Ocean & Coastal Management 80 (2013) 46–54

Contents lists available at SciVerse ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Content analysis for the U.S. coastal states' climate action plans in managing the risks of extreme climate events and disasters

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ARTICLE INFO

Article history:
Available online 4 May 2013

ABSTRACT

Climate action plans provide an increasingly important mechanism in climate change awareness, analysis, policy making, and implementation. Although recent efforts have initially analyzed the strengths and weaknesses of climate action plans, little research has empirically investigated the content of existing climate action plans in disaster risk management. This study developed thirty-two indicators to assess the plan content of twenty-four U.S. coastal states' climate action plans in managing the risks of extreme climate events and natural disasters. Correlation and regression analyses were conducted to detect the influence of contextual variables on plan content. The results indicate that these plans had a medium level of awareness, analysis, and action in regard to extreme climate conditions and disaster preparedness. Weak linkages were found between climate change and coastal disaster risk management. Large variations in indicators were found among the coastal states. The explanatory results show that none of the contextual variables significantly affected the plan content of these climate action plans. The policy recommendations provide insights for decision makers for mitigation of and adaptation to coastal climate change and disasters.

1. Introduction

The U.S. coastal states are vulnerable to extreme climate events and natural disasters such as hurricanes, tropical storms, tsunamis, and drought. Extreme climate events and natural disasters may be destructive and costly, causing the loss of human life and immense economic losses. Standardized losses for 133 extreme weather/climate events in the U.S. from 1980 to 2011 exceeded $875 billion (NCDC, 2012). Among the most costly disasters of insured losses in the U.S. were coastal disasters, including hurricanes Katrina 2005, Andrew 1992, Ike 2008, Rita 2005, Wilma 2005, Charley 2004, Ivan 2004, Irene 2011, and Sandy 2013. While the U.S. coastal counties comprise 17% of the nation's land area, they now contain 53% of the U.S. population. The continuously increasing population and rapid land development in coastal areas further intensifies high exposure in vulnerable coastal areas and adds to the risk of property loss from extreme weather events and disasters.

Climate change causes variances in the frequency, intensity, spatial extent, duration, and timing of extreme climate events such as heat waves, drought, wildfire, floods, and coastal storms (IPCC, 2012). Extreme climate events can be defined as "*the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or below) ends (tails) of the range of observed values of the variable*" (IPCC, 2012). Some independent non-extreme events may add to climate extremes. Although extreme climate events themselves do not always mean disaster, vulnerable coastal areas are faced with more challenges from these events. The linkage of extreme events and disasters depends on particular exposure and vulnerability, such as physical, geographic, and social conditions (Mileti, 1999; Wisner et al., 2004). Because natural extreme climate events themselves cannot be easily changed, exposure and vulnerability of human and natural systems are the key determinants of coastal disaster risks. To deal with disaster risks, there is an increasing acceptance of shifting away from post-disaster response efforts and reactive disaster crisis correction strategies toward proactive, prospective, integrative disaster risk management with development decisions (Lavell, 2010; UNISDR, 2011).

Climate action plans emerged in the mid-to-late 1990s (Wheeler, 2008). To date, over 35 states and hundreds of local jurisdictions in the U.S. have adopted climate action plans. Many more plans are under development at the state and local levels. Climate action plans are becoming an increasingly important planning tool to inform decision makers, list emission inventories

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0964-5691/$ – see front matter
http://dx.doi.org/10.1016/j.ocecoaman.2013.04.004

and sources, analyze potential impacts, and propose mitigation and adaptation measures. Climate change action plans demonstrate a positive consideration and commitment for climate change mitigation and adaptations. To date, no empirical model has statistically measured the content of climate action plans in coastal disaster management. In recognition of this gap in the current research, this study proposes a proactive model to empirically examine the content of the U.S. coastal states' climate action plans in addressing the risks of extreme events and climate-related disasters. The research questions below relate to coastal efforts to adapt to the extreme events and disasters from climate change:

1) How well do the U.S. coastal states' existing climate action plans manage the risks of climate extreme events and disasters, including awareness, analysis, and actions?
2) Do contextual variables affect coastal states' climate action plan content in adapting to extreme events and disasters?

2. Conceptual framework

The research conceptual framework is illustrated in Fig. 1. The below sections explain the dependent variable and three sets of independent variables.

2.1. Dependent variable: plan content in managing the risks of extreme events and disasters

The dependent variable is the plan content in managing the risk of extreme climate events and disasters. The research further develops the "AAA" (Awareness, Analysis, and Action) framework which was initially proposed by UKCIP (2003) and was applied by the California Climate Change Center (2006) and Tang et al. (2010). A plan evaluation protocol with thirty-two measureable indicators was built to assess the content of climate action plans in coastal disaster risks from climate change.

The Awareness component indicates the degree to which states understand climate change concepts and relevance to extreme weather events and coastal disasters. The *extreme events from climate change* exceed the threshold of climate variability and thus trigger potential climate disasters (Katz and Brown, 1992). The *uncertainty of climate change* is an unavoidable concept for disaster risk management decisions. Climate change adds greater uncertainty to extreme events and disasters (IPCC, 2012). Climate action plans should acknowledge the role of climate variability and uncertainty. *Climate evidence from the IPCC report* provides scientific evidence to inform decision makers to understand the facts of climate change (Cobb and Thompson, 2012). Even if the substantial debates still exist, the core conclusions from the IPCC reports were collaboratively determined by scientists and decision-makers and had more unique social impacts than any other climate reports. The *goal for building coastal resilience* goes beyond a "no regrets" target toward improving future ability to manage climate change risk (World Bank, 2009; Walker et al., 2010).

The Analysis component assesses the hazards, vulnerability, risks and costs of disasters from uncertain climate change. Godschalk et al. (1998) highlights the order of analytic sophistication in hazard analysis in terms of hazard identification, vulnerability assessment, and risk assessment. *Identification of coastal hazards from climate change* evaluates the magnitudes (intensities) and associated probabilities (likelihoods) of climate-induced hazards that may pose threats to human interests in coastal areas. *Vulnerability assessment* characterizes the exposed populations and property that may result from a hazard event of a given intensity in coastal areas. The assessment results can identify both physical vulnerability and social vulnerability. *Risk assessment* incorporates estimates of the injury and damage to provide a more complete description of the risk from the full range of possible hazard events in coastal areas. *Adaptation costs* measures the financial and economic costs from the potential adaptation strategies. A cost-benefit analysis is normally an effective assessment tool to estimate the costs in climate change mitigation and adaptation.

The Action component considers policies, tools, and strategies to adapt to climate change and reduce the risk of extreme events and disasters in coastal states. There is an increasing emphasis on comprehensive disaster risk management by developing resilience to potential climate impacts. Effective disaster risk management for climate change needs a more holistic, integrated, trans-disciplinary approach of risk reduction, risk transfer and disaster management actions (IPCC, 2012). This study further developed measurable indicators under these categories The details were described in the "notes" section at the end of paper.

These three "AAA" components establish a framework to understand the adaptive capacity of coastal climate action plans in managing the risks of extreme events and disasters. With this framework, we use the indicators to measure the strengths and weaknesses of current coastal climate action plans in coastal disaster management.

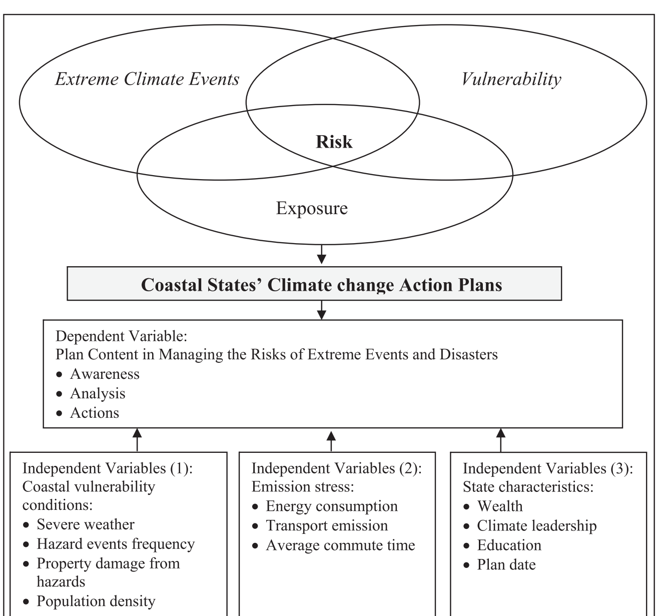

Fig. 1. Research conceptual framework.

2.2. Explaining variations of plan content in managing the risks of extreme events and disasters

An explanatory model is proposed to detect the factors influencing variations in plan content in managing the risks of extreme events and disasters among these coastal states. Climate action planning is a complex decision process which may be subject to geographic, political, socioeconomic characteristics. In this study, three sets of traditional contextual variables – coastal vulnerability conditions, emission stress, and state characteristics variables – are used to explain the variations of plan content in managing the risks of extreme events and disasters. The detailed variable measurements are stated in the methods section below.

3. Methods

3.1. Study area

The population of this study comprises 30 coastal states defined by the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration (NOAA), including the Gulf of Mexico states, Arctic Ocean states, Pacific Ocean states, and Great Lake states. This study collects the Climate Action Plans from the U.S. Environmental Protection Agency's (U.S. EPA) State and Local Climate and Energy Program website (http://epa.gov/statelocalclimate/state/state-examples/action-plans.html#all). An additional web search was conducted to find the most recent climate action plans for all coastal states. Eventually, this study found 24 coastal states' climate action plans out of a total of 30 coastal states. Table 1 lists these states, plan names, and plan dates. Six states, including Georgia, Indiana, Louisiana, Mississippi, Ohio, and Texas, do not have existing plans or may be in the process of the climate action planning. The dates of the collected plans range from 1997 to 2010. Ten plans were adopted prior to 2007 and fourteen were developed after 2008. All of these collected plans reflect the most current versions of climate action plans in these coastal states.

3.2. Data sources and data measurement

Dependent Variable: Plan content in managing the risks of extreme events and disasters: The dependent variable is measured by the scores actually received by each plan in terms of plan content for extreme events and disaster management. This study uses a three-point scoring system to calculate each jurisdiction's scores on each of three plan components. Within each component, there are multiple indicators – each of which is scored on a 0–2 scale. The score of "0" means that this item is not identified, recognized, or considered in the awareness and analysis section. The score of "1" refers to the item identified or mentioned but without details. The score of "2" measures the item that is thoroughly considered with details. For the indicators which may have the visualization features (e.g. maps, figures, tables), if the item is not visualized in the plan, it will receive a score of "0." If the item is crudely visualized which is not friendly read, it will receive a score of "1." If the item is visualized with detailed, high-solution maps, it will receive a score of "2." If an indicator is a policy-related item is not present, the score will be "0." If an indicator of policies, tools, or strategies has been considered by using the words "should", "may", "consider", "intend", "encourage", "prefer", or "suggest", it will receive a score of "1." If an indicator of policies, tools, or strategies uses the specific mandatory words such as "mandate", shall", "require", "must", or "will", it will receive the highest score of "2". When a specific policy, tool, or strategy has been adopted in an existing plan, it will be scored as "2."

The scores of each plan component and the overall plan can be calculated by the equations developed by Tang et al. (2010).

Indicator measurement for breadth and depth scores: This study further develops the methodological measurement of indicator breadth and depth scores analyzed in the recent literature (Tang et al., 2008, 2010). This study adopts two indices for assessing the degree to which an indicator is addressed across all plans. The first of these indices, the *indicator breadth score,* measures the extent to which each of the indicators is addressed across all plans. The breadth score measures a plan's coverage of a specific item or a group of items. The second index, the *indicator depth score,* measures the level of importance and analyzes how much importance is stated in a plan. The breadth and depth scores can identify the strengths and weaknesses of the selected indicators and extract deeper implications from the variations across the indicators. Indicator breadth and depth scores are computed using the equations developed by Tang et al. (2010).

3.2.1. Independent variables

Coastal vulnerability conditions category: The *severe weather* is measured by the number of severe weather events during 1960–2009. The *hazard event frequency* is measured by the number of hazard events from 1960 to 2009. The *property damage from hazard* is measured by the economic losses of hazard events from 1960 to 2009. These three variables (severe weather, hazard event

Table 1
List of the coastal states' climate action plans.

State	Year	Plan name	Plan maker
Alabama	1997	Policy Planning to Reduce Greenhouse Gas Emissions in Alabama	University of Alabama
Alaska	2009	Alaska Climate Change Strategy's Mitigation Advisory Group Final Report	Alaska Climate Change Sub-Cabinet
California	2006	California Climate Action Team Report	California Environmental Protection Agency
Connecticut	2005	Connecticut Climate Change Action Plan	Governor's Steering Committee on Climate Change
Delaware	2000	Delaware Climate Change Action Plan	Delaware Climate Change Consortium
Florida	2007	Florida's Energy and Climate Change Action Plan	Governor's Action Team on Energy and Climate Change
Hawaii	1998	Hawaii Climate Change Action Plan	State of Hawaii
Illinois	2007	Final Recommendations to the Governor	Illinois Climate Change Advisory Group
Maine	2004	A Climate Action Plan for Maine	Department of Environmental Protection
Maryland	2008	Climate Action Plan	Maryland Commission on Climate Change
Massachusetts	2004	Massachusetts Climate Protection Plan	Governor Office
Michigan	2009	Climate Action Plan	Michigan Climate Action Council
Minnesota	2008	Minnesota Climate Change Advisory Group Final Report	Minnesota Climate Change Advisory Group
New Hampshire	2009	The New Hampshire Climate Action Plan	New Hampshire Climate Change Policy Task Force
New Jersey	2009	New Jersey's Global Warming Response Act Recommendations Report	New Jersey Department of Environmental Protection
New York	2010	Climate Action Plan Interim Report	New York State Climate Action Council
North Carolina	2008	Recommended Mitigation Options for Controlling Greenhouse Gas Emissions	Climate Action Plan Advisory Group
Oregon	2008	A framework for addressing rapid climate change	The Governor's Climate Change Integration Group
Pennsylvania	2009	Climate Change Action Plan	Department of Environmental Protection
Rhode Island	2002	Rhode Island Greenhouse Gas Action Plan	Rhode Island Department of Environmental Management
South Carolina	2008	South Carolina Climate, Energy, and Commerce Committee Final Report	South Carolina Climate, Energy, and Commerce Committee
Virginia	2008	Climate Change Action Plan	Governor's Commission on Climate Change
Washington	2008	A Comprehensive Plan to Address the Challenges and Opportunities of Climate Change	Department of Ecology
Wisconsin	2008	Wisconsin Climate Change Action Plan	The Task Force on Global Warming

frequency, property damage from hazard) were collected from the Spatial Hazard Events and Losses Database for the United States, Version 9.0 [Online Database, 2011] at the University of South Carolina. The *population density* is measured by the number of people per square mile from the U.S. Census 2010 dataset.

Emission stress category: Energy consumption is measured by the total estimate of energy per capita per Trillion Btu in 2010. *Transport emission* is measured by the energy consumption of the transportation sectors per capita per Trillion Btu in 2010. Both of them were collected from the U.S. Energy Information Administration State Energy Data. The *average commute time* is measured by the commuting minutes for workers 16 years and older who were not working at home during 2006–2010, obtained from the U. S. Census Bureau.

State characteristics variables category: Wealth is measured by the per capita income in the past 12 months (in 2010 inflation-adjusted dollars), 2006–2010 – (US Dollars) from the U.S. Census Bureau. *Climate leadership* is measured by whether the state has Climate Change Commissions and Advisory Groups, from the Pew Center on Global Climate Change. *Educational attainment* is measured by the percentage of the persons 25 years and over with a bachelor's degree or higher during 2006–2010. *Plan date* is measured by the plan age by using the year 2012 minus the year that the climate action plan was adopted. The plan date is collected from each climate action plan.

3.3. Statistical reliability test

Cronbach's alpha is an approach to examine the reliability of plan evaluations. In this study, the Cronbach's alpha of each component internal consistency is between 0.800 and 0.956, indicating a high reliability level. Although Cronbach's alpha indicates a consistency of scoring through the evaluation, the alpha only demonstrates internal consistency of assigned scores within each separate variable. The Cronbach's alpha score itself has no information about reliability of actual performance of the plans.

3.4. Standardize the independent variables

Because the nature and ranges of the various independent variables have large variations, from some continuous and unbounded through proportions to a binary one, transformation is necessary to reduce the statistical biases. This study used LG10 to standardize the large data for correlation and regression analysis. However, it is important to recognize that the mix of types of independent variables still makes it almost impossible for any statistical method to treat them equally.

4. Results

4.1. Component scores

In Table 2, the Mean (M) score of all plans indicates a medium ($M = 57.4$ at a scale of 0–100) level of overall scores of these coastal states' climate action plans in managing the risks of extreme events and disasters. The minimal score of all plans is 1.4 and the maximal score of all plans is 97.2. Similar results were obtained for each component score: awareness component (M = 61.5), analysis component ($M = 57.8$), and action component ($M = 52.8$).

4.2. Scores for each state

Table 3 and Fig. 2 show each plan component scores and total scores among the 24 coastal states. Large variations were found among these states. Illinois only received 1.4 points for a total score, indicating a climate action plan with an extremely low score. In fact, Illinois only has a few pages of policy recommendations in its document. By considering the necessary elements, Illinois does not really have a climate action plan. Another eight states (Wisconsin, South Carolina, Alabama, Minnesota, Connecticut, Michigan, Maine, and Rhode Island) received scores less than 50.0 points (half of the total maximum score). Nine states (Massachusetts, Delaware, Washington, Hawaii, California, Virginia, North Carolina, Oregon, and Pennsylvania) received medium or medium–high total scores (between 50.7 and 77.1). Only six states (Alaska, New Hampshire, Maryland, New Jersey, Florida, and New York) had scores above 75.0 on a scale of 0–100.

Table 2
Descriptive statistics for plan components.

Components	Minimum	Maximum	Mean
I. Awareness	0.0	100.0	61.5
II. Analysis	0.0	100.0	57.8
III. Actions	4.2	91.7	52.8
III-1. Reduce Exposure	0.0	100.0	50.0
III-2. Increase Resilience to changing risks	0.0	100.0	75.5
III-3. Transformation	0.0	87.5	53.6
III-4. Reduce vulnerability	12.5	100.0	65.1
III-5. Prepare, Respond, Recover Effectively	0.0	100.0	26.0
III-6. Pool, Transfer, and Share Risks	0.0	87.5	46.3
Whole Plan	1.4	97.2	57.4

4.3. Indicator performance

Table 4 lists the breadth scores and depth scores for each indicator.

Awareness: In the awareness category, variations were found in the breadth and depth scores. A total of 75.0% of coastal climate action plans recognized extreme events from climate change; however, the low depth score (depth = 44.4%) indicates that the awareness level still denotes superficial recognition. The uncertainty of climate change has been relatively well recognized (breadth = 87.5%) with a medium–high depth score (depth = 76.2%). The majority of plans cited detailed climate change evidence from the IPCC assessment report (breadth = 87.5%, depth = 90.5%). However, less than half (breadth = 41.7%) of coastal

Table 3
Plan component scores and total scores (by percentage).

State	Awareness	Analysis	Actions	Whole plan
Illinois	0.0	0.0	4.2	1.4
Wisconsin	0.0	37.5	29.2	22.2
South Carolina	37.5	0.0	35.4	24.3
Alabama	50.0	25.0	4.2	26.4
Minnesota	37.5	25.0	16.7	26.4
Connecticut	25.0	12.5	68.8	35.4
Michigan	62.5	12.5	39.6	38.2
Maine	50.0	37.5	52.1	46.5
Rhode Island	25.0	75.0	43.8	47.9
Massachusetts	50.0	50.0	52.1	50.7
Delaware	50.0	75.0	37.5	54.2
Washington	62.5	62.5	54.2	59.7
Hawaii	75.0	75.0	52.1	67.4
California	75.0	75.0	56.3	68.8
Virginia	87.5	62.5	56.3	68.8
North Carolina	75.0	62.5	70.8	69.4
Oregon	100.0	50.0	58.3	69.4
Pennsylvania	62.5	75.0	70.8	69.4
Alaska	75.0	100.0	56.3	77.1
New Hampshire	100.0	87.5	66.7	84.7
Maryland	87.5	100.0	70.8	86.1
New Jersey	87.5	87.5	91.7	88.9
Florida	100.0	100.0	87.5	95.8
New York	100.0	100.0	91.7	97.2

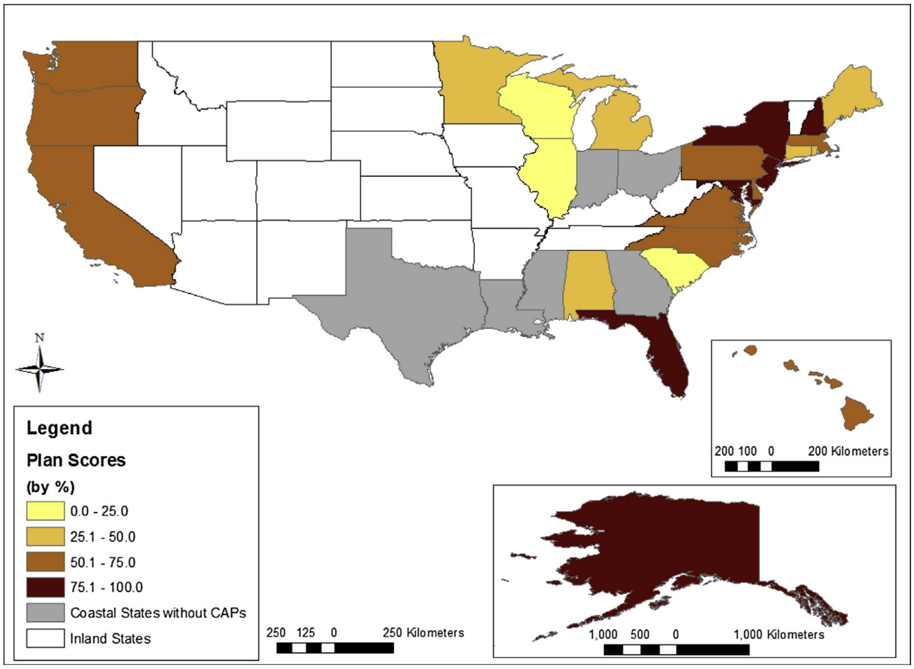

Fig. 2. Map of climate action plan scores.

plans set goals for building coastal resilience and the depth of these goals remained at lower levels (depth = 20.0%).

Analysis: A majority of coastal plans inventoried coastal hazards from climate change with a medium-low level of depth (breadth = 83.3%, depth = 65.0%). These plans normally identified the potential effects of droughts, floods, extreme sea level, waves, coastal impacts, heat waves, and other hazards. Although over two-thirds of the plans conducted vulnerability assessment, the score of assessment was very low (breadth = 66.7%, depth = 31.2%). They failed to use either maps or tables to illustrate the most vulnerable places (physical vulnerability) and the most vulnerable social groups (social vulnerability). Over two-thirds of plans

Table 4
Indicator scores.

Indicators	Measurement	Breadth (%)	Depth (%)
Awareness	A01. Extreme events from climate change	75.0	44.4
	A02. Uncertainty of climate change	87.5	76.2
	A03. Climate change evidence identified by IPCC assessment report	87.5	90.5
	A04. Goal for building coastal resilience	41.7	20.0
Analysis	B01. Identification of coastal hazards from climate change	83.3	65.0
	B02. Vulnerability assessment	66.7	31.2
	B03. Risk assessment	70.8	58.8
	B04. Assessment of adaptation costs	83.3	50.0
Action: reduce exposure	C01. Land use and development regulations	91.7	72.7
	C02. Property acquisition programs	50.0	58.3
	C03. Shoreline regulations and requirements	37.5	55.5
	C04. Defensive infrastructure and critical facilities policies	75.0	50.0
Action: increase resilience to changing risks	C05: Public awareness, education to climate change and hazards	91.7	90.9
	C06: Incorporation of risk management into economic development decision-making processes	91.7	63.6
	C07: Enhancement inter-organizational, cross-jurisdictional coordination	91.7	72.7
	C08: Establishment of environmental stewardship and sustainability platform	70.8	70.6
Action: transformation	C09. Identification of roles and responsibilities among sectors and stakeholders	79.2	26.3
	C10. Adaptive learning, continuous monitor, evaluate and update	87.5	38.1
	C11. Identification of potential financing sources	83.3	30.0
	C12. Advancing science data and analysis for climate change	75.0	33.3
Action: reduce vulnerability	C13. Building codes and design standards	95.8	65.2
	C14. Natural resource protection	79.2	57.9
	C15. Local incentive programs	83.3	45.0
	C16. Public-private sector initiatives	87.5	33.3
Action: prepare, respond, recover effectively	C17. Promotion of early warning and communication	20.8	40.0
	C18. Emergency preparedness and response procedures for extreme events	50.0	58.3
	C19. Development of local all-hazard mitigation plans	29.2	42.8
	C20. Integration of climate change into coastal zone management plans	33.3	75.0
Action: pool, transfer, and share risks	C21. Mutual and reserve funds/incentive loans	83.3	20.0
	C22. Financial insurance	75.0	33.3
	C23. Tax credits	83.3	35.0
	C24. Development impact fees	41.7	40.0

(breadth = 70.8%) assessed the frequency, intensity, spatial extent, duration, and timing of climate change on water, ecosystems, food, human settlements, infrastructure, tourism, human health, well-being, or security. However, the depth remained at the medium level (depth = 58.8%). The majority of plans (breadth = 83.2%) conducted a certain cost-benefit analysis to estimate the adaptation costs of climate change strategies, although the general depth score is at a medium level (depth = 50.0%).

Action: Large variations were found among the six sub-components in this action component (see Table 2). These coastal plans received a medium–high mean score in increasing resilience to changing risk ($M = 75.5$), and a medium mean score in reducing vulnerability efforts ($M = 65.1$), transformation ($M = 53.6$), and reducing exposure ($M = 50.0$). A relatively lower mean score was found in the subcomponents of pooling, transferring and sharing risks ($M = 46.3$) and preparing, responding, and recovering effectively ($M = 26.0$). Table 4 further lists each indicator's breadth and depth scores for each sub-component.

Reduce exposure: The high level of breadth score and the medium–high level of depth score (breadth = 91.7%, depth = 72.7%) indicates that land use and development regulations are the most frequently used tools in reducing exposure. Over 75.0% of plans have identified critical facility protection policies as an effective approach to reduce exposure in future climate change (breadth = 75.0%, depth = 50.0%). However, property acquisition programs and shoreline regulations only received relatively lower attention in both breadth and depth scores (breadth = 50.0%, 37.5%; depth = 58.3%, 55.5% respectively).

Increase Resilience to changing risks: Most plans have adopted public awareness and education programs to inform citizens about climate change and potential risks (breadth = 91.7%, depth = 90.9%). In addition, these plans emphasized incorporating climate risk management into economic development decisions (breadth = 91.7%, depth = 63.6%). They also adopted relevant strategies to enhance inter-organizational, cross-jurisdictional coordination for climate change mitigation and adaptation (breadth = 91.7%, depth = 72.7%). Over two-thirds of the plans established environmental stewardship or sustainability platforms to mitigate and adapt to climate change impacts on coastal areas (breadth = 70.8%, depth = 70.6%).

Transformation: The four indicators in the transformation subcomponent had medium–high breadth scores but very low depth scores. Over 79.2% plans identified the role of stakeholders' responsibilities in climate change actions, but the depth is very weak (depth = 26.3%). The responsibilities mainly focused on energy efficiency and emission reduction, rather than disaster adaptation. The majority (breadth = 87.5%) of plans emphasized adaptive learning, continuous monitoring, evaluation and updating procedures, but only a few specified disaster-related adaptation (depth = 38.1%). Potential financing sources for climate change actions were well identified, but mainly emphasized greenhouse gas emission strategies (breadth = 83.3%, depth = 30.0%) rather than disaster actions. Over 75.0% of plans paid attention to integrating science data and analysis for climate change decisions, but limited details were provided (breadth = 75.0%, depth = 33.3%).

Reduce vulnerability: Most of the plans used building codes and design standards to reduce climate change vulnerability (breadth = 95.8%), but many of them did not specifically link to coastal disasters (depth = 65.2%). A majority of the plans identified strategies in natural resource protection (breadth = 79.2%, depth = 57.9%), local incentive programs (breadth = 83.3%, depth = 45.0%), and public-private sector initiatives (breadth = 87.5%, depth = 33.3%). However, the lower depth scores mean that many of these indicators were not mandated or did not specifically address extreme events and coastal disasters.

Prepare, Respond, Recover Effectively: Only a small portion of plans promoted an early warning system for climate change (breadth = 20.8%, depth = 40.0%). The emergency preparedness and response procedures for extreme events were identified by half of the plans (breadth = 50.0%, depth = 58.3%). Only approximately one-third of the plans emphasized developing local all-hazard mitigation plans (breadth = 29.2%, depth = 42.8%) and integration with coastal zone management plans (breadth = 33.3%, depth = 75.0%).

Pool, Transfer, and Share Risks: Three indicators measure transferring and sharing risk through financial approaches, such as mutual and reserve funds/incentive loans (breadth = 83.3%, depth = 20.0%), financial insurance (breadth = 75.0%, depth = 33.3%), and tax credits (breadth = 83.3%, depth = 35.0%). The low depth scores were caused by the fact that these three indicators only addressed energy efficiency and emission reduction actions, rather than extreme events or coastal disasters. Development impact fees were weakly identified by the plans (breadth = 41.7%, depth = 40.0%).

4.4. Correlation and regression results

With the standardized data, the Pearson's Product–Moment Correlation coefficients show that none of the variables was statistically significant with total plan content scores: severe weather ($r = -0.265$; $p = 0.212$), hazard events frequency ($r = -0.234$; $p = 0.272$), property damage from hazards ($r = -0.040$; $p = 0.853$), population density ($r = 0.021$; $p = 0.924$), energy consumption ($r = -0.146$; $p = 0.497$), transport emission ($r = -0.066$; $p = 0.760$), average commute time ($r = 0.062$; $p = 0.773$), wealth ($r = 0.211$; $p = 0.322$), climate leadership ($r = -0.031$; $p = 0.887$), education ($r = 0.160$; $p = 0.454$), and plan date ($r = -0.164$; $p = 0.445$). The correlation results mean that none of the variables is statistically related to the plan content scores. The variables indicate either positive or negative relationships with the total content scores; however, these relationships cannot stand in a statistically significant level (as $P < 0.05$).

Furthermore, the results of Ordinary Least Squares (OLS) indicate that none of the variables in each category can statistically significant leads to higher plan scores. The non-significance results were found in the three sub-models based on the three categories: coastal vulnerability conditions (df = (4,19), $F = 0.564$, $P = 0.692$), emission stress (df = (3,20), $F = 0.255$, $P = 0.857$), and state characteristics (df = (4,19), $F = 0.475$, $P = 0.754$). The contextual variables selected in this study cannot statistically contribute to higher plan content scores. The coastal plan content scores may be affected by other variables or more complex joint variables.

5. Discussion

Regarding the first question ("How well do the U.S. coastal states' existing climate action plans manage the risks of climate extreme events and disasters, including awareness, analysis, and actions?"), the results indicate that the content of these coastal plans have a medium level of awareness, analysis, and actions for coastal disasters. In this study, large variations were found among the 32 selected indicators and 24 coastal states. These states are leading the way in the U.S. in addressing climate change at the state level. An important reason might be that the U.S. Environmental Protection Agency (EPA) made grants available during the late 1990s for states to reduce greenhouse gas emissions through climate action planning. More than one-half of the twenty-four states took advantage of this opportunity to integrate coastal hazard mitigation and adaptation with emission reduction. A majority of these states have recognized climate change impacts on hazards even though the analysis capacity still needs to be significantly improved in the future. The proposed action strategies in these plans also partially add to preparedness capacity building for extreme climate events and coastal disasters. At the same time, there are still inadequate linkages between climate change and disaster risk management. Many important disaster risk management strategies (e.g. property acquisition programs, shoreline regulations and requirements, integration of climate change into coastal zone management plans, development impact fees etc.) were limited adopted in coastal states' climate action plans. The policy recommendations below are offered for updating future coastal state climate action plans.

Expand the scope from emission reduction to climate resilience capacity building: The results of this study are consistent with previous studies on climate action plan assessment (Wheeler, 2008; Tang et al., 2010). The findings of this study confirmed that the key task of current climate action planning still mainly focuses on greenhouse gas emission reduction, rather than broader adaptive planning for climate risk management. These coastal states' climate action plans have some but limited contributions to coastal hazards mitigation and adaptation. With funding assistance from the EPA, the initial scope of climate action planning aimed to inventory greenhouse gas emissions and develop solutions for emission reduction (Wheeler, 2008). Although inter-organizational coordination was well recognized by these plans, the roles and responsibilities of sectors and stakeholders were rarely specified. Other stakeholders (e.g., emergency managers, coastal managers, etc.) were not fully involved in the planning framework. Not only do the current climate action plans lack substantial coordination and effective communication with coastal planners, emergency managers, and hazard planners, but it is interesting to note that the emergency communities also paid little attention to linking climate change with natural hazards (Bullock et al., 2009). Although hazard mitigation plans are required by the Disaster Mitigation Act of 2000, many state hazard mitigation plans still did not consider mitigation decisions with regard to climate change, rising sea levels, and climate extreme events (IPCC, 2012). The main reasons may include the misperceptions of climate change, limited understanding of uncertainties, inadequate communication of information, weak inter-organizational coordination, and lack of technical assistance or financial support. IPCC (2012) also found that few examples have integrated knowledge of and uncertainties in projected changes in exposure, vulnerability, and climate extremes. There is still an obvious gap between climate change and risk management plans that can integrate development decisions, hazard mitigation, and emergency preparedness. More creative solutions may be necessary to link emission reduction and disaster resilience.

Conduct place-based impact assessment by using advanced emerging methods: Methodologies, metrics, and databases for coastal hazard assessment need to be included in climate-related disaster management (Gornitz et al., 1994; Hammar-Klose and Thieler, 2001). This study found that most vulnerability assessment and risk assessment was a qualitative, descriptive analysis and not geo-specific. More quantitative metrics, indices, and software should be applied to coastal vulnerability and risk assessment. The lower depth scores of the analysis variables (e.g. identification of coastal hazards from climate change, vulnerability assessment, risk assessment, and assessment of adaptation costs) indicate limited analytic tools in existing coastal climate risk assessment. A clear gap between information producers and consumers still exists for local and regional climate decisions (Fowler and Wilby, 2007; Vedlitz et al., 2008). Insufficient tools were used for stakeholders to help them plan for climate change and coastal hazards. A disconnection between impact assessment and location-specified actions exists in the current plans. Downscaling climate change is a necessary step in developing location-based action policies to mitigate and adapt to the risks of climate change along coastal areas.

Develop more incentive, holistic policies to address risk: The findings of this study confirm those of Tang et al. (2010), in that the policies in current climate action plans focus predominantly on the built environment (e.g., energy, transportation, waste, and buildings) and pay little attention to the natural environment. However, investing in natural capital and ecosystem-based adaptation is an effective strategy for responding to extreme climate events and coastal disasters (UNEP, 2010). Reducing human activity in ecosystems and managing natural resources more sustainably can reduce vulnerabilities to extreme events and coastal disasters. A range of complementary approaches is needed for coastal climate actions. For example, the "no regret" adaptation principle should be applied to decisions in order to ensure net benefit of anticipated future climate and associated impacts (Callaway and Hellmuth, 2007; Heltberg et al., 2009). Additionally, more robust information tools are needed to enhance hazard preparedness, response and recovery in coastal regions. Financial incentive programs should extend from the energy efficiency domain to coastal hazard mitigation and adaptation.

Link the long-term targets with daily actions: Wheeler (2008) reported that few climate action plans have issued progress reports or evaluation procedures. This study found a low depth score in adaptive learning, continuous monitoring, evaluation and updating. The low score indicates that these plans generally lack measurable timelines and specified implementation commitments. There is a disconnection between long-term targets and daily actions. No legislative or executive actions were identified in these plans. The plans list a wide range of policy recommendations, but no guarantees were made to implement them. Many plans did not (or have been unwilling to, or may be unable to) specify the funding sources for climate change actions. In those plans that included multiple funding sources, most of the funding sources addressed emission reduction rather than adaptation strategies for hazards. The significant achievements of current climate action plans were emissions inventories, but not actual commitment to implementation.

Regarding to the second question ("Do the contextual variables affect coastal states' climate action plan content in adapting extreme events and disasters?"), the results indicate that none of the contextual variables were significantly related to plan content. These variables may have an indirect or remote influence rather than a significant direct influence. The findings of this study are consistent with the tsunami plan evaluation results, in that none of the jurisdictional variables affected the plan capacity for tsunami mitigation (Tang et al., 2008). Like a tsunami, climate change is unpredictable, non-urgent, abstract, remote, and uncertain. With limited resources, policy makers tend to have lower motivation to address these low-prioritized, invisible challenges. There may not be a linear relationship between these contextual variables and rational decisions for developing climate action plans. As we have identified above, the EPA emission reduction grants have likely pushed these states to jump-start this campaign. However, climate change planning is subject to many complex political and socio-economic factors. For example, three Gulf states – Texas, Louisiana, and Mississippi – are very vulnerable to extreme events and coastal hazards. These places are also experiencing rapid population growth along their coastal zones. However, these states do not have climate action plans. In a future study, the influence of external factors (e.g., climate vulnerability and public opinions) and internal factors (e.g. political will, staffing and structure, stakeholders) will be investigated.

6. Conclusions

Our study found a medium level but significant variations in the content of twenty-four states' coastal climate action plans across the U.S. The descriptive findings of this research can help coastal zone managers, land use planners, and emergency planners in coastal disaster management under climate change scenarios. No contextual variables contributed to plan content in risk management of extreme events and disasters. While this study focuses on a state-level planning capacity in coastal disaster risk management, it should be considered only an initial step in exploring the topic. *First,* the research did not use the standards of practices documented to actually reduce risks or the amount of damage resulting from extreme climate events, but compare the content on all relevant issues and depths of their treatment. The research framework of "Three Component Protocol" is not the universal industry standard, but it can be an academic plan framework for a climate action plan. In the future research plan, we need to incorporate more "applicable practices" indicators to improve the protocol. *Second*, this study evaluates the content of states' climate action plans in preparedness for coastal disasters. These states may have other types of regulatory documents, such as comprehensive land use plans, coastal zone management plans, hazard mitigation plans, or emergency management plans that include specific provisions that address the risks of climate change. Thus, the conclusion drawn from this study is only subject to the evaluation results from the states' climate action plans, which may not represent the states' actual preparedness capacity. *Third*, a gap always exists between planning documents and plan implementation effectiveness. The actual effectiveness of climate action plans needs to be carefully investigated in future studies. *Lastly*, the contextual variables analyzed in this study only partially address the factors influencing state-level climate action planning. An in-depth questionnaire survey or stakeholder interview should be conducted to understand the influential factors. Some additional direct variables should be analyzed to further identify the relationship between plan content and influencing factors.

6.1. Notes

- *Reduce exposure*: This category refers to reducing the elements in an area where hazard events may occur. Land use and development regulations are widely recognized as significant policies that affect coastal hazard mitigation. State mandates for land use and development can make a positive impact on land development patterns by steering development away from lower hazard areas (Burby and May, 1999). Property acquisition programs conserve critical ecosystems and reduce potential infrastructure development in vulnerable coastal areas (Schwab et al., 2007). Shoreline regulations and requirements reduce erosion of natural shorelines and protect shorelines from hazards (Tang et al., 2011). Defensive infrastructure and critical facilities policies direct the location of infrastructure (e.g., transportation, utility lines) and facilities (such as police stations, fire stations, and hospitals) outside of hazardous or environmentally sensitive coastal areas (Schwab et al., 2007).
- *Increase resilience to changing risks*: This category refers to increased long-term institutional and societal capacity for climate change preparedness. Public awareness and education programs can promote awareness of natural hazards and improve public resilience to the risk for climate change and hazards (Olshansky and Kartez, 1998). Incorporation of risk management into economic development decision-making processes is an important step to build long-term resilience. Enhancement inter-organizational, cross-jurisdictional coordination is definitely needed to avoid any negative impacts among sectors or scales that could potentially result from fragmented adaptation and implementation of plans (Brody et al., 2007). As the task of managing the risks of extreme events and coastal disasters affects multiple sectors, cross-organizational mechanisms are preferred to address the challenges associated with adaption to climate change (Brody et al., 2011). Establishment of environmental stewardship and sustainability platform encourages expanded, bottom-up, grass roots, and collective actions to build long-term resilience toward coastal disasters (Chapin III et al., 2009; Duxbury and Dickinson, 2007; IPCC, 2012).
- *Transformation*: This category refers to altering an existing system toward sustainable development pathways. Identification of roles and responsibilities among sectors and stakeholders helps translate the strategic goals to each specific sector. Adaptive learning, continuous monitoring, evaluation and updating can be important steps to transform dynamic information into decisions. Identification of potential financing sources shows real commitments to transformation. Advancing science data and analysis for climate change emphasizes integrating scientific data into socioeconomic transformation. Effective disaster risk management should integrate accurate regional climate prediction into climate-related decisions (Collins, 2007; Doherty et al., 2009). Much scientifically sound climate data still lack relevance to decision makers (Averyt, 2010). Effective communications can help decision makers and general citizens to understand the likelihood of extreme impacts of climate change (Moser and Dilling, 2007).
- *Reduce vulnerability*: This refers to reducing the risk of physical and social vulnerability to extreme events and disasters. Building codes and design standards can reduce the loss of and damage to buildings from natural hazards (Olshansky and Kartez, 1998). Natural resource protection reduces local vulnerability to the destruction of coastal ecosystems (William and Micalef, 2009). Local incentive programs provide incentives to stimulate coastal land owners, developers, business groups, and individuals to engage in coastal hazard vulnerability mitigation and adjustments (Tang et al., 2011). Local incentive programs include transfer/purchase development rights, density bonus, and others. Local participation is valuable to offer alternative perspectives and incentive approaches to problem-solving. Public-private sector initiatives help integrate more sources and options to reduce the likelihood of development in vulnerable areas. Common initiatives include land trust, acquisition, or easement programs (Schwab et al., 2007).
- *Prepare, respond, recover effectively*: This category builds an important bridge between corrective (reactive) disaster risk reduction and prospective (proactive) disaster risk management. Promotion of early warning and communication helps warn citizens and decision makers about impending creeping climate extremes and hazards that can increase hazard preparedness capacity (Rogers and Tsirkunov, 2010). Emergency preparedness and response procedures for extreme events prepare for evacuation routes, supplies, and sources during emergent disasters. Development of local all-hazard mitigation plans is required by the Disaster Mitigation Act (2000) in order to receive post-disaster assistance. Local knowledge is increasingly valued as important information for disaster preparedness (McAdoo et al., 2009). In addition, all-hazard mitigation plans provide an important opportunity to develop comprehensive mitigation strategies for coastal hazards. Integration of climate change into coastal zone management plans

provides a direct channel to respond to climate change in coastal areas. Current coastal zone management plans rarely consider the concept of climate change (Tang et al., 2011).

- *Transfer, and share risks*: This category refers to shifting the financial consequences of economic risks from one party to another, such as a household, community, business, or governmental authority. Mutual and reserve funds or incentive loans help transfer the risks of coastal hazards from landowners, developers, and builders. These funds or loans help distribute the public costs of private development in a more equitable manner (Olshansky and Kartez, 1998). Financial insurance can share the risk of extreme events and coastal disasters with insurance agencies. It can promote and encourage the use of insurance mechanisms to reduce the risk of disasters (IPCC, 2012). Tax credits can use taxation strategies for preserving specific coastal areas and implementing special tax assessment for specific coastal areas. The taxation policy not only provides financial incentives to discourage undesirable development patterns, but it can also offer incentives for building more resilient constructions beyond the minimal requirements from the building codes. Development impact fees help transfer and share the risks by discouraging the development of specific coastal areas (Tang et al., 2011).

Acknowledgment

The authors gratefully appreciate the three anonymous reviewers' constructive comments that greatly improved this paper. This project was support by the SKLEC Research Grant (SKLEC-KF201203) and University of Nebraska Rural Futures Institute. None of the conclusions expressed here necessarily reflects views other than those of the authors.

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