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Surveying local planning directors' actions for climate change

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Abstract

Purpose – The purpose of this paper is to examine how well local planners have recognized the issues surrounding climate change, the analysis that jurisdictions have conducted on climate change, and policies that have been implemented to address climate change.

Design/methodology/approach – This study conducted a mail questionnaire survey for 214 counties' planning directors in the USA and received 53 effective responses. This survey examined how well local planning directors have been prepared for climate change, including awareness, analysis scope, and implementation strategy.

Findings – The descriptive results indicate that the directors who responded to this survey had a relatively high (79.87 percent) level of awareness for climate change; but they had limited (34.94 percent) analysis scopes to assess the sources, impacts, and risk of climate change in their jurisdictions. These directors had partially but not fully (51.51 percent) developed local land use planning implementation strategies to mitigate or adapt climate change. The regression model indicates that the political commitment and planning personnel resources have significant influence on local planning directors' actions for climate change.

Originality/value – This paper provides policy implications to improve local land use planning ability for climate change mitigation and adaptation.

Keywords United States of America, Climate change, Community planning, Land, Mitigation, Adaptation, Planning

Paper type Research paper

1. Introduction

Climate change is a global issue with a significant local[1] dimension (Betsill, 2000). Localities and residents are direct receivers from climate change; at the same time, the local jurisdictional level is an appropriate scale to address climate change related problems. Many researchers believe that localities can predominately address the causes, driving forces, impacts and responses of climate change (Angel *et al.*, 1998; Wilbanks and Kates, 1999; Wiseman *et al.*, 2010). For example, local jurisdictions are the basic unit for make decisions on building infrastructure facilities, transportation system, and hazard mitigation (Bai, 2007). Localities can reinforce and complement regulatory

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policies to reduce emission (DeAngelo and Harvey, 1998). Local governments have considerable authority over local comprehensive land use planning to address a series of growth-related problems that were considered as important aspects of climate change mitigation and adaptations (Betsill and Bulkeley, 2006).

In the USA, the bottom-up approach to climate change actions[2] is necessary due to a shortage of federal progress on the issue (Kates and Wilbanks, 2003). Local climate change actions cover two critical components – mitigation and adaptation. Climate change mitigation means "implementing policies to reduce GHG emissions and enhance sinks" (IPCC, 2007). Climate change adaptation consists of "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (IPCC, 2007). Many local jurisdictions are playing participative roles to mitigate or adapt climate change. Wheeler (2008) founds that most local plans in his study have set emission reduction goals, or established emission inventories. Local climate change mitigation and adaptations can directly address sources of greenhouse gas emissions and provide local solutions (Lindseth, 2004). Land development patterns and energy consumption are examples of issues in which local jurisdictions play an essential role. Therefore, it is important to examine how local policy makers are addressing the threat of climate change.

Land use planning at local jurisdiction levels, including the cities and counties, is an extremely important approach to address climate change mitigation and adaptations. Although, at the local level, climate change is often viewed as an emerging topic, many land use planning studies in recent decades have addressed growth management and environmental quality issues; which are viewed as an important part of local climate change actions (American Planning Association, 2008). Local comprehensive land use planning can play an important role to mitigate or adapt climate change since it covers a local jurisdiction's entire planning area, addresses the long-term development issues, and embodies public policy relative to the future. Local land use planning can take the leadership in changing our land use patterns that can eventually contribute to climate change mitigation and adaptations (Lindley *et al.*, 2006; Moser and Luers, 2008). Local land use planning can mitigate climate change impacts through reducing greenhouse gas emissions from principal sources, such as transportation and housing. Moreover, local land use planning can mitigate climate change effects through adjusting land use activities and practices that reduce potential impacts. Local land use planning has considerable power to prompt the behavioral changes necessary to reduce greenhouse gas emissions (Betsill and Bulkeley, 2006). Local land use planning agencies have regulatory power to direct and manage land development to achieve desirable development patterns and reduce greenhouse gas emissions. Local land use planning offers an institutional framework to regulate land development and enforce mitigation measures. Many important carbon-related decisions fall within the responsibility and authority of local land use planning such as local zoning, subdivision regulations, building codes, sanitation codes, design standards, urban growth boundaries, and environmental land protection regulations. Local land use planning can also gain public control over lands and make use of planning authority to purchase development rights, or accept dedication of conservation easements. Local land use planning have a certain acquisition power to prioritize critical lands for open space, conservation easements, public transportation system, public school sites, and other public infrastructure facilities. At the same time, moving from agenda to actions for local climate change

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mitigation or adaptations is complex process (Tang *et al.*, 2010). It may be subject to many economic, social, environmental, institutional factors. It is important for us to identify the influential factors that will help understand more about local planning decision-making behaviors in climate change mitigation and adaptations.

However, few studies have provided empirical evidence on local land use planners' responses to address the challenge of climate change. In recognition of this gap, this study proposes to empirically examine local planning directors' responses to climate change. We examine how well local planners have recognized the issues surrounding climate change, the analysis that jurisdictions have conducted on climate change, and policies that have been implemented to address climate change. To explore local land use planning actions, this study addresses two critical research questions:

RQ1. To what extent do local planning directors effectively address climate change, including climate change awareness, analysis scope, and implementation strategies?

RQ2. Which factors are influencing local planning directors' actions for climate change?

2. Dependent and independent variables

Based on the above statement of the role of local land use planning in climate change actions, we propose the conceptual framework for the dependent and independent variables in Figure 1.

2.1 Dependent variables

The dependent variable is local planning directors' actions for climate change. Three sub-components were utilized to create an index of directors' actions:

(1) awareness;

(2) analysis scope; and

(3) implementation strategy.

Awareness measures the degree to which local planning directors understand the concepts of climate change. It is an important step for local decision makers to take actions

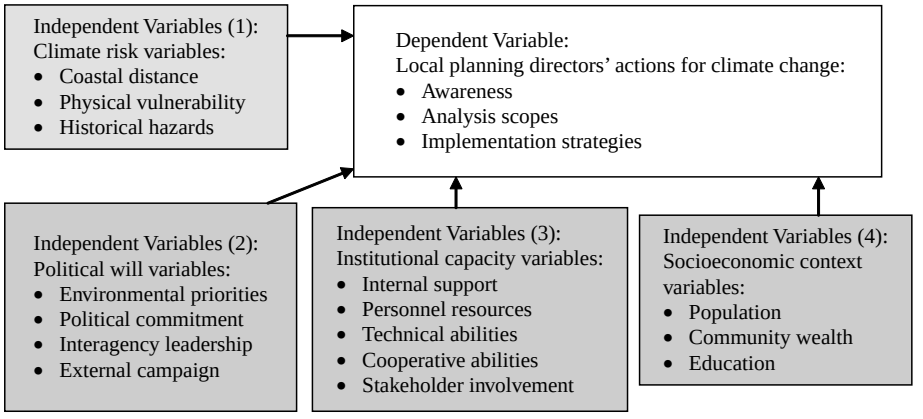

Figure 1.
Research framework of dependent and independent variables

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for climate change when they are able to be aware of the scientific underpinning of climate change, climate variability, and global warming (Lindseth, 2004). Analysis scope assesses local abilities to analyze the major drivers, sources, or contributors to climate change as well as possible impacts of climate change in planning areas (Angel *et al.*, 1998; Tang *et al.*, 2010). Implementation strategy measures the abilities of local actions in climate change mitigation and adaptations. Strategies may include multiple aspects: collaboration policies (Lindseth, 2004), financial tools (Yarnal *et al.*, 2003), land use or urban design policies (Betsill, 2001), transportation policies (Andrews *et al.*, 2008), energy strategies (Andrews *et al.*, 2008; Nelson, 2008), waste strategies (California Air Resources Board *et al.*, 2008), resources management strategies (Mayors Climate Protection Center, 2007), hazard mitigation policies, and monitoring procedures. The final index of local planning directors' actions for climate change measures how well local planning directors have included climate change issues in their land use planning process.

2.2 Independent variables

We propose that geographic, political, institutional, social, and economic aspects may influence the local planning directors' actions for climate change. This study proposes an independent factor framework with four categories of variables to empirically examine factors influencing local planning directors' actions for climate change. Qi *et al.* (2008) developed a general behavioral model to identify the local motivation, power, capacity, incentive, constraints factors affecting local government actions on climate change. Tang *et al.* (2010) analyzed the capacity variables, climate risk variables, and emission stress variables to explain local climate change action plan quality. Brody *et al.* (2008a) identified the impacts of hazard risk variables and socioeconomic variables on local climate change decisions. In this study, we consider the following four category factors: climate risk variables, political will variables, institutional capacity variables, and socioeconomic context variables.

Climate risk variables. The extent of climate-related risks might influence the willingness of a locality to take actions on climate change. This study considers three climate risk variables: coastal distance, physical vulnerability, and historical hazard. Coastal distance is an important variable to measure the potential impacts of climate change in highly vulnerable coastal areas (Tang *et al.*, 2010). A dichotomous measure is used to indicate whether a jurisdiction is directly adjacent to a coastline. Physical vulnerability measures the vulnerable lands in a local jurisdiction to potential hazard events. Local jurisdictions with expected vulnerable lands are more likely to have climate change policies (Brody *et al.*, 2008a, b). In this study, we use the percentage of a locality's lands located in the 100-year floodplain to represent the extent of local physical vulnerability. Historical hazard damages, such as flooding and hurricanes, can provide motivation as well as the experience to mitigate climate-related hazards. Historical hazard damages are measured by the damage costs caused by the major natural hazard events in the past ten years in a local jurisdiction.

Political will variables. Examine the influence of local political authority and power for enacting climate change actions. Local land use planning may be subject to a number of complex political context (Mollenkopf, 2005; Logan and Molotch, 2007). Local engagement and commitment is the key to long-term progress and the economic societal transformations that will significantly reduce carbon emissions (Lutsey and Sperling, 2008). The political will variable includes environmental priorities, political commitment,

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interagency leadership, and external campaigns. Environmental priorities variable measured how well environmental issues have been considered in local planning arrangement. Local jurisdictions that place environmental challenges as a high priority may have more considerations for climate change actions. Political commitment measures the political support from upper administrative levels for planning agencies to address climate change mitigation and adaptations. The political commitment includes senior appointed and elected officials' support for emission reduction goals, promotion of emission reduction goals, and status of emission reduction activities within a jurisdiction. Interagency leadership measures whether local jurisdictions create a cross-agency climate change committee. Interagency work offers a leadership opportunity for local land use planners to tackle climate change actions with other local partners. External campaign measures if local jurisdictions actively receive the information from international or national campaigns, such as Intergovernmental Panel on Climate Change (IPCC), Cities for Climate Protection (CCP) Campaign, and US Conference of Mayors Climate Protection Agreement, United States Climate Action Partnership (USCAP), Climate Registry Information System (CRIS), and International Council for Local Environmental Initiatives (ICLEI).

Institutional capacity variables. Local land use planning is a complex process which can be affected by jurisdictional frameworks and planners' resources, skills, and experiences. In this study, institutional capacity is measured by internal support, personnel resources, technical abilities, cooperative abilities, and stakeholder involvement. Internal support measures which kinds of support the planning agency can receive to address climate change. It detects the degree of support from budget adequacy, technical expertise, access to senior appointed and elected officials, and enforcement authority. Personnel resources are associated with increased levels of personnel, financial resources, technical expertise, and commitment to developing high quality planning products. Technical abilities measure the degree to which a jurisdiction uses data sources. Cooperative abilities measures if individuals or agencies have been involved in a jurisdiction's land use planning process. Stakeholder involvement measures community groups involved in local land use planning. It detects how well a local planning agency can organize multiple stakeholders for climate change actions.

Socioeconomic context variables. Measure the influence of demographic information on local climate change actions. This study uses population, community wealth, and education to detect the influence of socioeconomic context. Population is measured by the number of people in a jurisdiction in 2007. Local jurisdictions with larger populations may have more expertise, resources and financial support for climate change actions, but may also face more environmental and economic pressure from increased greenhouse gas emissions. Community wealth is measured by the medium house value in a jurisdiction in 2000. A wealthy community may have more money, higher awareness, and more interest in climate change. Education is measured by the percentage of people with bachelor or higher degree in 2000. A jurisdiction with higher education level may have a higher perception of the need for environmental protection and more enthusiasm for participating in environmental management activities.

3. Research design

3.1 Data collection

A mail questionnaire was sent to planning directors in 214 US counties. County-level land use planning deal with undeveloped lands and natural lands;

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however, county-level planning is facing with considerable development pressure and unavoidable conflicting interests about the usage of the undeveloped lands. Thus, it has critical obligations and opportunities to decide low-carbon urban growth patterns and protect sensitive natural resources. The survey was approved by the University of Nebraska-Lincoln's Institutional Review Board (IRB#2009019604EX) in January 2009. Three rounds of requests were sent to the planning directors from March 2009 to May 2009. We mailed two reminders after the first-round of survey forms were sent. The survey population consists of 214 planning department directors in county governments. We initially designed the survey for three sub-groups, including:

(1) all California counties;

(2) all coastal counties in the Pacific Coast; and

(3) the top 100 fastest growing counties in the USA.

However, we only received 53 completed survey forms by May 2009 and we therefore grouped the survey as one pool (see the map in Figure 2). The overall effective survey response rate is 24.76 percent from the survey population of 214 counties (Table I). The total effective samples in this paper are 53 counties. These 53 counties were collected from among the California state, Pacific states, and top 100 fast growth counties. The survey probed a wide array of planning directors' attitudes and policies on climate change and land use policies. The questionnaire included 26 questions and required approximately 30 minutes to complete.

3.2 Variable measurement

The measurement and data sources of independent variables are illustrated in Table II. The dependent variable is measured by the total scores (at a range of 0-100 percent). This study also introduces indicator performance to measure the quality of indicators in the questionnaire survey form. Indicator performance includes two sub-items: indicator

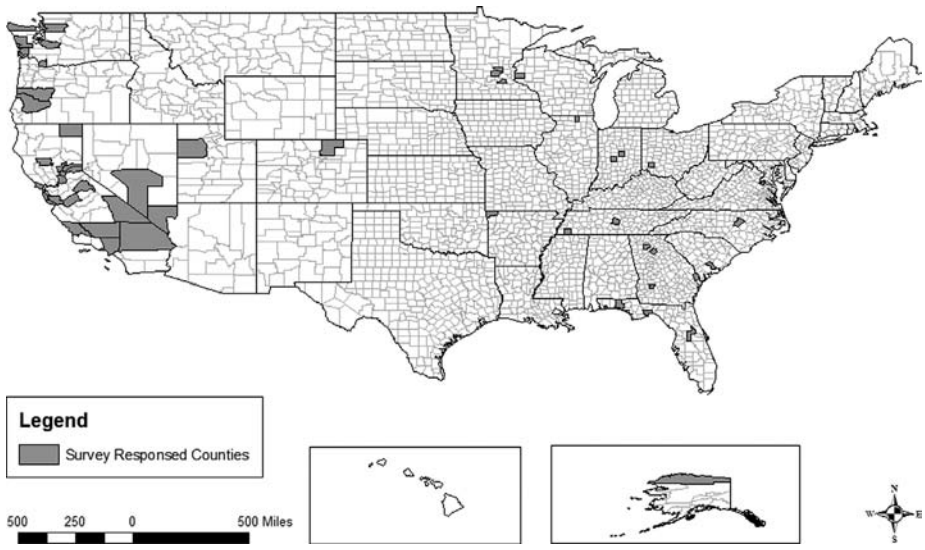

Figure 2.
Survey responded counties

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Place	Responded counties	Total counties	Response rate (%)
California state	17	58	29.31
Pacific states	27	133	20.30
Top 100 fast growth counties	26	100	26.00
Top 100 fast growth counties (not in Washington, Oregon, California states)	26	96	27.08
Effective samples in this paper (non-overlapping)	53	214	24.76

Note: The total effective samples in this paper are 53 counties; these 53 counties were collected from among the California state, Pacific states, and top 100 fast growth counties

Table I.
The response rate among the different places

breadth score and depth score. Indicator breadth measures the extent to which each of the indicators was addressed across all jurisdictions. Indicator depth measures the level of importance in a jurisdiction.

3.3 Data analysis

We analyzed the data in three related phases. First, we used descriptive statistics to report the dependent variable – local planning directors' actions for climate change. Second, we computed the bivariate correlation between local planning directors' actions for climate change actions and all independent variables. This step allowed us to examine the effect of a wide range of independent variables on the dependent variable. Third, we analyzed these variables in a multiple regression equation to test their overall effects. Based on the measurement of our dependent variable and independent variables, this study uses linear regression model to detect the critical factors influencing local planning directors' actions for climate change. It enabled us to more effectively isolate the statistical effect of the most powerful predictors.

Before we run the regression models, we further tested the basic assumptions and related statistical issues. This study used Ramsey regression specification error test (RESET) to detect the misspecification problem in the regression model. The RESET results showed no violation of model misspecification in this study. This study also used the variance inflation factor to detect a regression model's multicollinearity problem. The testing results exhibited no significant violation of ordinary least squares regression assumptions. We also tested the inter-item scale reliability for the variables, the minimal Cronbach's α of tested components reaches to 0.826 which is above the level of general acceptance.

4. Results

4.1 Descriptive statistics for the mean score

The descriptive statistics for each component and total score are listed in Table III. The mean of the total score for local planning directors' actions for climate change is 55.44 percent at a range of 0-100 percent. Of the three components, awareness received the highest score ($M = 79.87$ percent at a range of 0-100 percent), indicating jurisdictions have a relatively high awareness of climate change. Implementation strategies received the second highest score ($M = 51.51$ percent at a range of 0-100 percent) of the three plan components, indicating policies, tools, and strategies

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Variables	Measurement	Scale	Data sources	Mean	SD
Coastal distance	A jurisdiction receives a score of 1 if a jurisdiction is directly connecting to coastal lines and a score of 0 if it is not	Dichotomous (1 or 0)	GIS layers	0.38	0.49
Physical vulnerability	Approximately what percent of your jurisdiction's 100-year floodplains is located in each of the following types of areas? It measured by percentage of 1-100	Interval (range: 0-100%)	Survey	22.36	17.67
Historical hazards	In the past 10 years, how much damage has your community experienced from natural hazards. It measured by a scale of 0-5 for each of the four listed items	Interval (range: 1-16)	Survey	7.06	1.77
Environmental priorities	To what extent are each of the following issues considered to be high priorities in your jurisdiction? It is measured by a scale of 1-4	Interval (range: 1-4)	Survey	3.70	1.10
Political commitment	How would you rate the commitment to address climate change mitigation and adaptations? It measured by a scale of 1-5 for three listed items	Interval (range: 1-15)	Survey	7.02	3.66
Interagency leadership	Does your jurisdiction have an interagency committee to address climate change management issues?	Dichotomous (1 or 0)	Survey	0.21	0.41
External campaign	Please rate the degree to which your jurisdiction has used each of the following resources for climate change mitigation and adaptations. It measured by a scale of 1-5 for six listed items	Interval (range: 1-30)	Survey	8.89	4.50

Table II.
Independent variable measurement

(*continued*)

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Variables	Measurement	Scale	Data sources	Mean	SD
Internal support	How would you rate the support of your planning agency to address climate change mitigation and adaptations? It measured by a scale of 1-5 for four listed items	Interval (range: 1-20)	Survey	9.51	3.32
Personnel resources	How many full-time equivalent persons in your department?	Interval	Survey	27.75	37.94
Technical abilities	Please rate the degree to which your jurisdiction uses each of the following data sources in map or digital form for land use planning. It measured by a scale of 1-5 for 15 items	Interval (range: 1-75)	Survey	54.92	7.88
Cooperative abilities	To what extent have the following individuals or agencies been involved in your jurisdiction's land use planning? It measured by a scale of 1-5 for 17 items	Interval (range: 1-85)	Survey	50.17	12.22
Stakeholder involvement	How are each of the following community groups involved in your jurisdiction's land use planning? It measured by a scale of 1-5 for 12 listed items	Interval (range: 1-60)	Survey	40.96	10.85
Population	Population in a jurisdiction in 2007	Interval	US census	498,921	1,392,745
Wealth	Median house value in 2000	Interval	US census	63,554	17,210
Education	People with bachelor or higher degrees in 2000	Interval (range: 1-100%)	US census	24.94	10.37

Table II.

have been partially considered to mitigate and adapt the impact of climate change. The medium level of mean score in implementation strategies indicates that there is still much room to improve local land use planning actions in climate change mitigation and adaptation. However, the analysis ($M = 34.94$ percent at a range of 0-100 percent) indicated a very low level of actions, indicating planning directors are not acting on their awareness of and strategies for acting on climate change.

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4.2 Indicator performance

The indicator performance scores are listed in Table IV. The results show that most indicators received extremely high breadth scores, signifying most jurisdictions have covered the indicators listed in this survey. Only a few jurisdictions did not consider all of the indicators listed in this survey. Because the indicator breath scores do not provide many variations, it is useful to illustrate the depth score to find the insights of the indicators. The following result sections only discuss the indicator depth scores to answer how well those jurisdictions have considered them.

4.2.1 Awareness. For the question "To what extent have you been aware of climate change?", the results show that local planning directors in this survey have relatively high awareness for climate change issues. Local planning directors recognize the fundamental concepts of climate change or global warming (84.15 percent), and the concept of greenhouse gas emissions (80.75 percent). The effect of stratospheric ozone depletion has raised concerns about climate change (Hartmann *et al.*, 2000). Local planning directors received a 74.72 percent cumulative score in their understanding of ozone layer depletion.

4.2.2 Analysis scopes. The indicators in the analysis component received low scores. For the question "To what extent have you analyzed the impacts of climate change for your jurisdictions?", the results identified that local planning directors weakly (43.02 percent) analyze the possible impacts of climate change in their jurisdictions. This indicates the depth of analysis for climate change impacts at the local level is low. Additionally, climate change vulnerability assessment was limited (36.23 percent). Fewer (36.60 percent) jurisdictions have conducted a scientific estimate for current year emissions or forecast future emissions. For the question "To what extent have you set strategic targets for climate change in your jurisdictions?", few planning directors have set long-term emission reduction targets (33.21 percent), and rarely set specified targets for each professional departments (25.66 percent).

4.2.3 Implementation strategies. The scores in the policy component were varied. Some strategies are used by only a few jurisdictions including carbon reduction fees (20.75 percent) while other implementation strategies are quite popular such as retaining habitat areas and wildlife corridors (75.09 percent). In general, environmental policies are often used (48.68-78.11 percent), while financial strategies receive minimal attention (20.75-59.62 percent).

Considering the question "To what extent have you established coordination procedures for climate change in your jurisdictions?", local planning directors do not have strong coordination procedures within the jurisdictional boundaries. The results

Components	Number of jurisdictions	Number of variables	Min.	Max.	Mean	SD
Awareness[a]	53	3	20.00	100.00	79.87	21.50
Analysis scope[a]	53	5	12.00	76.00	34.94	17.11
Implementation strategy[a]	53	56	23.21	80.36	51.51	13.94
Total[b]	53	64	29.10	82.79	55.44	13.77

Note: Significant at: [a]each component possible maximal score is 100 percent and [b]each plan's total possible maximal score is 100 percent

Table III.
Descriptive statistics for total score and components performance

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Components	Questions	Indicators	Breadth (%)	Depth (%)
Awareness	Q1. To what extent have you been aware of climate change?	1a. Concept of climate change or global warming	100.00	84.15
		1b. Concept of greenhouse gas emission	98.10	80.75
		1c. Concept of ozone layer depletion	96.20	74.72
Analysis scope	Q2. To what extent have you analyzed the impacts of climate change for your jurisdictions?	2a. Potential impacts of climate change	98.10	43.02
		2b. Climate change vulnerability assessment	98.10	36.23
		2c. Current year emission estimates and future emission forecasts	98.10	36.60
	Q3. To what extent have you set strategic targets for climate change in your jurisdictions?	3a. Long-term emission reduction targets	100.00	33.21
		3b. Specified targets for each professional department	100.00	25.66
Implementation strategies	Q4. To what extent have you established coordination procedures for climate change in your jurisdictions?	4a. Public education and participation procedures	100.00	34.34
		4b. Inter-organizational coordination procedures	100.00	35.85
		4c. Local agreement procedures	100.00	27.92
		4d. Stakeholder coordination and environmental stewardship	100.00	37.36
	Q5. To what extent are each of the following issues considered to be used for climate change mitigation and adaptations in your jurisdiction?	5a. Business development	94.30	40.75
		5b. Land development	94.30	53.21
		5c. Housing	94.30	45.28
		5d. Infrastructure	94.30	44.53
		5e. Environmental protection	94.30	49.81
		5f. Hazard mitigation	94.30	40.38
		5g. Transportation	94.30	51.32
		5h. Recreation	94.30	35.09
		5i. Energy	92.50	44.91
		5j. Agriculture	94.30	41.89
		5k. Water use	84.90	39.25
		5m. Waste management	92.50	43.02
		5n. Urban design	94.30	42.26
		5o. Revenue and taxation	94.30	32.45
	Q6. To what extent have you used the following land use policies in your jurisdiction's land use planning?	6a. Jobs housing balance development	98.10	54.34
		6b. Land supply inventory	100.00	69.06
		6c. Density bonus or bonus zoning	100.00	57.74
		6d. Transit-oriented development	100.00	49.43
		6e. Neighborhood enhancement	100.00	58.11

(*continued*)

Table IV.
Indicator performances

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Components	Questions	Indicators	Breadth (%)	Depth (%)
		6f. Mixed use	100.00	70.94
		6g. Infill/compact development	98.10	61.89
		6h. Growth control	100.00	61.89
	Q7. To what extent have you used the following urban design policies in your jurisdiction's land use planning?	7a. Leadership in Energy and Environmental Design (LEED) standards	100.00	41.51
		7b. Disaster-resistant building codes	98.10	55.09
		7c. Green building and green infrastructure	100.00	45.66
		7d. Low-impact surface design and permeable surface	100.00	50.94
		7e. Livable/walkable/healthy communities	100.00	55.85
		7f. Urban heat island effect reduction	100.00	30.19
	Q8. To what extent have you used the following transportation policies in your jurisdiction's land use planning?	8a. Alternative transportation and multimodal access	100.00	56.98
		8b. Parking sharing and adjusted standards	100.00	52.08
		8c. Clean energy vehicles/ transit system	100.00	43.77
	Q9. To what extent have you used the following energy policies in your jurisdiction's land use planning?	9a. Renewable energy and solar energy	100.00	47.92
		9b. Energy efficiency and energy stars	100.00	47.55
		9c. Energy conservation programs	100.00	48.68
	Q10. To what extent have you used the following environmental resources policies in your jurisdiction's land use planning?	10a. Creation of conservation zones	100.00	73.58
		10b. Retain habitat areas and wildlife corridors	100.00	75.09
		10c. Waste recycling and conservation programs	100.00	48.68
		10d. Watershed-based and ecosystem-based land management	100.00	64.53
		10e. Vegetation (forest/ woodlands) protection	100.00	67.92
		10f. Air quality standards and emission reduction	100.00	55.09
		10g. Storm water management	100.00	78.11
		10h. Water conservation land use and landscapes	100.00	58.49
	Q11. To what extent have you used the following hazard mitigation policies in your jurisdiction's land use planning?	11a. Site assessment standards	100.00	70.94
		11b. Hazard sensitive areas protection	100.00	69.81
		11c. Hazards planning	100.00	67.55

(*continued*)

Table IV.

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Components	Questions	Indicators	Breadth (%)	Depth (%)
	Q12. To what extent have you used the following financial policies in your jurisdiction's land use planning?	12a. Carbon reduction fee	100.00	20.75
		12b. Carbon tax	100.00	20.75
		12c. New development impact fees	100.00	59.62
	Q13. To what extent have you used the following implementation and monitoring procedures in your jurisdiction's land use planning?	13a. Establish growth location priorities	98.10	65.28
		13b. Identify plan amendment procedures	98.10	69.06
		13c. Identify roles and responsibilities among sectors and stakeholders	98.10	60.75
		13d. Identify continuously monitor, evaluate and update	98.10	59.25

Table IV.

show that the coordination procedures for public education and participation are still very weak (34.34 percent). At the same time, local jurisdictions lack effective procedures to coordinate inter-organizational issues relating to climate change (35.85 percent), local agreements across city and county jurisdictions (27.92 percent), and stakeholder involvement and environmental stewardship for climate change issues (37.36 percent).

For the question "To what extent are each of the following issues considered to be used for climate change mitigation and adaptations in your jurisdiction?", results indicate low to medium levels of integrating climate change mitigation and adaptations into planning topics: business development (40.75 percent), land development (53.21 percent), housing (45.28 percent), infrastructure (44.53 percent), environmental protection (49.81 percent), hazard mitigation (40.38 percent), transportation (51.32 percent), recreation (35.09 percent), energy (44.91 percent), agriculture (41.89 percent), water use (39.25 percent), waste management (43.02 percent), urban design (42.26 percent), and revenue and taxation (32.45 percent).

For the question "To what extent have you used the following land use policies in your jurisdiction's land use planning?", land use policies have been used at the medium level to address climate change. Local jurisdictions have begun to consider major land use policies that help reduce greenhouse gas emissions, such as job-housing development (54.34 percent), land supply inventory (69.06 percent), density bonus or bonus zoning (57.74 percent), transit-oriented development (49.43 percent), neighborhood enhancement (58.11 percent), infill and compact development (70.94 percent), and growth control (61.89 percent).

For the question "To what extent have you used the following urban design policies in your jurisdiction's land use planning?", local planning directors have relatively low to medium levels of adoption for urban design policies that address climate change such as LEED standards (41.51 percent), disaster-resistant building codes (55.09 percent), green building and green infrastructure (45.66 percent), low-impact surface design and permeable surface (50.94 percent), livable/walkable/healthy communities (55.85 percent), and urban heat island effect reduction (30.19 percent).

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For the question "To what extent have you used the following transportation policies in your jurisdiction's land use planning?", local planning directors have medium levels of adoption for transportation policies that address climate change including alternative transportation and multimodal access policy (56.98 percent), parking sharing and adjusted standards (52.08 percent), and clean energy vehicles and transit system (43.77 percent).

For the question "To what extent have you used the following energy policies in your jurisdiction's land use planning?", local planning directors have medium levels of adoptions in including renewable energy and solar energy (47.92 percent), energy efficiency and energy stars (47.55 percent), and energy conservation programs (48.68 percent).

For the question "To what extent have you used the following environmental policies in your jurisdiction's land use planning?", local planning directors have medium to high levels of adoption for environmental resources to address climate change including; creation of conservation zones (73.58 percent), retain habitat areas and wildlife corridors (75.09 percent), waste recycling and conservation programs (48.68 percent), watershed- and ecosystem-based land management (64.53 percent), vegetation protection (67.92 percent), air quality standards and emission reduction (55.09 percent), storm water management (78.11 percent), and water conservation land use (58.49 percent).

For the question "To what extent have you used the following hazard mitigation policies in your jurisdiction's land use planning?", local planning directors in general have medium-high level of adoptions in hazard mitigation policies to address climate change: site assessment standards (70.94 percent), hazard sensitive areas protection (69.81 percent), and hazards planning (67.55 percent).

For the question "To what extent have you used the following financial policies in your jurisdiction's land use planning?", carbon reduction fees (20.75 percent) and carbon tax (20.75 percent) policies receive very low level of attention. However, the policy for adopting new development impact fees (59.62 percent) received medium level of attention.

For the question "To what extent have you used the following implementation and monitoring procedures in your jurisdiction's land use planning?", the implementation and monitoring procedures are received the medium or medium-high level of attention in establishment of growth location priorities (65.28 percent), identification of plan amendment procedures (69.06 percent), identification of roles and responsibilities among sectors and stakeholders (60.75 percent), and identification of continuously monitor, evaluation and updating procedures (59.25 percent).

4.3 Correlation results

The Pearson's product-moment correlation coefficients indicate the degree of association among variables. The correlation matrix in Table V shows independent variables which are significantly correlated with the dependent variable – local planning directors' actions for climate change were $p < 0.05$. According to the correlation coefficients, this study ranks the correlation relationships between each variable and the local planning directors' actions for climate change as follows: political commitment ($r = 0.699^{**}$) > interagency leadership ($r = 0.391^{*}$) > personnel resources ($r = 0.342^{*}$) > external campaign ($r = 0.312^{*}$) > technical abilities ($r = 0.272^{*}$). This rank indicates the some variables are more correlated with the local planning directors' actions for climate change than others.

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.775 **	1																
3	0.843 **	0.408 **	1															
4	0.735 **	0.254	0.642 **	1														
5	0.242	−0.06	0.489 **	0.203	1													
6	−0.000	0.143	−0.090	−0.12	0.062 **	1												
7	0.005	−0.25	0.238	0.108	0.619 **	0.125	1											
8	0.328 *	0.069 **	0.370 **	0.413 **	0.287 *	0.032	0.019	1										
9	0.699 **	0.390 **	0.729 **	0.576 **	0.329 **	0.039	0.199	0.312 *	1									
10	0.391 **	0.221	0.515 **	0.186 **	0.369 **	0.037	0.063 **	0.014	0.383 **	1								
11	0.312 *	0.033	0.394 **	0.390 **	0.281 *	0.063	0.435 **	−0.06	0.255 **	0.222	1							
12	0.298 *	0.254	0.184	0.264 *	0.010 **	−0.047	−0.12	0.011	0.384 **	0.232 **	0.127	1						
13	0.342 *	0.101	0.453 **	0.304 *	0.370 **	−0.146	0.159	−0.1	0.363 **	0.537 **	0.513 **	0.202	1					
14	0.272 *	0.113	0.129	0.474 **	0.087	−0.037	0.043	0.256	0.177	0.047	0.152	0.169	0.109	1				
15	0.177	0.03	0.055	0.411 **	−0.04	0.016 **	0.057	0.252	0.076	−0.26	0.096	0.017	−0.14	0.592 **	1			
16	0.117	0.073	0.008	0.223	−0.02	−0.373 **	−0.03	−0.11	0.029	−0.18 *	−0.06	−0.06	0.042 **	0.21	0.390 **	1		
17	0.207	0.112	0.196	0.199	0.187	−0.067	0.129	−0.295 *	0.244	0.326 *	0.362 **	0.095	0.622 **	0.035	−0.1	0.008	1	
18	0.132	−0.01	0.213	0.146	0.114	−0.275 *	−0.100	0.288 *	0.165	0.132	−0.03	0.193	0.189	0.223	−0.15	−0.16	0.02	1
19	0.171	−0.03	0.264	0.23	0.153	−0.375 **	−0.02	0.218	0.205	0.155	−0.03	0.142	0.223	0.267	−0.15	−0.05	0.11	0.884 **

Notes: Significant at: * $p < 0.05$ level (two-tailed) and ** $p < 0.01$ level (two-tailed); 1 – planning action index; 2 – awareness score; 3 – analysis scope score; 4 – implementation strategy score; 5 – coastal distance; 6 – physical vulnerability; 7 – historical hazards; 8 – environmental priorities; 9 – political commitment; 10 – interagency leadership; 11 – external campaign; 12 – institutional support; 13 – personnel resources; 14 – technical abilities; 15 – cooperative abilities; 16 – stakeholder involvement; 17 – population; 18 – wealth; 19 – education

Table V.
Correlations matrix

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In these four categories of variables, political will variables and institutional capacity variables were significantly correlated with local planning directors' actions for climate change. Five variables, including local political commitment, interagency leadership, planning personnel resources, external campaign, and technical abilities, are significantly correlated with local planning directors' actions for climate change.

4.4 Regression results for independent variables

The correlation results quantify the degree to which two variables are statistically related, however, correlation is not enough to examine the factors influencing the local planning action index. Regression models are used to determine which variables are statistically significant at the 0.05 and 0.01 levels. The regression results in Table VI highlight the relationship of the four sets of independent variables with local planning directors' actions for climate change.

Climate risk variables. In regard to climate risk variables, the significance of this model is not significant ($p = 0.188$), indicating that the climate risk variables do not result in higher local planning directors' actions for climate change.

Political will variables. In these four political will variables, political commitment has very significant ($p = 0.000^{**}$) impact on local planning directors' actions for climate change. Other three variables have a certain influence on local planning directors' actions for climate change.

Institutional capacity variables. The results of the regression analysis for institutional capacity variables suggest that planning personnel resources make a statistically significant contribution to local planning directors' actions for climate change. The planning personnel resources have a statistically ($p = 0.031^{*}$) positive impact on local planning directors' actions for climate change. High numbers of planners can bring more human resources, expertise and personnel to devote to climate change campaigns.

Socioeconomic context variables. The regression results of this study show that none of socioeconomic context variables indicate significance with local planning action index to climate change.

5. Discussions

The descriptive findings indicate that local planning directors have partially, but not fully, taken actions to address the threats of climate change. More specifically, those planning directors responded to this survey have a relatively high level of awareness for climate change. Climate change has become an accepted concept for the planning directors who have responded to this survey. The finding also tells that local planning directors responded to this survey have inadequate ability to analyze emission sources, potential impacts and risks. The finding indicates that a gap may exist between the scientific arena and policy decision makers to understand the climate change models, information, sources, impacts, and risks. The findings from the 53 responded planning directors indicate that local planning agencies have adopted some policies to mitigate or adapt climate change; however, many strategies are stayed a relatively low or medium level. For example, many of planning policies were only suggested by those planning directors, but they were not mandated yet. It is a time for planners to re-evaluate the existing planning toolbox to develop more effective strategies to mitigate or adapt climate change at local levels. It is interesting that local jurisdictions

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Categories	Variables	Coefficients	SE	Stand. Coeff.	t	Sig.
Climate risk	Coastal distance	10.881	4.880	0.386	2.230	0.030 *
	Physical vulnerability	0.003	0.107	0.003	0.025	0.980
	Historical hazards	− 1.824	1.358	− 0.234	− 1.343	0.185
	$n = 53$; F-ratio (3, 49) = 1.658; significance = 0.188; adjusted $R^2 = 0.037$					
Political will	Environmental priorities	2.029	1.304	0.162	1.556	0.126
	Political commitment	2.095	0.432	0.556	4.845	0.000 **
	Interagency leadership	4.819	3.603	0.143	1.338	0.187
	External campaign	0.455	0.314	0.149	1.449	0.154
	$n = 53$; F-ratio (4, 48) = 14.332; significance = 0.000 **; adjusted $R^2 = 0.506$					
Institutional capacity	Institutional support	0.901	0.552	0.217	1.631	0.110
	Personnel resources	0.110	0.050	0.303	2.219	0.031 *
	Technical abilities	0.204	0.290	0.117	0.702	0.486
	Cooperative abilities	0.148	0.199	0.131	0.745	0.460
	Stakeholder involvement	0.052	0.179	0.041	0.290	0.773
	$n = 53$; F-ratio (5, 47) = 2.777; significance = 0.028 *; adjusted $R^2 = 0.146$					
Socioeconomic context	Population	1.857E-06	0.000	0.188	1.332	0.189
	Wealth	− 2.185E-05	0.000	− 0.023	− 0.078	0.938
	Education	0.226	0.400	0.170	0.566	0.574
	$n = 53$; F-ratio (3, 49) = 1.133; significance = 0.345; adjusted $R^2 = 0.008$					

Note: Significant at: *0.05 and **0.01 levels

Table VI.
Regression results

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have included climate change as a long-term value in their local land use planning processes. At the same time, local planning directors have used their power and authority to develop planning strategies that help mitigate or adapt to climate change.

Based on the descriptive results, we propose the following recommendations for the planning process. First, planners need to promote climate change knowledge-sharing. Local planning directors are highly aware of climate change, but they have inadequate understanding of the uncertainty, impacts, mitigation, and adaptations for climate change. At the same time, many local decision makers are unaware of, or unconcerned about, climate change. Since climate change is still a relatively new topic for many local decision makers, time may be needed to stimulate local jurisdictions to actively participate in the process. It is helpful to identify institutional partners at local, regional, national, and international levels and promote knowledge-sharing among them. The information linkage provides guidelines for decision makers working on the larger scale on information sharing and technical support. It is important to increase decision makers' awareness of future impacts of climate change and help them understand how actions for climate change can be integrated into their planning.

Second, new methods should be developed to evaluate the impacts of climate change on local jurisdictions. Scenarios based on low-carbon emissions should also be included in possible future scenarios. Lack of accurate assessment for possible impacts of climate change causes local planners to underestimate the risk of climate change and overconfidently believe that their development patterns are tightly linking to low-carbon development patterns. It is important to forecast future emissions to help planners understand how actions for climate change can be integrated into planning. It is time to re-evaluate socioeconomic scenarios currently utilized in the local planning processes (Bizikova *et al.*, 2007). The new scenarios should direct the development trajectory toward long-term sustainable low-carbon development policies. The lack of effective evaluation methods and appropriate scenarios is not surprising given such obstacles as uncertainty of climate change impacts, misunderstanding of information, minimal public interest in carbon reduction, inadequate technical support, and the difficulty of operating programs in an intergovernmental collaboration setting.

Our third recommendation is to develop a more comprehensive toolbox to incorporate climate change into the local planning context. The findings of this study are consistent with previous literature (American Planning Association, 2008) demonstrating that local planners have already contributed to greenhouse gas mitigation by some established planning policies, such as growth boundary control and compact development policy. Though there are examples of incorporating carbon reduction into local land use practices, overall the level of local response to climate change has been limited. Our research found that planning directors have recognized with a high level of breadth scores for the surveyed items, but they have various levels of climate change actions with varied depth scores. Local planners tend to develop policies to address more immediate community-based issues rather than long-term mitigation or adaptations (Lindell and Whitney, 1995). The findings of this study are consistent with previous research showing climate change policies have been weakly considered in current land use planning (Tang *et al.*, 2009). In many jurisdictions, climate change action plans are prepared by environmental agencies or consulting companies and are not tied to local land use plans. Local planners have opportunities to develop more incentive tools, such as local taxations,

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infrastructure investments, waste management, transportation planning, and capital improvement planning, to mitigate and adapt local development patterns.

The regression indicates political commitment is the most powerful predictor of local planning directors' actions for climate change. In addition, personnel resources have shown significant influence on actions. The regression model results indicate that local land use planning responses to climate change is still a complex decision process which includes internal and external factors. We find that a core issue related to political commitment is the linkage of short-term local goals with long-term strategic values at a broader scale. It is extremely important to connect the long-term values that motivate people to climate change action with immediate local-focused political commitment. Both planning directors and elected officials need to understand the multiple received values (e.g. social benefits, economic benefits, and environmental benefits) from climate change actions at local levels. We also found that planners' powers and authority are important foundations to initiate creative solutions for climate change. In fact, moving from agenda to actions for local climate change mitigation or adaptations is complex process (Tang *et al.*, 2010). It may be subject to many economic, social, environmental, institutional factors.

Changes in local policy can also have an impact on local jurisdictions dealing effectively with climate change. Local planning agencies need to actively seek political understanding and support for climate change actions. It is crucial for local land use planners to seek support from elected officials to establish long- or short-term goals for emission reduction, promotion of emission reduction strategies, and review of the status of emission reduction activities. An effective strategy to get more political commitment from the local elected officials is to "think locally, act locally". Local political decision makers tend to take more responsibilities for local-related issues (e.g. water quality, air quality) rather than cross-boundary issues (Betsill, 2000). A more effective approach is to localize global climate change as a part of local campaigns. Much research (Qi *et al.*, 2008; Tang *et al.*, 2010) has found that top-down directives exert pressure on localities to enact strong measures to address the climate change problem while climate change is still relatively novel in the local governmental consciousness. Climate change is often considered a global, national or regional problem outside the domain for local communities; however, this study further confirms that local political commitment provides the essential motivation for localities to address climate change issues. Second, planners are critical to improving local actions for climate change. Climate change is a complex, long-term, interdisciplinary problem which requires more knowledge, coordination and communication, and policy implementation and monitoring.

We also recommend that climate change issues be integrated into higher education for the next generation of planners as well as continuous education for practicing planners. Because many past textbooks and education curriculum may not cover the concepts of climate change, continuous training is an effective approach to update planners' awareness, skills, and motivations to actively participate in climate change actions.

In summary, this study makes critical contributions to rational planning theory (Verma, 1996) by identifying if local land use planning leaders are aware of climate change and participate in mitigation and adaptations. The survey provides the first-hand information from local planning directors to understand how local policy makers can think about long-term global challenge of climate change. The findings add to theory of rational planning by integrating local initiatives into global climate

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change issues. The research helps planners to recognize the value and power of local planners in climate change. The results can help improve local planning capacity for climate change.

6. Conclusions and future studies

This study concluded that the directors responded to this survey had a relatively high level of awareness for climate change; but they had limited analysis scopes to assess the sources, impacts, and risk of climate change in their jurisdictions. These directors had partially but not fully developed local land use planning implementation strategies to mitigate or adapt climate change. This study also concluded that the political commitment and planning personnel resources have significant influence on local planning directors' actions for climate change.

There are some limitations in this research. The relatively lower response rate of 24.76 percent may have some bias for the findings. It is possible that a large number of directors do not believe in it and as a result did not respond to the survey. Even for those responders, we may assume those were taking climate change actions would be more actively to respond for our survey. In addition, in our total 53 responded counties, we have 17 California counties and 27 Pacific counties. Those states may generally have more active role in climate change policies. The results may overstate the average level of local climate change actions (awareness, analysis, and implementation strategies) in the USA. Thus, we should be careful to apply the findings from this survey research to other places. A relatively small sample size may lack enough statistical power to extend the conclusions to other jurisdictions which are outside of our surveyed counties. While this study's results want to be extended to other places, geographical variations, socioeconomic characteristics, and policy framework can be external validity threats. The future study can conduct a follow-up survey those non-responded counties to identify why they were not response to the previous survey. Furthermore, some detailed case studies will also help understand the variations of local climate change actions among different jurisdictions. Self-reported method in this study may over-report the engagement of local land use planners in the use of these strategies to address climate change. In the future study, an additional survey with more detailed question, such as flood zone remapping, collaboration with universities for climate change, will help us deeply understand the actual progress of local climate change actions. Furthermore, in our independent variables, we only detected a limited number of the variables. Our future work will further detect the influence of political proclivities (democrats, republican) or the state mandates on local climate change actions.

Notes

1. "Local" is defined at the city and county jurisdictional level in this study.
2. "Action" is defined as climate change mitigation and adaptations.

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