaptation policies and strategies is likely very low (Picketts et al. 2012). Last, but not least, climate change and its effects on our physical experience of life on earth are often subtle and elusive, and hard to predict. Even though sectors such as agriculture, water resources, infrastructure, and urban and rural settlements show strong sensitivity to climate change, less research has been done to address anthropogenic climatic impacts (IPCC 2014; Melillo et al. 2014). Difficulties in predicting the impact of future climate change and analyzing climatic extremes often challenge planners and policy-makers who seek to integrate climate change into SHMPs. Arguably, all of these reasons together lead to the inconsistencies in climate adaptation policies in SHMPs.

The large variations among geographical areas in the plan quality scores can be explained by the various hazard experiences in different areas. Regional differences in plan quality probably result from the likelihood of climate-related hazard occurrences in coastal areas. Coastal areas are more likely to experience climate-related disasters such as a rising sea level, a hazard that mainly results from climate change. Coastal areas are increasingly populated and developed, and climate-induced hazards (e.g., severe storms) could further increase. This suggestion can be affirmed by the statistics in this study: of the 16 states that have higher than mean scores for each category, only Colorado is a complete inland state, and the rest are either coastal areas or very close to oceans. The high degree of hazard occurrences helps inform planners and policy makers, and results in a high degree of attention to climate change issues in those states' hazard mitigation plans (Berke et al. 2012). The relatively low scores in the awareness category, along with a relative high quality of assessment category and action category in many states' hazard mitigation plans, further prove this phenomenon. The results of this research are consistent with Babcock's study (2013) of climate change adaptation in state hazard mitigation plans, in particular, that coastal states are more likely to include a discussion of climate change than land-locked states. There may need to be better communication of how hazard risks will be affected by climate change.

Meanwhile, many external factors, such as financial and political will, have a great deal of influence on developing and implementing climate change-related adaptation strategies in a certain area. Even though big cities have a stronger financial capacity, few climate change-related adaptation programs have received financial support (Carmin et al. 2012). In other words, even if climate change may have a direct and strong effect on those states, they did not pay much attention to climate change issues in their plans. This finding suggests that external factors such as political influences should also be researched in the future. Other external factors also influence the adaptive ability in a certain area, including the local or regional ability to approach resources, and the level of institutions' attention and trans-agency collaboration (Burch 2010; Tang et al. 2013).

CHAPTER 6 POLICY RECOMMENDATIONS

The first policy recommendation is to establish multiple qualitative approaches, understandable scenarios, and robust policies to bridge the gap between climate science and climate adaptation practices. Approaches and strategies established under the consideration of high uncertainty underlie the foundation of a long lasting disaster management and resilience program (Measham et al. 2011; Berke and Lyles. 2013). However, this study found that the consideration of uncertainty is absent from the current state plans. This finding aligns with a variety of research suggesting that establishing approaches addressing uncertainty is a shortcoming in current adaptation planning (Preston et al. 2011) and that a detailed and clear state planning policy to direct approaches on handling the deep uncertainty of climate change is absent from the current planning mechanism (Baker et al. 2012). Uncertainty is an inherent characteristic of climate change projections (Melillo et al. 2014), and the need to address it in the adaptation planning process is one of the most important elements that is very distinctive from conventional planning (Hamin 2011). The approaches, strategies, and policies outlined in hazard mitigation plans could serve as flexible instruments that guide responses and strategies to deal with climate change uncertainty (Brody 2003). Easy ways to begin to consider and manage climate-related uncertainty include establishing robust policies that target a wide range of multiple futures (Means et al. 2010), creating multiple qualitative scenario methods (Parson et al. 2007), using ranges of values instead of single estimate distributions (Morgan et al. 2009), and developing no-regret strategies in planning. Meanwhile, adjusting planning to real-time changes in science and policy is important to combine experience-learning into future climate change adaptation planning and implementing (Preston et al. 2011; Berke and Lyles 2013).

The second policy recommendation is to incorporate statewide climate change specialists into state-level hazard mitigation planning teams that can integrate the best available climate change resources into future climate change projections. The research found that even though most states' hazard mitigation plans took climate change into account, only a few states introduced climate-related evidence and teams in their planning processes. This finding suggests that a huge disconnection still exists between climate change and hazard mitigation decisions (Melillo et al. 2014), a disconnection that challenges practitioners to make effective, comprehensive disaster management decisions by adequately accessing and interpreting climate data. There is an inadequate supply of climatologists who can analyze and interpret past, present, and future climate data in a manner that engages in the planning process, as most managers, planners, and regulators have not received formal and systematical training in climate change (Hansen et al. 2015). Reliable resources and trans-governmental cooperation are increasingly critical for government to prepare for climate change adaptation (Hansen et al. 2015) and this relies on numerous cumulative cooperative activities across various departments and programs (Snover et al. 2007) at the local, state, national, and international levels (Field 2012). Therefore, organizing an experienced interdisciplinary climate change preparedness team with a cross-section of climate change expertise is beneficial for appropriate, timely, and effective communication (Hansen et al. 2015) to integrate each other's theories, methods, and data among all stakeholder groups (Snover et al. 2007).

The third policy recommendation is to conduct more downscaled climate risk assessments targeting vulnerable populations and groups to build long-lasting disaster resilience in community level. Although there are numerous climate and climate resources available, unfortunately, most analyses of vulnerable populations are not accessed or just stay at a qualitative statement. "Place-based" hazard climate change's impacts differ based on distinctive geographical, bio-physical, and social conditions (Measham et al. 2011). Climate change is a hazard that may take place at any geographical scale, but ultimately is manifested and adapted to in an individual manner depending on the unique disaster-experience of a particular target area. In this research, the results show that most SHMPs have integrated geo-related data and maps to assist the identification of vulnerable communities and infrastructures influenced by climate-related hazards, but most of the analyses of the vulnerable populations are not mentioned in any form, which indicates that a stronger relationship needs to be developed between information producers and customers. Building a strong connection between such detailed data on vulnerable populations at the local level and in adaptation plans can reduce the risk significantly (Romsdahl et al. 2013), and these areas are where significant and meaningful climate change adaptation strategies should and could be implemented.

The fourth policy recommendation is to incorporate collaborative resiliency efforts into existing mitigation approaches and strategies. The findings of this study show very low breadth and depth scores in indicators related to some advanced planning theories, such as smart growth, green infrastructures, and clean energy. This result corresponds with the conclusion produced by Eakin and Patt (2011) that most adaptation activities in the U.S. are inclined to sustain and protect existing activities instead of developing long-term change. Effective preparedness, including smarter urban planning and improvements in existing building designs and techniques will reduce energy consumption and the expansion of green space, and assist in facilitating climate change adaptation (NOAA 2012). The increasing risks to the current and future energy supply system in the United States from climatic extremes ignites the demand for a more reliable, affordable and accessible energy supply system (Clarke et al. 2007). Renewable energy sources, including solar, wind, hydropower, biofuels, and geothermal, can help meet this growing demand (Melillo et al. 2014). Green infrastructure is also believed to be an effective adaptation approach to improve a community's resiliency to the effects of climate change (McDonald et al. 2005; Kousky et al. 2013) and meet projected climate change impacts (NOAA 2012), including mitigating flood impacts and heat island effects, and protecting water resources and conserving open space for recreation (Hurd et al. 2008). Investing in nonstructural strategies and ecosystem-based adaptation are effective ways to cope with climate-related disasters (Melillo et al. 2014). Vulnerabilities to climate-related hazards could be significantly reduced by reducing or eliminating the influences of human activities. However, this is often difficult to achieve and many areas take a short-term approach. More detailed information needs to be developed and disseminated to support the decision-making and implementation in those areas. Current hazard mitigation plans tend to narrowly focus on emergency response, failing to address long-term risk management, such as climate change adaptation (Berke et al. 2012; Fu et al. 2013).

The fifth policy recommendation is to strengthen climate change-related outreach and public awareness of the need for oversight, cooperation, and advocacy for climate change adaptation for disaster preparedness efforts. The results indicate very low breadth and depth scores for public awareness and education to climate change. This also confirms one of the suggestions offered by Melillo et al. (2014), that one of the most critical obstacles to climate change adaptation is the lack of professional education for experts and the public. Typically, climate change adaptation is a novel concept and challenge to most planners and regulators, not to mention the general public (Hansen et al. 2015). The educational programs designed for incorporating climate change adaptation into people's daily work and lives are barely noticed (Hansen et al. 2015; Melillo et al. 2014). Most of them still do not recognize the potential benefits of climate change adaptation and the necessary demand for their engagement in it (Hansen et al. 2015). Public awareness and perception of potential climate change risks are very vital for the support of government's climate change adaptation efforts and commitments (Eisenack et al. 2014). Also, the increasing disaster experiences related to climate change offer valuable opportunities to increase public and governmental awareness to support such educational efforts in a focused manner (Baynham et al. 2014). Therefore, behind the need to build a strong adaptive capacity for climate change is the demand to lift up a broader appreciation (Field 2012), i.e., awareness of long-lasting mitigation strategies that could eventually become mainstreamed implementation strategies to reduce climate change vulnerability.

The sixth policy recommendation is to prioritize climate change impacts and strategies to motivate implementation. Although most of the plans successfully covered most strategies, the study found that most states failed to prioritize climate change impacts and adaptation strategies or translate them into on-the-ground climate risk reduction. The centerpiece of any plan is its implementation. Plans will have little effectiveness if they lack a solid adaptive ability resulting in programs and actions that lead to hazard-resilient communities (Melillo et al. 2014). Governments may begin to develop climate change adaptation plans, but those initiatives appear to be sustained at a preliminary level, and only few of these adaptation measures appear to be implemented (IPCC 2014). Even in the states that have high scores in climate-related literacy and public awareness, less specific legislative and executive actions can be pinpointed. This is consistent with Preston's conclusions (2011), after evaluating 57 adaptation plans from Australia, the United Kingdom, and the United States, that most of the climate change adaptation plans are largely under-developed. With respect to climate-related literacy and public awareness, important information such as funding, and responsible departments and organizations are absent from these plans, and no guarantees are made to implement these actions. Most of the climate change-related adaptations are only involved in the planning process superficially and are only rarely implemented in reality (Preston et al. 2011; Bierbaum et al. 2013).

The seventh policy recommendation is to formulate specific and holistic climate-related requirements and mandates to mainstream climate planning into existing natural resources, public health, and emergency management policies and strategies. The study found that many state hazard mitigation plans still did not formulate mitigation decisions under the consideration of climate extreme events. This aligns with the conclusion of Lavell et al. (2012): that most of the SHMPs remain at initial stages of development in incorporating climate change into their plans, and mainly focus on identifying relevant risks and assessing future risks. Federal and national level leadership and guidance play a pivotal role in disaster adaptation planning and implementation at any governmental and geographical scale (Cruce 2010), as these governmental entities reserve the organizational and financial authority to provide risk management-related adaptation and other public goods (Field 2012). Lower levels of government will feel hard-pressed to initiate, establish and implement effective adaptation strategies without the clear, firm political will from national and federal governments to promote them (Amundsen et al. 2010). More importantly, hazard mitigation planners usually have little incentive to exceed the federal and state baseline requirements (Lyles et al. 2014). Even though general guidance by FEMA was released in 2011, detailed climate directive criteria and mandates to consider the future probability of climate-related hazards are still absent in current planning mechanisms. It is true that without recognizing climate change in SHMPs, some adaptation measures can still help reduce the risks and vulnerabilities of climate change (Babcock 2013). However, the lack of specific criteria for applicable identification and mitigation actions for state-level hazard managers is still an important reason for uneven treatment of climate change in SHMPs.

CHAPTER 7 CONCLUSIONS

The study demonstrates that the SHMPs produced during 2010-2015 treated climate change issues in an uneven fashion. Large variations were found among the 50 state hazard mitigation plans, and the quality of these plans was found to be at a medium level. This study serves as a comprehensive screening for climate change awareness, assessment, and adaptation considerations in current state hazard mitigation plans.

As a study that especially targets state hazard mitigation plans, this research is beneficial to understand the motivations and limitations existing in these plans by statistically assessing their content, which will advance the development and implementation of the plans and the planning processes. A comprehensive set of indicators to examine the quality of SHMPs has been established and applied in this study. These indicators were utilized to empirically measure the quality of available state hazard mitigation planning documents. These measures provide a clear basis on which to assess which section in each plan is deficient and could be enhanced. Results of this study could inform planners, politicians, public officials, and citizens to work in more effective and collaborative ways regarding climate change adaptations during hazard mitigation planning processes. The plan evaluation indicators presented in this paper offer a useful approach to guide plan preparation.

This study should be considered as a preliminary effort in examining the quality of SHMPs. There are several limitations. The indicators used in this study are only document-based rather than practice-based. Therefore, the evaluation protocol should be regarded as an academic planning protocol rather than implementation of best practices. More realistic practice-based indicators should be taken into account to improve the evaluation protocol. Secondly, the study only focuses on the text of climate change adaptations in SHMPs. However, other kinds of plans, such as comprehensive plans, emergency management plans and, in particular, climate action plans may also have specific regulatory sections or provisions stressing climate change adaptation issues. Therefore, the results of this study only take into consideration evaluation based on state hazard mitigation plans rather than states' actual hazard mitigation capacity. An evaluation methodology that considers numerous documents across departments and agencies should be developed in the future as a continuation of this study. Third, there is an inevitable gap between actual practices and planning documents. Therefore, the results of this study only represent the states' theoretical capacity for climate-related hazard mitigation. Finally, the indicators selected to evaluate the state hazard mitigation plans only partially represent the elements that affect and comprise those plans. Further questionnaire-based and interview-based research also should be conducted to explore additional external factors such as political will, public will, and financial capacity as a continuation of this study.

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