EVALUATION AND CASE STUDY OF FLOOD ADAPTATION TOOLS IN LOCAL CLIMATE ACTION PLANS OF US CITIES

By
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To my family and friends

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EVALUATION AND CASE STUDY OF FLOOD ADAPTATION STRATEGIES IN LOCAL CLIMATE ACTION PLANS IN US

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Climate change is a pressing issue faced by the our generation. Climate change has brought a series of impacts on the urban environment. Among them flooding is one of the most common challenges. In order to mitigate and adapt to flooding, many cities adopted strategies in their Local Climate Action Plans(LCAPs) to address flooding. This research is aiming to analyze the appearance, categories and the influencing factors of the flooding adaptation tools in the LCAPs.

This research reviews a range of materials. The information extracted including the climate change, the modern cities' response to climate change, the climate action plan, and the flooding adaptation tools. This research engages a multiple case study with embedded analysis units method to evaluate the flooding adaptation tools in six LCAPs. They are the LCAP of King County, WA, Chicago, IL, Portland, OR, Miami, FL, New York City, NY, Los Angeles, CA. The research examines the content of the LCAPs systematically, then analysis the appearance and categories of the flooding adaptation tools in- depth. The research also analyzes the different conditions in selected cities(county). Examines the climate influencing factors and capacity influencing factors in different cites(county), in order to find out how the factors influencing the utilization of the tools.

The analyze and discussion about the collected data show that the appearance of flooding adaptation tools in the LCAPs is of high frequency. And there are a mainly three categories of them: 1)technology, 2)natural, law, 3)regulation and policy. The three kinds of tools usually appears together in

the LCAPs. The research also generate other important finding such as the linkage between the flooding adaptation and urban planning, the urban planner's position in the creation of LCAPs, etc.

CHAPTER 1

INTRODUCTION

Climate change and its implications has became a major threat to the safety and prosperity of modern cities in the 21st century. The rise of sea levels, flooding, drought, Urban Heat Island Effect, extreme weather and pestilence are possibly booming on the horizon for the modern cities. Of the aforementioned perils, flooding is the most common problem to be faced. This is because most of modern cities are constructed on floodplains and coastal areas. And manmade environments undermine the natural hydrological cycle in urban areas, which are prone to flooding problems before the climate change became a recognizable issue. However, climate change altered both precipitation amount and pattern, thereby making the problem even dangerous.

Coastal flooding, river flooding, urban flooding and flash flooding are all common phenomena. Sea level rise, hurricanes, tropical storms and high- intensity rain falls can cause flooding in cities. Many US cities have experienced flooding in recent years. Flooding can severely impair many systems and sectors in the urban areas. The transportation system, the infrastructure system and the housing sector are all vulnerable to flooding hazards. For example, the northeast has experienced significant flooding caused by the remnants of Tropical Storm Lee in September , 2011.

Recently, a considerable number of the U.S cities are seeking ways to mitigate and adapt to climate change on the local level by creating and implementing a series of actions. The extensive impact of climate change calls for an integrated response and the collaborate efforts of different sectors transcend the reduction of GHG emission . It is essential that an integrated framework be implemented for agencies, civic organizations, businesses and individuals to work

together so as to meet these new ecological challenges. As a beginning, many American cities have created Local Climate Action Plans(LCAPs).

LCAP is a comprehensive and integrated plan created under the auspices of city governments and through the collaboration of a range of agencies, NGOs and stakeholders. LCAP is based on the scientific GHG emission calculation within a city's boundary, and then sets the GHG emission reduction targets for the city. Most importantly, it creates practical mitigation and adaptation strategies for cities facing potential climate change. LCAP designs feasible, economical and operable action strategies to guide the future efforts toward a sustainable, climate resilient city. These strategies can cover the sectors including building and energy, urban form and mobility, consumption and solid waste, urban forestry and natural system, food and agriculture, etc. Guided by the LCAP, city governments and agencies can carry out policies and programs to mitigate GHG emission and prepare for the challenges of existing changes. LCAP also has co-benefits such as improved public health, creation of more jobs, enhanced social equity and foster a healthy natural system.

The relationship between LCAP and flooding is obvious. First, flooding hazard is one of the major effects triggered by climate change. It should be addressed in the LCAPs. Moreover, it can be a motivation for the creation of LCAPs. Second, resolving flooding issues requires the collaboration of different sectors and disciplines, and the LCAPs can provide a framework for such collaborate efforts. Third, adaptation strategies can at the same time reduce the GHG emission, so the LCAPs are willing to include flooding issues. In some cities which face flooding problems, their LCAPs often treat flooding as an important issue and creates adaptation tools to make cities more resilient to flooding. Different cities usually use different kinds of tools related to individual problems, including those pertaining to technology, natural, policy and law.

This thesis seeks to determine how local governments use different tools in LCAPs to make cities more resilient to flooding caused or exacerbated by climate change. By understanding this, we can better realize the formulation and application of flooding adaptation tools, and the outcomes of this study can foster and enhance the use of flooding adaptation tools in future LCAPs.

My research questions are: 1) How many times do flooding issues appear in a LCAP and in what sections do they appear; 2) What tools does LCAPs use to address flooding; 3) What are the characteristics of flooding adaptation tools; 4) How do the flooding adaptation tools vary due to different conditions in different cities.

Following the Introduction, this paper will progress in five chapters. The next chapter, Literature Review, involves the answers to a series of questions, including: 1) the definition, the observed effects, the causes, the trends and the impacts of climate change; 2) climate change's implications for modern cities, especially flooding' s implications; 3) modern cities' response to climate change. 4) importance, origins, content, establishing procedure, implementation, monitoring and assessment, the evaluation methods and responsibilities of Local Climate Action Plan(LCAP) 5) the tools that LCAP which are used to address flooding.

Following literature review, methodology outlines the research design of my study. This study employs a multiple- case study research with embedded units. The objective of the case study is to find out how cities with different conditions use flood adaptation tools in their LCAPs. There are three embedded analysis units in the case study research: 1) the appearance of flood adaptation tools in the LCAPs; 2) the characteristics of the flooding adaptation tools; 3) how the flooding adaptation tools vary because of the different conditions of the cities.

The Findings chapter includes detailed data collection of the cases studied. Results are then organized into charts, tables and narratives to provide a clear vision of the information.The Analysis and Discussion chapter discusses the findings of the case study and synthesizes the case study. It further describes the limitations of this study and the recommendations for future studies. The Conclusion chapter concludes this paper and advances recommendations for the enhancement of future LCAPs concerning flood adaptation tools.

CHAPTER 2

LITERATURE REVIEW

This chapter firstly explains what constitutes climate change and presents the causes and effects of climate change. Climate change is unequivocal and can impact human settlements in a variety of ways. Secondly, this chapter documents a set of impacts that climate change exerts on modern cities, especially inland cities, setting the stage for the necessity to mitigate and adapt for these coming changes. Finally, this chapter introduces the current responses modern inland cities have made toward this ecological challenge.

The Definition of Climate Change

Climate change refers to an alteration to the accustomed state of an environment, identified(e. g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change(UNFCCC),where climate change is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods(IPCC Report, 2007). The abnormal climate change in the past 100 years is due to GHG emission from human activities, including energy supply, transport, industry, residential and commercial buildings, forestry, deforestation and agriculture sectors.

The Observed Effects of Climate Change

The Intergovernmental Panel on Climate Change(IPCC)'s climate change assessment report(2007) states that the observed evidences of climate change include:

Increased Temperature

The temperature has a linear rising trend over the 50 years from 1956 to 2005, this trend is twice that for the 100 years from 1906 to 2005. The temperature rose by 0.74°C. Increased temperature was caused by the Green House Gas(GHG) emission and is itself the cause of many other negative effects, such as sea level rising, precipitation variation, etc.

Sea Level Rise

Global warming is accompanied by sea level rise. Global average sea level rose by 1.8mm per year over 1961 to 2003 and the figure is 3.1mm from 1993 to 2003(IPCC Report, 2007 p.30). Sea level rise are a significant threaten to the safety and prosperity of coastal cities. And, because it is to some extent irreversible, the adaptive approaches need to be taken to address it.

Decreased Snow And Ice Extent

Decreases in snow and ice extent are also observed consistent with global warming. Satellite data shows that annual average Arctic ice extent shrunk by 2.7% per decade. Mountain snow cover has decreased, too(IPCC Report, 2007 p.30). The decrease of snow ice extent threatens the biodiversity and it can cause sea level rise.

Precipitation Variation

Precipitation variation is observed at continental, regional and ocean basin scales. In eastern parts of North and South America, northern Europe and northern and central Asia, precipitation amounts have been increasing significantly from 1900 to 2005. However, in the

Sahel, the Mediterranean, southern Africa and parts of southern Asia, precipitation amounts have been on the decline(IPCC Report, 2007 p.30).

Extreme Weather

Some kinds of extreme weather events have changed in frequency and intensity during the last 50 years. Hot days and nights have become more frequent while cold days and nights have been less frequent in most land areas. Heat waves, the intensity and frequency of heavy precipitation events have increased. Tropical cyclone' s frequency increased in some regions(IPCC Report, 2007 p.30).

How Does Climate Change Impact Modern Cities?

Heat Waves

The urban heat-island effect(UHI) have exacerbated heat waves in cities. This trend comes from lowered evaporative cooling, increased heat storage and sensible heat flux caused by lowered vegetation cover, increased impervious cover and complex surfaces, and possibly from heat trapping by elevated levels of locally produced CO2. (CD, SB, & RC., 2001) Modern cities have a significant heat-island effect: about 5–11°C warmer than the surrounding rural areas.(Aniello, Morgan,& Busbey, 1995) Urban sprawl further exacerbates the UHI(Frumkin H, 2004) Heat waves can exert significant negative impacts on urban health. An example was the extended period of record high temperatures(Schar, Vidale, & Luthi, 2004) experienced in Europe in summer 2003.This caused excess mortality of more than 35,000 people within a 1-to 2-week period in early August.(Kosatsky T, 2005)

Flooding and Storms

Many of the largest and most populous cities are located along the coastal areas, and are threatened by sea-level rise, windstorms and waves. This makes coastal cities exposed to the

threat of flooding. The precipitation variations have brought more extreme rainfall events to the urban areas, which may exacerbate flooding. In addition, many cities border on rivers and lakes, which increase the risk of river and lake flooding. Moreover, the construction patterns of some cities lead to the degradation of natural hydrological systems(e.g., deforestation and building on floodplains). This can undermine flooding management, increase the flooding risk and increase the damage during these periods. Heavy rains then easily turn into flash flooding(Lendrum & Corvala´n, 2007) Flooding has a decidedly negative impact on urban environments. It can damage the roads, infrastructure and buildings, and disrupt the transportation and bring infectious disease. It can also damage crops and cause soil erosion, contaminate the water supply. Poorer populations are often situated in an unadvantageous condition during a flood. These problems can be addressed only by the mutual efforts of development decisions, social collaborations and adequate response plans.(Lendrum &Corvala´n, 2007)

Droughts

In urban areas, climate change related hazards include more frequent and severe droughts(Lendrum & Corvala´n, 2007). Climate change leads to precipitation variability. It can prolong the time period between wet seasons and decrease precipitation in some places, which can culminate into drought.

Infectious Diseases

Many infectious diseases(e.g., dengue) are waterborne and vector borne; these diseases have a strong connection with climate conditions. Climate change is therefore projected to cause such infectious increases(Lendrum & Corvala´n, 2007).

Air Pollution

According to Lendrum and Corvala´n(2007), many pollutants including ozone are affected by atmospheric conditions and tend to be higher on warmer days. Thus, there are significant air pollution risks associated with increasing temperatures. Air pollution can further undermine the public health in the urban areas.

What Are The Modern Cities' Responses To Climate Change?

Mitigation strategies

GHG emission inventory. The first step to reduce GHG emission for the city government is to create the GHG emission inventory to understand the scope, scale and source of the existing emissions(Chicago Green House Gas Emissions, 2008). The GHG emission inventory should include all direct and indirect GHG emissions, the composition of green house gases and the emission amount by different sectors including energy, transportation, waste and wastewater, industry process and products.

Set reduction goals. The second step for reducing GHG emission is to set reduction goals for the city. The goals should be reasonable and categorized into different levels; for example, short-term goals, long-term goals and intermediate goals. The reduction target should also include abstract targets and concrete targets as wedges(Chicago Green House Gas Emissions, 2008).

Creating mitigation strategies. After setting abstract and concrete goals for reducing the GHG emission, city governments should create strategies and actions to achieve their goals. Identification of potential strategies include a participatory process. This process should include architects, transportation officials, environmentalists, biking advocates, other professional organizations, community groups, the business community, and concerned citizens(Chicago

Green House Gas Emissions, 2008).Furthermore, there is no one solution, rather dozens of solution strategies to be implemented simultaneously. The set of strategies should be selected based on their feasibility, potential for CO2e reductions, and capacity for rapid implementation at the urban and regional level(Chicago Green House Gas Emissions, 2008).These strategies should also cover a range of sectors, including energy, transportation, commercial and residential buildings and industry sector.

Adaptation Strategies

Adaptation is any action or strategy that reduces vulnerability to the influence of climate change. Adaptation can be categorized into three classes: preparation, passive adaptation and active adaptation(Lowe, Foster, & Winkelman, 2009). The main goal of these strategies is to improve local resilience. In other words, safeguard that a community has the ability to bounce back quickly from climate impact(Lowe, Foster and Winkelman, 2009). For example, water conservation programs both save water for critical uses during drought(adaptation)while saving energy and reducing emissions related to pumping(mitigation) (Lowe, et al., 2009).

The GHG emissions already present in the atmosphere for more than a century of fossil fuel use will produce inevitable changes for local communities. Model-based projections indicate that by 2050 past accumulation of GHG in the atmosphere will lead to a global average temperature increase of 2°C relative to the pre-industrial climate regardless of current and future efforts to reduce these emissions. This temperature increase will lead to inalterable climate changes with associated environmental and societal aftershocks. With the changing climate, small towns and cities are faced with the risks of increased flooding, more severe weather events, loss of snowpack and water supply and increases in severe heat events, among other potentially devastating effects(Lowe, et al., 2009).

Consequently, it is essential to implement actions and strategies that will reduce the vulnerability of communities. This type of action or intervention is commonly referred to as adaptation, which is any action or strategy that reduces vulnerability to the impacts of climate change. Adaptation can be further defined by three classes of action: Preparation, Passive Adaptation and Active Adaptation(Lowe, et al., 2009).

Adaptation can be motivated by a diverse set of current and future climate hazards, including observed and expected changes in average climate, climate variability, and climate extremes(Chicago Area Climate Change Quick Guide, 2008). Some aspects of future climate change can be predicted with reasonably high confidence, and adaptation strategies should build on these observation and predictions. Adaptation can be either autonomous or purposefully planned. It can be either reactive or proactive/ anticipatory. The form of adaptation involves a broad range of measures, including technical, institutional, legal, educational, and behavioral measures. Research and data collection may also be considered as adaptation measures because they facilitate the implementation of effective actions for reducing climatic risks. Adaptation involves a wide range of people in many public and private organizations. Depending on the specific issue under consideration, adaptation to climate change may have close links with natural resource management, water management, disaster preparedness, urban planning, sustainable development, poverty reduction, etc. Take Chicago as an example, its adaptation strategies include: heat managing, pursuit of innovative cooling, air quality protection, storm water management, implementation of green urban design, preservation of plants and trees, engaging both the public and business spheres and an overall plan for the future.

Climate Action Plan

Definition

A CAP outlines institutional and policy structures including specific policy proposals or planning processes that a state will use to develop and implement for climate change mitigation and adaptation strategy. A CAP usually addresses issues including: 1) regional and local climate risks and vulnerabilities, 2) baseline GHG emissions, 3) goals and targets, 4) identification of mitigation actions, 5) forecast impacts of mitigation actions, 6) recommendations and strategy for implementation. ("Climate Change Action Plans," 2011)

Why is Climate Action Plan Necessary?

Climate change should be addressed at the regional and city scales for several reasons. First, 50 % of the world's population is now living in urban areas (Kennedy, 2009). High population density in urban area makes them vulnerable to climate change. Second, cities are responsible for the mitigation and adaptation of climate change because they are one of the major drivers of GHG emissions. Third, cities have resources such as knowledge, creativity, and funds to reduce the these emissions (Kennedy, 2009). Fourth, reducing GHG emission can also bring co- benefits to urban areas.

Moreover, given the background that climate change exerts significant influences on modern cities, and some of these are irreversible, they need to take the initiative to create comprehensive adaptation strategies to make themselves more resilient to these threats including sea level rising, urban heat island (UHI), storms, floods and droughts.

In addition, although climate change is an global issue, many actions can be taken at local level. For example, local governments can alter GHG emission patterns significantly through their influence on utilities, land use, building codes, transportation, taxation, environmental

programs, and other relevant policy areas. Climate Action Plan is needed because it can provide a framework for creating, guiding and implementing these actions("Developing an Action Plan," 2011).

The Origins of Local Climate Action Plan

The local CAPs are created through the technological assistance of the Local Governments for Sustainability, which was founded in 1990 as the International Council for Local Environment Initiatives (ICLEI). It has over 1220 local government members come from 70 different countries. ICLEI can provide technical consulting, training and information services to build capacity, share and support local government to implement sustainable developments at the local level("About ICLEI", n.d. , para. 1, 2 and 3).

After the establishment of ICLEI, the first initiative of local climate action was the Urban CO^2 Reduction Project, which was implemented in 14 cities across the US, Europe and Canada("ICLEI Climate Program", n.d., para. 1). In 1992, the Earth Summit held in Rio adopted the United Nations Framework Convention on Climate Change (UNFCCC). In 1993, the first Municipal Leaders Summit on Climate Change was held in New York, established the Cities for Climate Protection (CCP) Campaign. In the past 18 years, CCP has been viewed as the tool to initiate local mitigation and adaptation actions in both developed and developing countries, and provided input to cities and local governments. CCP designed a five step process frame for local governments. The first step is to measure local emissions of GHG, the second step is to set an emission reduction target, the third step is to plan actions on the government and community level to reach this target, the fourth step is to implement the LCAP, the fifth and final step is to monitor emission reductions. CCP also provides software tools for the accounting and monitoring of urban GHG emissions to participating governments("Mitigation", n.d., para. 2) for

participating cities. In addition, ICLEI added the topic of adaptation to its Strategic Plan in 2006("Adaptation", n.d., para.1).

Under the frame provided by the ICLEI, many US cities have developed their CAPs, till October 2009, ICLEI has 707 members in the United States. Among these, 103 members (15%) had completed LCAP (Bassett &Shandas, 2010).

Who is responsible for establishing the Climate Change Action Plan?

Both the mayor and other elected leaders must support the energy and excitement behind the planning process (Bassett &Shandas, 2010). Environment departments are seen as the most natural fit, with engineering and public works departments also taking lead roles. Planners play important roles on committees and work groups, and were called in on areas where their expertise was recognized, as in land use and transportation(Bassett &Shandas, 2010).

The organizations and interests represented on the CAP working groups and steering committees varied widely (Bassett &Shandas, 2010) due to their different locales. Governments, local jurisdictions, universities and foundations can all be involved in the establishing procedure of Climate Action Plan. In some places, like Anchorage, AK, universities are taking a lead role in preparing climate change plans(Bassett &Shandas, 2010).

Bassett and Shandas (2010) note that CAPs were spearheaded by public works departments, environmental services departments and sustainability bureaus. Consultants, including the International Council for Local Environmental Initiatives (ICLEI) have played important roles as well.

According to Bassett and Shandas(2010), traditional city planning departments have not consistently been deeply involved in climate action planning. But there is the potential for planners to take a more central role in future LCAP planning, because they have both

participatory techniques and the capacity to develop broad inclusionary processes, that could engage the community in climate action planning. In addition, planners could help devise policies to make them more efficient and accessible (Bassett &Shandas, 2010).

The Purpose of Climate Action Plan

Local Climate Action Plans(LCAPs) aim at providing a fundamental inventory for GHG emissions, setting a long-term emission reduction target, making appropriate action policies, coordinating cross-boundary issues and implementing decisions (Tang, Brody, Quinn, Chang, &Wei, 2009).

LCAPs provide a feasible, bottom-up means to establish strategic goals to lower emissions, identify emission sources and amounts, make appropriate policies and establish mechanisms for co-ordination, monitoring, measuring and reporting performance(Tang et al., 2009).

The Content of Climate Action Plan

Local Climate Action Plans usually have three critical components termed "AAA":(1)Awareness;(2)Analysis; and(3)Action.

Awareness measures the degree to which local jurisdictions understand the concepts of climate change (Tang et al., 2009).

Analysis components should provide an emission inventory and cover the major drivers, sources or contributors to climate change(Angel et al.1998).

The action strategy should identify and quantify appropriate measures to achieving a reduction in emissions. Actions should involve policies, tools and strategies to address climate change mitigation and adaptations, protect the environment and safeguard human health. This component of the plan should demonstrate how local jurisdictions will reduce GHG emissions(Tang et al., 2009). These actions should include:(1) Communication and collaboration

policies(Lindseth 2004); (2) Financial tools(Yarnal et al.2003); (3) Land use policies (Betsill 2001);(4)Transportation policies(Andrews 2008);(5)Energy strategies(Andrews 2008,Nelson 2008);(6)Waste strategies(California Air Resources Board et al.2008);(7)Resources management strategies(Mayors Climate Protection Center 2007);and(8)Implementation and monitoring strategies(California Air Resources Board et al.2008).

CAPs most commonly focus on seven categories of actions affecting the wider community: three of them are very familiar to urban planners: transportation, solid waste recycling and land use. Other five categories includes adopting zoning ordinances to reduce auto use(55%);enhancing transit services by actions such as increasing hours of operation or extending the number of lines(80%);developing infrastructure for bicycling(75%);supporting tree-planting programs(75%);and setting up programs to improve the energy efficiency of existing residential buildings through weatherization, energy audits and so forth(Bassett &Shandas, 2010).

The Establishing Procedure Of LCAP

The 1st step of the establishing of LCAP is creating a staff and organizational structure to carry out work and manage funds. The 2nd step is to find a nonprofit partner. The 3rd step is to engage a group of funding partners. The 4th step is to create a climate planning task force. The 5th step is to create a research advisory committee and research plan. The 6th step is to conduct research on climate change impacts on the region and priorities for adaptation. The 7th step is to analyze baseline GHG emissions. The 8th step is to create a process for engaging municipal departments and sister agencies. The 9th step is to create a process for engaging local civic and nonprofit leaders. The 10th step is to assess and summarize existing city initiatives, resources and capacities. The 11th step is to create an inventory of best practices from other cities. The

12th step is to collect ideas for emissions reductions and adaptation approaches from the task force, departments, and civic and nonprofit leaders. The 13th step is to analyze emissions reductions options, including size of potential reductions, cost-effectiveness, feasibility, and other benefits. The 14th step is to vet and prioritize climate mitigation and adaptation options with all stakeholders. The 15th step is to choose overall goals for emissions reductions and actions to achieve them. The 16th step is to develop implementation plans, structures, and partnerships for the highest priority actions. The 17th step is to establish performance monitoring tools. The 18th step is to develop and implement an on-going communications strategy. The 19th step is to launch an agreed upon climate action plan. The 20th step is to continue on-going planning, monitoring, and reassessment.

The Implement of Climate Action Plan

Implementation oriented strategies. At the very start, Local Climate Action Plans(LCAP) are implementation oriented plans. The mitigation and adaptation strategies in CAPs are cost-effective, concrete, flexible and can be quickly put into practice by local governments, communities and citizens.

Develop implementation plans. After the establishment of LCAP, some local governments will develop a plan for the implementation of the LCAP. This plan includes specifics such as responsible parties, timelines, CO_{2e} reductions, financing strategies, costs of implementation, revenues and staffing needs. Local governments need to work mutually with state governments, county governments and other local jurisdictions to implement the LCAP. For instance, Miami works with Miami-Dade County, and the State of Florida to implement the LCAP.(Miplan, 2008) Chula Vista, CA has also developed an implementation plan to identify the steps, actors, timelines for completion and capital for the LCAP.

Design implementation initiatives. Some cities designed initiatives to guide climate mitigation and adaptation actions after the establishment of the LCAP. For example, A.T. Kearney, in partnership with the Civic Consulting Alliance, began an initiative CCAP Lead by Example to help 15 city departments and relative agencies to define clear and actionable initiatives. Under the organization of Lead by Example, 400 initiatives for mitigating climate change were developed and will be completed in the future 18 months(A.T. Kearney, 2009).

Employing Existing Mechanisms. To facilitate the implementation of climate action plans, local governments can employ existing mechanisms to address the projected impacts of climate change. Some scholars predict these changes will come in familiar forms such as floods, droughts, severe heat events, etc(Lowe et al. 2009). So local governments can use their existing policy structures such as zoning and housing regulations, current urban forestry and coastal buffer programs to improve the city's resilience (Lowe et al. 2009). Local governments can also utilize mechanisms existing in the form of private sector to support federal and state policymakers. For example, they can work with private insurance agencies to discourage land use that risks the prospect of flooding. Many federal laws, including the Clean Water Act and the Coastal Zone Management Act, can be amended to address adaptations more effectively (Lowe et al. 2009).

Garnering Support. In order to increase support for LCAPs, local governments should convince citizens and local leaders that mitigation and adaptation to climate change is a valuable and pressing objective. Local governments can take advantage of recent events such as hurricanes to motivate the public and their leaders. Additionally, scholars found that the release of IPCC's report and scholars' researches can help to garner the support of the public(Lowe et al. 2009).

Obtaining Financial Support. One important challenge to fully implementing LCAPs is the allocation of funds. The federal government can provide more funding mechanisms for local adaptation actions, programs like FEMA PDM grants can also provide funding for local governments. Additionally, federal legislation can also provide additional financial support. (Lowe et al. 2009).The Chicago's CAP has received Federal Stimulus funding, state funding, pro-bono consultant support, foundation support, utility partners and City of Chicago in-kind support("Economics and green jobs", n.d., para. 2).(http://www.chicagoclimateaction.org/pages/ccap_frequently_asked_questions/89.php)

Some of the LCAPs contain implementation strategies, such as the CAP of Chattanooga, TN, it provides implementation matrix identifying lead agency, partners, and time frames(Bassett & Shandas, 2010). To date, most of the LCAPs are not fully utilized, so it is difficult to evaluate the results of the implementation.

The Monitor and Assessment of Climate Action Plan

The on-going monitoring and assessment of LCAP is critical for the plans' success. Each strategy should be continuously assessed and monitored (Chicago Climate Action Plan(CCAP), 2008). Miami will review its GHG emission and their subsequent reductions. A review iof ts action plan should result in revisions to improve the attainment of reduction goals(Miplan, 2008).

Evaluating Climate Change Action Plans

Brody's Method. Tang et al. (2009)'s study provides a model to empirically examine LCAP's quality. It developed a conceptual framework using 36 indicators which are categorized into three components. These three components are Awareness, Analysis and Action. Awareness measures the extent to which local governments understand the concepts of climate change. Analysis should provide an emission inventory and cover the major drivers, sources or

contributors to climate change. Actions should demonstrate how a local government will reduce GHG emissions. Brody and his co-researchers' evaluation method sets the local climate action plan's quality as the dependent variable. Independent variables are categorized into three groups as following:

According to Tang et al., capacity variables include political will, state mandates and community wealth. The capacity variables are based on three hypotheses. The first hypothesis here is that a local government with stronger political will may have a higher quality plan. The second hypothesis is that a local government with mandates in climate change may also have a higher quality. The third hypothesis is that a wealthier local government may develop a higher quality LCAP(Tang et al., 2009).

Climate risk variables include coastal distance, population density, and hazard damage. The selection of these three variables are also based on three hypotheses. The first one is that the city located in coastal areas may have a higher quality plan. The second one is that the city with higher population density may have a higher quality plan. The third one is that the city with more historical hazard potential may have a higher quality plan(Tang et al., 2009).

Emission stress variables include energy consumption, light transportation, average commuting time and vehicular emission. They are based on four hypotheses. The first one is that the cities with a higher energy consumption will adopt lower quality climate change plans. The second one is that the cities with a higher percentage of people using light transportation will adopt higher quality LCAPs. The third one is that the cities with higher vehicle emissions may feel pressure to develop higher quality LCAPs. The fourth is that the cities with higher average commuting time adopt lower quality climate change action plans(Tang et al., 2009).

Brody and his co-researchers selected 40 different CAPs to conduct the analysis. Firstly, they employ descriptive statistics to assess the quality of the 40 LCAPs. That entails calculating minimum, maximum and mean scores of each component and the total action plan, and then assess the plan quality through the outcomes. Secondly, they use ordinary least squares multiple regression analysis to identify which factors significantly influence LCAP's quality. IN other words, they measure the breadth and depth of each 36 indicators and evaluate their performances in the local climate action plan(Tang et al., 2009).

Then, Brody and his co-researchers use multiple regression analysis to identify the independent variables' influences on the quality of climate action plans. Brody's study found significant variation in the quality of LCAPs. There are several limitations of this study. First, the sample size of Brody's study is relatively limited to reach the conclusion. Second, it focused only on LCAPs, did not examine the relative plans such as comprehensive plans, transportation plans or natural hazard plans which may also including climate change mitigation and adaptation strategies. Third, the study limits on the quality of LCAPs. Fourth, it is limited to a short time period. Fifth, the study did not compare the city with and without a LCAP. Finally, this study did not examine the practice of the actions.

Bassett and Shandas' Method. Bassett and Shandas(2010) developed a plan evaluation matrix using a two-part process. First, they create a matrix including some categories of actions. They categorized the strategies into three main categories: 1) Local government emissions; 2) Community emissions; 3) Adaptation. These three main categories have been further divided into 30 strategies. Second, they evaluate plans on their breadth and depth.

They also interviewed, transcribed, and coded responses from 16 informants participated in the planning process in order to gather data to better understand the relationship between types of CAP actions and policies and the process of plan preparation.

Bassett and Shandas's study found that leadership is very important in the creation process of LCAP, however the process varies across cities. The study also found that the LCAP is connected to its local political context. However, the study indicated that many of the strategies in the LCAPs are traditional planning strategies, not innovation. This method, however, is limited to the sample size and the short time period. It also lacks a statistical analysis of the LCAPs.

Tools That CAPs Use To Address Flooding

Technology

Grey Infrastructure Upgrade. According to Robert Andoh in 2011, Grey Infrastructure relevant to flooding refers to traditional piped drainage and water treatment systems, including pipes, tanks, conventional treatment systems including energy-intensive water treatment systems and processes such as membranes and reverse osmosis. In current cities, the grey infrastructure systems were designed and constructed under the standard and criteria of former climate patterns without considering the climate change. Consequently, these existing grey infrastructure systems are not suitable in a changing climate and are prone to be obsolescent.

Upgrading of the traditional Grey Infrastructure can both help to reduce GHG emission and make cities more resilient to climate change including more stormwater and flooding. For example, by designing new styles of road section, cities can promote the public transportation so as to reduce GHG emission. By applying physical interventions such as dikes and levees(Heleen Mees, 2010), cities can deal with flooding and sea level rising. Other strategies of upgrading grey

infrastructure include the maintenance of existing infrastructures, enhancing the levees, building tunnels, resurfacing and reconstruction of roads, building water reclamation infrastructures and retrofitting grey infrastructure into green.

Low Impact Development. In developed areas, roofs, pavements, and other impervious surfaces prevent stormwater from soaking into the ground. Instead, it runs over the land surface and flows directly into small tributaries and larger streams. This will increase flood risk and lead to property damage.

LID is a tool to deal with the stormwater runoff problem.

In the mid 1990s, Maryland outlined an approach for addressing suburban storm water management(NAHB, 2003). This approach was the origin of LID. LID contains a series of technologies to ensure that a site's post-development hydrologic functions mimic the pre-development state(NAHB, 2003).These functions include groundwater recharge, infiltration, and frequency and volume of discharges. LID uses various land planning and design practices and technologies to conserve natural resource systems and reduce infrastructure costs(NAHB, 2003). LID still allows land to be developed in a cost-effective way to help mitigate potential environmental changes. Some scholar view LID as best suited for new, suburban development (NAHB, 2003).

LID focuses on identifying project-specific site solutions and has many advantages; it aims to benefit all the stakeholders and the environment. In terms of stormwater management, compared to the conventional stormwater management strategies, LID can reduce the need for paving, curb and gutter, piping, inlet structures, and storm water ponds by treating water at its source instead of at the end of the pipe(NAHB, 2003). In addition, municipalities also benefit in the long term because of reduced maintenance costs. In terms of wastewater management, LID

uses a variety of on-site wastewater treatment systems which serve as alternatives or enhancements to conventional septic systems(NAHB, 2003). In terms of circulation and design, LID provides new designs for streets, sidewalks, and driveways that can maintain the function of circulation by reducing expanses of impervious surfaces that can alter local hydrology and degrade water quality(NAHB, 2003). LID's new street design strategy can improve the layout of lots and help to increase the volume of open space(NAHB, 2003).

LID technology can be structural or non-structural. Structural technologies can be categorized into infiltration systems, filtering systems, conveyance systems and others. Equipments for these systems include permeable pavements, sand filter, infiltration trench, dry wells, bioretention cells, level spreaders, wetlands, grassed swales, rain barrels and cisterns. Nonstructural technologies often use natural features or are land use strategies(NAHB, 2003).

LID can help to manage stormwater and prevent flooding by reducing the quantity of urban runoff, providing natural plants and soil which absorb excess stormwater, and relieves pressure placed on sewage treatment plants during heavy rains because less stormwater seeps into the sewage system(NAHB, 2003).

Similar approaches which contain the same design elements include Conservation Design, environmentally friendly design, resource-efficient design, and better site design(NAHB, 2003).

Building Upgrade. Some cities take action to upgrade and retrofit buildings to adapt to the climate change. Reinforcing and retrofitting has been shown to be an effective measure against natural disasters..

Land Hazard Mapping And Inventories. The mapping of land hazard and creating land hazard inventories can help to provide an accurate map of landslide, flood areas and other hazard risk areas.

Flood Insurance Rate Map(FIRM). The FIRM method was created by the Federal Emergency Management Agency (FEMA). It is the official map of a community delineating both the special hazard areas and the risk premium zones("Flood Insurance Rate Maps", 2011).Private citizens, insurance companies and brokers use the FIRM in locating properties and buildings to determine whether flood insurance is required. Community officials use the FIRM to administer floodplain management regulations and to mitigate flood damage. Lending institutions and federal agencies use the FIRM to locate properties and buildings in relation to mapped flood hazards, and to determine whether flood insurance is required for making loans or providing grants following a disaster for the purchase or construction of a building("Flood Insurance Rate Maps", 2011). However, the FIRMs have not been significantly revised since 1983(PlaNYC, 2011). The maps should be redeveloped to reflect current building environments and changing flood patterns.

Natural

Restoration, Protection and Preservation. The protection and restoration of natural environments, such as wetlands, meadows, lakes, streams, patches of woods and forests, etc. can help to mitigate stormwater from the outset. Vegetation and soil have natural stormwater functions such as the absorption of stormwater on-site and the mitigation of runoffs. Instead of conventional stormwater disposal, prevention before stormwater becomes a problem (Horner, n.d.); as much as possible we should avoid structural solutions that are expensive to build and maintain(Horner, n.d.) By conservation of water bodies, we can better maintain the health of the hydrologic systems. The benefits of conservation also includes the achievement of multiple objectives such as temperature maintenance and water quality control(Horner, n.d.).

Green Infrastructure. Generally, green infrastructure means viewing natural systems as regional infrastructure. The green infrastructure concept originates from two important planning ideas: 1)the linking of parks and other green spaces for the benefit of people, and 2)the linking of natural areas to benefiting biodiversity and countering habitat fragmentation(Benedict &McMahon, 2002) In 1903, Frederick Law Olmsted stated that "no single park, no matter how large and how well designed, would provide the citizens with the beneficial influences of nature." He insisted that parks needed "to be linked to one another and to surrounding residential neighborhoods." Benedict and McMahon (2002) claim this idea has sparked the modern greenways movement.

Benedict and McMahon (2002) also identify the GI as an interconnected network of green space that conserves natural ecosystem values and provides enormous benefits to the public. In 1999, The Conservation Fund and the USDA Forest Service formed the Green Infrastructure Work Group, this group define the green infrastructure as " an interconnected network of waterways, wetlands, woodlands, wildlife habitats and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for America's communities and people."

The EPA defines green infrastructure as a stormwater management strategy. The EPA website states that green infrastructure uses stormwater "management approaches and technologies to infiltrate, evapotranspire, a capture and reuse stormwater to maintain or restore natural hydrology. At the largest scale, the preservation and restoration of natural landscape features(such as forests, floodplains and wetlands)are critical components of green stormwater infrastructure. On a smaller scale, green infrastructure practices include rain gardens, porous

pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting for non-potable uses such as toilet flushing and landscape irrigation.”

Green infrastructure has two components: hubs and links. Hubs "anchor green infrastructure networks, providing origins and destinations for the wildlife and ecological processes moving to or through them. " Links are "the connections tying the system together and enabling green infrastructure networks to work." (Benedict & McMahon, 2002) According to McMahon (2000), hubs include "reserves, managed native landscapes, agricultural preservation districts, regional parks and preserves, cultural/historic/recreational sites and trailheads". Links include "landscape linkages, conservation corridors, greenbelts, trail corridors and utilitarian corridors"(Benedict & McMahon, 2002). GI systems can contain: wilderness areas, river corridors, managed landscapes such as parks and nature reserves, working lands such as farms, ranches, greenways, street trees and green roofs.

Both LID and green infrastructure can deal with stormwater management. However, LID "focuses specifically on water management issues." Green infrastructure's scope is broader. It can also tackle with air pollution, urban heat island effects, wildlife conservation and recreational needs.(Understanding LID, n.d.) Other. Similar approaches which also contains protection and restoration include "Conservation Design, environmentally friendly design, resource-efficient design, and better site design."(NAHB, 2003)

Laws, Regulations and Policies

Laws and Regulations at the federal, state and local level can integrate climate change and flood-relate issue into considerations. They can provide guidance for flood management and work as drivers for climate change adaptation. Policy tools play significant roles in flood

management. Several laws, regulations and policy approaches concerning flood management included in the CAPs are as follows:

Coastal Evacuation Plan. Planning for safe evacuation from flood-risk areas; this includes the identification of flood prone areas and appropriate evacuation routes. When hurricanes are approaching, local governments will issue a mandatory evacuation order to force people living in coastal areas to move inland.

National Flood Insurance Program(NFIP). Insurances can be used as incentives and disincentives aiming to reduce the flood risk. The Federal Emergency Management Agency (FEMA) administrates this program. NFIP imposes the minimum requirements for local governments' flood zoning and flood building codes, and provides incentives for homeowners to invest in risk reduction beyond these minimum standards (Aerts & Botzen, 2011). Aerts and Botzen (2011) points out that the NFIP is very effective in limiting the vulnerability of new constructions in flood hazards through flood proofing measures. But it is ineffective in limiting new developments in high-risk areas and in reducing the vulnerability of existing buildings to flood hazards. In addition, climate change and further urban developments have not been reflected in NFIP. Consequently, NFIP should be further assessed and improved to incorporate climate change in to consideration(Aerts & Botzen, 2011).

Relocation. Relocation refers to the displacement of residents living in coastal or flood prone areas when hurricanes or floods occur. Relocation also refers to the integrate strategy of moving coastal residents to inland cities to protect their safety.

Flood Control Zone District. Flood Control Zone District(FCZD) can provide a proactive, regional approach to flooding and provide funds to improve aging and inadequate flood protection facilities("King County Flood Control District", 2011).

Land Use Planning. According to World Meteorological Organization(WMO)'s report (2008) Land use and flooding are connected at two aspects: 1) The construction on floodplains provides economic benefits while creating flooding risks for the society. 2)The development of land can stimulate flooding; therefore land use planning and flood management should be interlinked(WMO,2008). Land Use Planning should take development decisions based on the knowledge of flooding risks(WMO,2008)

Other Plans and Programs. There are some other plans and programs aiming to reduce flood risk and watershed management. For example, the Integrated Regional Water Management in Chula Vista, CA, the Water And Wastewater Integrated Resources Plan in Los Angeles(LA), the Water Quality Plan in LA.

Land Development Ordinance. Land development Ordinance usually contains contents relate to flood management. It issues regulations to protect natural environments, as well as integrate land development and stormwater management.

Neighborhood Plan Ordinance. Neighborhood plan ordinance(NPO) can provide guide neighborhood design and construction such as street layout, sidewalks, stormwater drains and landscape, while incorporating climate change and flood risk into consideration.

Building Codes. Aerts and Botzen(2011) suggest that building codes are a powerful tool for regulating land use, and hence identifying the potential vulnerability of land use to flood risks. Local building codes can go beyond the NFIP standards. For example, New York City's flood-related building codes raise stricter requirements for buildings in the A and V flood zones; this applies to new structures and significant improvements of the structure (Aerts & Botzen, 2011).

Flood zoning. Aerts and Botzen (2011) suggest that zoning can be defined as legislation; flood zoning helps to restore or maintain wetlands and other natural areas (Aerts & Botzen,

2011). It can also help avoid some certain kinds of land uses and critical infrastructure construction in areas vulnerable to flooding, while providing public access in coastal areas. Flood zoning can help buildings avoid the risk of flooding through regulations, such as height penalty, although sometimes resilience to climate change is not specifically mentioned in the current zoning policies for waterfronts(Aerts & Botzen, 2011).

Federal and state level laws and regulations. Some federal and state level laws, ordinances and regulations play important roles in guiding local level ordinances and regulations. For example, the federal Clean Water Act ,the Clean Air Act, the Flood Disaster Protection Act, the Endangered Species Act and the CAM Act all guide the flood management issues at state and local level. There are also many state level ordinances. For instance, California Environmental Quality Act, etc. And there are other relevant ordinances, regulations and codes concerning flood management. For example,

Other

Other tools to addressing flood hazards include executive directives such as Evacuation Order. This is an emergent strategy and should be used a certain time before the hazards happen. But it is not often addressed in the LCAPs and planning.

CHAPTER 3

METHODOLOGY

This chapter describes a methodology for evaluating and comparative case study of the flood-related adaptation strategies in eight US cities' local climate action plans. The methodology utilized multiple case study with embedded units.

Selection of Case Studies

The six case studies discussed in this research are shown in Table 3-1.

These cases are selected because of several reasons. First, these six cities(county) are selected based on the geographic diversity. Among the six cities(county), two of them (Chicago, Portland) are inland cities. Other four of them (King County, Miami, New York City and Los Angeles) are coastal cities. The cities' latitudes, relationship with lakes and geographic features are also different. By study cities of different location, we can better understand the differences usage of flood-related adaptation tools. Second, these cities(county) have different populations, areas, and socio- political characteristics. By selecting cities(county) of different level we can capture more variation in climate change actions (Bassett and Shandas, 2010) and better understand how cities with different level of resources addressing climate planning. Third, these cities(county) have different climate characteristics and precipitation amount. The climate change's impacts on their precipitation patterns varies, too. By selecting cities with different climate features, we can get an initial understanding of how cities with different natural environment addressing climate planning. Fourth, these cities(county) are selected because they all face flood problems. It's easier to find out flood-related adaptation tools in their local climate action plans. Fifth, these cities(county) are selected in different EPA's 10 regions.

Analysis Methodology Design

My methodology is constructed on the basis of Brody's research method and Bassett's research method. Some of the influencing factors of the LCAP I employ in the analysis is borrowed from Brody's study, such as, the coastal distance, the population density, the political will, etc. I try to find how these factors influence the flooding adaptation tools in the LCAPs. I also used the policy analysis methodology in Bassett's study. I will examine the LCAP documents to collect data. This study employs a multiple case study with embedded units methods. There are three embedded analysis units: 1) The appearance of flooding issues in the LCAPs and how the flooding adaptation tools varies because of the different condition in the selected cities(county); 2) The characteristics of the flooding adaptation tools.

The Appearance Of Flooding Issues In The LCAPs And How Do The Flooding Adaptation Tools Varies Because Of The Different Condition In The Selected Cities(County)

This analysis unit including two steps. The first step of the analysis seeks to find out how many times flooding issue is mentioned in each selected LCAPs. As such, the analysis will also examine how climate change affects the local precipitation and flooding. And in what section of the LCAP do the flooding issues appear. How many times do they appear in the awareness section, analysis section and action section. In order to qualify the flood adaptation tools in the LCAP a researcher must first understand the climate characteristic and the appearance of flooding issues in the LCAPs.

In this analysis, I will examine the six cities'(county) LCAP respectively. Firstly, I will examine the climate change's impacts on precipitation variation patterns in each city(county). In order to understand the background of the using of flooding adaptation tools, we must first realize the climate change's impacts at local level. At the same time, I will examine the flooding'

s impacts on the city. The LCAP documents often provide of a description of climate change's impacts in the first few chapters to lay foundation for the strategies in the following chapters. The LCAPs may also depict the impacts of flooding on the city.

Secondly, I will examine how many times do flooding issues appear in each of the LCAPs. The times of appearance may represent the awareness of a city of the flooding issues. It may also reflect to what extent local governments pay attention to the flooding issues.

Thirdly, I will systematically examine the sections of the appearance of the flood issues in each LCAP. The LCAP can be divided into three sections: 1) Awareness, 2) Analysis; 3) Action. In order to further analyze how a LCAP address the flooding issue, we should examine the awareness of the issue in each city(county), whether the LCAP give flooding issue a fully analysis, and are there enough actions designed in order to better implement the LCAP.

After all the LCAPs have been examined and an understanding of situation of the flooding issues in the LCAPs is achieved, the author can begin to draw some conclusion. This analysis is seeking to find out the local climate change's impacts, the frequency of appearance of flooding issues and the in which sections do the flooding issues appear. These may better explain a city's background of tools' adoption, awareness of the flooding issue and the way they address this issue.

The second step of this analysis unit aims to explore how the flooding adaptation tools in the LCAP varies because of the climate risk and the capacity of a city(county). This analysis is also based on two assumptions: 1) a city's climate risk is determined by the city's coastal distance, proximity with a lake, precipitation variation pattern, population density, the year of the last significant flood event, and the amount of property in the city within the 100 year flood plain; 2)

a city's climate change adaptation capacity is determined by its population size, area, political will and wealth and the age of it LCAP.

The second step of the analysis is seeking to explore how the flooding adaptation tools in a LCAP vary because of the different conditions of the selected cities(county). By exploring this, we can better understand how cities(county) that with different resources, at different locations and have different climate conditions address the local flooding issue.

The Characteristics Of The Flooding Adaptation Tools

The second analysis unit involves exploring the characteristics of the flooding adaptation tools. The objective of this analysis is to find out the characteristics of different tools. Then categorize them into five kinds of categories: 1) technology; 2) natural; 3) policy; 4) law, regulation and policy. Tools in each of these categories are designed to address flooding directly or indirectly based on natural scientific principles or social science methods.

Technology tools refer to flooding adaptation tools using technological, physical or construction approaches to deal with the flooding. For example, LID is using technological permeable pavements, rainwater harvesting facilities, etc to address flooding. So it should be placed in technology category. Technology tools address the floods directly.

Natural tools refer to flooding adaptation tools that mitigate or adapt to flooding through a natural way. Usually these tools make efforts to restore, protect and enhance the natural system's stormwater management functions to deal with flooding. For example, Green Infrastructure creates and reconnects green networks in the urban built environment. It can reduce storm runoff, restore the natural water flows, etc. So GI should be placed in the natural category. Natural tools address the floods directly, too.

Law, regulation and policy tools refer to tools that using urban planning strategies, financial incentives, laws and regulations to regulate the construction in the floodplain, facilitate the implementation of technology tools and natural tools, organize the actions of flooding adaptation, etc. Building Codes, Urban Design Codes should be placed in this category. Law, regulation and policy tools address the floods indirectly.

The placement of flooding adaptation tools in different categories is important from a sustainable perspective. First, we can rethink the way we are using technologies. We should use technology to restore, protect and preserve the natural system, not to exploit the natural system without consideration of its capacity. Second, we can better understand the functions of natural systems. The natural system can work as green infrastructures, and they can serve better than the grey infrastructures. Third, it provokes us to think about how should we design laws, regulations and policies. They should be designed with more consideration and respect to the environment and sustainability. Finally, by getting a panoramic view of the different kinds of tools, we can better understand how to use them collectively to reach an sustainable goal.

After all, this research is seeking to determine how the local governments using the flooding adaptation tools to solve the problems, including that how the flooding issues connected with other issues, why are these issues connected together, and how they use tools of different characteristics to reach a same goal. Ultimately, the purpose of this research is to better understand how local governments are using flooding adaptation tools in LCAPs to address the flooding problem caused or worsened by the climate change. By focusing on the using of the flooding adaptation tools in the LCAP, I hope this applied research can further foster and enhance the formulating of flooding adaptation strategies in the LCAPs.

Data Collection

Data collection for the case studies primarily involved document review. Documents reviewed included LCAPs, local climate action plan progress reports, relevant articles and books, and IPCC reports. Data collection also include reviewing of federal and local governments' relevant websites. For example, the ICLEI's website, the United Census website, the FEMA's website, and local governments' Climate Change websites. A summary of findings and analysis of data collected is presented in the following chapter.

Table 3-1. The list of selected cases.

Number	City	Name of the Local Climate Action Plan	Year
1	King County, WA	Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments	2007
2	Chicago, IL	Chicago Climate Action Plan: Our City, Our Future	2008
3	Portland, OR	City Of Portland And Multnomah County: Climate Action Plan 2009	2009
4	Miami, FL	Miplan: City of Miami Climate Action Plan	2008
5	New York City, NY	PlaNYC: A Greener, Greater New York	2007
6	Los Angeles, CA	Climate LA	2007

Table 3-2. The influencing factors of the LCAPs.

Factors		Measurement	Data Source
Climate risk Factors	Coastal distance	Whether a city is in National Oceanic and Atmospheric Administration. (NOAA) designated coastal county (at least 15% of its area is in coastal watershed)	GIS layers
	Proximity with a lake	Whether a city is located by the side of a lake.	GIS layers
	Precipitation Amount	Annual precipitation amount (inches) in 2000.	http://www.currentresults.com/Weather/US/average-annual-precipitation-by-city.php
	Population density	Population density in each city in 2000 (by 1000 units).	Calculated by author
	Year of last significant flood event	Year of last significant flood event.	Websites

Table 3-2. Continued

Factors		Measurement	Data Source
Climate risk factors	The amount of property in the city within the 100 year flood plain	The number of parcels. within the SFHA zone.	GIS Database
Capacity factors	Population	Population in each county in 2000.	Census 2010
	Area	Area within a city(county)'s political boundary(square kilo-meters).	http://en.wikipedia.org
	Political will	Whether the city(county) is partici-pate in the major. 1) Climate Protection Campaign(CPC). 2) Mayors' Climate Protection Agreement	http://www.iclei.org/index .php?id= 1484&region=NA http://www.usmayors.org/ climateprotection/
	Wealth	Median family income (in 2000 inflation-adjusted dollars).	Census 2010
	Age of the LCAP	The creation year of the LCAP.	LCAP

CHAPTER 4

FINDINGS

This chapter presents a multiple case study of the selected LCAPs. It describes the precipitation variations in each city(county) caused by climate change and the appearance of the flooding adaptation tools. It then presents the influencing factors of the LCAP in selected cities(county). After that, it categorizes the tools into four characteristics and presents the different conditions in the selected cities using independent variables.

The Precipitation Variations In Each City(County) Caused By Climate Change

King County has a lot of rainfalls. The precipitation will have very small increase due to the climate change according to the projected climate change for the US Pacific northwest. The precipitation in summer will decrease while in winter will increase. In future year, the weather in King County may swing between dry and wet. The precipitation variation is hard to see. King County is certain to experience sea level rise and subsequent flooding. Whether the heavy rainstorms will increase is still uncertain. The Chicago's states that Chicago will have many more heavy rain storms and snow storms due to the climate change. Portland's rainstorms and snowstorms will have increased severity due to climate change. Miami city will have precipitation patterns changes due to climate change. But the LCAP does not state the change clearly. New York City's precipitation will increase steadily in the future 70 years due to climate change. It will increase by + 0 to 5% , + 0 to 10% , + 5 to 10% respectively in the 2020s, 2050s and 2080s compared to the 1970-2020 baseline. Los Angeles(LA) is a city with relatively low precipitation amounts. The climate change's impact on rainfall patterns will bring severe drought routine. However, LA still face flooding problems because of the sea level rising and more severe storms.

The Appearance of Flooding Adaptation Tools in the Local Climate Action Plans(LCAPs) and The Influencing Factors of the LCAPs

Examining the appearance of flooding adaptation tools in different sections is important for three reasons. First, it can reflect the roadmap that an LCAP employs to address the flooding issue. Second, we can find out the weakness of an LCAP by examine how much attention does it pay to different sections. Third, by realizing the weakness of an LCAP, we can realize what section should be enhanced in future LCAPs. Following is the findings of this analysis:

King County, WA

Flooding is mentioned in King County's LCAP: The Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments at high frequency. It appears for 57 times. The high frequency of appearance indicates that King County pay high attention to the flooding problem. The time of appearances in awareness, analysis and action section is respectively 7, 31 and 19. This suggests that King County do plenty of analysis work to analyze the flooding issue.

In terms of the awareness section, the flooding issue is mentioned in the first chapter to inform that King County has increased flooding in coastal and freshwater systems. Then, the flooding issue is emphasized for several times. After emphasizing the importance of the issue, the LCAP convinces the audiences that it's time to take adaptation strategies to make cities more resilient to climate change and flooding. In addition, flooding adaptation can bring many benefits such as protecting the safety of families and bring new agricultural opportunities. Following this the LCAP presents a series of reasons why the local governments should be proactive to address the flooding issue. And, the LCAP provoke us to move beyond what we thought as common barriers to design and implement flooding adaptation strategies.

In terms of analysis section, in the first step, the LCAP firstly cites the research results from IPCC report to demonstrate that more extreme precipitation is likely to happen and there is increasing risk of flooding. In the second step, an analysis of regional impacts of climate change on different sectors is conducted suggesting that: 1) increased risk of flooding will impact the hydrology and water resources sector, 2) flooding may cause more travel disruptions on transportation sector, 3)the infrastructure sector will be impact and need to be updated or build for flood control, 4) the business system will be impact because of the impacts on business infrastructure located in floodplains or coastal areas, 5) flooding or other extreme weather may lead to increased demands on emergency response services. In the third step, a climate change vulnerability assessment is conducted. The vulnerability assessment includes a sensitivity analysis, an evaluation of the capacity of the systems and an assessment of how vulnerable the system is to the climate change. For example, the outcome of the sensitivity analysis suggests that the infrastructure sector has an uncertain sensitivity to flooding. The capacity analysis shows that the adaptive capacity of stormwater management is medium. Vulnerability analysis shows that the vulnerability of stormwater management is medium. After the vulnerability assessment, there should be a risk assessment. Risk is described as Consequence ×Probability. The outcome of risk assessment shows that flooding has medium risk on the stormwater management planning area. After conducting the vulnerability assessment and risk assessment, it is able to identify the priority of planning areas(Table X.). The LCAP indicates that King County's priority planning areas include water supply and stream flow management, coastal hazards management, and flood hazard management.

In terms of flooding adaptive action, the King County's LCAP designed a series of actions including modifying policies, practices, and procedures(e. g., reinforce trends that increase

vulnerability or reduce adaptive capacity such as development along flood plains). Below is a list of the actions:

Chicago, IL

Chicago's LCAP Chicago Climate Action Plan: Our City, Our Future mentioned flooding for 7 times. Among those 2 times is in awareness section, 5 is in action section and none is in analysis section. In terms of awareness, Chicago's LCAP describes the risk of increased flooding in the introduction chapter by stating that Chicago will have more rain storms and growing flood risk. Then in the Adaptation Strategy chapter, the LCAP delineate the specific impacts of the increased intensity of downpours, include making travel more dangerous, flooding basements, pollute water bodies, stress the infrastructure system and disrupt transportation.

Chicago's LCAP does not provide any analysis of flooding or stormwater issues. This is a weak point of this LCAP. Analysis can be good strategy to realize the impacts of flooding issue, the risk of flooding issue and the necessary to take adaptation strategies. The more the analysis is conducted in a LCAP, the more scientific and convincing it will be.

Chicago's LCAP contains several flooding adaptation strategies. For example, the Low Impact Development(LID), green infrastructure, and a watershed plan which is created in collaboration with the Metropolitan Water Reclamation District(MWRD). The watershed plan will incorporate projected climate changes into its consideration. The city is also finding ways such as use vacant lands or parking lots to manage stormwater. Another flooding adaptation strategy is the Green Urban Design(GUD) plan. This plan is created under the collaboration among different agencies and stakeholders, aiming to use green technology such as green roofs and permeable pavements to manage flooding and to enhance the capacity of the city's water infrastructure. Other actions include preserve natural spaces and planting trees.

Portland, OR

The Portland's LCAP . City Of Portland And Multnomah County: Climate Action Plan 2009 mentions flooding and stormwater for 9 times in total. Among them 4 times is in awareness section, 1time is in analysis action, and 4 times is in action section.

In terms of awareness section, the LCAP outlines the vision for 2050. One of the objectives is residents and businesses should minimize and reuse stormwater. Then in the 2030's objectives, the LCAP indicates that the city will experience more severe and increased rainstorms and suggests that buildings should be built stronger to withstand those storms. After that, in the climate change preparation chapter, the LCAP emphasizes that the Oregon state will have increased and more severe rainstorms. The coastal area will experience more flooding, causing damage to roads, buildings, sewer systems. Then the LCAP calls for adaptation strategies for climate change including flooding.

In terms of analysis, the LCAP analyzed the green house effect and states that the warming weather will change the precipitation patterns and bring increased frequency and intensity of storms. It further indicates that Oregon state will threatened by stronger storms and increased coastal flooding.

In terms of action, the LCAP created several flooding adaptation strategies including: participating in the Oregon code- development process to make building codes support buildings that can resist climate change, protecting natural system to maintain its hydrological functions, using green infrastructure to manage stormwater.

Miami, FL

The Miami's LCAP Miplan: City of Miami Climate Action Plan mentions flooding for 5 times. Among those 1time is in awareness section, two times is in analysis section, two times is in action section.

In terms of awareness, the Introduction chapter states that Miami is threatened by sea level rise. The subsequent flooding will undermine low-lying buildings.

In terms of analysis, the LCAP analyzed the climate change's impacts on Miami city. It cites a study by the Organization of Economic Cooperation and Development to suggest that Miami presently has $400 billion in property at risk from coastal flooding and by 2070 the value can exceed $3.5 trillion. The study also suggests that the Greater Miami is one of the 20 cities with the most population at risk from coastal flooding. The LCAP also cites another study by Elizabeth A. Stanton and Frank Ackerman of Tufts University suggesting that by 2070 70% of the Miami- Dade will be vulnerable to flooding.

In terms of action, the LCAP suggests that the city should incorporate climate change into long-term planning, including the consideration of flood mitigation. Besides, the LCAP creates an action of increasing water management by water conservation, pollution prevention and water resource planning.

New York City, NY

New York City's LCAP PlaNYC: A Greener, Greater New York mentions flooding for 18 times. Among those 4 times is in awareness section, 2 times is in analysis section, 12 times is in action section. The frequent appearance of flooding shows that NYC view flooding as an important issue to address. And the content of NYC's LCAP is abundant.

In terms of awareness, the LCAP evoke the audiences' awareness of flooding in the first chapter by stating that NYC is at the risk of increased flooding because the sea level rise and more intense storms. Then, under the topic of protecting public health, the LCAP calls for attention that flooding has significant impacts on public health.

In terms of analysis, PlaNYC conducts a vulnerability assessment and a risks assessment of climate change. The LCAP also includes climate change projections assessing the precipitation, sea level rise and rapid ice- melt sea level rise, 1- in- 100 year flood to reoccur on average in 2020s, 2050s and 2080s.The LCAP also create a Potential Future 1- in- 100 Year Flood Zones map to illustrate the flooding risk areas in the city. NYC will also use the LiDAR technology to collect data to develop models and flood maps that can reflect sea level rise scenarios. They are also making the projected flood maps publicly- available.

In terms of action, the LCAP creates a series of flooding adaptation actions as following: Working with FEMA to update the Flood Insurance Rate Maps(FIRMs), updating regulations to increase the resilience of buildings to flooding. Local laws and zoning regulations will be modified to guide new constructed buildings in order to make them better to withstand flooding, extreme weather and other conditions. NYC incorporates climate change into the consideration of Waterfront Revitalization Program(WRP). NYC also conducts a study of the urban design implications of enhanced flood protection for buildings and launched a study of rising water tables, inland flooding, wind and extreme heat events on buildings. NYC's propaganda programs about flooding include the Notify NYC plan, providing an online portal. and providing publicly available data on the locations of hazardous material storage in flooding zones. Other actions including grey infrastructure upgrades, Green Infrastructure(GI), modifying codes and regulations, providing incentives, working with the insurance industry to develop strategies to

encourage the use of flood protections in buildings, identifying and evaluating citywide coastal protective measures, launching a Flash Flood Emergency Plan, protecting natural systems' functions include flood preventing.

Los Angeles, CA

The Los Angeles(LA)'s LCAP Climate LA mentioned flooding for 14 times. Among those 14 times of appearances, none is in awareness section or analysis action. All of the 14 times are in action section. The LA's LCAP spare one chapter focusing on water issues. One of the long-term strategy of water is enhancing stormwater capture.

The Influencing Factors of the LCAPs in The Selected Cities(County)

See Table 4-7.

The Characteristics Of The Flood Adaptation Tools

Technology

Technology flooding adaptation tools are adopted broadly in the selected LCAPs. King County utilizes 3 technology tools including Grey Infrastructure Update, New Infrastructure Building and LID. Chicago uses LID. Portland uses LID and Building Design. Miami employs Building Strengthen. NYC uses 4 kinds of technology tools including Grey Infrastructure Update, New Infrastructure Building, LID and Projected Flood Maps that incorporate sea level rise. LA uses 4 technology tools including Stormwater Infiltration, LID, Grey Infrastructure Update and Stormwater Recycle.

Natural

All of the LCAPs consider natural methods for stormwater management and flooding adaptation. King County, Chicago, Portland and NYC use Green Infrastructure, Protection and Restoration as natural tools for stormwater management. Miami unitize Water Conservation. LA launches Hazard Park Wetland and Stream Restoration Project, North Atwater Creek Restoration

and Water Quality Enhancement Project and Other Restoration and Enhancement Projects as natural flooding adaptation tools.

Law, Regulation and Policy

Law, regulation and policy tools account for a considerable proportion in the LCAPs. King County uses Flood Hazard Management Plan, Modify of Current Policies, Zoning, Building Codes, Propaganda, Flood Maps, Conduct Research and Tax Policy, Regional Flood Zoning Districts, Modify of Current Laws and Regulations. Chicago uses Metropolitan Water Reclamation District, Watershed Plan, Green Urban Design, Green Alley Program, Green Steering Committee and Share the information with community and Landscape Ordinance. Portland uses Building Codes to guide the building construction better adapt to flooding. Miami use s Land Use Planning. NYC employs Building Codes, Design Codes, Zoning Resolution, Waterfront Revitalization Program, Update Flood Insurance Rate Maps, Flood Insurance and Flash Flood Emergency Plan, updating Local Laws and Zoning Regulations. LA uses Hazard Park Wetland and Stream Restoration Project, North Atwater Creek Restoration and Water Quality Enhancement Project, Other Restoration and Enhancement Projects, Proposition O and Regulation Updating as law, regulation and policy tools.

Table 4-1. Times of appearance of flooding in LCAPs.

City(County)	Times of appearances of the flooding issue	Times of appearance in each section	
King County, WA	57	Awareness	7
		Analysis	31
		Action	19

Table 4-1. Continued

City(county)	Times of appearances of the flooding issue	Times of appearance in each section	
Chicago, IL	7	Awareness	2
		Analysis	0
		Action	5
Portland, OR	9	Awareness	4
		Analysis	1
		Action	4
Miami, FL	5	Awareness	1
		Analysis	2
		Action	2
New York City, NY	16	Awareness	4
		Analysis	2
		Action	12

Table 4-2. Vulnerability- risk matrix for identifying priority areas.

	Low vulnerability	High vulnerability
High risk	*May be* priority planning areas	*Should be* priority planning areas
Low risk	*Are unlikely to be* priority planning areas	*May be* priority planning areas

Table 4-3. Flooding Adaptation Actions In The King County's LCAP

Planning area	Goal	Action
Stormwater and floodwater management	Increase capacity to manage stormwater	Increase capacity of stormwater collection systems to accommodate projected changes in precipitation.
		Modify urban landscaping requirements to reduce stormwater runoff.
		Preserve ecological buffers.
	Reduce property damage caused by stormwater and flooding.	Move or abandon buildings in flooding hazardous areas.
		Change zoning to discourage development in flood hazard areas.
		Updating building codes to require more flood resistant structures in floodplains.
	Improve information used to manage stormwater and flooding.	Increase the use of climate and weather information in managing stormwater/ flood risk and individual events.
		Update flood maps to reflect changing risk associated with climate change.

Table 4-3. Continued

Planning area	Goal	Action
Coastal ecosystem	Reduce property damage from erosion, flooding and sea level rise.	Conducting research to find out how stormwater and flooding will affect your community.
	Reduce property damage from erosion, flooding and sea level rise.	Reduce development in coastal hazardous areas.

Table 4-4. The flooding adaptation actions in PlaNYC

Planning area	General action	Specific action
Waterways	Grey infrastructure upgrades	Expand the sewer network: Complete 60 miles of new or rehabilitated sewers. Optimize the existing sewer system: Inspect all tide gates in the city and repair as needed, Complete Alley Creek CSO Facility, Clean 138 miles of interceptor sewers.
	Green Infrastructure	Expand the Bluebelt program: Expand Bluebelt system into Queens. Build public green infrastructure projects: Complete 30 green infrastructure pilot projects, collect monitoring data, and publish findings, Capture the first inch of runoff from 70 additional acres of impervious surface. Engage and enlist community stakeholders in sustainable stormwater management: Implement a green infrastructure grant program, Seek input through the Green Infrastructure citizens group. Modify codes to increase the capture of stormwater: Require greater on-site detention and infiltration for new development and redevelopment, Require greater stormwater runoff controls from construction sites, Study potential code changes to incorporate blue roofs on existing buildings, Develop new design standards for sidewalks, Study improved regulation of open industrial uses to reduce runoff.

Table 4-4. Continued

Planning area	General action	Specific action
Waterways	Green Infrastructure	Provide incentives for green infrastructure: Evaluate the feasibility of using price signals to reduce stormwater runoff, Evaluate the efficacy of the green roof tax abatement. Enhance wetlands protection. Restore and create wetlands. Improve wetlands mitigation.
Water supply	Ensure the quality of drinking water	Continue the Watershed Protection Program. Complete the Croton Water Filtration Plant.
Climate change	Increase the resilience of the city's built and natural environment	Update regulations to increase the resilience of buildings: Conduct study of the urban design implications of enhanced flood protection for buildings, Pursue amendments to freeboard requirements to require freeboard for wider range of buildings to account for climate change projections, Incorporate consideration of climate change within the policies of the City's Waterfront Revitalization Program (WRP), Launch study of effects of rising water tables, inland flooding, wind, and extreme heat events on buildings. Work with the insurance industry to develop strategies to encourage the use of flood protections in buildings : Explore measures to promote flood protection in areas that may be subject to flooding based on climate forecasts.
	Protect public health from the effects of climate change	Enhance our understanding of the flooding' s impacts of climate change on public health.
	Increase city's preparedness for extreme climate events	Integrate climate change projections into emergency management and preparedness.

Table 4-5. The comparison of the appearance of flooding adaptation tools in LCAPs.

City(county)	Awareness	Analysis	Action
King County, WA	Moderate	Sufficient	Sufficient
Chicago, IL	Insufficient	Missing	Moderate
Portland, OR	Moderate	Insufficient	Moderate
Miami, FL	Insufficient	Insufficient	Insufficient
New York City, NY	Moderate	Insufficient	Sufficient
Los Angeles, CA	Missing	Missing	Sufficient

Note: Sufficient: >10 times; Moderate: 4-10 times; Insufficient: 1-4 times; Missing: 0 time.

Table 4-6. The flooding adaptation actions in LA's LCAP.

Planning area	Goal	Actions
Water	Enhance stormwater capture	Retrofit the Big Tujunga Dam to enhance flood protection measures. Tujunga Spreading Grounds Enhancement Project: proposes to deepen the spreading basins, increase the storage capacity.
Water	Enhance stormwater capture	Pacoima Spreading Grounds Enhancement Project: This project proposes to deepen the spreading basins, increase their storage capacity. Development of additional projects.
Open space and greening		Identify and develop promising locations for stormwater infiltration to recharge groundwater aquifers. Revitalize the Los Angeles River to create open space opportunities. along the 32-mile corridor within the City of Los Angeles. Plant 1 million trees throughout Los Angeles. Identify opportunities to “daylight" streams: Hazard Park Wetland and Stream Restoration Project, North Atwater Creek Restoration and Water Quality Enhancement Project, Other Restoration and Enhancement Projects. Proposition O: fund stormwater projects
Policy and procedures		Leasing Policy and Procedures.
building		Green roofs.

Table 4-7. The influencing factors of the LCAPs in the selected cities(county).

Influencing factors		King County, WA	Chicago, IL	Portland, OR	Miami, FL	New York City, NY	Los Angeles, CA
Climate risk factors	Coastal distance	Coastal county	Inland city	Inland city	Coastal city	Coastal city	Coastal city
	Proximity with a lake	Yes	Yes	No	No	No	No
	Precipitation amount(inches per year in 2000)	104.3	36.3	37.07	55.9	49.69	15.14

Table 4-7. Continued

Influencing factors		King County, WA	Chicago, IL	Port-land, OR	Mi-ami, FL	New York City, NY	Los An-geles, CA
Climate risk fac-tors	Population density(people per square mile)	908	11,864.4	4,288.4	12,139	27,532	8,092.3
	Year of the most recent significant flood event	2009	2011	2011	2005	2011	2010
	Property in the flood plain	8,000 par-cels	-	-	79 parcels	993 par-cels	-
Capacity factors	Popula-tion(million)	1.93	2.7	0.58	0.40	8.17	3.8
	Area(square miles)	2,134	234.0	145.4	55.27	468.9	502.693
	Political will	CPC/MPCA	CPC/MCPA	CPC/MCPA	CPC/MCPA	CPC/MCPA	CPC/MCPA
	Wealth	$66,035	$42,724	$40146	$33,814	$188,697(wealthiest), $9,320(poorest)	$36687
	Age of plan	4	3	2	3	4	4

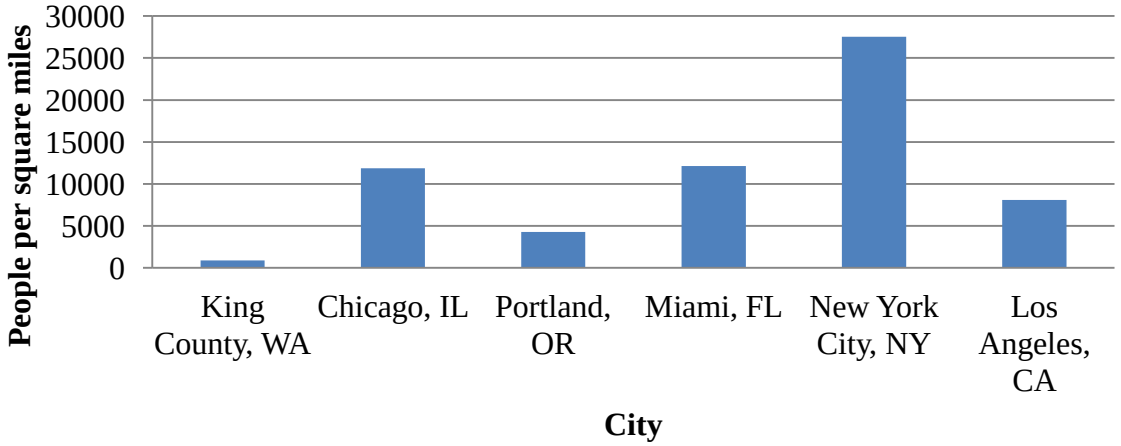

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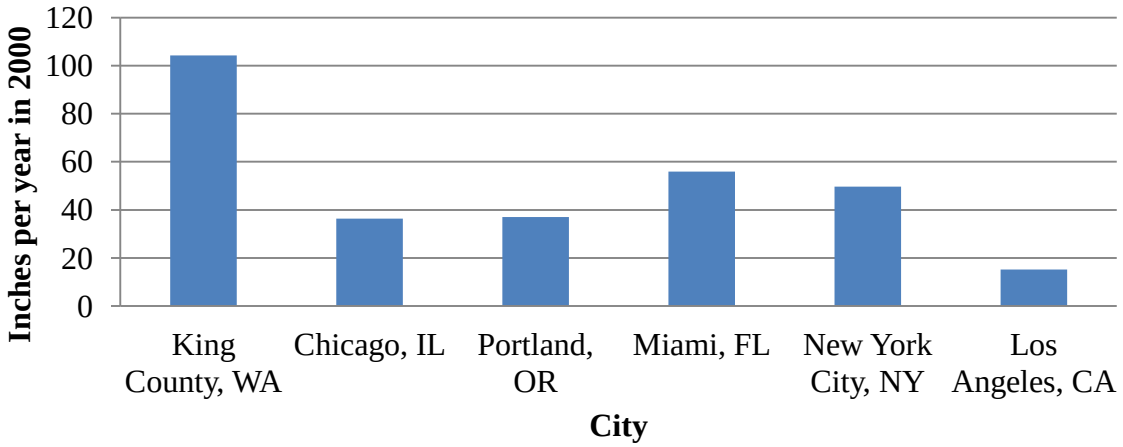
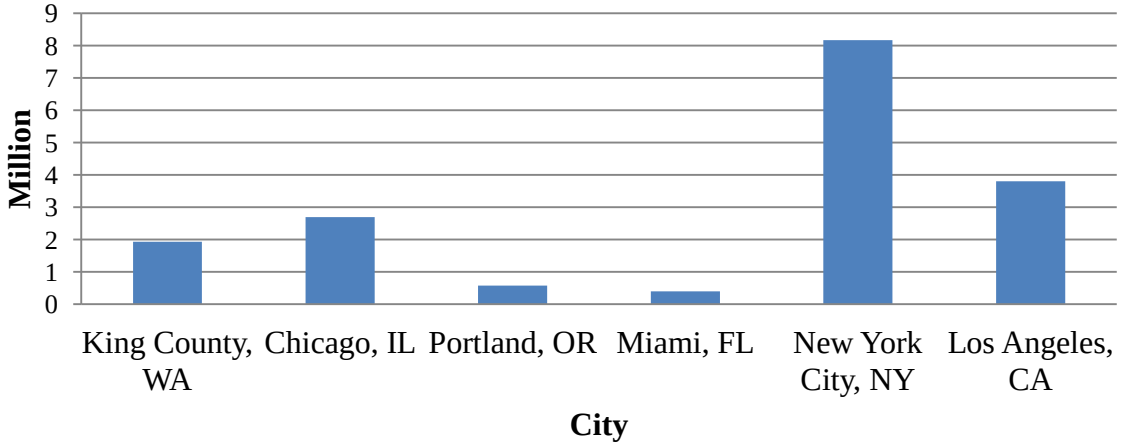
Figure 4-1. Conditions in different cities(county). A) Population density. B) Annual precipitation amount. C) Population. D) Areas. E) Age of plan. (Source: Yun C, 2011).





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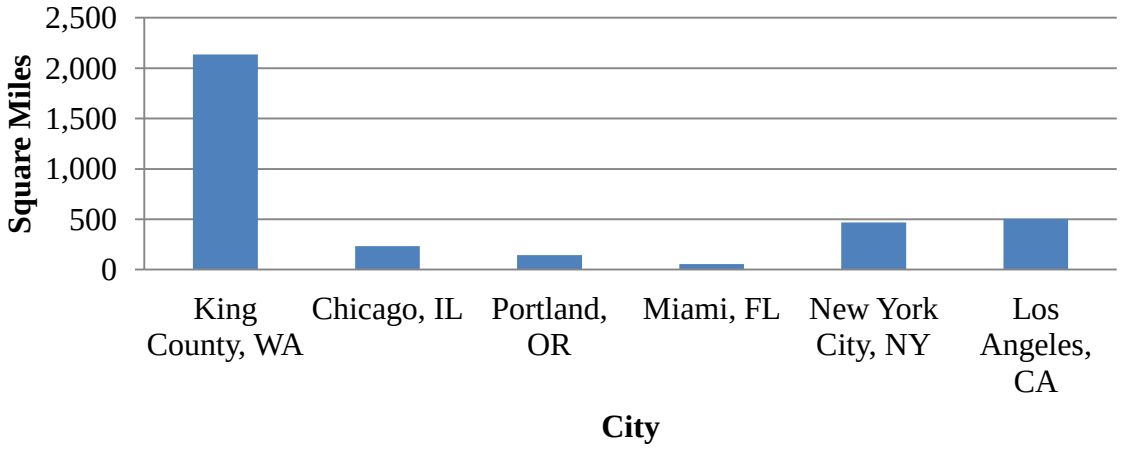

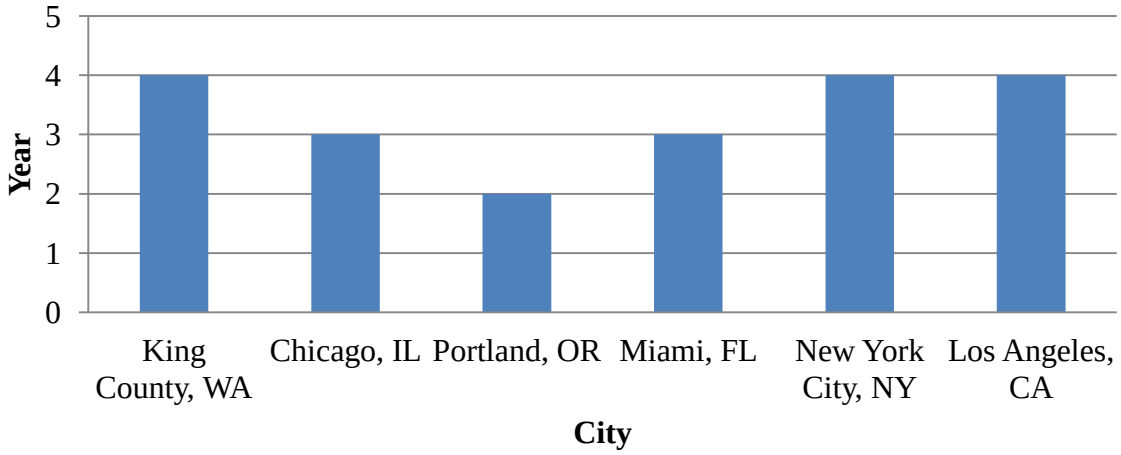

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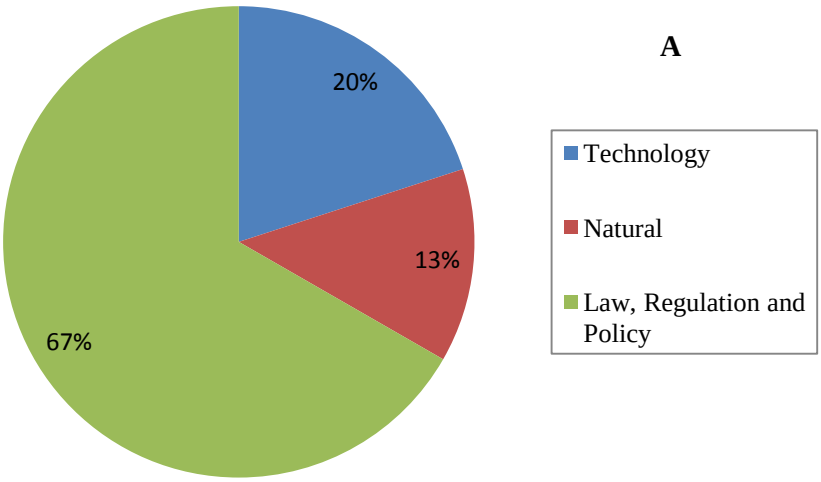


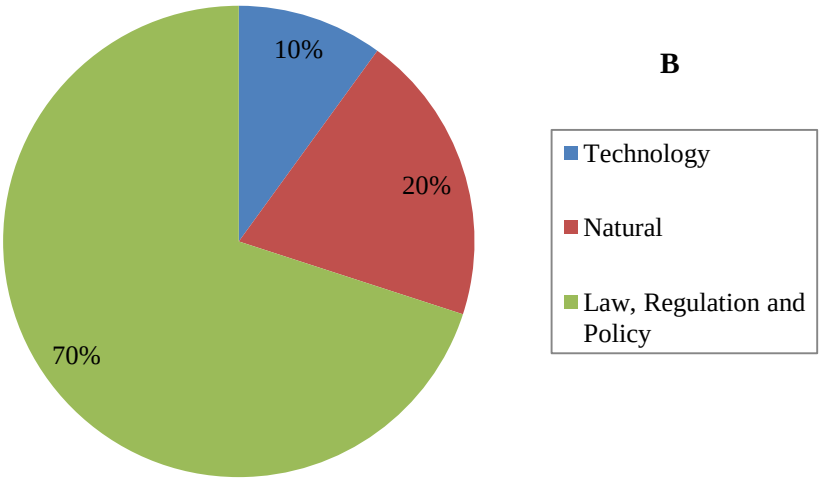
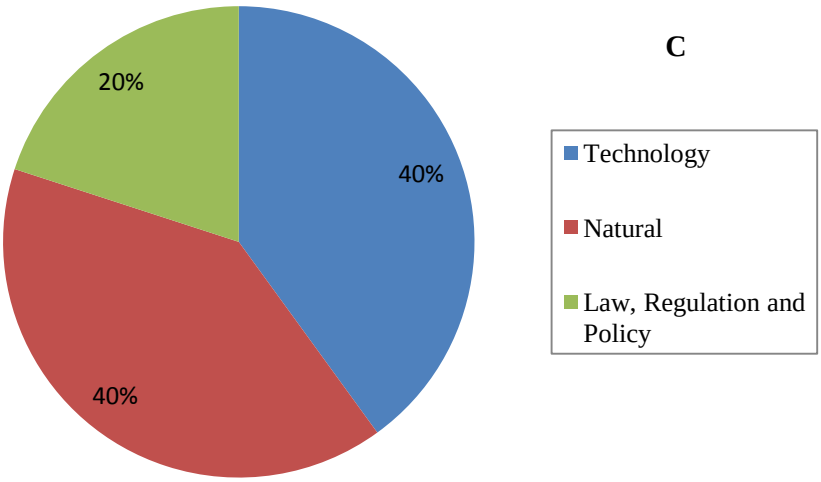
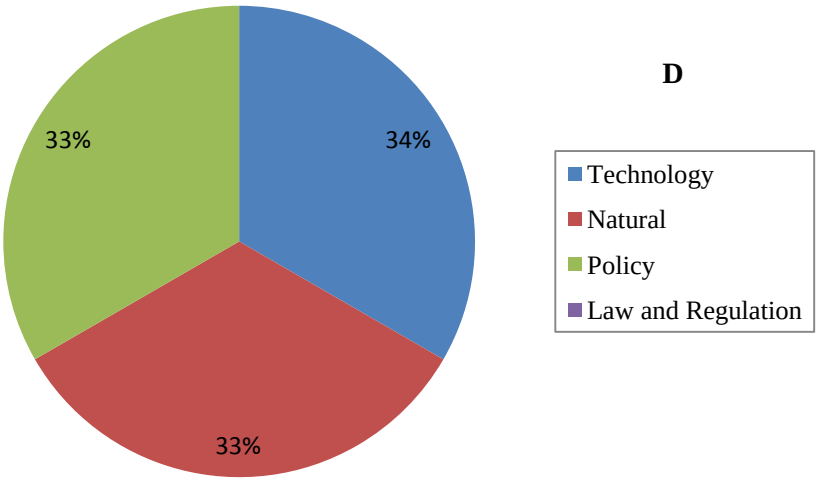


Figure 4-2. The composition of flooding adaptation tools in selected cities(county). A) King County, CA. B) Chicago, IL. C) Portland, OR. D) Miami, FL. E) NYC, NY. F) LA, CA. (Source: Yun C, 2011).





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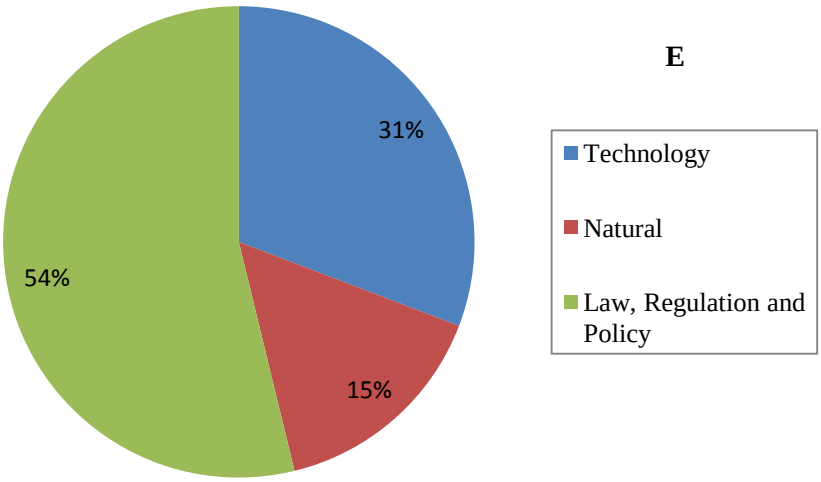

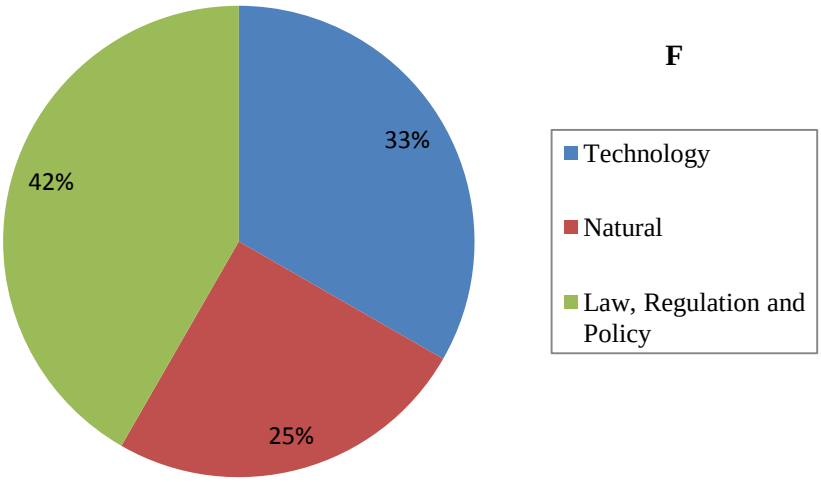

Figure 4-2. Continued

Table 4-8. The name and characteristics of the tools in the LCAP.

City(county)	Characteristic of tools	Name of the tools	Number
King County, WA	Technology	Grey infrastructure update, New infrastructure building, LID.	3
	Natural	Green Infrastructure, Protection and restoration.	2
	Law, regulation and policy	Flood Hazard Management Plan, Modify of current policies, Propaganda, Flood Maps, Conduct research, Tax policy. Regional Flood Zoning Districts, Modify of current laws and regulations, Zoning, Building Codes	10
Chicago, IL	Technology	LID.	1
	Natural	Green Infrastructure, Protection and restoration.	2
	Law, regulation and policy	Metropolitan Water Reclamation District, Watershed plan, Green Urban Design, Green Alley program, Green steering, committee, Share the information. Landscape Ordinance.	7
Portland, OR	Technology	LID, Building design.	2
	Natural	Green Infrastructure, Protection and restoration.	2
	Law, regulation and policy	Building Codes.	1
Miami, FL	Technology	Building strengthen.	1
	Natural	Water conservation.	1
	Law, regulation and policy	Land Use Planning.	1
New York City, NY	Technology	Grey infrastructure update, New infrastructure building, LID, Projected flood maps that incorporate projected sea level rise.	4
	Natural	Green Infrastructure, Protection and restoration.	2
	Law, regulation and policy	Waterfront revitalization program, Update Flood Insurance Rate Maps, Flood Insurance, Flash Flood Emergency plan, Update local Laws and Zoning regulations, Building Codes, Design Codes.	7

Table 4-8. Continued

City(county)	Characteristic of tools	Name of the tools	Number
Los Angeles, CA	Technology	Stormwater infiltration, LID, Grey infrastructure update, Stormwater recycle.	4
	Natural	Hazard Park Wetland and Stream Restoration project, North Atwater Creek restoration and water quality enhancement project, Other restoration and enhancement projects.	3
	Law, regulation and policy	LA County Flood Control District, Stormwater capture projects, Land Use Planning, Proposition O, Regulation update.	5

Table 4-9. The numbers of flood adaptation tools of different characteristics.

City(County)	Technology	Natural	Law, regulation and policy	Total
King County, WA	3	2	10	15
Chicago, IL	1	2	7	10
Portland, OR	2	2	1	5
Miami, FL	1	1	1	3
New York City, NY	4	2	7	13
Los Angeles, CA	4	3	5	12
Total	15	12	31	58
Percentage	25.9%	20.7%	53.4%	100%

CHAPTER 5

ANALYSIS AND DISCUSSION

Case Study Synthesis

The Appearance of Flooding Adaptation Tools and How Do The Influencing Factors Influence The Flooding Adaptation Tools

Flooding is a significant threat to the city's safety and prosperity. Addressing the flooding problem is considered a priority in the city's agenda. Local Climate Action Plans frequently feature flooding issues, signifying the great relevance of this important topic in public discourse. There are several reasons for this emphasis. Firstly, all of the selected cities(county) are facing perhaps eminent flooding problems, although precipitation amounts and variation patterns due to climate change are different in the selected cities(country), and flooding can be the motivation for the creation of the LCAPs. For example, Chicago, Portland and NYC will experience more precipitation and more severe rainstorms. King County will experience a very small increase in precipitation; the patterns' change is still unclear. Miami's precipitation change is also unclear in the LCAP, too. LA will experience more drought. However, all these cities are threatened by flooding caused not only by the increase in rainfalls, but also by the rise in sea level and extreme rains.

Secondly, flooding adaptation strategies is a kind of "No Regret" strategy. That is to say, all the cities(county) are located by the side of sea, rivers and lakes, this increased the risk of river flooding and sea flooding even the climate change doesn't bring more flooding. Whether the precipitation change or not, flooding adaptation strategies will bring benefits to the city.

Thirdly, the occurrence of more hurricanes and storms have aroused the attention among both governments and individuals. It is obvious that the prospect of flooding is quite probable and needs to be addressed.

The awareness of flooding is well showcased in the LCAPs. All of the LCAPs, except LA, mentioned flooding in the awareness section. Among them, King County's LCAP mentioned flooding 7 times. The LCAPs usually state flooding as one of climate change's impacts, then depicts the impacts on different systems and sectors. After that, they often suggest that adaptation strategies are merely important, but critical. The frequent appearances in the this section also suggests that flooding looms prominently in the minds of policy makers..

The analysis of flooding is still insufficiently covered within the LCAPs. Most of the LCAPs lack the analysis of these issues, such as impacts, the city's systems' vulnerability to flooding, the risk analysis and the priority analysis. Among the selected LCAPs, only the King County's LCAP conducts sufficient analysis. Portland, Miami and NYC's LCAPs reveal inadequate analyses. In fact, Chicago and LA's LCAPs do not contain a flooding analysis at all. This is probably because King County 's LCAP is a guidance manual for the cities among the cities; it needs to provide a analysis model. Some of the LCAPs do not conduct their own analysis, but refer to IPCC's reports or other scholars' research outcomes, which is also appropriate. In conclusion, analysis in LCAPs needs to be strengthened to provide more of a basis for preventative and adaptive actions.

The actions of flooding adaptation strategies are well developed in the LCAPs. All of these create a series of actions relating to flooding. The King County, NYC and LA's LCAPs contains the most actions among the selected cities. Portland and Miami generate comparatively less initiative. The range of actions is broad and can be categorized into 3 groups: 1) increase the

capacity of stormwater management, 2) reduce the damage caused by flooding, 3) improve the information about flooding.

Many adaptation strategies are not the result of policy innovation. They are often based on current systems and infrastructures, for example, using vacant land to manage stormwater, expanding current sewage systems, etc. Some of the actions have been formed into projects or programs, which are most utilized in NYC, LA and Chicago. Many LCAPs set goals and timelines for these actions, and this will facilitate the implementation of these actions and make them easier to assess. Most flooding adaptation tools already exist in former sustainability planning such as LID and Green Infrastructure. But they may be locally innovative. That is to say, these measures are first introduced and implemented at the local level.

Most of the actions are concrete, easily implemented and cost effective. The actions in different LCAPs are very diverse and have no standard forms. This is probably due to the different political environments prevailing in these different cities.

How Do Climate Risk Variables Factors Influence The Flooding Adaptation Tools

This study found that a coastal city or a city near lakes will probably employ more flooding adaptation tools. If a city is both a coastal city and near a lake, it seems reasonable to adopt more flooding adaptation tools, such as King County has done. These cities may has relatively plenty of flooding tools, such as Chicago, NYC and LA. If a city is situated inland and is not near a lake, it seems to have less flooding adaptation tools, Portland, for example. This is probably because those cities are facing more flooding risk. And the proximity with a lake or a sea can awaken the awareness of flooding among city leaders and citizens.

This study found that flooding is not necessarily associated with precipitation amount, but actually more closely connected with the increased frequency and intensity of extreme

rainstorms. Sea level rise is another cause of flooding. So a city with lower annual precipitation amounts may adopt flooding adaptation tools in its LCAP. For example, L.A has the least annual precipitation amounts among the select cities. However, it still adopted flooding adaptation tools in its LCAP.

Another finding of this study is that population density can increase the climate risk of a city, largely because climate hazards at the same level will affect more people and property. But the relationship of the flooding adaptation tools with population density cannot be identified by this study.

One of the major findings of the study is that a city like Miami, which is likely to experience significant flooding, seems to be the least concerned with this prospect in its LCAP. Although Miami has 79 parcels out of its total 185 parcels in the flood zone. This is probably because Miami did not place flooding as a high priority. The most recent significant flooding event in Miami is in 2005. Then, during the following 6 years, it did not experience severe flooding. This may reduce the sense of emergency to address flooding. Moreover, the Miplan focused on creating the GHG emission inventory, set reduction goals and creating implementation strategies. It spared only one page for adaptation strategies. The lack of flooding adaptation tools in the LCAP did not entail that Miami is without adaptation strategies. Miami-Dade County has other plans and strategies dealing with flooding, such as updating Flood Zone Maps, providing elevation certificates, flood insurance and so forth. Actually, Miami- Dade county has a noticeable flood addressing history. After Hurricane Irene struck in 1999, the Miami-Dade County Flood Management Task Force was created, along with other regional strategies. Immediately following the October floods in 2000, the state formed the Governor's South Florida Flood Management Working Group to advance the implementation of flood

mitigation and adaptation strategies. However, the Miplan did not include these strategies. It is possible that because the city already had such plans and strategies, the LCAP did not focus on it repeatedly.

This study also found that there are other plans which can deal with flooding, not only LCAPs, for example, the flooding hazard management plan, the comprehensive land use plan, etc. The LCAP often extracts the flooding adaptation elements of those plans, or occasionally serves as the motivation for the creation of those plans.

The study also found that King County employs the most flooding adaptation tools; more, in fact, than the other cities. This may suggest that a regional level LCAP is more comprehensive and contain more content than their city level counterparts. The regional level should guide the creation of the city level's LCAPs.

How Do Capacity Risk Factors Influence The Flooding Adaptation Tools

This study found that the population amount seems to affect the flooding adaptation tools. Generally speaking, a city with a higher population amount are inclined to adopt more flooding adaptation tools. NYC is the most populous among the selected cities. Correspondingly, it contains more flooding adaptation tools. LA and Chicago are less populated, so their LCAPs contain only a moderate amount of flooding adaptation tools. Portland and Miami have smaller population s, their LCAPs contain less flooding adaptation tools, too. The only exception is King County. Its population is a little smaller than Chicago's, but it employs the most flooding adaptation tools.

The area of a city seems to influence its LCAP, too. King County has the vastesty territory among the selected cities. Its LCAP also contains the most flooding adaptation tools. LA and the NYC are the second biggest among the selected cities; accordingly, their LCAPs contain the

second most flooding adaptation tools. Chicago's area is smaller than LA and NYC, so it contains less flooding adaptation tools than either LA and NYC. Portland is the fifth big city, thus, the number of its flooding adaptation tools is the second smallest. Miami is the smallest among the selected cities, and, therefore, it adopts the least flooding adaptation tools. But this study is too limited to draw conclusions on the relationship between the area factor and the tools. The variation of the tools may be linked to other influencing factors.

Political will is a feature of the making of LCAP. CPC can motivate the cities to create their LCAPs and provide information, funds and technology support to them. MCPA can also provide support for cities to create LCAPs. But the political will doesn't seem to have correlation with the content of the LCAPs. All the selected cities(county) have participated in both the CPC and MCPA. This has no relationship with the content of their LCAPs.

The wealth of a city seems to influence its LCAP. King County and NYC are the richest areas among the selected cities(county). They employ the most flooding adaptation tools in their LCAPs. Chicago and LA are the second richest cities among the selected cities, and they use less flood adaptation tools than either of the former. Portland and Miami are the least richest cities among the selected cities. The flooding adaptation tools in their LCAPs are likewise the least. This is probably because wealthier cities can provide more funds to launch the adaptation actions, organize the creation of planning and implement adaptation strategies.

The result of this study suggests that the capacity factors impact the composition of LCAPs, too. The area(county) with a higher capacity, such as King County and NYC, employ more laws, regulations and policy tools. King County, NYC, and Chicago use a greater proportion of such tools. Portland and Miami use comparatively less of these tools. This is probably because city governments with a higher capacity occupy more political resources to

create and implement these tools. Chicago, NYC and LA also have a stronger urban planning basis; this may also influence the LCAPs' quality and content.

The Characteristics Of Flooding Adaptation Tools

This study found that all the cities utilize technological tools to adapt to flooding scenarios. Technology flooding adaptation tools are the most commonly used by the LCAPs. That is probably because these tools exhibit high applicability. They can be used in different climate conditions, and are not sensitive to different political environments. Technology tools are also easy to implement and very replicable. Many of these tools are not the result of innovation but already exist, indicating that are likely mature and reliable. The wide acceptance of technological tools suggests that they have been tested as an effective way to address flooding.

This study found that in terms of flooding adaptation, local governments not only consider man made environment only, but they also pay attention to the natural environment. Natural tools are well accepted by the LCAPs; these tools are utilized by all the selected LCAPs, which suggests that the concept of environmental protection is highly accepted by the cities(county). Natural systems' flooding adaptation function is well understand by these local governments. Natural tools are widely accepted probably because of several reasons. Firstly, they are suitable for any city, despite their climate condition, natural environment and political environment. Secondly, natural tools can have many co- benefits. For example, the existence of parks and gardens in the city can mitigate the GHG concentration, cooling down the temperature, providing recreational spaces for citizens and beautifying the city. Thirdly, natural tools are welcomed by all the cities(county) because they are easy to implement; they usually have foundations in former conservation or sustainability planning. Fourth, natural tools do not have any negative impacts. Updating grey infrastructure may exert negative impacts on natural environments and

undermine the ecosystem; furthermore, they may bring about other hazard themselves. Relying on traditional methods rather than innovation, natural tools adopted by different cities(county) are overall quite familiar and uncontroversial. Most use green infrastructure and conservation methods.

One of the major findings of this study is that the law, regulation and policy tools play significant roles in flooding adaptation. They compose 53.40% of the total amount of tools. In NYC, its proportion exceeds 53.8%. In King County and Chicago, this proportion is 66.7% and 70% respectively. Miami and LA also features 33.3% and 41.7% of policy tools. The figure for Portland is20%. The law, regulation and policy tools are very diverse including:1) Traditional urban planning tools, such as Land Use Planning, Urban Design and Watershed Plan. 2) Other types of plans, such as the Flood Hazard Management Plan, the Water Front Revitalization Program and Flood Emergency Plan. 3) Financial incentives such as insurance and tax policy. 4) FIRMs and Flood Maps. 5) Propaganda. 6) Researches; 7) Building Codes; 8) Zoning; 9) Relevant laws and regulations. The adoption of these tools are not uniform among the selected cities(county). There are no standard forms. King County and Chicago use the most law, regulation and policy tools , including traditional planning tools, financial incentives and building or design codes. Miami uses only land use planning, probably because of the different climate risk, the political environments and the city's capacity, which I will discuss in the next few paragraphs.

This study indicated that there are strong linkages between flooding adaptation and urban planning or building design. Among all of these tools, the Land Use Planning, Watershed Planning, Building Codes and Urban Design Codes are the most common used kinds. Flooding adaptation and land use planning are interlinked together. Urban planning and urban design

codes can help prevent flooding by avoiding development in the flood risk areas. Watershed plans can help to better manage the flood prone areas. Building codes can encourage the construction of flood proofing buildings. This further suggests that urban planners should take responsibility to manage stormwater and adapt to flooding. Financial incentives are also useful to help risk management. These financial tools work by promoting flood resistant building designs and providing funds for flooding adaptation programs. FIRMs and other kinds of flood maps can provide technology support for flooding adaptation planning. Propaganda can create awareness among citizens and gather support for the planning. All of these suggest that flooding adaptation processes should engage urban planners who play a central role in this planning area.

This study found that law, regulation and policy tools can be the motivation for the creation of flooding adaptation strategies. It authorizes the local governments and property owners the right to take flooding adaptation actions and retrofit their houses. Usually the cities(county) update their current laws and regulations to require the protection of wetlands and regulate urban planning and design. The most widely used law and regulation tools are design codes and building codes, which integrate climate change into their consideration by avoiding development in the flooding risk areas and promoting building design that can make buildings better withstand flooding. Chicago uses Landscape Ordinance to require accommodating more plants that can tolerate climate change. These laws and regulations are also connected with urban planning; these tools are not innovative but a modification of traditional laws and regulations.

The popularity of law, regulation and policy tools is probably because the LCAP was created under the organization of local governments, who have a good grasp of these tools. Although these tools do not address flooding directly, they are necessary because they can provide incentives for technological and natural tools and facilitate their implementation.

The findings of this study indentified the necessity of collaboration among different kinds of tools. If we want to transfer flooding adaptation from strategies into practice, we can not simply use one variety of tools, but should employ the three categories of tools together.

This study also found that there are not many innovations among the LCAPs. Most of the adaptation strategies in the LCAP consist of traditional urban planning, or water conservation strategies, or building techniques, or they are at least based on existing programs. However, these tools may be first introduced to the localities, probably because LCAP is not as concerned with creating innovative strategies as utilizing already existing strategies. LCAPs predominantly focus on the design of objectives and multi-step actions to achieve those objectives, not on the strategies.

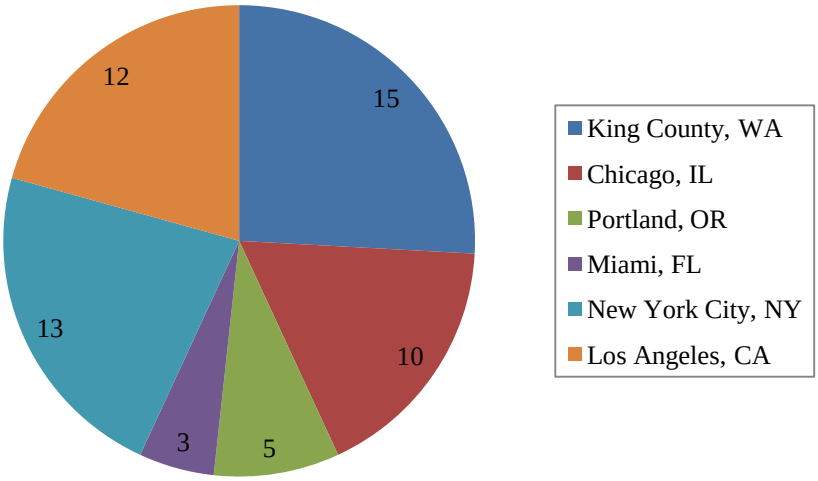

Figure 5-1. Numbers of flooding adaptation tools in each LCAP and their percentages. (Source: By Yun C, 2011)

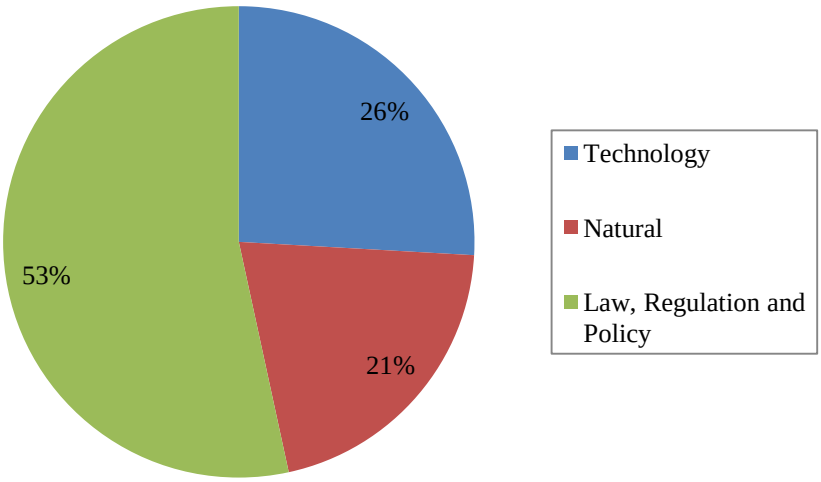

Figure 5-2. Numbers of flooding adaptation tools in each LCAP and their percentages. (Source: © By Yun C)

CHAPTER 6

CONCLUSIONS

Global warming and climate change is attested by convincing scientific evidence and have already altered urban areas. Growing awareness of this issue prompts local governments to adopt measures to address it. Recently, many US local cities have begun to create Local Climate Action Plans containing climate change mitigation and adaptation strategies. Rising sea levels, urban heat island effects and flooding are, thus far, the most significant changes exerted on urban areas. Consequentially, flooding adaptation is a significant part of the LCAPs.

The case study confirmed that flooding issues have received significant attention in the LCAPs, where the prospect appears frequently. Present in all the awareness, analysis and action sections, flooding issues are sufficiently introduced in the first section in the LCAPs. The flooding adaptation actions are well developed in the action sections. However, the analysis of flood occurrence, impacts, risk and priority is the Achilles' heal of the LCAPs; a weak link that could conceivably undermine the strength of the whole.

Flooding adaptation tools in the LCAPs are diverse and do not have a standard form. But they can be categorized into several kinds. According to their characteristics, they can be categorized into the following: technological, natural, law, regulation and policy. According to function, they can be categorized into capacity increasing and damage reducing. All of the cities employ more than one category of flooding adaptation tools. The relative sectors include urban planning sector, financial sector, building design sector, transportation sector and environmental sector. Accordingly, flooding management can only be achieved through the collaboration and communication between different sectors and stakeholders. The case study also finds that flooding adaptation tools are not innovations, but have already existed; they comprise methods in

sustainability planning, traditional stormwater management methods, financial tools, or are a modified edition of traditional planning tools. Moreover, flooding adaptation tools have an intimate association with urban planning, whose practitioners should responsibly play central roles in the flooding management process. The study also found that there are other kinds of plans such as zoning, land use plans, floodplain management plans, stormwater management, and hazard mitigation plans aiming to address flooding scenarios. The LCAP might be more accurately described as a framework of those plans.

The climate change risk variables include coastal distance, the proximity with lakes, annual precipitation and population density. The analysis of the case study indicates that the coastal distance and proximity with lakes can affect the adoption of flooding adaptation tools in the LCAPs, while the precipitation amounts do not seem to correlate with the use of flooding adaptation tools in the LCAPs. Population density can increase the climate risk of a city, however, it doesn't seem to affect flooding adaptation tools very much.

The capacity variables include population, area, political will and wealth. The analysis of the case study suggests that population seems to affect the LCAP's quality significantly. The area of a city and the quality of flooding adaptation tools have a positive correlation. Political will is important to promote the formation of LCAP because it provides needed leadership. The wealth of a city enriches the LCAPs, probably because wealthier cities can provide more funds to launch adaptation actions, organize planning and implement adaptation strategies. In addition, the capacity variables affect the composition of the LCAPs, too. The cities with higher capacities use more varieties of flooding adaptation tools and more policy tools.

In summation, flooding is an extremely important issue and will likely be exacerbated by climate change. Flooding has been considered in the LCAP, and the appropriate adaptation tools

are quite diverse among the different LCAPs. The use of flooding adaptation tools varies due to the different conditions of different cities(county).

Limitations of Research

All researches, particularly those at the Masters level, have many limitations. This research has plenty of limitations; the following are the most important limitations: First, the sample size was limited. The research only selected six cities(county) as research samples. This decreases the confidence of analysis outcomes. Further, there is only one county in the samples, which weakens the comparative study between the regional level CAPs and the local level CAPs.

Second, the research lacked quantitative analysis. Lacking statistical analysis is one of the greatest limitation of this research. It likewise weakens the confidence of the analysis outcomes. Without statistical analysis, it is difficult to identify how independent variables influence the dependent variables. We do not even attempt to mention the magnitudes of the influences.

Third, the research did not evaluate the relationship among the flooding adaptation tools. Because of the short time period of the research, it did not probe into every tool and identify the relationship.

Fourth, the research did not evaluate the implementation and effectiveness of the tools. The research has not evaluated the implementation of the actions and strategies. And because the selected LCAPs were created only 4-5 ago, it is too early to fathom the effectiveness of them. In consequence, this research cannot provide a reliable reference for tool adoption in future LCAPs.

Fifth, the study didn't examine the different strategies addressing river flooding, urban flooding and sea flooding. The adaptation strategies of sea level rise and urban flooding may be different.

Finally, the study focused only on the LCAPs and didn't divert attention to other plans relevant to flooding. Ultimately, this study cannot arrive at an integrated view on how local governments address flooding; indeed, we cannot tell the differences and relationships between LCAPs and other plans.

Recommendations for Future Study

The recommendations for the future study of flooding adaptation tools in the LCAPs are closely associated with the limitations of this study. First, the research could be expanded to encompass more cities across states and counties. A sample including more cities and counties of variable sizes, climate features and locations may provide a clearer vision of the use of flooding adaptation tools. Comparisons between flooding adaptation tools on both the regional and local level can be informative case studies.

This study also requires further statistical analysis to identify the relationship between independent variables and dependent variables. Further analysis can calculate the magnitude of the influences that independent variables exert on dependent variables. This will make the correlations between the two clearer.

Further, this study has raised a question on how to categorize flooding adaptation tools. Is it necessary to create standard forms for these tools to be better utilized? Or we should use diverse tools depending on the local condition? Further research may successfully answer this question.

Third, future research should study the implementation and effectiveness of flooding adaptation tools. This may provide an optimization of flood adaptation tools and provide strong support for their enhancement in the future LCAPs.

Fourth, a future study can analyze the different strategies coping with river flooding, urban flooding and sea level rise respectively in-depth. The strategies used in the LCAPs to address the three kinds of floodings are different.

Finally, research is needed on the entire picture of different city plans to address flooding; and the relationship between LCAP and other plans must be explored. Ideally, we should clarify the different functions of these plans, enhance the strength of each plan and avoid the duplicated work in order to save the governments' limited resources.

In the end, a more profound understanding of this issue can only better enhance future flood adaptation strategies in the LCAP. The LCAP should conduct more analysis on flooding' s overall impact on urban systems, conduct vulnerability analysis, capacity analysis, risk analysis and priority analysis concerning flooding issues. Future LCAP should also use more systematic flooding adaptation tools in order to gain a synergistic effect.

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BIOGRAPHICAL SKETCH

Cao Yun graduated with honors from Huazhong University of Science and Technology(HUST) in 2009 with a Bachelor of Urban Planning. She then enrolled the Graduate School of College of Architecture and Urban Planning, HUST, majoring in urban planning. She graduated in December 2011 from the University of Florida with a Master of Science in architectural studies with a concentration in sustainable design. And, she will graduate from HUST in March 2012 to get a graduate degree in urban planning. Cao Yun currently resides in Gainesville, Florida and spends most of her time studying, reading and playing with friends.