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Coordinated planning effort as multilevel climate governance: Insights from coastal resilience and climate adaptation

Hyun Kim[a,*], David W. Marcouiller[b], Kyle Maurice Woosnam[c,d]

[a] Chungnam National University, Daejeon, South Korea
[b] University of Wisconsin-Madison, Madison, WI, USA
[c] University of Georgia, Warnell School of Forestry & Natural Resources, GA, USA
[d] University of Johannesburg, School of Tourism & Hospitality Management, Auckland Park, South Africa

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ABSTRACT

Using flood risks and potential impacts of sea level change within the U.S. Great Lakes region over the past 20 years, we explore the association between coordinated planning effort as a form of multilevel climate governance and community resilience attributes under climate risk. Content analysis and coastal adaptation principles allowed us to evaluate coordinated planning effort at county and state levels to derive a horizontal or vertical coordination index which was then used to evaluate if synergies generated among plans were correlated with climate risk mitigation and enhanced adaptation to climate change. Further, we incorporated evaluation results of varied community resilience characteristics and coordinated planning effort metrics in the context of climate change. Empirical results suggest that the extent of coordinated planning effort at the county and state levels is closely associated with coastal community resilience and climate change adaptation.

1. Introduction

Climate risks affect community conditions and are best approached with pro-active planning and public policies focused on resiliency. Communities[1] with higher levels of resilience have the potential to mitigate losses from climate risks and shorten recovery periods (Aerts et al., 2014; Beatley, 2014; Masterson et al., 2014; The National Research Council, NRC, 2012). In recent work that addressed enhanced climate resilience and adaptation, Glavovic (2014) suggested that human, physical, economic, social, and natural components need to be collectively considered.

Planning and public policy measures to mitigate climate risk, enhance resilience, and adapt to climate change have been an increasing area of current research (Frick-Trzebitzky and Bruns, 2019; Kim and Marcouiller, 2020; Smith and Glavovic, 2014). The spatial coordination of policy, planning networks, plan quality assessment, and attributes of the planning process need to accompany public policy development that addresses climate change (Baynham and Stevens, 2014; Berke et al., 2012, 2015; Löschner and Nordbeck, 2019; Rivera and Kapucu, 2015; Woodruff, 2018). Indeed, climate change planning to mitigate and adapt to future outcomes involves a complex set of human interventions and inter-relationships.

By incorporating the complexities of community resilience into efforts to enhance climate change adaptation, reduce vulnerability, and mitigate hazards, Bulkeley (2013) and Wallace (2017) regarded multilevel planning processes, transnational networks, and policy strategies as adaptation frameworks. Further, developing and implementing policies to address adaptation to climate change need to combine planning and network perspectives (van Buuren et al., 2014), institutional arrangement (Empinotti et al., 2019), decision-making among and within appropriate institutions (Bauer et al., 2012), multisector coordination (Fink, 2019; Hughes, 2017), and climate policy coherence (Scobie, 2016).

Multilevel governance as a term used to reflect multiple decision-making processes can be useful in recognizing the crucial role of planning, policy, and institutional capacity (Amundsen et al., 2010; Bulkeley, 2010, 2013; Bulkeley and Betsill, 2005; Leck and Simon, 2013; Vedeld et al., 2016; Wheeler, 2008). Such a perspective is analogous to vertical and horizontal coordination (Davoudi et al., 2010; Wilson and Piper, 2010) and multiscalar climate change governance dynamics (Moser, 2009).

However, most studies do not typically evaluate multilevel governance as a process of adaptation planning within coordinated spatial

* Corresponding author.
E-mail addresses: hkim9129@gmail.com (H. Kim), dwmarcou@wisc.edu (D.W. Marcouiller), woosnam@uga.edu (K.M. Woosnam).

[1] In this study, the term 'community' reflects spatial scale at the US county level and allows for comparable use of available secondary data. This is done to examine 'vulnerability', 'resilience', and 'adaptation' within the context of local planning and public policy.

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policy frameworks. Further, few studies have been conducted examining the planning effort through coordination of planning networks (Berke et al., 2015; Woodruff, 2018). There is a clear need for empirical studies that directly address coordination between plans or policies with the intent to integrate climate change adaptation and community resilience. This is true throughout oceanic coastal North America and uniquely important in regions proximate to the inland coasts of the U.S. Great Lakes.

In this study, we use the term 'coordinated planning effort' to identify multiple scales of action and cross-national learning in a period of increased global climate risks. In addition, we use the term 'horizontal or vertical coordination index' to measure the extent to which county and state plans (or within a county or state) address the selected climate adaptation-related principles. Such an approach is in keeping with the arguments of Wilson and Piper (2010, p.100) who claim that "mitigation and adaptation are not being addressed solely or even wholly at one level." Further, our work accounts for whether "a new emphasis on planning as an 'enabling' mode of governance" will be useful in managing climate risks and diagnosing barriers to climate change adaptation (Bulkeley, 2010, p. 292).

To better understand the role of coordinated planning effort in climate change adaptation in the context of coastal environments, we incorporate plan quality metrics with respect to recent state and county mitigation and adaptation plans. The four realms of planning explicitly included in our assessment involved hazard mitigation plans, climate action plans, land use plans, and outdoor recreation plans. By measuring the extent of coordination among these four types of plans, we identified how coordinated planning effort can be effective in coastal resilience and climate adaptation. Our empirical work focused on the unique inland coastal regions of the U.S. Great Lakes.

This manuscript is organized into four subsequent sections. Following this introduction, we outline the existing literature on community resilience and climate change adaptation with an interest in coordinated planning effort as multilevel governance. Methods and data used in this empirical study are summarized in the third section. Results of our empirical models are then discussed culminating in a final section that summarizes our work, outlines policy implications, and provides a framework for future research.

2. Community resilience, coordinated planning effort, and climate change adaptation

Community resilience in the context of natural disasters and climate change includes a diverse set of components. These also relate to investments in physical attributes and infrastructure of the built environment, social and economic factors, information and communication, and local decision-making competence (Cutter et al., 2014; Norris et al., 2008). The NRC (2012, pp.126–127) suggests that community organization, standards and codes, performance metrics and the development of a resilience rating system are operational necessities. Further, education and communication, and pro-active resource management can be crucial to obtain effective implementation of local resilience planning. Focusing on the importance of local government capacity and implementation efforts to manage climate risks, Kusumasari et al. (2010) demonstrated that socio-economic dimensions and interventions such as institutional attributes, human resources, policies for effective implementation, financial capacity, technical characteristics, and leadership can be key functional factors in promoting resilience. Similarly, Maclean et al. (2014) suggested knowledge skills and learning, community networks, people-place connections, community infrastructure, diverse and innovative economies, and engaged governance as crucial components in upscaling climate change adaptation.

In attempting to identify the measurable capacity of local and state government planning systems, previous research (c.f., Davoudi et al., 2010; Stone et al., 2012) has evaluated policy documents, strategies, and plans put forward to enhance resilience, build adaptive capacity, and reduce vulnerability. Plans can represent both the quality of the planning process and the strength of implementation when examining outcomes of planning effort and blueprints for future actions (Berke et al., 2015; Berke et al., 2019; Kim and Marcouiller, 2018). Formulating good quality plans is a starting point to accomplish goals and implement policies. In this context, communities having better hazard mitigation plans that integrate effective land use planning that includes public property acquisition, feasible development regulations including building standards, resilient public infrastructure, and fiscal buffers have been shown to reduce climate change-induced risks (Beatley, 2009; Berke et al., 2014; Nelson and French, 2002).

Reflecting on the crucial role of the planning process as a mechanism to address climate change issues, Smith and Glavovic (2014, p. 408) underscored that high-quality climate risk-related plans can "play a pivotal role in building capacity and facilitating more collaborative ways of thinking and working to achieve resilience and sustainability." An implied consensus exists which claims plan quality is an important moderator in affecting local government decisions and facilitating plan implementation. Recent studies (c.f. Bunnell and Jepson, 2011; Lyles et al., 2014; Nelson and French, 2002; Stevens and Shoubridge, 2015) prioritized the effects of state-level planning mandates and the extent of plan quality measured by defined principles and protocols. Further, enhanced qualitative methods have been applied to evaluate planning effort in response to diverse types of extreme weather events in disaster-stricken areas.

In the process of land use planning for sustainable development, Berke et al. (2006, p.6) demonstrated that a "network of plans" can have both authoritative and coordinative synergies based on combining plans in non-hierarchical jurisdictional structures (considered as a form of horizontal coordination). By adopting the concept of network of plans, Woodruff (2018, p.2) argued the need for coordination of plans that forward a "planning ecosystem" approach. Decision making benefits from the combined integration of local, regional, state, and federal levels (regarded as a form of vertical coordination) that include hazard mitigation plans, comprehensive plans that account for rational land use, and open space plans. Further, these perspectives are in-line with work conducted by Kaza and Hopkins (2012) that examined relationships among plans in the process of urban development. Following such thinking, in this study we adopt a coordination of plans across scales (as a form of horizontal or vertical coordination) in the context of climate change and examine the role of coordinated planning effort as a viewpoint of multilevel climate governance.

By integrating multilevel governance and coordinated planning effort, improved community resilience can be achieved through the collaboration of multiple stakeholders and improved intergovernmental cooperation. This viewpoint can be regarded as another scale of coordinating governance to address climate change (Adger, 2001). Further, this is consistent with the writings of Wallace (2017, p. 156) who notes the importance of "networking organizations to build a culture of collaboration" and Birkmann et al. (2010, p. 202) who regarded (adaptive) governance as "self-regulation through coordination and cooperation."

Intergovernmental coordination among federal, state, and local jurisdictions facilitates risk management through cost-sharing, resource response, provision of resilient infrastructure, and coordination of development (i.e., land use and community welfare). The effectiveness of disaster management in mitigating climate risks and adapting to climate change depends on coordinated intergovernmental collaboration (Hughes, 2017; Wallace, 2017). Whether discussed as coordinated adaptation, climate adaptation governance, non-hierarchical institutional structures, public and private collaborations or intergovernmental and interorganizational relationships, this concept of cooperation (or coordination) is vital for responding to the consequences of climate change (Hughes, 2017; Huitema et al., 2016; Mees, 2017). Effective climate change adaptation can be linked with multilevel responses (Adger, 2001).

While the world marches forward into uncharted climate territory, human responses to natural disasters are evolving. Empirical assessments focused on the role of pro-active planning can assist in improved approaches to develop more resilient communities. There is increasing consensus in the academic literature that intergovernmental coordination is key to improving planning effort and its resulting outcomes that address resilience to climate risks. Our contribution to this literature is incremental yet important.

3. Research design and methods

Our empirical assessment of coordinated planning effort, community resilience, and climate change adaptation was accomplished in three phases. These included (1) collecting secondary data and using this data to develop quantitative explanatory models, (2) evaluating the extent of coordination between state and county plans using qualitative document-based content analysis, and (3) triangulating spatial results with content analysis to examine whether interplay exists between coordinated planning effort and community resilience in the context of climate change. An explanation of each of these phases will be provided following a discussion of the research study area.

3.1. Study area

This research was undertaken considering 212 coastal counties within the U.S. Great Lakes Region across eight states (i.e., Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, New York, Michigan) as illustrated in Fig. 1. Per National Oceanic and Atmospheric Administration (NOAA) (2013), of the 672 coastal counties within the region, these 212 have experienced differential coastal flood impacts and storm surges over the last 20 years and are expected to confront indirect risks from sea-level change. This region has experienced roughly 10 percent of the number of flood events in the U.S. that have caused at least US $50,000 in damages to property and crops from 1990 to 2009 (Peterson et al., 2013).

The eight states within the U.S. Great Lakes region stand out as states that expend relatively more effort for hazard mitigation and climate change adaptation. Among the eight states, Michigan, Wisconsin, and Ohio are known to have stronger building regulations for disaster risk reduction and public safety interests than the others (May, 2013). Further, these states provide for local government enforcement of building codes. According to Lysák and Bugge-Henriksen (2016), Minnesota and New York are known to have more focused climate change adaptation policies than others. That said, efforts at hazard mitigation and climate change adaptation vary widely across the eight states and 212 coastal counties. This unique regional delineation provides for a useful empirical examination of coordinated planning effort with respect to risk mitigation and climate change adaptation.

3.2. Selected variables and explanatory models: Phase one

The first research phase examined the role of coastal community resilience to climate risks by incorporating characteristics that reflect socio-economic (SEC), environmental and geographic (EGC), institutional and policy (IPC), and climate stress (CSC) by place. These characteristics were analyzed using negative binomial regression and generalized linear models.

To represent flood-specific institutional capacity and policy effort over time, we selected those coastal communities that had formal disaster events that led to presidential disaster declarations and community rating systems for which data were available concerning flooding events over the last 20 years. We used a negative binomial regression model due to the positively-skewed distribution of the outcome variable (Hilbe, 2011), direct economic impacts, and climate risks (*Flood losses*) that included both the effect and non-effect of flood risk. In this study, we selected flood loss as a proxy for economic loss due to climate risks. This was done to reflect the value of financial flood loss. We recognize that human loss and social loss due to flooding extend to important, yet more empirically complex forms, of loss. This provides further limitation to our work but allows standardized and tractable metrics of

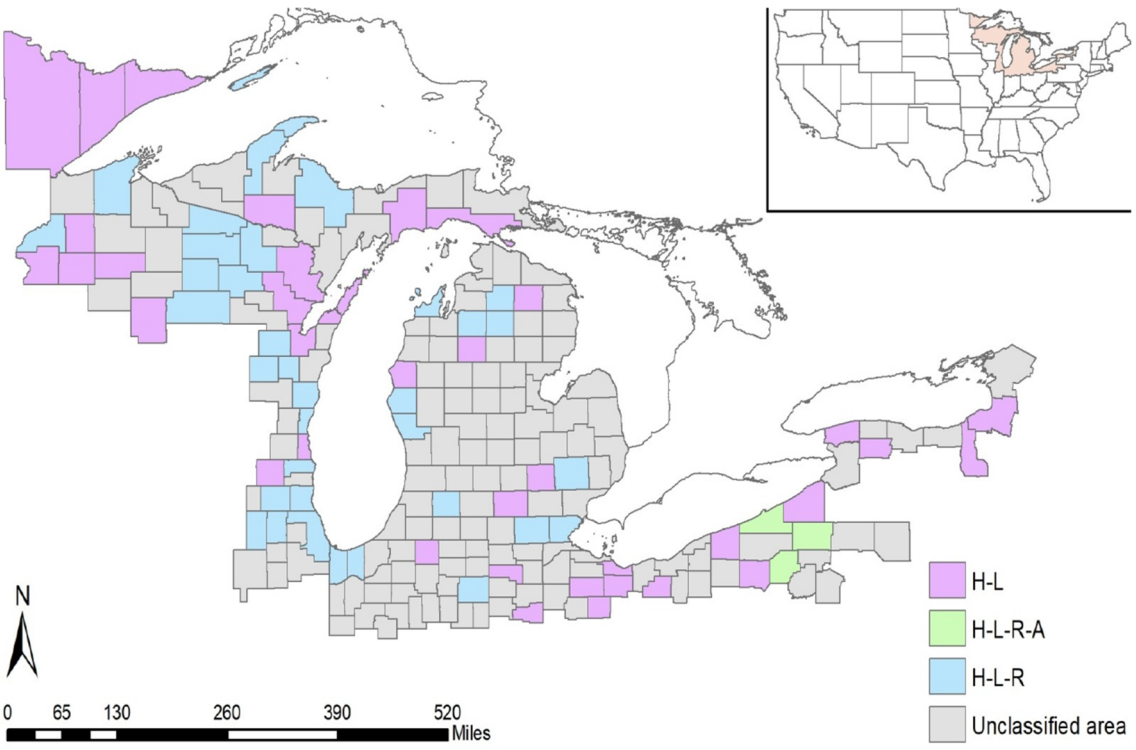

Fig. 1. Study area and county planning effort distribution. Note: H is hazard mitigation plan, L is land use plan, R is outdoor recreation plan, A is climate change action plan, - indicates networks of each plan.

economic loss. This step allowed us to re-select 141 counties among the 212 counties in our study area that have exhibited flood risk.

For the selected flood risk prone counties, we employed a generalized linear model (GLM) to embrace the attributes of the dependent variable that only involve the effect of flood risk. The GLM method can be "a flexible method of generalizing OLS models that use response variables with error distributions that are not normally distributed" (Bandyopadhyay and Green, 2018, p. 487; Wooldridge, 2006).

Place-based characteristics were identified from a variety of secondary sources. These included the National Climatic Data Center of the National Oceanic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), U.S. Census Bureau (including County Business Patterns), Dave Leip's Atlas of U.S. Presidential Elections, the Center for Climate and Energy Solutions, NASA's Moderate Resolution Imaging Spectroradiometer classification database, Socioeconomic Data and Application Center, and NOAA Sea Level Rise Impact Viewer.

Socio-economic characteristics (SEC) associated with climate change opportunity, civic capacity (Zahran et al., 2008), and community capacity against climate risks are logical conceptual variables to include in an explanatory model of economic loss due to flooding. Operationally, these were specified to include population density (*Population*), housing density (*Housing*), unemployment status (*Unemployment*), median household income adjusted for 2002 inflation (*Income*), income inequality measured by median household income level (*GINI*), percent population over 65 years of age (*Age*), percent population of non-white persons (*Nonwhite*), percent population with less than a high school diploma (*Education*), and percent of voter turnout in the 2004 presidential general election (*Vote*).

Institutional and policy characteristics (IPC) conceptually involve local political tendencies and administrative structure. This is supported by the works of Leiserowitz (2006) and Kim and Marcouiller (2016) who found stronger support for climate policy in regions that leaned toward more progressive governance approaches. Operationally, the *Political interest* variable was selected and involved presidential general election results coded binary as won by leaders elected as Democrat or Republican. The *Fragmentation* variable was specified as the number of sub-county administrations. The *Climate adaptation* variable reflected the progress of a state on making climate change adaptation plans classified as 'nothing', 'recommended', 'progress', and 'completed' by the Center for Climate and Energy Solution. The *Regulation* variable reflected building regulation status at the state level following the approach of May (2013) on regulation provision categorized as 'minimalist', 'enabling', 'mandatory', and 'energetic. Note that this *Regulation* variable also followed the work of Kim and Marcouiller (2018) to capture the role of non-structural mitigation measures in reducing climate risks.

Coded as binary outcomes, community adoption status (*CRS*) represents whether a county participated in a community rating system as part of a voluntary flood insurance program. Likewise, community experience status defined whether a county was given a presidential disaster declaration for flood damage over the last 20 years (*PDD*). Community adoption status (*Mitigation*) reflected whether a county had an approved mitigation plan by FEMA. Underlying components associated with nonstructural mitigation measures or climate adaptation options are closely associated with the findings of many recent studies (e.g., Aerts et al., 2014; Kim et al., 2018; Rivera et al., 2015; Scrieciu et al., 2014; van Wesenbeeck et al., 2017; Ward et al., 2017) and reflect the role of policy instruments (e.g., political will, coordinated planning) in reducing climate risks and promoting resilience.

Environmental and geographical characteristics (EGC) are also logical conceptual elements in the development of our explanatory models. Operationally, these were specified as the percent area of floodplain (*Floodplain*), percent of wetland area (*Wetlands*), and percent of forest, shrubland, water, and grassland area (*Ecosystem*). Following the work of Brody et al. (2014) on environmental characteristics contributing to coastal community resilience, we viewed *Floodplain* and *Wetlands* variables to reflect positive environmental resilience. This calls attention to the importance of ecological buffers or natural landscapes to reduce climate risks (e.g., Beatley, 2009; van Wesenbeeck et al., 2017). These environmental and geographical characteristic variables are useful to capture their role in enhancing coastal community resilience and climate change adaptation in coastal regions of the U.S Great Lakes.

With respect to capturing climate risk characteristics (CSC), we selected flood occurrence days over the last 20 years (*Flood duration*). As potential impacts due to sea level change, the *Sea level change* variable coded binary was defined by whether a county was in a low-elevation coastal zone. Climate risk variables and potential risk of sea level change are important outcome variables that reflect direct climate risks and potential climate change impacts within coastal regions of the US Great Lakes. Climate change stress and local climate policy options have been shown to be conceptually important (Zahran et al., 2008). Operationally, we proxied climate stress characteristics to include percent of employees working in carbon-intensive industrial sectors (*Carbon employment*) like agriculture, forestry, mining, construction, manufacturing, transportation, warehousing, and utilities. This concept is further captured by the percent of employees working in climate change vulnerable industrial sectors (*Vulnerable industry*) such as tourism, timber, and farming. In addition, average commuting time from home to workplace for workers over 16 years old (*Commuting*) was specified as a proxy variable associated with CO_2 emissions and reflects the extent to which workers in the region were a potential contributor to increased climate change. Considering potential multi-collinearity among all independent variables described above and outlined in Table 1, we examined VIF scores, which revealed a coefficient of 4.92. Following previous explanatory modeling of climate change conducted by Kim et al. (2018), this value suggests acceptable levels of multicollinearity among independent variables. For the first research phase, the hypothetical association was formulated with reference to each county i and per capita property damage due to flood events (*Flood losses*):

$$Flood\ \ losses_i = f\,(SEC_i,\ IPC_i,\ EGC_i,\ CSC_i) \tag{1}$$

In this equation, the *Flood losses* variable, as an outcome variable, was log transformed to approximate a normal distribution.

3.3. Document-based planning strategy measures: Phase two

In the second research phase, we used a document-based qualitative method to evaluate the extent of coordination between plans at state and county levels. Contextualizing community resilience, coastal climate adaptation, climate change policy, and land use policies outlined above (e.g., Beatley, 2009; Berke et al., 2015; Masterson et al., 2014), we secured 11 principles as evaluation criteria to measure the coordination between plans at state and county levels as outlined in Fig. 2. The selected principles included 1) development regulation, 2) land-use management/planning/acquisition policies, 3) building standards/structural resilience, 4) natural-resource protection/conservation and restoration, 5) local infrastructure, 6) landscape and site design, 7) public information, awareness, and education, 8) public facilities, 9) taxation and financial incentives/penalties, 10) property acquisition, and 11) private-public sector initiatives.

Such a method is much more akin to the analysis of planning strategies than to plan quality principles (e.g., fact base, goals, policies, coordination, implementation) used in prior research (e.g., Berke et al., 2014; Lyles et al., 2014; Kim and Marcouiller, 2018; Woodruff and Regan, 2019). In the study reported here, we relied more heavily on planning strategies than plan quality through measuring whether county and state plans related to climate change adaptation and resilience efforts that included the same principles (i.e., see above discussion).

Table 1
Concept measurement and data source.

Variable name	Definition/measurement	Data source	Mean	SD	Range
Dependent variable					
Flood losses	Per capita property damage by coastal flooding (US$)	SHELDUS	39.72	146.72	0–1,213.07
Socio-economic characteristic variables (SEC)					
Population	Population density (number of people per km^2)	U.S. Census Bureau	269.62	622.89	4.15–5,645.2
Housing	Housing density (number of housing per Km^2)		114.03	254.99	3.4–2,240.95
Unemployment	Unemployment rate		9.30	2.82	3.60–21.40
GINI	Median household income inequality index		0.41	0.02	0.33–0.48
Income	Median household income (US$)		46,675	9,122	31,076–79,897
Age	65-year old and over (%)		15.99	3.87	7.06–30.81
Nonwhite	Non-white (%)		9.23	9.60	1.61–85.78
Education	Population with less than high school degree (%)		11.92	3.58	4.24–39.48
Vote	Voter turnout in presidential general election in 2004 (%)	Dave Leip's Atlas of presidential elections	46.18	10.51	24.87–71.97
Climate stress characteristic variables (CSC)					
Flood duration	The length of coastal flood (days)	SHELDUS	4.16	4.60	0–35
Sea level change	Whether a county is located in low elevation coastal zone (0 = no, 1 = yes)	Socioeconomic Data and Applications Center	0.37	0.48	0–1
Carbon employment	Employees in agriculture, forestry, mining construction, manufacturing, transportation, warehousing, and utilities (%)	County Business Pattern	30.44	15.73	0.53–197.38
Vulnerable industry	Climate change vulnerable industries including tourism, timber, and farming (%)		22.76	9.43	10.74–65.40
Commuting	Average commuting time, travel time to work for workers 16+ years (minutes)	U.S. Census Bureau	9.37	1.89	4.80–15.84
Institutional and policy characteristic variables (IPC)					
Political interest	Presidential general election in 2004 (1 = democratic party, 0 = republican party)	Dave Leip's Atlas of presidential elections	0.30	0.36	0–1
Fragmentation	Number of sub-county jurisdictions	U.S. Census Bureau	20.90	12.60	1–128
Climate adaptation	State status in adopting a climate change adaptation plan (0 = nothing, 1 = recommended, 2 = progress, 3 = completed)	Center for Climate and Energy Solutions	1.28	1.18	0–3
Regulation	Building regulation (1 = minimalist, 2 = enabling, 3 = mandatory, 4 = energetic)	May (2013)'s State regulation provisions	2.54	0.93	0–3
CRS	Whether a county adopted community rating system (0 = no, 1 = yes)	FEMA	0.15	0.36	0–1
PDD	Whether a county experienced presidential disaster declaration (0 = no, 1 = yes)		0.59	0.49	0–1
Mitigation	Whether a county has a FEMA approved mitigation plan (0 = no, 1 = yes)		0.77	0.41	0–1
Environmental and geographical characteristic variables (EGC)					
Ecosystem	Areas including forest, shrubland, water, and grassland (%)	NASA's MODIS classification	94.12	11.90	20–100
Wetlands	Wetland area (%)	NOAA	15.58	11.89	2–50
Floodplain	Floodplain area (%)		6.36	5.23	0–31
Coordinated planning effort characteristic variables (CPE)					
H^c-L^c	Coordination between local hazard mitigation plan and land use plan	Hazard mitigation plan, land use plan	0.75	0.08	0.54–0.95
H^s-L^s	Coordination between state hazard mitigation plan and land use plan		0.83	0.09	0.63–0.95
H^{cs}-L^{cs}	Coordination between state and local hazard mitigation plan and land use plan		0.79	0.06	0.68–0.95
H^c-L^c-R^c	Coordination between local hazard mitigation plan, land use plan, and outdoor recreation plan	Hazard mitigation plan, land use plan, and outdoor recreation plan	0.76	0.08	0.60–0.92
H^s-L^s-R^s	Coordination between state hazard mitigation plan, land use plan, and outdoor recreation plan		0.83	0.11	0.68–0.95
H^{cs}-L^{cs}-R^{cs}	Coordination between state and local hazard mitigation plan, land use plan, and outdoor recreation plan		0.80	0.06	0.67–0.93
H^s-L^s-R^s-A^s	Coordination between hazard mitigation plan, land use plan, outdoor recreation plan, and climate action plan at state level*	Hazard mitigation plan, land use plan, outdoor recreation plan, and climate action plan	0.88	0.02	0.86–0.91

Note: data units in parentheses
Note: H: hazard mitigation plan, L: land use plan, R: outdoor recreation plan, A: climate action plan, **C**: county, **S**: state, * Pennsylvania included.

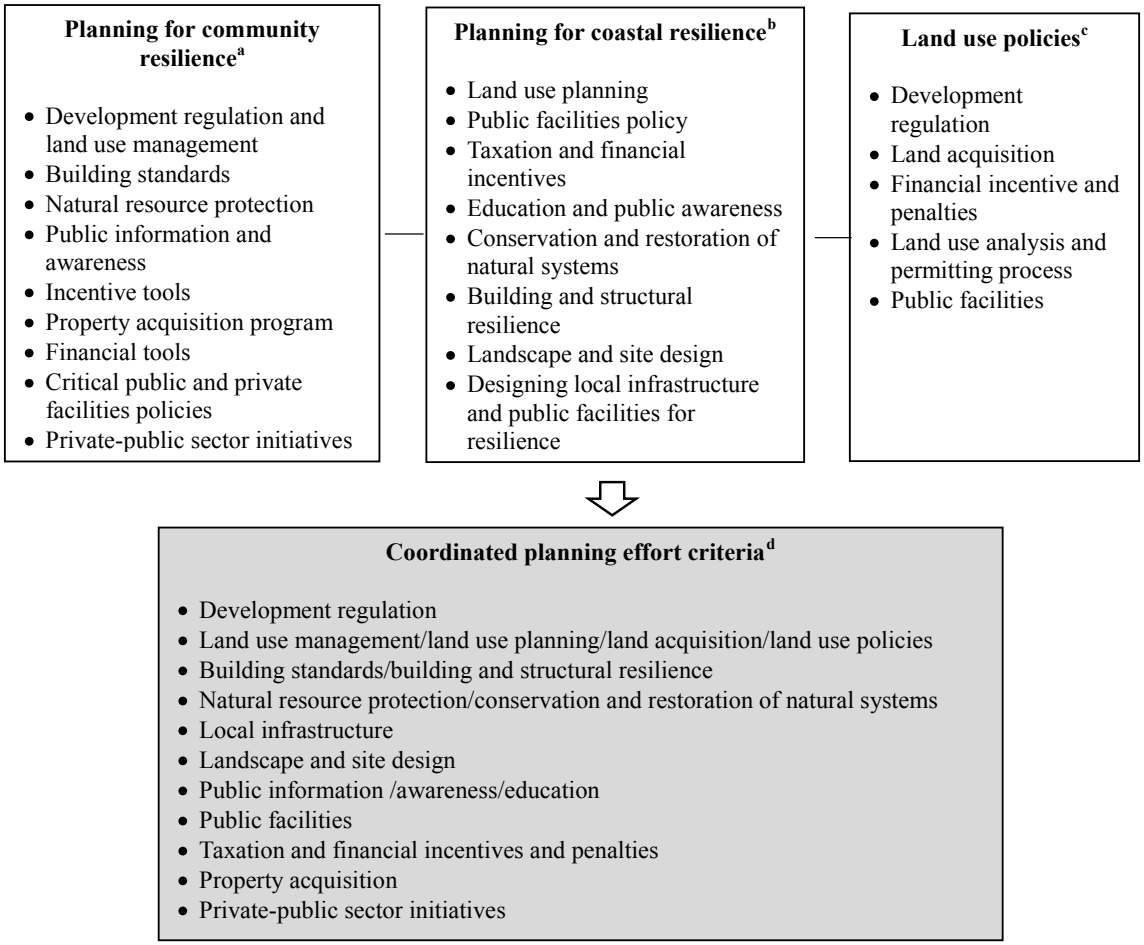

Fig. 2. Coordinated planning effort evaluation criteria. Note: a: derived from Masterson et al. (2014), b: derived from Beatley (2009), c: derived from Berke et al. (2015), d: used in this study.

Our evaluation assessed the degree to which 1) hazard mitigation plans, 2) land use plans, 3) climate change action plans, and 4) outdoor recreation plans were coordinated. These four types of climate risk-related plans were deemed ideal for reflecting resilience, effectiveness of coordination among plans, and climate adaptation at both county and state levels. The 11 selected principles that measured coordinated planning effort at state and county levels were examined with respect to these four types of planning documents.

To measure the extent of coordination between plans at county and (or) state level, we designated seven protocols. These were coded as H^c-L^c, H^s-L^s, H^{cs}-L^{cs}, H^c-L^c-R^c, H^s-L^s-R^s, H^{cs}-L^{cs}-R^{cs}, *and* H^s-L^s-R^s-A^s. Within coded variables, a hyphen ('-') denotes coordination between plans, *H* denotes hazard mitigation plans, *L* indicates land use plans, *A* denotes climate change adaptation plans, and *R* indicates outdoor recreation plans. Further, superscripts *C, S,* and *CS* denote county-level, state-level, and county-state-level, respectively. From official county and state websites within the study area, we collected 212 county hazard mitigation plans (H^c), 212 county land use plans (L^c), 38 county climate change adaptation plans (A^c), 33 county outdoor recreation plans (R^c), eight state-level hazard mitigation plans (H^s), eight state level land use plans (L^s), three state level climate change adaptation plans (A^s), and five state outdoor recreation plans (R^s). Based on the collected plans, we evaluated the degree to which hazard mitigation plans and land use plans were coordinated among counties (H^c-L^c) as a horizontal coordination and between county and state level (H^{cs}-L^{cs}) as a vertical coordination. In addition, we measured the extent of planning coordination between hazard mitigation plans, land use plans, and outdoor recreation plans at county levels (H^c-L^c-R^c), county and state levels (H^{cs}-L^{cs}-R^{cs}) and between four plans at state levels (H^s-L^s-R^s-A^s).

Based on the four types of plans at county and state levels, we adopted a content analysis procedure used in Berke et al. (2014), Lyles et al. (2014), and Kim and Marcouiller (2018). For this assessment, two researchers independently coded '0' or '1' for each of the 11 principles noted before, where '0' indicated that each principle was not identified and '1' indicated the principle was identified or addressed. When some disagreement occurred between the two coders, each instance was discussed and recoded as appropriate to a coordination score. Using Cronbach's α, we checked inter-coder reliability and internal consistency among the disagreement scores. With a Cronbach's α value of 0.625, our principles demonstrated moderately high levels of internal consistency, and following the work of DeVellis (2003), were deemed acceptable for our qualitative assessment reported here. This measurement is limited in reflecting land use management strategies. Increased density in a land use plan focus on growth while decreased density in a hazard mitigation plan can focus on reducing development in the floodplain. In our work, we measured the degree of coordination among climate risk-related plans at the county and state levels and were mot able to tease out references to contradictory density strategies.

However, in the study, we paid more attention to measure the degree of coordination among climate risk-related plans at the county and state levels in the context of multilevel governance rather than such contradictory strategies within the relevant plans. Along with each coded value and the seven horizontal or vertical coordination protocols outlined above, we measured the degree to which plans were coordinated using an equal weighting min–max transformation (as a coordination index). To normalize this index, we used a min–max transformation that reflected each coded value from the 11 principles in the county *i* (or state *i*) and the total value of each coded value among counties or states. Coding was additive.

3.4. Triangulating to assess interplay: Phase three

In the third research phase, we examined the degree to which an interplay existed between the degree of coordinated planning effort (CPE) based on the coordination index measured in the second phase and community resilience in the context of climate change. This phase is useful to further identify the potential role of coordinated planning effort with implications for multilevel climate governance among coastal regions of the U.S. Great Lakes. To account for the hypothetical association between coordinated planning effort and socioeconomic, climate stress (including flood losses), institutional and policy, and environmental and geographical attributes, we formulated the following empirical Eq. (2) with specific reference to each county *i* or state *i*:

$$CPE_i = g(SEC_i, IPC_i, EGC_i, SC_i Flood\ \ losses_i) \quad (2)$$

Through (2), we measure the association and extent of coordinated planning effort to address coastal resilience and climate change adaptation. Further, using this process, we can make conclusions about explicit linkages between coastal community well-being, adaptation and resilience, and threats from climate risks.

4. Findings

Descriptive summary statistics that reflect the five broad characteristic groupings (socio-economic, climate stress, institutional and policy, environmental and geographical, and coordinated planning effort) with property losses by flooding (*Flood losses*) as an outcome variable are outlined in Table 1. The Gini coefficient (*GINI*) derived from median household income level ranged between 0.33 and 0.48, with Kendall County, Illinois being the lowest and Cook County, Illinois the highest within the selected study counties. Climate stress characteristics that reflected association with climate change was measured using a sectoral grouping. This *Vulnerable industry* metric ranged from approximately 11% to 65%. Further, roughly 40% of the study area was located in low elevation coastal zones.

With respect to multilevel institutional and policy attributes, the *Political interests* variable reflected counties being led by more Republicans than Democrats. Such preference could suggest political majorities with relatively less proactive climate change policy interest. Most U.S. Great Lakes states revealed a 'recommended' status as climate adaptation adoption and exhibited either 'enabling' and 'mandatory' as building regulation policy. These findings suggest modestly effective progress or action toward climate change adaptation at the state level. Whereas most coastal counties within the study area displayed lower levels of adoption for rating systems as part of voluntary flood insurance programs, most counties exhibited a higher level of adoption status on FEMA-approved hazard mitigation plans. In terms of coordinated planning effort, our indexed values ranged from 0.54 to 0.95. The mean value of coordination between hazard mitigation plans and land use plans at the county level (H^c-L^c) was lower than that of coordination among hazard mitigation plans, land use plans, climate action plans, and outdoor recreation plans at the state level (H^s-L^s-A^s-R^s).

Results from the first research phase suggested associations between independent and outcome variables and are summarized in Table 2. Such empirical findings can be useful to identify community resilience parameters in the context of climate change. Using *Flood losses* as the outcome variable, four models were specified to control parameters within environmental and geographical characteristic variables. Among socio-economic characteristic variables, *Population*, *Housing*, and *GINI* variables were statistically significant predictors of coastal community resilience to climate risks (see Models 3 and 4). The economic inequality attribute (*GINI*) was positively related to flood losses. This result supports the findings of Kapucu and Özerdem (2013), and suggests the pivotal role of social equity in enhancing resilience. *Age* and *Non-white* variables were positively correlated with climate risks within these Great Lakes coastal communities which is consistent with other studies. As a proxy for civic engagement and social capital, the *Vote* variable represented voter turnout and played a positive role in reducing vulnerability. This potential resilience enhancement factor supports similar findings in Aldrich (2012) and Kim and Marcouiller (2016).

Among institutional and policy characteristics, *Regulation*, *CRS*, and *Mitigation* variables were significant and had a positive influence on lowering flood loss. This is consistent with results of other studies (e.g., Aerts et al., 2014; Ward et al., 2017). Important policy solutions that target nonstructural mitigation measures or climate adaptation options included retention areas, flood-proofing buildings, early warning systems, building codes, and post-disaster support. These were confirmed

Table 2
Community resilience and climate adaptation.

	Model 1	Model 2	Model 3	Model 4
SEC				
Population	−0.0002	−0.033	−0.018**	−0.515*
	[0.007]	[0.350]	[0.008]	[0.269]
Housing	−0.0006	−0.269	−0.036**	−0.965*
	[0.016]	[0.773]	[0.018]	[0.526]
Unemployment	−0.102	−11.850*	−0.027	−4.733
	[0.076]	[6.177]	[0.164]	[3.435]
GINI	1.601	44.829	29.990**	12.931**
	[7.571]	[32.630]	[12.790]	[4.560]
Income	−0.0004*	−0.005*	−0.0006	−0.002
	[0.0002]	[0.002]	[0.007]	[0.001]
Age	−0.037	−3.133	−0.033	10.212**
	[0.071]	[4.358]	[0.133]	[3.536]
Nonwhite	0.059**	1.997	0.016	3.323*
	[0.027]	[2.158]	[0.058]	[1.888]
Education	−0.014	−5.833	−0.094	−1.615
	[0.054]	[4.556]	[0.157]	[5.282]
Vote	−0.020**	−0.351	−0.012	−0.113
	[0.006]	[0.381]	[0.008]	[0.286]
CSC				
Flood duration	0.269**	7.793	0.134	1.932
	[0.079]	[7.095]	[0.146]	[3.430]
IPC				
Political interest	0.609	26.820	0.763	30.376
	[0.543]	[57.746]	[1.018]	[28.282]
Fragmentation	0.011	1.627	0.028	1.254
	[0.023]	[1.754]	[0.021]	[0.952]
Regulation	−0.288*	−6.594*	−0.669*	−4.682
	[0.244]	[25.624]	[0.354]	[11.520]
CRS	−4.56e−06**	−0.0008*	−1.07e−06	−0.0003
	[2.07e−06]	[0.0006]	[2.40e−06]	[0.0005]
PDD	1.133**	20.834	2.190**	9.420
	[0.381]	[18.900]	[0.883]	[20.259]
Mitigation	−6.66e−06*	−0.0001*	−4.47e−07*	−0.0009
	[3.55e−06]	[0.0001]	[3.90e−06]	[0.0008]
EGC				
Ecosystem	0.063	5.296		
	[0.059]	[3.716]		
Wetlands			−0.037**	−1.908**
			[0.016]	[0.750]
Floodplain			−0.157*	−7.255*
			[0.081]	[3.753]
Constant	13.404	11.690	6.062	19.470
	[8.202]	[3.848]	[8.351]	[21.625]
Number of observations	212[a]	141[b]	74[c]	52[d]
Wald Chi^2	102.63***		193.09***	
AIC		13.30		11.67
BIC		382.78		171.52

Note: negative binomial regression used in Models 1 and 3 and generalized linear model employed in Models 2 and 4, *: statistical significance at 10%, **: statistical significance at 5%, ***: statistical significance at 1%, robust standard errors in brackets, a: entire study areas, b: selected study areas excluding areas with zero flood losses, c: selected study areas excluding areas with missing wetlands and floodplain data, d: selected study areas excluding areas with b and c.

to be robust strategies for climate change adaptation. Among environmental and geographical characteristics, *Wetland* and *Floodplain* areas within these coastal regions were negatively related to flood loss and remain as important ecological characteristics of communities trying to adapt to climate change.

Results of the second research phase are summarized in Table 3. In this coastal region of the Great Lakes, the degree of coordination between county-level hazard mitigation plans and land use plans (H^c-L^c) showed coordination index values exceeding 0.63. Among the 212 counties, Cook County and DeKalb County in Illinois, Allen County and Erie County in Ohio, Genesee County in New York, Vilas County in Wisconsin, and Kalkaska County in Michigan ranked highly. Only 33 of 212 counties had scores higher than 0.63 for local coordinated planning effort among hazard mitigation plans, land use plans, and outdoor recreation plans (H^c-L^c-R^c). State level coordinated planning effort between hazard mitigation plans and land use plans (H^s-L^s) are also summarized in Fig. 3. Note from this Figure that Michigan exhibited the highest planning effort levels. This result reflects the extent of coordinated effort among three plans at the state level (H^s-L^s-R^s). With respect to coordinated effort of hazard mitigation plans and land use

Table 3
Coordination measures.

State	County	**C** coordination index			**S coordination** index			**CS** coordination index		
		H-L	H-L-R	H-L-R-A	H-L	H-L-R	H-L-R-A	H-L	H-L-R	H-L-R-A
Minnesota (3)	Cook	0.6818			**0.9090**			0.7954		
	Lake	0.6363						0.7727		
	St. Louis	0.8181						0.8636		
Wisconsin (25)	Barron	0.6818			**0.7727**	**0.7121**		0.7272		
	Bayfield	0.8181	0.7424					0.7954	0.7272	
	Brown	0.7727						0.7727		
	Burnett	0.7727	0.7121					0.7727	0.7121	
	Calumet	0.7272	0.7424					0.7500	0.7272	
	Clark	0.8636						0.8181		
	Door	0.5909						0.6818		
	Forest	0.7272						0.7500		
	Langlade	0.7272						0.7500		
	Lincoln	0.6818						0.7272		
	Marathon	0.7272						0.7500		
	Marinette	0.7272						0.7500		
	Milwaukee	0.7272						0.7500		
	Oconto	0.7727						0.7727		
	Oneida	0.7727						0.7727		
	Outagamie	0.6363	0.6363					0.7054	0.6742	
	Ozaukee	0.7272	0.8484					0.7500	0.7803	
	Polk	0.7727						0.7727		
	Racine	0.7272	0.8484					0.7500	0.7803	
	Rusk	0.6363						0.7045		
	Sheboygan	0.6363	0.7575					0.7045	0.7348	
	Vilas	0.9090	0.8636					0.8409	0.7878	
	Walworth	0.8636						0.8181		
	Washburn	0.7272						0.7500		
	Winnebago	0.7272	0.6969					0.7500	0.7045	
Illinois (5)	Cook	0.9545	0.8484		**0.8181**	**0.8484**		0.8863	0.8484	
	DeKalb	0.9545	0.8636					0.8863	0.8560	
	Kane	0.7272	0.6969					0.7727	0.7727	
	Lake	0.7272	0.7575					0.7727	0.8030	
	McHenry	0.7272	0.7272					0.7727	0.7878	
Indiana (4)	Allen	0.7272	0.6969		**0.6363**	**0.6818**		0.6818	0.6893	
	Elkhart	0.7272						0.6818		
	Lake	0.8181	0.7424					0.7272	0.7121	
	Porter	0.7272	0.7272					0.6818	0.7045	
Ohio (8)	Allen	0.9545			**0.8181**			0.8863		
	Ashtabula	0.7272						0.7727		
	Crawford	0.7272						0.7727		
	Defiance	0.8636						0.8409		
	Erie	0.9545						0.8863		
	Huron	0.7272						0.7727		
	Medina	0.6818						0.7500		
	Seneca	0.7272						0.7727		
Pennsylvania (4)	Erie	0.6818	0.8181	0.8181		**0.8636**	**0.9090**	0.7727	0.8409	0.8636
	Mercer	0.7272						0.7954		
	Venango	0.8636	0.9242	0.9242				0.8636	0.8939	0.9166
	Warren	0.7272	0.8484	0.8484				0.7954	0.8560	0.8787
New York (5)	Cayuga	0.7727			**0.7272**			0.7500		
	Chautauqua	0.7727						0.7500		
	Genesee	0.9545						0.8409		
	Niagara	0.7272						0.7272		
	Oswego	0.7272						0.7272		

(*continued on next page*)

Table 3 (*continued*)

State	County	**C** coordination index			**S coordination** index			**CS** coordination index		
		H-L	H-L-R	H-L-R-A	H-L	H-L-R	H-L-R-A	H-L	H-L-R	H-L-R-A
Michigan (21)	Crawford	0.7727	0.6969		**0.9545**	**0.9545**		0.8636	0.8257	
	Houghton	0.8636	0.8030					0.9090	0.8787	
	Iron	0.7272						0.8409		
	Jackson	0.7272						0.8409		
	Kalamazoo	0.8636	0.9242					0.9090	0.9393	
	Kalkaska	0.9545	0.8484					0.9545	0.9015	
	Keweenaw	0.7272	0.8181					0.8409	0.8863	
	Leelanau	0.7272	0.7272					0.8409	0.8409	
	Lenawee	0.7272	0.7272					0.8409	0.8409	
	Livingston	0.7272						0.8409		
	Mackinac	0.7727						0.8636		
	Marquette	0.7272	0.6363					0.8409	0.7954	
	Mason	0.7272						0.8409		
	Missaukee	0.7727						0.8636		
	Monroe	0.6363	0.6666					0.7954	0.8106	
	Montmorency	0.6363						0.7954		
	Muskegon	0.6363	0.7121					0.7954	0.8333	
	Oakland	0.6818	0.8181					0.8181	0.8863	
	Oceana	0.7272	0.7272					0.8409	0.8409	
	Otsego	0.5454	0.6060					0.7500	0.7803	
	Schoolcraft	0.6363						0.7954		

Note: C index is county level, S index is state level, CS index is county and state level, H: hazard mitigation plan, L: land use plan, A: climate action plan, R: outdoor recreation plan, bold numbers indicate state level index values.

plans at state and county levels (H^{cs}-L^{cs}), counties had indexed values that exceeded 0.68. Within 33 counties, the degree of coordinated effort among hazard mitigation plans, land use plans, and outdoor recreation plans among counties and states (H^{cs}-L^{cs}-R^{cs}) was like that of county coordination among the three plans (H^{c}-L^{c}-R^{c}).

For the third research phase, we triangulated the association results of coastal community characteristics and coordinated planning effort in mitigating flood risks and adapting to climate change. The association is based on the coordination index between climate change-related plans at county and state levels. Generalized linear models with six different types of outcome variables are summarized in Table 4. For the analysis, we integrated the results of planning coordination as depicted in Table 3. Social capital attributes, climate stress characteristics, climate adaptation effort, and presidential disaster declaration were significant in Models 5, 6, and 7. This is likely explained by the higher level of coordination between hazard mitigation plans and land use plans. As predicted, climate risk attributes and potential sea level change were positively related to the degree to which plans were coordinated. As shown in Models 8, 9 and 10, results were similar to the degree of horizontal or vertical coordination between hazard mitigation plans, land use plans, and outdoor recreation plans. This result suggested that climate risk exposure can drive increased horizontal or vertical coordination. Variable-related efforts of institutions and public policy (e.g., a community rating system, approved mitigation plans, and building regulations) were closely correlated with higher levels of planning coordination. This finding suggests that more robust institutional and policy efforts can contribute to improved coordination between plans at county and state levels.

5. Conclusions, caveats, and further research needs

Coastal communities increasingly experience significant threats to human and ecosystem health, economic loss, infrastructure damage, and weakened capacity to rebound from natural disasters (Beatley, 2014). In this study, we addressed one critically important issue in minimizing coastal flood losses and adaptations to climate change – the coordination of planning effort. An index tracking coordination of plans related to climate risks at county and state levels was used to evaluate if greater coordination among plans was correlated with climate risk mitigation and enhanced community adaptation to climate change. Using a mixed-methods approach, we modeled socio-economic, governance and environmental characteristics at the county level in US coastal regions bordering the Great Lakes.

Based on this empirical work, we conclude that coordinated planning effort plays an important role leading to higher levels of community resilience in mitigating disaster losses and enhancing adaptation to climate change. Secondary data on socio-economic and environmental parameters were modeled while governance parameters were identified from a qualitative content analysis of policy documents assessing coordination of plans in four fields of practice. These included the four planning fields of hazard mitigation, land use, climate action, and outdoor recreation. From this perspective, we conclude that more resilient coastal communities with higher levels of economic activity, better social capital, stronger institutional and policy capacities that address hazard mitigation and climate change adaptation lead to lower climate risks. This reflects the positive role of coordinated planning effort in mitigating climate risks and enhancing climate change adaptation. In this context, our empirical research is aligned with the work of Kapucu et al. (2013, pp. 355-356) who demonstrated that “communities can improve their resiliency by employing inclusive planning processes, maintaining key environmental features, and recognizing the importance of regulations that mitigate disaster impacts.”

Empirical findings that support proactive climate policy, intergovernmental coordinated planning efforts, and climate adaptation planning in practice need to be viewed cautiously. There are several caveats that affect context. We highlight two of the most important. First, we were constrained by the availability of planning document-based measures and community resilience variables. Actual planning outcomes measured consistently and comprehensively would improve this empiricism. Further, geographic scale that captures, and is able to distinguish planning coordination at more finely grained resolutions (neighborhoods, municipalities, towns), would allow deeper insight into planning coordination. Related to this, the geographic context of our results was constrained to coastal regions of the US Great Lakes. The northern borders of these inland seas are Canadian. There is a need for further research that compares and contrasts planning coordination effort between US and Canadian local, provincial/State, and federal efforts.

These limitations represent opportunities for further research that extend to new questions. What process elements dictate planning effort

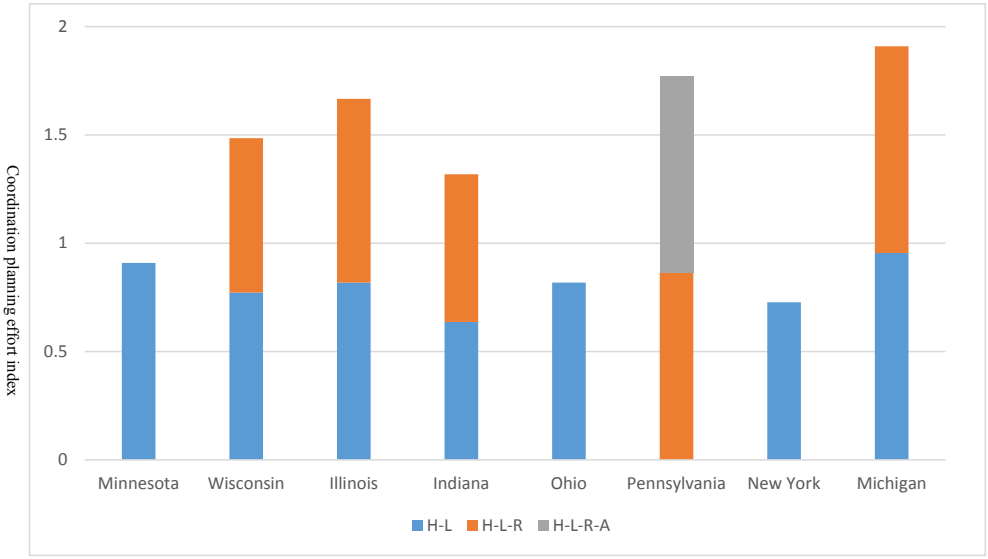

Fig. 3. Coordination planning evaluation at the state level. Note: H is hazard mitigation plan, L is land use plan, R is outdoor recreation plan, A is climate change action plan, - indicates coordination of each plan, H-L is coordination between hazard mitigation plan and land use plan, H-L-R is coordination between hazard mitigation plan, land use plan, and outdoor recreation plan, H-L-R-A is coordination between hazard mitigation plan, land use plan, outdoor recreation plan, and climate change action plan.

to improve our adaptation to climate change? How does coordination among various levels of government serve to ameliorate problems encountered during disaster response and the resiliency planning needed to minimize the risk of future disasters? These extended future research questions can serve to improve our ability to plan for disaster resilience and climate change adaptation.

Important policy analysis arenas include research on local implementation practices (Uittenbroek, 2016), collaborative policy management (e.g., Kapucu and Hu, 2016), institutional transboundary capacities (e.g., Milman et al., 2013), anticipatory adaptation (e.g., Smit et al., 2000), anticipatory governance as a flexible decision framework to address current decisions toward maximizing future alternatives

Table 4
Coordinated planning effort and climate change adaptation.

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	H^{c}-L^{c}	H^{s}-L^{s}	H^{cs}-L^{cs}	H^{c}-L^{c}-R^{c}	H^{s}-L^{s}-R^{s}	H^{cs}-L^{cs}-R^{cs}
SEC						
Vote	0.003*	0.003*	0.0008	0.003	0.002	0.001
	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]	[0.001]
CSC and Flood losses						
Flood losses	0.0003	0.0006**	0.0004*	0.0003	0.0007*	0.0002
	[0.0006]	[0.0002]	[0.0002]	[0.0004]	[0.0004]	[0.0003]
Sea level change	9.35e−08**	2.82e−08	3.27e−08	1.74e−09	4.10e−08	2.14e−08
	[4.42e−08]	[4.88e−08]	[3.07e−08]	[6.47e−08]	[7.28e−08]	[4.16e−08]
Carbon employment	0.001	0.001*	0.001**	0.001	0.001	0.0009
	[0.001]	[0.001]	[0.0008]	[0.002]	[0.002]	[0.0001]
Vulnerable industry	0.0004	0.0008	0.0002	0.0004	0.001	0.0008
	[0.001]	[0.0007]	[0.0005]	[0.001]	[0.001]	[0.001]
Commuting	0.004	0.012**	0.004	0.023**	0.017**	0.020**
	[0.005]	[0.005]	[0.003]	[0.009]	[0.008]	[0.007]
IPC						
Political interest	0.002	0.012	0.007	0.001	0.041	0.021
	[0.045]	[0.028]	[0.022]	[0.048]	[0.049]	[0.037]
Climate adaptation	0.002	0.017**	0.009	0.0003	0.012	0.006
	[0.009]	[0.007]	[0.005]	[0.010]	[0.014]	[0.009]
Regulation	0.010	0.009	0.0004	0.047**	0.013	0.030**
	[0.012]	[0.007]	[0.007]	[0.018]	[0.016]	[0.014]
CRS	2.07e−08	2.29e−08	2.18e−08	1.43e−07*	3.40e−08	8.85e−08
	[4.63e−08]	[5.85e−08]	[3.94e−08]	[8.40e−08]	[8.32e−08]	[7.08e−08]
PDD	0.035	0.090***	0.027*	0.007	0.155***	0.081**
	[0.026]	[0.021]	[0.015]	[0.036]	[0.038]	[0.025]
Mitigation	1.87e−08	1.10e−07	6.46e−08	2.92e−07*	8.96e−08	1.01e−07
	[6.98e−08]	[7.19e−08]	[5.25e−08]	[1.61e−07]	[1.14e−07]	[1.09e−07]
EGC						
Ecosystem	0.002*	0.002*	0.002**	0.007*	0.001	0.003
	[0.001]	[0.001]	[0.001]	[0.004]	[0.003]	[0.002]
Constant	0.611**	0.744***	0.677***	1.661***	1.243**	1.452***
	[0.197]	[0.195]	[0.151]	[0.419]	[0.399]	[0.292]
Number of observations	75			33		
Log pseudolikelihood	81.062	97.644	117.710	42.672	42.909	53.395
AIC	1.788	2.230	2.765	1.737	1.752	2.387
BIC	262.86	263.04	263.17	66.288	66.290	66.357

Note: H: hazard mitigation plan, L: land use plan, R: outdoor recreation plan, C: county, S: state, CS: county and state level, *: statistical significance at 10%, **: statistical significance at 5%, ***: statistical significance at 1%, robust standard errors in brackets.

(Quay, 2010), and time lag effects of socio-economic change (e.g., Hultquist et al., 2017). Indeed, ample room exists for further research along these lines of enquiry.

Our data and evaluation approach to planning coordination suggest that socioeconomic inequalities exacerbate flood loss and impede resilience. Institutions and policies can promote planning coordination. That said, further research is needed to explore questions of scale, legacies of planning, political interests, perceptions and experiences of climate risk. Further research needs to reflect such tangible, as well as intangible, parameters in addressing climate governance. Multi-criteria models (e.g., da Cruz and Marques, 2019) can examine how current intergovernmental/organizational operations and cross-sector collaborations play a role in climate adaptation and response to extreme events.

In relation to measuring policy integration, network analysis can be used to assess the quality of local and state cooperation and "systematic comparisons between issue integration based on actors and integration based on laws" in the context of climate change adaptation and climate governance (Metz et al., 2020, p.1). In addition, considering time lag effects of community resilience parameters, future research needs to include the association between socio-economic and climate change policy. Despite these limitations and assuming that research into this line of enquiry continues, it is safe and clear to state the obvious takeaway from this work. Better coordinated planning effort to improve coastal resilience results in mitigating climate risks and enhancing climate change adaptation.

CRediT authorship contribution statement

Hyun Kim: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **David W. Marcouiller:** Formal analysis, Investigation, Writing - review & editing. **Kyle M. Woosnam:** Investigation, Writing - review & editing.

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