AN INVESTIGATION OF CLIMATE CHANGE GOVERNANCE TRENDS IN THE UNITED STATES: CHALLENGES AND EFFECTIVE DRIVERS

by

Matt Doolin
Zhe Wang
Muxi Yang
Pa Ye
Dr. Elizabeth Albright, Adviser
April 24th, 2015

Masters project submitted in partial fulfillment of the requirements for the Master of Environmental

Management degree in the Nicholas School of the Environment of Duke University

Table of Contents

Executive Summary

Climate change has become one of the most pressing environmental issues for our society. To effectively address climate change, the Intergovernmental Panel on Climate Change (IPCC) highlighted socioeconomic pathways, adaptation/mitigation actions, and governance as the three best ways to reduce emissions and halt the negative impacts from climate change. When studying governance structure, a clear and precise definition of 'climate change governance' is crucial. In this study, 'governance' refers to a range of initiatives, regulations, and government decisions aiming to establish cooperation between governmental and private sector stakeholders in dealing with a particular issue: climate change. Effective governance is achieved through a combination of strategic planning, integrating development decision-making, inter-department cooperation, adequate resources, and societal mobilization and education. This research project is organized into three phases that investigate and evaluate the effectiveness of the current climate change governance structure at different levels of government, identify effective drivers, and provide policy recommendations for improvement.

In phase I, current climate change governance structures were identified using results from an online survey and in-depth interviews. Survey and interview respondents were made up of federal, state, city, and county level government officials leading climate change initiatives. Key trends we identified regarding current governance structures were: 1) very few officials are working on climate change full time; 2) cooperation between departments is key to success and is becoming more common; 3) states and cities have different emission reduction priorities; 4) main challenges include budgetary constraints and organizational structure.

In phase II, utilizing information from the surveys, interviews and past literature research, we identified nine variables that we thought were the most important for effective climate change governance. By conducting factor analysis, these variables were split into three factors: Policy Support and Planning, Policy Development, and Utility Policy. Using the scores for each state and the calculated weights produced from factor analysis, we produced a climate governance effectiveness ranking for all 50 states. Not surprisingly, our results indicate more effective climate governance occurring in states along the West Coast and in the Northeast. Florida had the highest score for policy support and planning, confirming our previous findings that capacity building in the form of developing a well-informed and integrated strategic plan with sound research contributed most to effective climate change governance. Oregon had the highest score for policy development, which reinforces the importance of strong planning and cooperation for effective climate governance.

In phase III, two case studies were conducted on Florida and Oregon to evaluate how they have excelled in each factor and how that has impacted climate change projects in these states. Each state took a different approach and has different concerns regarding climate mitigation vs. adaptation. Florida showed advantages in conducting multi-level strategic planning,

incorporating climate adaption initiatives into the city planning and infrastructure improvement process, establishing multi-disciplinary research institutions for climate change impact and mitigation strategy research, and establishing education programs to promote climate change awareness and support. We specifically analyzed a climate adaptation project in the City of Miami that focused on storm water management due to rising sea levels. This project was based on a detailed impact analysis and had coordination among key departments, including the planning department, to take aggressive action against the expected risks of climate change. For this specific case, the benefits associated with the project relied on key economic factors such as tourism revenue and property values that would be impacted by rising sea levels and a cost-benefit analysis reflects this. Although the capital costs for the project are quite high, they are greatly outweighed by the consequences of inaction.

The Oregon case study focused on a climate mitigation project to install a solar system along an interstate highway to offset CO_2 emissions in the transportation system. In terms of policy development, Oregon utilized an innovative financing strategy to encourage private entities to financially support the project and utilized local companies for design and construction. As a result, the Baldock Solar Highway Project successfully utilized public and private resources and funding through cooperation with other entities, to incorporate CO_2 emission reduction into the ODOT strategic plan. After conducting a cost-benefit analysis on the project, costs appeared to outweigh the benefits. However, this did not account for non-quantifiable benefits such as boosts to the local economy, or the achievement of state policy goals. Finally, this puts Oregon in a good position given the expected shift towards more aggressive renewable energy goals and carbon standards nationwide.

Overall, this project makes several key points and recommendations:

- Identifying the current trends in governance structure and combining this with the governance effectiveness index can help provide states that are not addressing climate change now with the best strategies for future structure and implementation.
- The current major challenges associated with climate change governance in the U.S are inadequate budgetary and human resources, and a low priority placed on climate change
- Organizations are recognizing the importance of inter-department cooperation, and are taking steps towards restructuring and integration. However, more efforts are needed for strategic planning and social mobilization.
- The most effective drivers of climate change governance are policy support and planning and policy development. Therefore, it is most efficient to invest financial and human resources in developing these two areas.
- It is beneficial to devote resources to incorporating climate adaptation initiatives into urban planning and infrastructure improvements, for states with high vulnerability to climate change impacts. Moreover, devoting resources into policy development can help states secure strategic positions when facing aggressive nationwide mitigation standards.

Acknowledgements

This project was client-based and designed to meet the needs of the Association of Climate Change Officers (ACCO). ACCO provided assistance and guidance throughout various stages of the process. The team would like to specifically thank Executive Director Daniel Kreeger and Knowledge Center Program Manager Philip Santiago for all their help and input on the project. The team would also like to thank our Master's Project advisor, Dr. Elizabeth Albright of Duke University, the staff of the SSRI Help Desk, all the government officials who responded to our survey, and the eight respondents who were willing to participate in follow-up interviews.

About ACCO: ACCO, formed in 2008, operates out of Washington D.C. as a non-profit organization. ACCO seeks to enable all organizations to be more sustainable by building enterprise capacity and empowering leaders to respond to climate change threats and increase business competitiveness. ACCO's mission is to "define, develop and support the functions, resources and communities necessary for effective organizational leadership in addressing climate-related risks and opportunities" (ACCO, 2014).

Introduction

Climate change has become one of the most pressing environmental issues for our society. According to the fifth Intergovernmental Panel on Climate Change (IPCC) assessment report, there is unequivocal evidence for the warming of climate system: global temperature has been showing an increasing trend from 1880 to 2012, global mean sea level rose by 0.19 m from 1901 to 2013, precipitation significantly increased in the northern hemisphere since 1901, and it is likely that extreme weather events will occur more frequently (IPCC, 2014). Studies have suggested that anthropogenic activities have resulted in continuous increase in global greenhouse gas (GHG) emissions from 1850 to 2010 (IPCC, 2014). Recognizing the issue, the international community has agreed that keeping the temperature increase below 2° Celsius is vital to prevent irreversible changes to the Earth's climate system under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

Despite the indisputable evidence for the degree of damage and the urgency of the climate change crisis, there have been few effective international and national policies that address climate change mitigation. At the international level, despite continuous efforts under the UNFCCC and Kyoto Protocol, including setting up legally binding mitigation commitments for 42 developed countries (Annex-I) and establishing financial and technological transfer to encourage mitigation for 150 developing countries (non-Annex-I), global emissions still show a continuous increasing trend over the past 10 years. Moreover, the first emission reduction commitments from Annex-I countries under the Kyoto Protocol expired on December 31st, 2012, while the second commitment period will expire at the end of 2020. This means that there will be no official emission reduction plan post 2020 without further efforts. In addition, there are no comprehensive international climate adaptation or loss and damage mechanisms in place to support resiliency building.

At the national level, North America accounts for approximately 20% of worldwide carbon emissions with the majority coming from the United States and Canada (Energy Information Administration, 2013). According to data from the Energy Information Administration (2014), the United States is the second largest producer of carbon dioxide emissions in the world. Yet the US has not passed any comprehensive federal climate change legislation that limits carbon emissions but has goals to reduce total carbon emissions by 17% below 2005 levels by the year 2020 (Executive Office of the President, 2013; Fitzpatrick, 2013). However, it is unlikely that the US will meet these goals. Therefore, there is a disconnection between the widely acknowledged impacts of climate change and the scarce effective national climate change policies.

Meanwhile, regional and city level climate change mitigation initiatives are burgeoning in the US. For example, regional climate change programs such as Regional Greenhouse Gas Initiative (RGGI), the California Cap-and-Trade program, and the Western Climate Initiative have been established to coordinate regional mitigation efforts. Cities are also participating in national and international cooperative networks such as C40 Cities Climate Leadership Group, International Council for Local Environmental Initiatives (ICLEI), Cities for Climate Protection (CCP) and the US Conference of Mayors Climate Protection Agreement (McCarney, 2011). However, regional and city level climate change efforts face two major challenges. First, these efforts are often decoupled from national climate policies, limiting the resources and support available to them (Corfee-Morlot, 2009). Second, the governance structure for regional and city level policies is often chaotic, involving multiple departments working on the issue with limited coordination (McCarney, 2011).

This research project investigates US climate change mitigation governance structures at the federal, state, city, and county levels and seeks to evaluate the effectiveness of climate governance and propose strategies for improvement. Specifically, the research project addresses the following questions:

1) What are the observed organizational structures of climate change governance at the state and city level?
2) Which governance structures drive effective and efficient climate change policy formulation and implementation?
3) How do we benchmark the effectiveness of climate governance and provide policy recommendations?

To answer the above research questions, we collected data on climate change policies and emissions at the city, state, federal and county levels and conducted the following analyses:

1) Surveyed approximately 380 US state and city within the environmental-related networks such as C40 and ICLEI
2) Interviewed eight federal/state/city/county level government officials working on climate change governance
3) Summarized the observed organizational structures at different governance levels
4) Identified key barriers and drivers for effective climate change governance
5) Developed a climate change governance effectiveness index for all US states indicating governance improvement opportunities
6) Conducted case studies for effective and innovative governance measures

This report has four sections. We provide a literature review on current US climate change governance in section I. The quantitative and qualitative research methodology and design are described in section II. In section III, we present our main findings on the governance structure, key barriers, and measure of effectiveness. We then conclude our discussion with policy recommendations and implications in section IV.

I. Background

1. 1 Definition of Climate Change Governance

A clear and precise definition of 'climate change governance' is crucial for studying governance structure. In some narrow definitions, 'governance' refers to governments and the process of regulating the private and public sector (Pierre, 2002). In many other cases, 'governance' represents "all co-existing forms of collective regulation of societal circumstances: from institutionalized civil society self-regulation through various forms of cooperation between public and private stakeholders to sovereign action by governmental stakeholders" (Mayntz, 2006; Frohlich and Knieling, 2013). In this study, 'governance' refers to a range of initiatives, regulations, and government decisions aiming to establish cooperation between governmental and private sector stakeholders in dealing with a particular issue: climate change.

According to previous studies, the range of initiative and instruments can be classified into three main categories: 1) formal 'sovereign/legal instruments' such as environmental law enforcement and urban planning regulations, 2) 'economic measures' such as carbon taxes, and 3) 'information sharing' measures to promote policy learning and experience diffusion (Frohlich and Knieling, 2013; Soltwedel, 2005; Braun and Giraud, 2009). The key to governance is thus coordinating these instruments among different state, non-state, private, and general public stakeholders.

1.2 Previous Climate Change Governance Efforts and Challenges

Following the definition provided above, a number of governmental efforts can be categorized as climate change governance in the US. Among the legal methods, US EPA established CO_2 emission standards for new emission sources under the Clean Air Act, enforced renewable fuel standards for utilities, and proposed emission standards for existing power plants. In the economic measures category, climate change governance efforts include the CO_2 emission trading schemes, also called carbon markets, in California and six northeastern states (referred to as Regional Greenhouse Gas Initiative (RGGI)). In addition, various city and regional networks connecting city and regional scale climate policies have been formed. Local Governments for Sustainability (ICLEI), Cities for Climate Protection (CCP), Urban Sustainability Directors Network (USDN) are examples of platforms that facilitate city level information sharing, partnership formation, and policy cooperation. However, there stills lacks initiatives that incorporate climate change impacts into the urban planning process. With the legal, economic, and coordinative instruments, climate change mitigation and adaptation still remain as major challenges and there is hardly any evidence for emissions reduction or reliance improvement. In other words, there still lacks effective climate change governance. Below are some factors contributing to the complexity and challenges of the issue.

1.2.1 Scientific uncertainty

While there is unequivocal evidence for GHGs' contribution to rising temperatures in the climate system, there lacks clear evidence proving other effects of emissions (i.e. correlation between public health threats and emissions) (Meadowcroft, 2009). The estimate of climate change damages also varies widely. The complicated interactions between each of the earth system components make it challenging to estimate the effect of changing emissions on other components. Cost-benefit analysis (CBA) is one of the most frequently used tools to justify policy decisions. The benefit of mediating climate change is extremely difficult to predict. This requires precise modeling of the temperature change and precipitation changes\ from different levels of emissions and the interaction among different earth system components in response to these changes. As such a complicated system with numerous feedbacks and transient states, how and when the earth system will respond to changes in emissions is essentially impossible to predict. As a result, the benefits of avoided emissions are extremely challenging to measure (Meadowcroft, 2009). In addition, the cost of emission reduction is hard to estimate as there is no conclusive evidence for cost-effective measures for emission reduction (Aldy and Pizer, 2009). Fossil fuels remain the world's primary energy source that is heavily integrated into the entire economy (Meadowcroft, 2009). It is hard to imagine the costs of transforming the economy to become carbon neutral, especially when the actual, full benefits are unknown.

1.2.2 Distributional and equity issues

Equity is another huge concern in developing climate change policies (Meadowcroft, 2009). It is a global problem, meaning that emissions are a common pool but the level of impact is unevenly distributed worldwide. In other words, this is a global problem that requires every country to participate to develop the solution while disproportionally affecting certain countries. Therefore, allocation of mitigation responsibilities becomes the most difficult task for every government (Arvai et al., 2006). The highly centralized international consensus-driven framework, the Kyoto Protocol under the United Nations Framework Convention for Climate Change (UNFCCC), has been proven ineffective (Ostrom, 2010). How to create incentives for mitigation that collectively benefit everyone becomes a major challenge at the international level.

1.2.3 Long timeframe

The climate system evolves over decades, which means that the consequences of climate change takes decades and centuries to show (Meadowcroft, 2009). Similarly, the effect of our mitigation efforts requires a long timeframe to realize. It would be hard to justify current mitigation investments that do not payoff in the current time frame. Therefore, it is challenging to justify its position on the political agenda, since governments generally prioritize current and urgent issues.

1.3 Multi-level Governance Structure

Considering the complexity of the climate change issue, its global impact, and the distributional issues mentioned above, governance should be most effective at the federal level (Wiener, 2007). A strong national strategy, such as the presidents' action plan, boosts confidence for relevant stakeholders and stimulates more aggressive policies. However, governance at the federal level faces more political stress, jurisdictional complexity, and other constraints, compared to governance at the local or state level. Moreover, the comprehensive nature of climate change governance requires collective-decision making from all parties involved, meaning that a centralized federal government decision might not fit well with local circumstances (Betsill and Bulkely, 2006).

There are three main types of multi-level governance frameworks: the nationally led top-down approach, the regional/city driven bottom-up approach, or a hybrid model of the two (Corfee-Morlot et al, 2009). The top-down approach is often referred to as the "centralized enabling framework" where state/city governments are empowered or facilitated by a central agency to develop local policies (Corfee-Morlot et al, 2009). This framework stresses the importance of centralized planning with a clear hierarchy (Betsill and Bulkely, 2006). The central agency often provides financial support or coordinates local climate actions. For example, Norway is one of the countries that adopted an aggressive centralized program. A government white paper is passed in Norway after the Kyoto Protocol on the national level and established a $1 million USD local climate policy program to encourage local initiatives. As a result, 26 projects were developed in 37 municipalities and 8 counties (Corfee-Morlot et al, 2009). A clear national strategic plan and financial support from the central government stimulated strong local policies. Besides Norway, France and the United Kingdom all established central funding programs in the inter-ministerial agency working on climate and energy research in France and the Carbon Trust and Energy Savings Trust in the UK.

In a bottom-up framework, regional or city governments have the authority to develop individual smaller-scale policies despite the opinion of the central government (Corfee-Morlot et al, 2009). They are also allowed to surpass the national strategic goal. In this framework, policy learning and experience diffusion play key roles in successful policymaking. The regional/city policies can influence or even promote national actions. The governance action occurs simultaneously across all levels with more interaction between different levels of governance (Betsill and Bulkeley, 2006). The interaction between the city of Portland and state of Oregon is an example. The City of Portland started pushing green building in 1994 and has the highest number of Leadership of Energy & Environment Design (LEED) certified buildings in the US as of 2007 (Corfee-Morlot et al, 2009). The Green Building program, originally a city level green technical assistance program in Portland, evolved into a policy program coordinating with the Oregon state Energy Trust to provide financial incentives for green building projects. Therefore, regional/city level efforts can promote higher-level actions through information sharing (Corfee-Morlot et al, 2009).

Lacking a centralized climate action strategy in the US, the majority of US climate regulatory actions are often characterized as “decentralized,” thus taking the bottom-up framework (VanDeveer, 2010; Lutsey and Sperling, 2008). The bottom-up approach has two main benefits: 1) testing innovative policy designs in different political settings and 2) “local tailoring” of specific policies that are more adapted to local environments, which might be easier to implement and enforce (Lutsey and Sperling, 2008). However, such decentralized structure requires more interaction and coordination among different jurisdictions. Problems with regulatory overlap can result in the following negative impacts: 1) duplicate policies wasting regulatory resources or lack of regulation in some jurisdictions, 2) "cross-boundary mismatch" in pollution sources and impacted areas and 3) emission leakage and competitive issues, which will be discussed later (Alder, 2005; Lutsey and Sperling, 2008)

Finally, the hybrid framework refers to the structure in which the central government works closely with local governments in policy-making. Sweden, Finland, Brazil, and Japan all developed hybrid frameworks (Corfee-Morlot et al, 2009). In Sweden, for example, a National Investment Program was set up to promote employment rate and stimulate a low-carbon economy transition. The regional/local governments then established local policies that are in line with the national goals. In the hybrid framework, local initiatives and central support move hand in hand, which generates increased interaction and cooperation at different levels of government (Corfee-Morlot et al, 2009).

1.3.1 Climate change governance at the state level

There are great variations in state level climate governance efforts with three main types: 1) 20 states, mainly in the Northeast and Western US, and Washington D.C. have enacted GHG mitigation plans with explicit emission reduction goals, 2) about 15 states have climate action plan with some GHG reduction programs (such as Renewable Portfolio Standards), but not explicit emission reduction goals, and 3) the rest of the states, mainly in the Southeast US, have no specific climate governance actions (Rabe, Roman, and Dobelis 2005; Center for Climate and Energy Solutions). The incentives for state level regulation are three-fold: establish political advantage in elections, gain early-action advantage for avoiding competition, and fear for more stringent regulations outside of their own jurisdictional control (Carlson, 2009; Rabe, Roman, and Dobelis, 2005).

Specifically on the second point, through developing effective state-level climate regulations, states can improve their competitiveness. First, with climate regulations and related environmental policies, states can more effectively practice natural resource management such as water use control (using less water for traditional electricity production) and forestry management (preserving forest for CO2 sequestration). Second, climate regulations can also help states improve energy security and reliability from increasing production of renewable sources.

Third, climate regulations can induce technology development and innovation in energy efficiency, which might produce economic advantages for the state. Finally, local industry protection can be executed in some climate regulations. For example, LEED projects encourage using regional/local materials for green building construction to avoid transportation emissions, which can promote and optimize the local supply chain (Rabe, Roman, and Dobelis, 2005). Besides individual state level regulations, there is also an increasing trend of regional climate initiatives, such as North America 2050, Western Climate Initiative, RGGI, Pacific Coast Collaborative, Midwest Greenhouse Gas Reduction Accord, and Transportation and Climate Initiatives. These regional initiatives promote information sharing and partnership formation.

Another type of interaction, interaction between state level regulations and federal standards, has both positive and negative implications. Renewable Portfolio Standards and automobile fuel-efficiency standards are two examples. On the positive side, strategic coordination between states and federal government can provide pressure for more stringent standards (Goulder and Stavins, 2011). The California's stringent Corporate Average Fuel Economy standards (CAFE) led to the tightening of federal CAFE standards (Goulder and Stavins, 2011; Goulder et al, 2012). The second benefit is that state regulations can serve as a test of effectiveness for federal policies. On the negative side, emission leakage and loss of cost-effectiveness from the overlapping of standards are two main issues (Goulder and Stavins, 2011). When the stringencies of federal and state regulations are inconsistent, the compliance of parties in more stringent states leads to increased emission in less stringent states. Moreover, difference in stringency will elevate marginal cost of mitigation in some states, which leads to a loss of cost-effectiveness of the policy (Aldy and Stavins, 2012).

1.3.2 Climate change governance at the city level

Studies have found that even though climate change is happening at the global scale, the impact, especially to humans, is focused in cities (Corfee-Morlot et al, 2009). Sizeable GHG emissions are also generated in the metropolitan city area (McCarney, 2011). Therefore, city governments have more control over mitigation actions. In addition, these governments have more authority over city development planning and are more capable of incorporating climate change policies into the urban planning process. City governments are also more likely to foster partnerships with relevant stakeholders from closer relations with them. Generally, city level climate governance takes three main forms: 1) cities participate in national and statewide networks such as US Conference of Mayors agreements, ICLEI, and C40, which facilitate information sharing among cities (Burch et al., 2013, Bulkeley and Betsill, 2005, Bulkeley H, Moser S, 2007); 2) cities participate in regional climate initiatives such as RGGI, and 3) private-public partnership in specific sectors, such as in the utilities and energy sector (Burch et al., 2013; Bulkeley H, Schroeder H, 2008).

Past literature has examined the reasoning behind the successful passage of environmental legislations at the local level. Zahran et al (2008) found that the vulnerability of a local government to extreme weather events was a major contributor to whether or not climate change legislation had been passed. Areas more prone to experiencing droughts or floods and were located on the coast were more likely to implement climate change legislation. This makes intuitive sense as these cities would experience the majority of the consequences from unabated climate change.

Despite the stated advantages, climate change governance at the city/local level also faces several challenges including a lack of jurisdictional cooperation, an inability to secure funding and a lack of regulatory authority (Jessen and Sippel, 2009). McCarney identified that cities lack both vertical jurisdictional coordination across levels of city government and horizontal inter-jurisdictional coordination across different city departments (McCarney, 2011). City/ local level mitigation or adaptation policies are often developed with little cooperation or coordination across different sectors such as building in terms of energy efficiency, electricity generation in terms of the use of renewables, transportation in terms of vehicle efficiency, land-use planning, and water provision in terms of limiting emissions related to pumping (Corfee-Morlot, et al 2009; McCarney, 2009). Therefore, policy formation at the city level is lacking an "integrated urban planning framework" that incorporates long-term climate change risk into urban development planning (Corfee-Morlot et al, 2009). City governments also lack adequate resources and funding support for policy development, which will be discussed in more detail in the Key Dimensions of Climate Change Governance section.

Finally, studies have proposed that some city governments are not granted sufficient regulatory authority in developing GHG emissions reduction policies, such as promoting renewables, funding transportation development, taxation, etc. In some cases, states have preempted local agencies to formulate local policies, thereby creating obstacles to city-level policymaking. In addition, some local governments lack support from a central government, which impedes capacity and momentum building in private sectors. For example, London expects to achieve only half of its CO2 reduction goal by 2025 without central government regulations (GLA, 2007).

1.4 Multi-sector Governance

Coordination of emission regulatory policies in each sector in both bottom-up and top-down regulatory framework at the state and city level is crucial. Seven sectors serve as main emission sources: power, household, transportation, industry, services, agriculture, and waste (Sijim et al, 2005). Among them emissions from service, agriculture, and waste are non-energy related GHG emissions from service activities, crop production, livestock, and landfills, which are non-point sources that are difficult to regulate. Therefore, this study focuses on the power, residential household, transportation, and industry sectors. Power plants and vehicles are the two largest emission contributors, with each accounting for 32% and 28% of US GHG emissions respectively (US EPA, 2012). Industry accounts for 20% of emissions while residential household buildings and industrial buildings represents 10% (US EPA, 2012).

Policies targeting power plants and vehicles have been developed, which include Renewable Portfolio Standards (RPS) that promote renewable energy production in the power sector and Corporate Average Fuel Economy (CAFE) standards for the transportation sector. The commercial building energy codes have been tightening energy use standards to encourage emission reduction in the buildings sector. Energy efficiency technologies and green infrastructures are also blooming and adding emission reduction potential. With regulations in each individual sector, the key is to coordinate regulatory stringency according to the state-wide or nationwide emission reduction goal. Moreover, as mentioned before, climate change should be considered in the context of urban planning and development, which inevitably suggests a more realistic developmental planning approach.

1.5 Key Dimensions of Climate Change Governance

Effective adoption of multi-level and multi-sector governance frameworks depends on five key dimensions of climate change governance (Meadowcroft, 2009):

1) Building strategic capacity
2) Integrating climate change into development decision-making
3) Establishing cooperation among departments
4) Ensuring resources and funding
5) Conducting societal education and mobilization

1.5.1 Strategic Capacity Building

The most important component of strategic capacity building is political leadership. A clear position from top government officials sends a positive and strong signal to other officials and private sector/societal stakeholders (Meadowcroft, 2009). In addition, determining a lead agency can facilitate cross-functional interaction and coordination in climate change initiatives. As mentioned before, coordination among different stakeholders in different sectors is the key to effective climate change governance. The second component of capacity building is knowledge and provision of expert advice (Meadowcroft, 2009). As mentioned in the previous section, scientific uncertainty is a major challenge. Sound decisions are often based on adequate evidences, analysis, and predicted results. Therefore, the government needs to ensure that its decision regarding climate change policies is based on reliable scientific analysis and authoritative experts. The best strategy is to establish an advisory board comprised of leading experts in climate science, economics, and public policy to support well-informed decisions.

1.5.2 Development decision-making integration

Development and welfare improvement are central to every government. Climate change policies should not be depicted as costly measures that only benefit future generations (Shellenberger and Nordhaus, 2004). Rather, a more feasible and cost-effective approach is to incorporate climate change policies into the developmental urban-planning process (Meadowcroft, 2009). This is true for both climate mitigation and climate adaptation. For example, building a case for a natural gas combined cycle plant to replace a coal-fired power plant is easier when the coal plant is in its initiation planning process rather than taking the coal plant off-line to build a new natural gas plant. Similarly, on the adaptation side, the natural disaster resiliency building is much more efficient when planned in accordance with city infrastructure development. Specifically, the government can take the following strategies: 1) require climate change mitigation and adaptation opportunities to be considered in city/state/sector development plans, 2) establish cross-functional coordination meetings between climate change departments and development planning departments, and 3) "require climate change impact assessments for all major infrastructure projects" (Meadowcroft, 2009).

1.5.3 Resources and Funding

Inadequate resources and funding is another key dimension to climate change governance. The allocation of funding across both vertical and horizontal jurisdictions is difficult within a fragmented structure. It is necessary to establish a clear, integrated financial mechanism to support effective climate change policy development (McCarney, 2011) For example, a lack of municipal finance can impede the local government's ability to provide the infrastructure for climate change adaption as well as enforcing regulations on climate change mitigation (Bulkeley, 2010).

1.5.4 Societal Mobilization and Education

Societal stakeholders such as non-governmental organizations (NGOs) and the general public are also essential in pushing climate change governance forward (Meadowcroft, 2009). The following strategies can be useful. First, send consistent signals such as continuously promoting energy efficiency and stop subsidizing heavily polluting industries. Second, promote transparency and information sharing. Establishing a Climate Action Plan detailing the emission reduction goal and roadmap is a good first-step. Publishing greenhouse gas inventories is another powerful tool for encouraging the public to participate in GHG monitoring and surveillance. The advantage of promoting transparency is three fold: 1) building societal norms and encouraging residence behavior change, 2) stronger monitoring and surveillance force, and 3) stimulate innovative ideas in policy development and implementation (Meadowcroft, 2009).

The third strategy for societal mobilization is to establish educational programs in schools and for the general public. Schools and universities can add courses relating to climate change and energy efficiency into the curriculum to raise awareness among students. Media is another powerful tool for creating the “window of opportunity” that attracts public attention and communicates important messages (Kingdon, 2010).

1.6 Key Responsibility of Climate Change Officers

Considering the complicated dimensions of climate change governance, this study also concerns the responsibilities of climate change officers executing the strategies. The Association of Climate Change Officers (ACCO) defines climate change officers as “professionals who apply knowledge of climate-related risks and opportunities to their organizations near-term and long-term strategies” (ACCO, 2014). As mentioned before, the majority of political actions on climate change are generated at the city and local level. Therefore, local climate change professionals can play a pivotal role in determining the existence and strength of climate change legislation. However, there is a gap in climate change policy literature that captures or evaluates the effectiveness of climate change officers under the existing governance structure of the city. Currently, climate change officers have a wide variety of roles and responsibilities in different departments across governments, making an analysis of successful governance structure difficult (Cote, 2011). A lack of consistency between roles has led to uncertainty over how to develop a successful city management structure in order to effectively address climate change in different settings. For example, the implementation of the 2000 Sustainability Greenhouse Gas Action Plan in New Jersey was interrupted by a lack of coordination at different departments involved in the process (Corfee-Morlot et al, 2009). Determining how climate change officers interact at all levels of an organization and identifying their current roles and responsibilities in the governance process can help provide a general framework for duplication. Although all situations are different, many governments have similar obstacles that impede climate change action that could be identified and accounted for. Therefore, this study aims to fill the gaps by collecting responsibilities of climate change officers at different city governments and identifying overlaps or gaps in responsibilities.

II. Research design

2.1 Overview

This project used the Mixed-Methods Approach, which focuses on “collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies” (Creswell, 2007). Specifically, we used the Concurrent Triangulation Strategy (Figure 1), to collect qualitative and quantitative data concurrently and put equal priority in data collection and analysis (Terrell, 2011). We chose this methodology because quantitative data and qualitative data are equally important in our study. This method saves data collection time, since we can collect both types of data simultaneously.

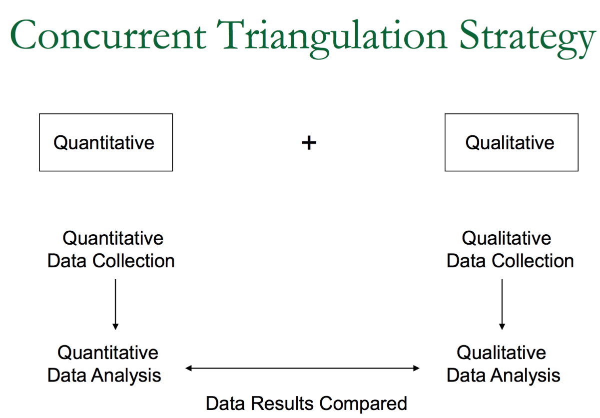

Figure 1-Structure of Concurrent Triangulation Strategy

To answer the three research questions we raised in the Introduction section, we conducted three phases of data collection and analysis. In Phase I, we developed and distributed an online survey (Appendix B) with both qualitative and quantitative questions, aiming to gain a general understanding of climate change governance at federal, state and local levels. After receiving survey responses, we conducted semi-structured interviews, gathering qualitative data by transcribing the interviews. From Phase I, we explored the current organizational structure of climate change governance at all levels of government, as well as the key barriers for effective climate governance.

Qualitative results from Phase I offered an exploratory view of the observed governance structure in different levels of government, but those results cannot be easily generalized. For this reason, in Phase II, we narrowed our research scope to state level, collecting quantitative data from state climate action plans and conducted a factor analysis. Factor analysis enabled us to group key contributing variables of effective climate governance into higher hierarchy indicators. From that we were able to identify the principal factors contributing to climate change effectiveness, and to build an effectiveness index for each state. After this, we compared the index rankings with GHG emission reduction performance rankings based on data from state GHG inventories, as well as the state energy efficiency scores from ACEEE's 2013 report, to verify the validity of our results. From Phase II, we could derive the critical drivers for the theoretical optimum governance structure we identified in literature review, and the relative importance of each factor to climate change governance effectiveness.

In Phase III, we conducted case studies on the states that received the highest factor scores in Phase II, applying cost-benefit analysis to evaluate their climate initiatives, and made recommendations on improving the effectiveness of governance.

2.2 Phase I: Survey and Interviews

2.2.1 Survey

Our research examines climate change governance at all levels, for which the research units are federal, state, county and city governments of difference sizes, locations and economic development levels in both the United States and Canada. The 380 participants were recruited from a contact list provided by our client ACCO, which included over 2,000 government officials working on climate change as a part of climate change networks such as C40, ICLEI's Climate Preparedness programs, Western Climate Initiative, Urban Sustainability Directors Network (USDN), and EPA Climate Leaders Program. Our group also identified a list of 120 officials in those climate change networks. The respondents included key climate change officers within different Department of Environmental Protection, Department of Environmental Quality, Department of Water Resources, Department of Air Quality, Department of Energy, Department of Transportation, and Public Utility Commission at the federal and state levels. At the city and county levels, respondents were mainly mayors, city managers or the department heads of the Environmental, Sustainability, and Climate Change Departments.

The purpose of the survey questionnaire was to investigate U.S. and Canadian climate change mitigation and adaptation governance structures, and identify features and barriers in their climate governance. The survey (Appendix B) contained 51 multiple-choice, dichotomous, open-ended and ranking questions covering demographics, general information about the respondent's organization, the governance structure and structural changes in the recent years, as well as the respondents' opinions on the challenges and effectiveness for his or her department in dealing with climate change issues. The survey was developed and distributed online using Qualtrics Survey Software supported by Duke University, and the responses were stored in the Qualtrics database.

The subjects of the survey were the federal, state and local government officials that worked directly or indirectly with climate change issues. Since the survey was only distributed to officials in ACCO's network of climate change practitioners, our sampling process was not entirely randomized. To deal with this issue, we compared the list that ACCO sent the survey to with all the member governments in those climate change networks mentioned above, as well as the contacts identified by our group, to confirm if ACCO's list was representative. Our comparisons showed that ACCO's contacts were dispersed over all the states in the US and the climate change networks covered most states and cities of different sizes. Thus, we could be more confident in the representativeness of our survey results.

We started survey distribution on January 21st, 2015, and closed it on March 21st, 2015. During the period, we sent reminder emails to all survey contacts from both compiled lists in the first two weeks. In the following weeks, we sent reminder emails to respondents who had started the survey but had not finished it.

By Mar 21st, we received 60 responses after sending the survey to 380 officers. Out of the 60, 27 were complete answers that were eligible for further analysis. Since our valid response number is small, we were not able to break down all the responses into different levels of governments for comparison. Instead, we summarized the valid responses for each question, using bar charts to present the quantitative results.

2.2.2 Interviews

After receiving the survey responses, our group identified four climate officers who played key roles in leading climate change initiatives in their departments, which underwent governance restructuring. In addition, we included four officials who did not finish the survey but are of interest to our analysis due to their leadership roles in their departments. The eight participants were selected from all levels of governments, with one from the federal level, three from the state level, three from the city level, and one from the county level. The titles and government levels of these participants are listed in Table 1.

Table 1. The titles and government levels of interview participants.

Title	Level of government
Director of Office of Sustainability and Support, DOE	Federal
Senior Water Resources Engineer, California Department of Water Resources	State
Senior Sustainability Manager, Planning and Sustainability Department, Portland, Oregon	City
Chief, Office of Sustainability, Dade County, Miami	County
Energy and Sustainability Manager, City of Rochester	City
Sustainability Officer, City of Las Vegas	City
Planner IV, Delaware	State
Commissioner, Maine Public Utilities Commission	State

For each of the government officers, we conducted a 30-minute phone conversation. The interviews were aimed at clarifying survey questions, as well as gaining more information on how the interviewee's department cooperates with other departments, how much budget his/her department has for climate change activities, and his/her opinions on the challenges and expectations of improving the effectiveness of their governance.

The interviews were conducted between Feb 19th, 2015 and Feb 27th, 2015. All interviews were led by at least two team members, and were recorded with the respondents' approval. The audio records for the phone interviews were transcribed by the four team members, which were then analyzed using NVivo Software.

We applied the node structure in Table 2 to code all the responses. Nodes provided the storage areas in NVivo for references to coded text. After coding, we conducted two types of NVivo queries: word frequency and matrix coding. In the word frequency query, words with the same stem and synonyms were grouped together, while conjunctions and transitional words were ignored. The word frequency query indicated the most frequently occurring words in the sources, from which we could identify the implicit themes by grouping those words into larger concepts. We were also able to find common themes from all the responses. In addition, we could trace the most frequent words back to the original sources to get a more comprehensive understanding of related topics raised by the participants. Then we applied the matrix coding query to state respondents. The purpose of this was to compare the difference among the three states in terms of their climate change governance scale, department mission, staff responsibilities, cooperation with other departments, and governance effectiveness.

Table 2. Node Structure for NVivo Analysis

Respondents
- Federal
  - DOE
- State
  - California
  - Delaware
  - Maine
- County
  - Dade-FL
- City
  - Las Vegas-NV
  - Portland-OR
  - Rochester-NY

Governance Structure
- Scale
- Mission
- Responsibilities
- Climate Publications
  - Action Plan
  - Others
- Cooperation
- Budget
  - Funding Sources
- Restructuring
  - Reasons
  - Changes

Effectiveness
- Rating
- Achievements
- Challenges

2.3 Phase II: Factor Analysis

After summarizing the observed governance structure from survey and interviews, we found several general trends regarding state level climate change governance structures. The second step for deeper analysis was to categorize the factors that contribute to a government's effectiveness in addressing climate change issues according to their correlations, and to identify the most important contributors under the theoretical optimum governance structure.

2.3.1 Background for Factor Analysis

An accurate evaluation method should be created to measure the effectiveness of state level climate governance and offer further recommendations. The general idea was to generate an index for each state to reflect their governance effectiveness. In this sense, the index was intended to comprehensively cover climate change governance related factors (e.g. climate change budget, related policy, etc.) that contribute to the overall level of effectiveness. Meanwhile, since the factors calculated in the index were latent variables of broad categories such as climate change policy and cooperation, it was more reasonable to collect data for specific variables such as the number of coordinating departments under each larger category. As a consequence, we found factor analysis to be suitable for conducting this analysis.

Factor analysis is a method for finding several factors comprising a large number of original variables by analyzing the relationship among variables. It is aimed at reducing the number of variables and the analysis dimension to a few representative factors. (Junping Jia, 2011) Since this approach can combine a number of variables into several interpretable underlying factors, it offered the possibility to investigate concepts not easily measured in this research project. (Maike Rahn, 2013)

2.3.2 Theory and Steps

Suppose there are p variables X1, X2, …, Xp, here k factors (k<p) F1, F2, …, Fk are required to structure the relationship below:

$$\begin{cases} x_1 = a_{11}f_1 + a_{12}f_2 + \cdots + a_{1k}f_k + \varepsilon_1 \\ x_2 = a_{21}f_1 + a_{22}f_2 + \cdots + a_{2k}f_k + \varepsilon_2 \\ \cdots \cdots \\ x_p = a_{p1}f_1 + a_{p2}f_2 + \cdots + a_{pk}f_k + \varepsilon_p \end{cases}$$

In this model, each variable is the linear combination of all the factors plus the error term. Here the coefficient a_{ij} represents the linear correlation between variable x_i andf_j, which is also called the factor loading.

According to the model above, $\sum_{j=1}^{k} a_{ij}^2$ is the communality, which demonstrates the explanatory ability of factor k to one original variable. While $\sum_{i=1}^{p} a_{ij}^2$ represents the relative importance contribution of factor j to all the variables.

The process of factor analysis consists of four steps including data testing, factor extraction, factor naming and interpretation, and factor scoring.

Since the function of factor analysis is dimension reduction, variables selected for factor analysis have to be correlated with each other (In general, most of the correlation coefficients among variables should be larger than 0.3). In addition, the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's test of sphericity can also be used in the data availability test. Factor analysis requires the sample to be large enough, so the number of samples should be at least five times as many as the variables and the dataset should be at least 100.

Factor extraction is the step of extracting a few factors covering most of the information from the original variables to reduce dimensions. Methods for conducting factor extraction include principle components, unweight least square, maximum likelihood and so on. Generally speaking, factors with eigenvalue larger than one should be considered as the final factor. As mentioned above, factors extracted are actually the latent variables or broad categories wanted in the research, so its name and interpretation is crucial. If the extracted factors do not have clear real-world meaning, the approach of factor rotation can be undertaken for clarification.

The final step is factor scoring. Each factor score is the linear combination of variables and can be determined by the following scoring function:

$$\begin{cases} f_1 = b_{11}x_1 + b_{12}x_2 + \cdots + b_{1p}x_p \\ f_2 = b_{21}x_1 + b_{22}x_2 + \cdots + b_{2p}x_p \\ \cdots\cdots \\ f_k = b_{k1}x_1 + b_{k2}x_2 + \cdots + b_{kp}x_p \end{cases}$$

After calculating each factor score, the total score can be calculated using the weighted average of each factor. The weight used here is the variance contribution of each factor. The total score function is:

$$F = \frac{\lambda_1}{\lambda_1 + \lambda_2 + \lambda_3} F_1 + \frac{\lambda_2}{\lambda_1 + \lambda_2 + \lambda_3} F_2 + \frac{\lambda_3}{\lambda_1 + \lambda_2 + \lambda_3} F_3$$

Here λ is the eigenvalue of each factor.

2.3.3 Data for Factor Analysis

Data for conducting the factor analysis and generating the index were collected from state GHG inventories and climate action plans. The nine variables included are shown in Table 3:

Table 3. Variables for Factor Analysis.

Number	Variables
1	Budget or expenditures on climate change
2-4	Number of climate change policies in each sector (three variables each covering: utility, transportation and building policies)
5	Ratio of climate change coordination departments to total number of departments
6-7	Presence and Publicity of Climate Action Plan (two binary variables)
8	Presence of climate research advisory committees (binary variable)
9	Presence of cooperation between planning division with climate department (binary variable)

Each variable is further summarized below:

Budget or expenditures on climate change: This variable is the ACEEE scoring of state-led financial incentives for energy efficiency programs. Scores range from 0 to 2.5, which demonstrates the relative financial investments states put towards climate change activities each year. This parameter measured the level of financial support. We assumed that government expenditures are positively related with the effectiveness of a state government dealing with climate change. The larger a state's climate change budget was, the more effort the state was marking, and the more emission reductions the state should have. (ACEEE State Energy Efficiency Scorecard, 2013)

Number of climate change policies in each sector (three variables each covering: utility, transportation and building): As illustrated in the Introduction, our research looked at the utility, transportation and building sectors. The number of policies in those sectors indicates the importance a state places on each sector to address climate change. The more climate change policies a state has in each sector, the more effective their governance should be (Center for Climate and Energy Solutions, 2014).

Table 4. Policies counted for the variable "Number of climate change policies in each sector"

Sector	Policies counted
Energy	Public Benefit Fund
	Renewable and Alternative Portfolio Standards
	Net Metering
	Mandatory Green Pricing Program
	Decoupling
	REC tracking System
	Energy Efficiency Standards and Targets
	CCS Incentives
	CCS/EOR Regs
	Hydraulic Fracturing Chemical Disclosure
Transportation	Mandates & Incentives for Biofuels
	Low Carbon Fuel Standard
	Medium and Heavy Duty Vehicles
	Plug-In Electric Vehicles
	VMT-related Policies & Initiatives

	Zero Emission Vehicle Program
Building	Residential Building Energy Codes
	Commercial Building Energy Codes
	Property Assessed Clean Energy Program (PACE)
	Appliance Efficiency Standards
	Green Building Standards for State Buildings
	On-Bill Financing

Ratio of climate change coordination departments to total number of departments: This variable consists of two parts: state's total number of departments and the number of climate change coordination departments it has. The former part comes from State and Local Government websites, and by searching each department's website, for whether or not the department has climate change related work. Since climate change covers a wide variety of disciplines, coordination among departments is necessary. A higher ratio of coordination among departments can demonstrate more effective governance as there is more information sharing and learning (State and Local Government website, 2014).

Presence and Publicity of Climate Action Plan (two binary variables): These two dummy variables are found from the EPA's Climate Action Plan website. We can determine whether the climate action plan is publicly accessible by looking at whether a state published the climate action plan to their website. These two variables are assumed to be positively related with clime governance effectiveness. Public awareness is beneficial for monitoring and feedback, so if the climate action plan is open to the public, the government can consider the climate change policy more comprehensive and thus increases the efficiency. (EPA Climate Action Plans, 2014)

Presence of climate research advisory committees (binary variable): This binary variable is collected by looking at the Center for Climate and Energy Solutions website on the Active Climate Legislative Commissions and Executive Branch Advisory Groups section, this dummy variable illustrates the efforts this state put in climate change research and management. Considering that more effort results in better climate change governance performance, these two variables are also positively related to the effectiveness (Active Climate Legislative Commissions and Executive Branch Advisory Groups, 2012).

Presence of cooperation between planning division with climate department (binary variable): This variable is found from "Adaptation Planning – What U.S. States and Localities are Doing", which is indicating the extent of cooperation on an adaptation plan each state has in dealing with climate change issues. Greater cooperation results in the better performance of climate change initiatives and therefore governance (Terri, 2009).

2.3.4 Application

Although this factor analysis only concerns state level data, which is not a large sample size, this method was still viable, since the number of variables selected does not exceed one-fifth of the sample size. In addition, the variables are theoretically correlated with each other (e.g. more climate related policy, there should be higher budget), which satisfies the basic requirements.

With the support of factor analysis, the variables are grouped into higher level latent categories. By taking advantage of the factor scoring, the index is calculated by the weighted average of each factor using the total score function. Plugging in the data collected for each state, the specific score and ranking of each state could be generated and the effectiveness of climate change governance is evaluated. After data collection, all the steps of factor analysis including data standardization, testing, extraction and factor rotation are done by SPSS. The final step of factor scoring is calculated by Excel using specific state data and the weights provided from previous steps of the analysis.

The score ranking from the factor analysis will be compared to the ACEEE energy efficiency score card to verify the analysis results. Although some variation is expected, if the score ranking generally agree with the ACEEE ranking, the principle factors in the model successfully explains effectiveness of governance, which induces GHG emission.

2.4 Phase III: Case Study

After the data collection and separate analysis, we compared the themes derived from the survey and interview responses with the principal factors from the quantitative analysis, to see whether these findings match the findings from the qualitative analysis. In addition, we conducted case studies on the two states with highest scores for Factor 1 and Factor 2. The purpose of the case studies are to get deeper into the phenomenon we found in the previous two phases of studies, and to develop deductive inference on its reasons. It also allows us to discover achievements those states had in addressing climate change issues, and to evaluate the cost-effectiveness of their climate actions.

Based on the two separate case studies, we were able to make recommendations on what initiatives in the governance structure a state could adopt to improve its effectiveness in addressing climate change issues.

2.4.1 Florida Case Study

The Florida case study is organized in two parts: 1) discussion of performance in key variables in factor 1, policy support and planning, and 2) a pilot cost-benefit analysis (CBA) of the City of Miami Beach stormwater management project to illustrate the benefit and cost from adaptation projects within the planning process.

In the CBA, the costs of the projects are measured in three categories: 1) capital cost for construction, 2) operation and maintenance cost (O&M), and 3) environmental cost of CO_2 emission from electricity usage by pump stations. Benefits from the projects are also estimated in three categories: 1) avoided flooding damage, 2) avoided sea-level rise damage on property value, and 3) avoided revenue loss in tourism revenue. Table 4 shows the estimation method. Key parameters used in the CBA are shown in Table 5.

The CBA analysis compared costs and benefits of two scenarios: status-quo (continuing operation of existing pump stations and no new projects) and new plan (implementing new projects) from 2012 to 2031. In order to analyze the environmental impact of the projects, the costs of the project were estimated under two scenarios: low social cost of CO_2 and high social cost of CO_2.

Basic assumptions of this CBA are:

- Discount rate: The stormwater management plan is a public project funded by public funding, tax credits and public investment. The investment had social opportunity cost as it gave up potential investment opportunities for other projects. Therefore, according to Federal Agency CBA Standards (2013), we used a discount rate of 3%.
- The data on the costs of the projects were obtained from the stormwater management plan provided by CDM Smith to the City of Miami Beach. Capital and O&M costs included all projects in the stormwater management plan. Environmental cost was not provided in the stormwater management plan. With available data, we estimated the CO_2 cost of electricity consumed by the pump stations, which we assume represents a significant component of electricity consumption of all projects. Other projects are mostly structures that have no energy consumption, such as recharge wells, pipes, seawalls, and trenches.
- Benefit estimations of avoided damages were based on modeling results of the future damages from climate change on Florida or Miami-Dade County. Specific assumptions for benefit estimation in each category are included in Appendix C.

Table 5. Typology of costs and benefits for Florida Stormwater Management Plan.

Costs	Details
Capital	The project cost $206.3 million from 2012 to 2031.
Operation and Maintenance	O&M costs include monitoring and maintaining the pump stations, pipe lines and other infrastructures included in the management plan.
Environmental	CO2 emission of electricity usage of pump stations. $CO_2\ Emission\ Cost =$ $Energy\ consumption\ of\ pump\ station\ each\ year \times CO2\ Emission\ Rate\ in\ Florida \times$ $Social\ Cost\ of\ Carbon$ Status-quo scenario calculation is based on 28 existing pump stations. New-plan scenario is based on 17 new pump stations. Electricity consumption assumes 225kW motor running 90 hours per year. Social cost of carbon estimated in low and high scenario: low scenario assumes 3% discount rate and high scenario assumes the 95 percentile of 3% discount rate.

Benefits[1]	Details
Avoided Flooding Damage	*Avoided flooding damage = Flooding damage per year in Florida * state to city weight adjustment.* *State to city weight adjustment=City of Miami Beach GDP in 2008/ Florida GDP in 2008=6.45%*
Avoided property value from sea-level rise	The avoided property value damage increases exponentially from 2025 to 2031. *Avoided property value damage per year = Sea-level rise damage in Miami-Dade in 2025 * 5.5% *(1+0.15)$^{(t-2025)}$ * County to city weight adjustment* 5.5% represents cost of inaction in the real estate sector for Florida. 0.15 represents the growth rate of property damage from sea-level rise *County to city weight adjustment = City of Miami Beach property value in 2013/ Miami-Dade County property value in 2013 =13%*
Avoided tourism revenue loss	The avoided tourism revenue loss increases exponentially from 2025 to 2031. *Avoided tourism revenue loss per year = Florida tourism revenue loss in 2025 * 5.5% *(1+0.06)$^{(t-2025)}$ * state to city weight adjustment* *0.06 represents the growth rate of tourism revenue loss* *State to city weight adjustment = City of Miami Beach revenue from tourism in 2012/ Florida revenue from tourism in 2012 =3.2%*

Table 6. Key parameters for CBA of the Florida Stormwater Management Project.

Parameters	Units	Value	Data Sources
Project Capital Costs (total)	Million $	206.3	City of Miami Beach Stormwater Management Master Plan Executive Summary. Page ES-8.
Operation & Maintenance Cost (status-quo)	Million $	0.63[2]	City of Miami Beach Citywide Comprehensive Stormwater Management Master Plan. Presentation to the Finance Committee. June 2012.
Operation & Maintenance Cost (new plan)	Million $	0.9	
Annual Electricity consumption without new plan	MWh/yr	567	Grundfos .Storm Water Pumping Station Design Guide
Annual Electricity	Mwh/yr	911.25	Grundfos .Storm Water Pumping Station Design Guide

[1] Note: Detailed calculations shown in Appendix C

[2] Note: With limited available information, we assume pumping O&M cost is representative of system cost.

consumption with new plan			
Lifetime	years	20	City of Miami Beach Stormwater Management Master Plan.
Discount rate	%	3.00%	Federal Agency Benefit-Cost Analysis Principles and Standards for Social Programs
Shadow value of capital		0	
CO2-e emission Rate	lbs/MWh	1148.8	US Energy Information Administration, State Electricity Profiles Data for 2010
Social cost of CO2 emission	$/metric ton	Appendix D	EPA Interagency Working Group on Social Cost of Carbon, 2013

2.4.2 Oregon Case Study

The case study on Oregon examined Oregon's performance in policy development, which is indicated by Factor 2. Specifically, we looked at policy development in the transportation sector—the Solar Highway Program initialized by the Oregon Department of Transportation. We conducted a cost-benefit analysis (CBA) on the Baldock Solar Highway Project, to see the cost-effectiveness of this innovative strategy for emission reduction in the transportation sector.

Basic assumptions for the CBA are:

- Standing: The Baldock Solar project was developed by the cooperation between Oregon Department of Transportation (ODOT) and Portland General Electric, with the financial support from Bank of America. This project received 50% of funding from state renewable energy tax credits, and grants offered through the Energy Trust of Oregon and PGE's Clean Wind Fund. In addition, the design, construction, and maintenance of the Baldock Solar Highway Project was completed by local companies, for which the costs of the project mainly went into the local economy. In the meantime, the benefits, which included electricity generation, CO_2 emission offset, and job creation, are all provided to the Oregon residents. Thus, our project conducted a cost-benefit analysis from the perspective of the Commonwealth of Oregon.
- Shadow value of capital and discount rate: The Baldock Solar Highway project is a public project funded by private financing, tax credits and public investment. The investment had a social opportunity cost as it gave up potential investment opportunities for other projects. In addition, it is a long-term project with strong social benefits. Thus,

we used a factor of 1.1 for the shadow value capital, and a discount rate of 3% as suggested by HDR and CH2M Hill's study (HDR and CH2M Hill, 2011).

- Unskilled labor: The specific percentage of unskilled labor could not be found for the project. Thus, we assumed a 30% unskilled labor, as suggested by NREL's Solar Installation Labor Market Analysis (Friedman, B., Jordan, P., & Carrese, J., 2011). We also assumed a 50% shadow wage rate for unskilled labor.

The costs of the projects included capital costs, operation and maintenance costs, and environmental costs. The benefits included electricity generation, emission offset, Federal Investment Tax Credit, job creation, and local economy promotion. The explanation and calculation for each category is illustrated in Table 6. Key parameters for the CBA are listed in Table 7.

Table 7. Typology of costs and benefits for Baldock Solar Highway Project.

Costs	**Details**
Capital	The project cost $10 million in a 2-year design and construction period from late 2010 to early 2012. That included site evaluation for solar highway potential, permitting, land, solar system installation, and labor.
Operation and Maintenance	O&M costs include monitoring and maintaining the solar system, grid access fees, labor costs and annual site license payment. The O&M costs were calculated using 23% Renewable Energy Credit (REC) as indicated by the project website. Since Oregon does not have a REC market, we used the REC price in California as it is tradable between nearby states.
Environmental	The project might have impacts on the surrounding eco-system.

Benefits	**Details**
Electricity Generation	The project can generate 1,970MWhs of clean electricity annually, which is integrated to the grid for the Portland General Electric service area. The electricity price for all sectors in Oregon in 2012 was used. *Electricity benefits = Electricity generation * Electricity price*
Emission Offset	Avoided emissions that would occur if fossil fuel plants are used. The predominant one is CO_2 emission. Social cost of CO_2 was used to calculate the emission offset benefit. *CO_2 emission reduction benefits = Electricity generation * Grid CO_2 emission rate * CO_2 social cost*
Federal Investment Tax	This project qualified for a 30% Federal tax credit for solar investments and accelerated depreciation. The tax credit would be paid off in five years.

Credit	*Tax benefit = Investment * percentage of federal tax credit*
Job creation	The solar project created approximately 70 direct and indirect jobs during construction, among which 30% was unskilled construction workers. *Job creation benefits = Percentage of unskilled labor * Number of Job created* Market wage for skilled labor* (1-Shadow wage rate for unskilled labor)*
Local Economy Promotion	The project was designed, constructed, and would be maintained entirely by Oregon-based businesses, which would support at least nine companies including SolarWorld, PV Powered Inc. of Bend, SolarWay, Aadland Evans Constructors Inc. of Portland, Moyano Leadership Group Inc. of Salem, Advanced Energy Systems, Good Company, environmental and sustainability consulting.

Table 8. Key Parameters for CBA on the Baldock Solar Highway Project

Parameters	**Units**	**Value**	**Data Sources**
Project Capital Costs	Million $	10.53	Baldock Solar Highway Project website
Annual Electricity generation	MWh	1970	
Lifetime	Years	25	
Design, construction and completion time	Years	2	
Discount rate		3.00%	HDR and CH2M Hill (2011). Discounting Recommendations for Least Cost Planning in Oregon.
Shadow value of capital		1.1	
Average Electricity Price (2012)	$/MWh	82.6	EIA, Table "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector".
CO2-e emission Rate	lbs/MWh	846.97	eGrid 2010 Summary, 2014
Job creation	job/yr	70	Baldock Solar Highway Project website
Market wage for construction worker	$/yr	$39,350	Bureau of Labor Statistics, 2014 State Occupational Employment and Wage Estimates-Oregon
Shadow wage rate_unskilled		50%	Friedman, B., Jordan, P., & Carrese, J., 2011
% unskilled workers		30%	Discussed in the Basic assumptions above
Price of SRECs	$/MWh	50	SRECTrade, 2014
Social cost of CO2 emission	$/metric ton	Appendix D	EPA Interagency Working Group on Social Cost of Carbon, 2013

Since the social cost of CO_2 came from a projection conducted by EPA's Interagency Working Group, we examined the effects of low and high levels of CO_2 social cost on the project's performance. In addition, although this project was designed to operate 25 years, it has the potential to last 30 years. Because of that, we looked both 25-year lifetime and 30-year lifetime for comparison.

III. Results

3.1 Survey & Interview Results

Survey and interview results were used to determine what governance structures are currently in place to deal with climate change and how these vary across different levels of government. Survey results and interview responses were combined and we focused on the following four aspects of climate change governance: responsibilities, cooperation, achievements, and challenges. For survey results, we summarized our collected responses from Qualtrics and displayed the results using bar graphs. Since the interview results were strictly qualitative, NVivo was used to generate word clouds of the most frequently used words for each topic.

3.1.1 Respondent Information

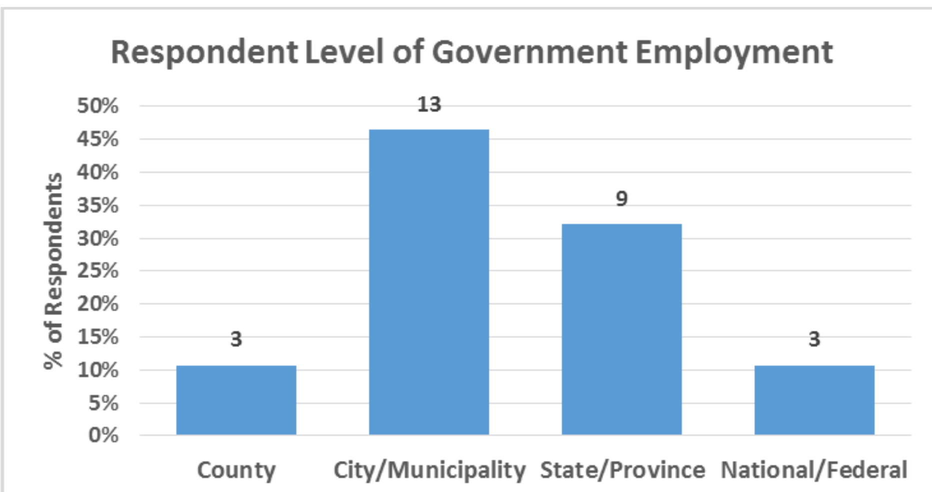

Figure 2-Governmental Level of Respondents

As mentioned previously, the survey was distributed to government officials at the city, county, state, and federal levels. The majority of our respondents work on climate change at the city or state level and generally hold management-level positions related to environmental services within the government's sustainability department. Many respondents are also members of regional climate change networks and initiatives that span the country including ICLEI, the Conference of Mayors, the Urban Sustainability Directors Network and others. Finally, respondents are roughly equally represented from the four United States regions of the Northeast, South, Midwest, and West, and respondents from Canada. Regional makeup is depicted in Table 8 below, followed by a map plotting survey respondent locations (Figure 3):

Table 9. Regional Breakdown.

Geographic Region	States	Responses
Northeast	ME, NH, VT, MA, CT, RI, NY, NJ, PA, DE, MD, WV, DC	7
South	VA, KY, NC, TN, SC, GA, AL, MS, AK, OK, TX, LA, FL	4
Midwest	ND, SD, NE, KS, MN, IA, MO, WI, IL, IN, MI, OH	4
West	CA, OR, WA, ID, UT, AZ, MT, WY, CO, NM	7
Canada	BC, ON, QC	5

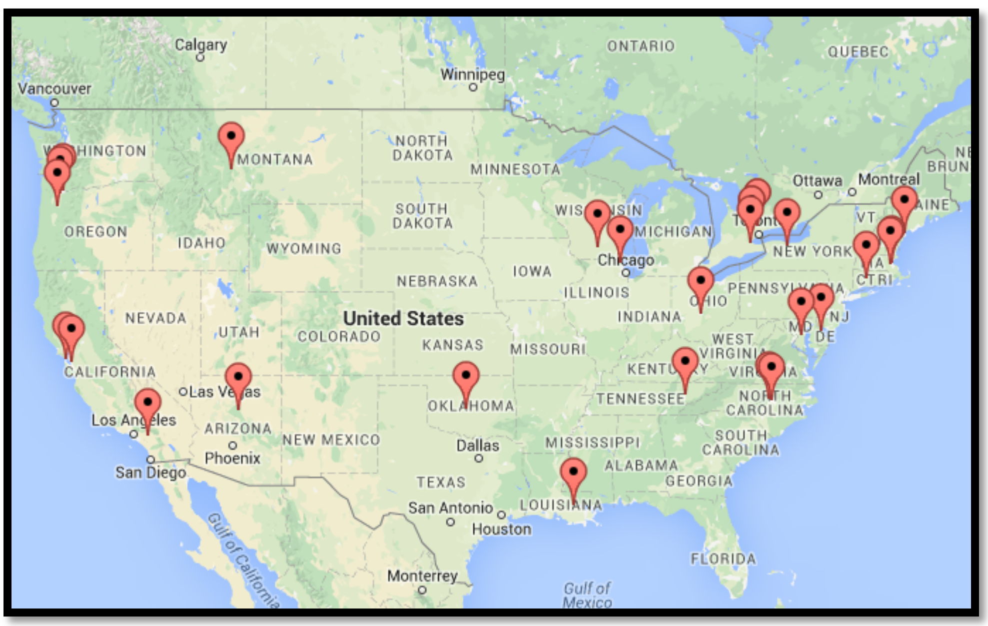

Figure 3. Respondent Geographic Locations.

3.1.2 Department Information

The first step in examining what the governance structures that deal with climate change in North America look like is determining what types of human resources are currently dedicated to the issue. Many of the government agencies that we surveyed are very large with most state and federal departments housing over 50 employees (Figure 4). City and county departments were much smaller and, in some cases, only had a single employee. However, only three respondents reported having more than ten employees working on climate change issues shown in Figure 5. Most people working on climate change at the governmental level are doing so in addition to their regular job responsibilities. There are very few full-time equivalent workers solely focused on climate change at any level. During our interviews, one official from the federal level stated:

"There are very few people who look at climate issues as their full time or primary job. It is very much an 'other' duty…"

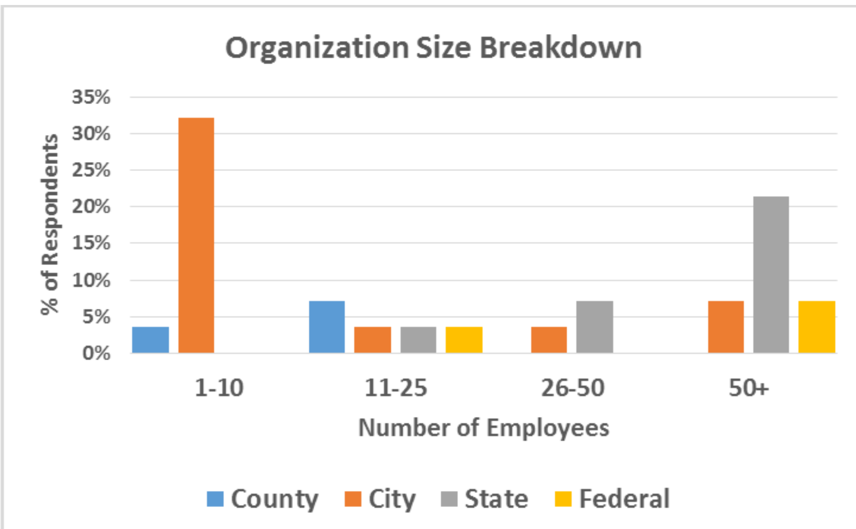

Figure 4. Organization Size.

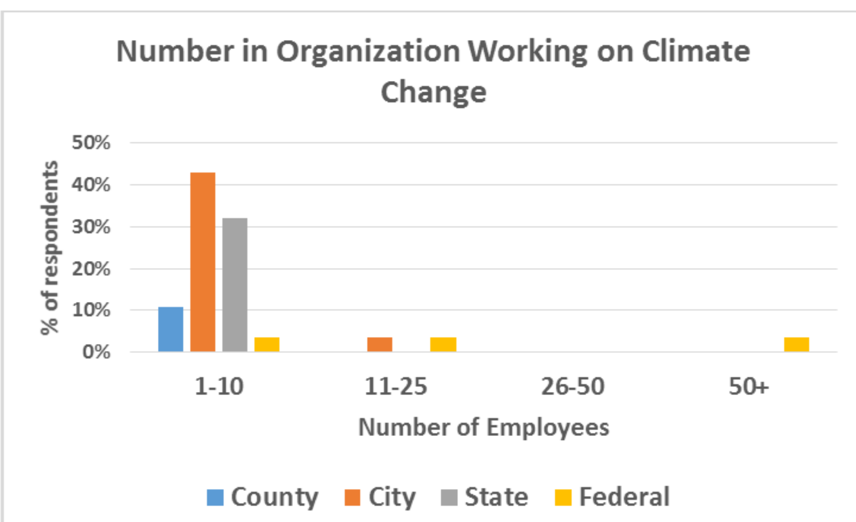

Figure 5. Number Within Organization Focused on Climate Change

3.1.3 Responsibilities

Survey responses indicate a wide variety of job responsibilities for lead climate change officers at each governance level, which is consistent with earlier findings that climate change related activities compose a small portion of total job responsibilities. However, across all levels of government, greenhouse gas accounting and management, policy design, and stakeholder engagement where the most commonly reported responsibilities. These three responsibilities are related to each other and would all be necessary for completing a climate change project. Greenhouse gas emissions must be accounted for in order to address climate change and these numbers can be used to inform policies. After policies are created, they must be communicated to the public and to others within the government. A full listing of respondent responsibilities is shown in Figure 6.

While asking about job responsibilities during our interviews, we found that energy, planning, risks, sustainability, information, and efficiency were common to all eight conversations (Figure 7). Tracing back to the original interview transcripts, respondents were more specifically referring to:

- Increasing energy efficiency and investing in renewable or alternative energy
- Developing and implementing climate action, safety and emergency, or sustainability plans
- Reviewing and integrating climate risks into management decisions
- Distributing information to other departments

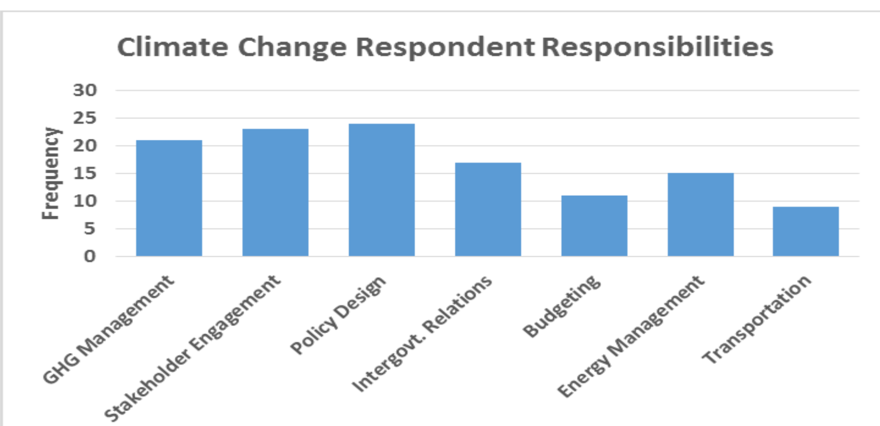

Figure 6. Key Job Responsibilities of Respondents

Figure 7. Word Cloud on Mission & Responsibilities

3.1.4 Cooperation between departments

Given the small number of people working on climate change in each department and the broad nature of climate change in general, cooperation within and across different levels of government is essential for developing and implementing successful programs. This importance is reflected in our survey responses as nearly all survey respondents indicated that their organization regularly cooperates with other governmental departments on climate change projects. Collaboration was most frequent among the departments of sustainability, transportation, public works, water resources and planning (Figure 8).

Additionally, the Nvivo analysis of interview responses returns a similar result with planning, departments, program/projects, water, transportation, and city/regional/local/municipal being the most frequently used words when asked about departmental cooperation (Figure 9). Respondents were generally talking about leading climate planning, cooperating with other departments in developing a Climate Action Plan, as well as other partnership programs, and sharing information with governments at regional and municipal levels. After these, the department of water resources and the department of transportation were most commonly mentioned. Some agencies are going further to include local stakeholders outside of the governmental departments and believe that this factor was key to the success of a climate related project.

"That was key to the success of the initiative was the fact that we invited everyone to the table who would be important in implementing or stopping implementation of the project."

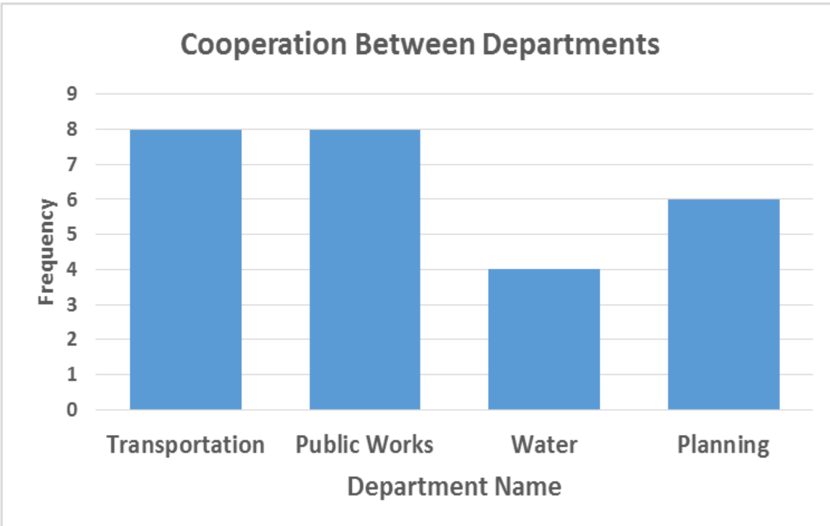

Figure 8. Cooperation between Departments

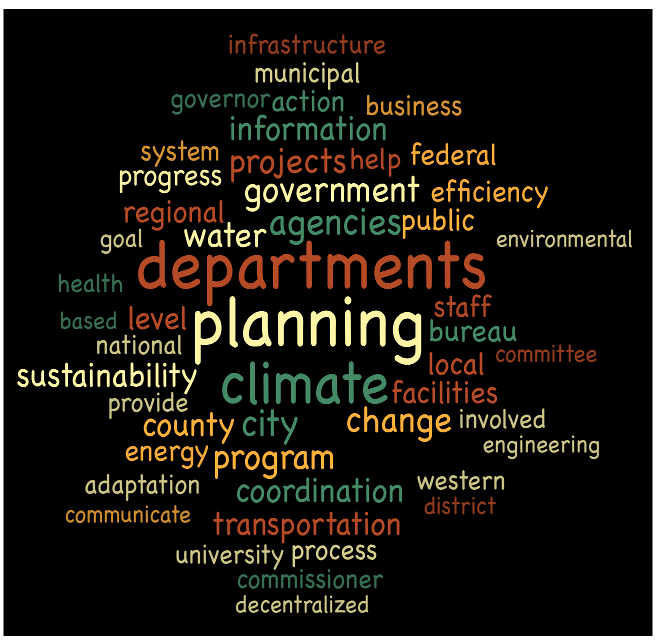

Figure 9. Word Cloud on Cooperation

3.1.5 Climate Change Achievements

Respondents in both survey and interviews mentioned that the integration of an effective structure in climate change and sustainability governance was the biggest achievement for their department. They were asked if their organization had undergone any restructuring specifically related to how they handle climate change. Restructuring in this question could refer to the creation or elimination of new positions or departments and the reorganizing of departmental functions or focus. Over half of the respondents indicated changes had been made within the last 6-8 years (Figure 10). The specific years listed for when restructuring took place closely coincide with the years that organizations developed their climate action plans following 2009, and it is likely that these plans were responsible for these structural changes.

Reasons for organizational restructuring were similar across the levels of government. Many respondents reported that restructuring was due to new leadership in the organization coming in with a focus on climate change. Commitment from leadership is essential for growth in climate change activities and led to a more integrated approach to managing climate change within government. For example, a few governments have merged the Bureau of Planning and the Office of Sustainable Development into one department to help integrate sustainability into early planning decisions and into all aspects of the governmental agency. In one instance, the reorganization led directly to the passage of new sustainable energy legislation. An interviewee respondent cited it as the main reason that carbon emission reductions and climate adaptation were included in the cities' most recent comprehensive plan.

The effect of organizational restructuring is shown positively in several aspects of climate change working areas including transportation initiatives and direct greenhouse gas emission reduction. Word frequency from interview responses proves this conclusion with climate change, sea level rise mitigation, and carbon/GHG emission reduction, showing as major themes under achievements (Figure 11). We also found that main achievements differed between government levels. States have focused more on reducing greenhouse emissions from utilities than other sources. Recent shifts towards utilities are likely due to the passage of the EPA's Clean Power Plan, but this trend appears to have been in place prior to these rulings. Alternatively, cities are more concentrated on reducing emissions from transportation sources. Since many cities do not have power plants within their limits, transportation emissions are likely the largest carbon dioxide contributor. Also, there are other benefits in local air quality improvements that are likely causing this trend.

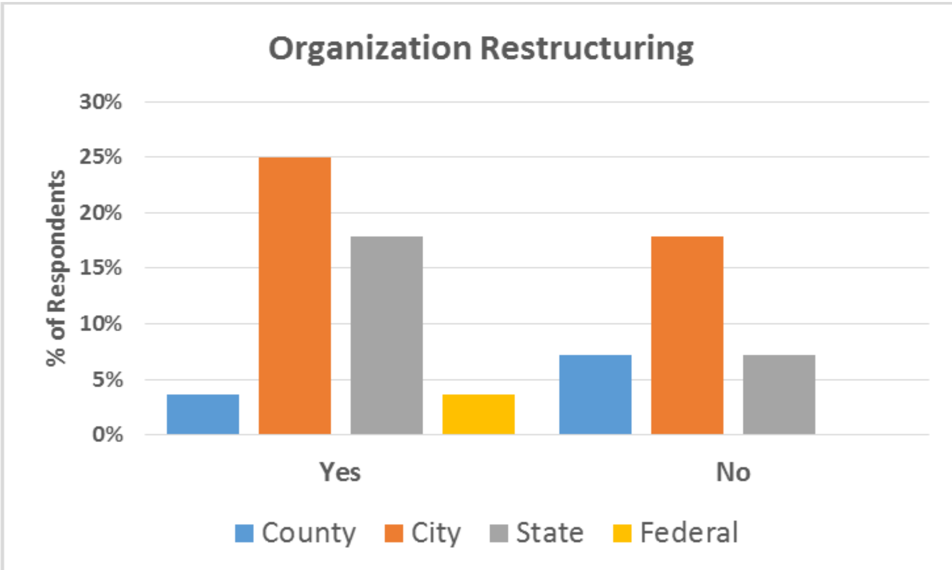

Figure 10. Recent Restructuring of Organization

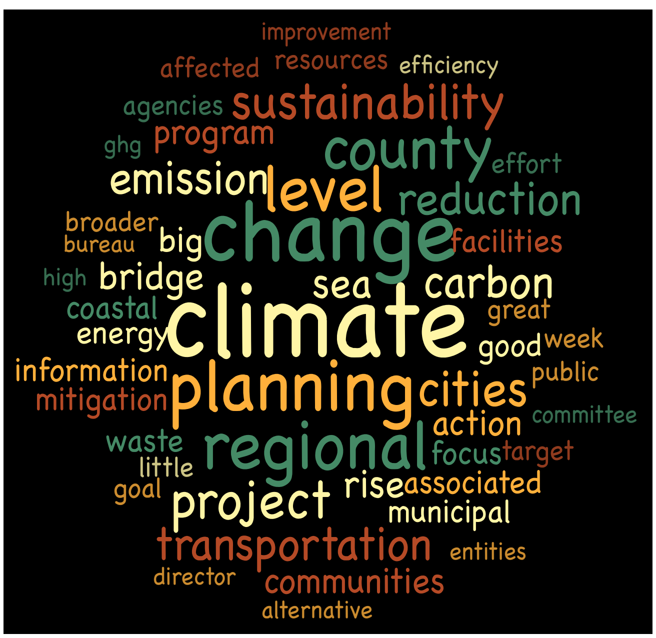

Figure 11. Word Cloud on Mission & Responsibilities

3.1.6 Climate Change Governance Challenges

Respondents were asked to rank seven challenges/organizational barriers to addressing climate change that their institution faces. The largest identified challenge or barrier that institutions face when addressing climate change is budgetary constraints. Not having many resources and being unsure of the stability of these resources makes long term climate projects very difficult to realistically implement. When it comes to money and climate change projects, an interview respondent stated:

"Planning is easy. Implementing is hard."

Roughly 60% of respondents indicated that their organization did not have a specific budget to handle issues related to climate change (Figure 12). This breakdown is expected given that insufficient budget was identified as the number one barrier to implementing climate change programs. The most common funding source for climate change activities was through a local tax program. Grants and state funding were the second and third most common funding sources. Given the political difficulty of increasing taxes, the shortage of state funding, and the competitive process to receive grants, it is not surprising that 65% of surveyed organizations have seen their climate change funding decrease in recent years. This further solidifies budgetary concerns as the top challenge to climate change actions by government entities. Organizations have been restructured to better deal with climate change issues and have published climate action plans, but progress has been limited by reduced funding to support these actions. Moreover, the budget issue was also highlighted by interviewees. As shown in the word cloud figure, the words money and budget were repeatedly used by the respondents when asked about challenges. They admitted that there was only enough budget to pursue a limited number of projects.

The second most identified challenge was organizational structure impediments. Many times there were unnecessary hurdles to overcome and a lack of communication between departments whose cooperation was needed to successfully complete a project. This structural challenge is what our study addresses and should be the easiest challenge to overcome through information sharing and a broader incorporation of climate change in general.

Finally, a low priority on climate change was a lower reported challenge from survey responses but was mentioned frequently over the course of our interviews. The priority of climate change issues was highlighted by half of the eight respondents. Many governments face important issues every day including fighting poverty, building a strong economy, education reform, etc. and climate change will often be overlooked. One interview respondent from the state level found this to be the biggest challenge for their position and stated:

"[Biggest challenge] is competing priorities. Sometimes it's hard to be heard above these big pressing problems."

As a result, implementation of climate action plans and policies became difficult, and financial and human resources for climate activities are generally deemed insufficient. A full list of responded challenges is shown in Figure 12.

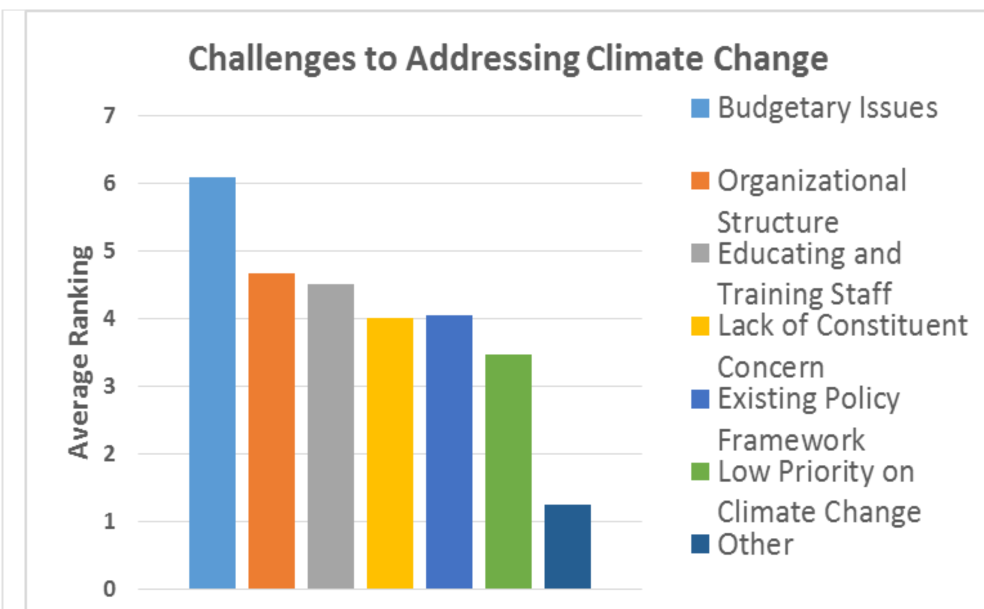

Figure 12. Major Challenges/Barriers to Addressing Climate Change

Figure 13. Word Cloud on Challenges

3.1.7 Interview Coding Query

We applied a matrix coding query to compare the governance structures mentioned by the three state respondents. The resulting table (Appendix E) from NVivo indicates how many times the conversation of each respondent was coded under each node.

3.3 Factor Analysis Results

After collecting data for all nine variables across all 50 states and Washington D.C., one important step before conducting the analysis was data standardization. Since four out of nine variables are dummy variables with 0 or 1 expression, we transformed other variables into a 0-1 scale. The function applied is below and the descriptive statistics are in Appendix F:

$$\text{Standardized Variable} = \frac{x - \min(x)}{\max(x) - \min(x)}$$

The first step of analysis was the KMO test to confirm data availability for factor analysis. The calculated KMO statistic was 0.769, which demonstrates a high suitability of the data for factor analysis.

For factor extraction, we selected the method of principle components, which should be chosen in most cases and will assume that original variables are the linear combination of factors. The criteria for determining the number of factors kept is the eigenvalue. If the factor has an eigenvalue larger than one, it would be extracted to be the common factor. With three common factors extracted, factor rotation was useful for clarifying the implication of each factor. Here we still employed the most commonly used method of Varimax, which could keep each factor orthogonal with the largest variance. These two steps of analysis are conducted by SPSS and the results tables are shown in Appendix F (Including Descriptive Statistics, Factor Extraction, Scree Plot, Rotated Factor Matrix, Factor Scoring Matrix, and Factor Score of Each State).

The categorization of variables is determined by the Rotated Factor Matrix (Appendix F, Table 1) which demonstrates how much each variable is related to each specific factor. The more strongly a variable is related to a factor, the more information from this variable can be covered in that factor. A threshold of 0.6 was selected to determine which variables should be included in each of the three factors. For example, if there are four variables that have a correlation of larger than 0.6 with factor 1, those four variables should be mainly represented by factor 1. According to this rule, we found that factor 1 and factor 2 each covers four of the variables, and factor 3 covers only one variable in this case (Table 9). Based on careful inspection of the meaning of variables in each category, we named each factor respectively as Policy Support and Planning, Policy Development and Utility Policy. The weight for each factor is calculated by dividing each factor's eigenvalue by the sum of all three eigenvalues. Here we used the eigenvalue after rotation because we also took rotation into consideration when categorizing variables into each factor.

Table 10. Factor Category and Explanation

Factor Name	Major Variable Information Included	Weight
Policy Support and Planning	(1) Presence of Climate Action Plan (2) Publicity of Climate Action Plan (3) Presence of Climate Research Advisory Committees (4) Presence of Cooperation between Planning Division with Climate Department.	0.448
Policy Development	(1) Number of Transportation Policies (2) Number of Building Policies (3) Percentage of Number of Departments Working on Climate Change (4) Climate Change Budget	0.379
Utility Policy	(1) Number of Utility Policies	0.174

The last step is to calculate the final score and ranking of each state using the score of each factor (Appendix F) and the weights. The functions for doing this were listed in section 2.3.2. The state score of each factor (Figure 14) and final results (Table 10) are shown below.

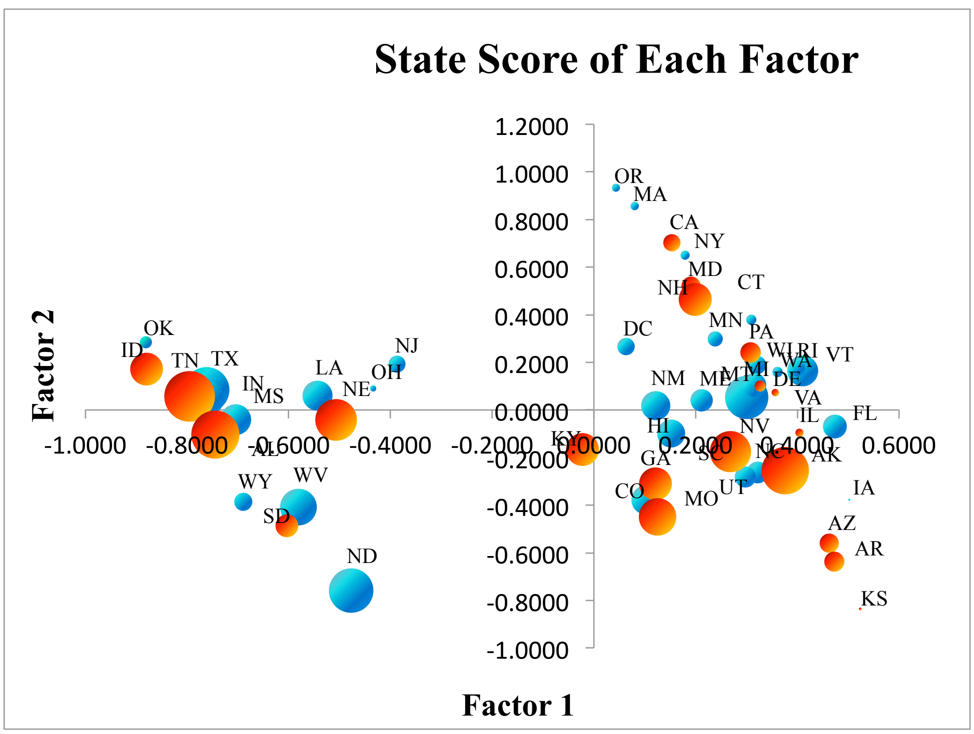

Figure 14. Factor Score for each State

Table 11. State Final Score and Ranking

Ranking	State	Score	Ranking	State	Score	Ranking	State	Score
1	Oregon	0.988	18	Delaware	0.407	35	Texas	-0.323
2	Massachusetts	0.949	19	District of Columbia	0.381	36	Louisiana	-0.330
3	New York	0.844	20	Maine	0.337	37	Ohio	-0.337
4	California	0.805	21	Illinois	0.297	38	Georgia	-0.372
5	Vermont	0.738	22	New Mexico	0.283	39	Kentucky	-0.373
6	Connecticut	0.706	23	Hawaii	0.186	40	Indiana	-0.500
7	Montana	0.671	24	North Carolina	0.140	41	Missouri	-0.562
8	Maryland	0.647	25	Iowa	0.126	42	Oklahoma	-0.571
9	Rhode Island	0.622	26	Utah	0.093	43	Mississippi	-0.583
10	Minnesota	0.576	27	Nevada	0.092	44	West Virginia	-0.760
11	Wisconsin	0.567	28	Colorado	-0.130	45	Nebraska	-0.843
12	Washington	0.539	29	New Jersey	-0.145	46	Idaho	-0.890
13	Michigan	0.516	30	Arizona	-0.159	47	North Dakota	-0.900
14	Florida	0.501	31	South Carolina	-0.194	48	Wyoming	-1.019
15	New Hampshire	0.478	32	Arkansas	-0.233	49	Tennessee	-1.172
16	Pennsylvania	0.478	33	Alaska	-0.259	50	South Dakota	-1.178
17	Virginia	0.420	34	Kansas	-0.313	51	Alabama	-1.240

The result shows that Oregon came in first with a score of 0.988, which illustrates that overall it has the highest climate change governance effectiveness among all the states. About half of the states have positive scores with Massachusetts, New York and California in the leading position. States such as North Dakota, Tennessee and South Dakota came in last place, with Alabama ranking the lowest.

It should be noted that due to timing constraints, we were not able to include a specific variable that measures changes in the political dynamics in the states in early 2015. For example, Florida banned the usage of term “climate change,” “global warming” or “sustainability” in official government documents in March 2015. This could potentially create obstacles in promoting public awareness, securing resources, and prioritization. A similar ban was proposed in Wisconsin in early April 2015 and North Carolina issued a new law that bans the use of sea-level rise predictions. These changes in political dynamics are likely to affect the state’s ability to perform effective climate change governance. Therefore, it is expected that the ranking of states will change to reflect this in the future.

Figure 20 shows that states with high rankings are clustered in the right corner, while the bottom ranking states are clustering in the left corner. As a consequence, we can conclude that factor 1 is playing a more important role in determining the overall performance of climate change governance, which matches well with the fact that factor 1 shares the highest weight among all three factors.

3.4 Cost-Benefit Analysis Results

3.4.1 City of Miami Beach Stormwater Management Projects

To quantitatively understand the benefit and cost of incorporating climate change adaptation initiatives into the city planning process, we conducted a pilot cost-benefit analysis (CBA) of one representative project: the City of Miami Beach Stormwater Management pump station project.

City of Miami Beach is one of the most vulnerable areas to flooding. To deal with this issue, the first Stormwater Management Plan was developed in 1997. The plan was updated in 2011 with proposed level of services, operation and maintenance (O&M) evaluations, and recommendations for best management practices. The new management plan has the following key features.

First, the updated plan analyzes problem sites based on meteorological data, stormwater modeling, watershed management models, land use analysis, neighborhood surveys, and flooding complaints. On the other hand, the 1997 plan was developed on an accelerated schedule to deal with flooding problems in high priority sites while the updated plan was developed based on a system-wide modeling result of the entire city. The prioritization in the old plan is determined from pollutant loading, pollutant concentration, flooding potential, citizen complaints, and staff ranking. Therefore, the updated plan takes a more comprehensive system-wide approach.

Second, the updated plan analyzes future tidal boundary conditions considering potential sea-level rise. Based on climate modeling results, the new plan is based on an expected sea level rise of 0.65-1.66 ft over 50 years (City of Miami Beach Stormwater Master Plan Final Report). (CDM Smith, 2011, p.2-41) Moreover, sea-level rise impacts on canals, spring tides, ground water levels, shoreline elevations, and extreme weather events such as hurricanes or coastal storms are evaluated. The new plan also analyzes the economic feasibility of developing the stormwater management plan considering sea-level rise.

Third, in the new plan, the public works department cooperated with a range of departments in developing the plan, including the department working on climate change. Specifically on environmental aspects, Miami-Dade Climate Change Advisory Task Force was tasked with identifying potential long-term climate change impacts, and provided data for long-range tidal and groundwater conditions and Miami-Dade County Department of Environmental Resources Management monitored the environmental permitting for infrastructure building proposed in the plan. The stormwater management plan will be incorporated as a part of sustainability initiatives in the Miami-Dade county sustainability plan, GreenPrint. (CDM Smith, 2011, p. 1-16)

With detailed impact analysis, research support, and coordination, the project is expected to enhance resiliency to flooding and sea-level rise. In a climate change adaptation context, the plan is a good start in predicting impacts and takes aggressive action to remedy expected risks, which is the signal of effective climate change governance.

Specifically, the management plan included the following types of projects:

- Building new pump stations with increased maintenance requirements as a part of measure for flooding remediation. (CDM Smith, 2011, p.9-10)[3] The new pump stations are 1) sized and located strategically according to available footprint, pumping capacity, stormwater modeling and sea-level rise data and 2) revised with a two-component ceramic-based coating as corrosion protection (CDM Smith, 2011, p.2-70)
- Installation of recharge wells for recharging surficial aquifer
- Upsize gravity pipes and storage vaults
- Detention basins and swales available for overflow storage when storage facilities are at capacity
- Backflow preventers to control tidal and rainfall backflows
- Exfiltration trenches to redirect surface and groundwater
- Porous pavements to avoid surface water build up
- Non-structural stormwater control measures including: operation and maintenance, land use planning, public information programs, fertilizer application controls, pesticide and herbicide use controls, solid waste management, street sweeping, erosion and sediment control (CDM Smith, 2011, p.2-77)

Based on data from the stormwater management plan and climate change impact modeling results in Florida, we quantified the costs and benefits of the project (Table 11).

[3] Pump stations collects runoffs and harvests stormwater, and it is usually connected to a wet well that stores water for alternative uses such as irrigation. Prior to the new stormwater plan, the city already installed 14 pump stations and had 14 under construction. It is proposed to build 17 more pump stations.

Table 12. Cost-Benefit Analysis for the City of Miami Beach Stormwater Management Projects

	CO2 Social Cost	Low		High	
	Discount rate: 3%	Status-quo	Stormwater Plan	Status-quo	Stormwater Plan
PV(Costs) [Million $]	Capital	$0.00	$150.70	$0.00	$150.70
	OM	$9.37	$13.39	$9.37	$13.39
	Environmental	$0.21	$0.34	$0.64	$1.03
	Total Costs	**$9.59**	**$164.43**	**$10.01**	**$165.12**
PV(Benefits) [million $]	Avoided Flooding Damage	$0.00	$51.37	$0.00	$51.37
	Avoided Property Damage	$0.00	$160.38	$0.00	$160.38
	Avoid revenue loss from tourism	$0.00	$82.11	$0.00	$82.11
	Total Benefits	**$0.00**	**$293.87**	**$0.00**	**$293.87**
NPV [3%] [Million $]	**Net Benefits**	**-$9.59**	**$129.43**	**$-10.01**	**$128.75**
BC Ratio [3%]		0	1.88	0.00	1.87

Values in 2012 USD[4]

The new projects in the management plan cost about 164.43 million dollars under the low CO2 cost scenario and 165.12 million dollars under the high CO2 cost scenario. The majority of the cost is capital cost for the construction of structural projects. The maintenance cost of new projects is higher, as expected, since new infrastructures (such as pump stations) are added. On the benefit side, the new projects are expected to produce significant benefits in avoided flooding damage, avoided property damage, and avoided revenue loss from tourism. The total net present value of the project is 129.43 million dollars, which suggests that it is beneficial to undertake the project.

[4] Note: money values were adjusted into 2012 USD by the CPI inflation rate. Calculation was done by the CPI Inflation Calculator on the website of US Bureau of Labor Statistics. Available at http://www.bls.gov/data/inflation_calculator.htm

3.4.2 The Baldock Solar Highway Project

To better evaluate Oregon's performance in developing policies and projects to achieve its emission reduction goal, we conducted another cost-benefit analysis on Oregon's Baldock Solar Highway Project. The Badock Project is the second project in Oregon's Solar Highway Program. Starting in 2008, the Solar Highway Program was designed to install solar panels along the highway to provide clean electricity and reduce emissions of the transportation system.
Some of the key characteristics of the Baldock Solar Highway Project are (Hamilton, 2012):

- **Timeline**: research, evaluation and design started in early 2010; construction began in August, 2011. The project started injecting electricity into the grid on January 17, 2012. It has a 25-year legal agreement with the Oregon DOT, with potential to renew in 5-year increments.
- **Size and Location**: the 1.75dc MW solar array has 6,994 solar panels at a rest stop on Interstate 5 south of Portland, making it the largest Solar Highway Project in the U.S. The annual production of 1,970 MWhs of electricity would be used for operation and maintenance of the State Highway system—including powering the Baldock Safety Rest Areas.
- **Business Model**: the project utilized a public-private partnership. Bank of America financed and owns the project. Portland General Electric operates and maintains the array under a lease arrangement. Oregon DOT leased the land for the installation of solar, and charged a small site license fee and receives a percentage of the renewable energy certificates generated by the project annually. The project will be paid off by revenue from selling electricity in the state.

Among the cost and benefit categories identified in Table 6 (Method Section), we were not able to quantify the benefit from local economy promotion. For the rest of the components, we quantified the values based on available data. The present values are listed in Table 12.

Table 13. Cost-Benefit Analysis for the Baldock Solar Highway project

		Low CO_2 Social Costs, 25-year	High CO_2 Social Costs, 25-year	Low CO_2 Social Costs, 30-year	High CO_2 Social Costs, 30-year
PV(Costs) [Million $]	Capital	$11.08	$11.08	$11.08	$11.08
	O&M	$0.37	$0.37	$0.42	$0.42
	Environmental	negligible	negligible	negligible	negligible
	Total Costs	**$11.45**	**$11.45**	**$11.50**	**$11.50**
PV(Benefits) [Million $]	Electricity Generation	$2.67	$2.67	$3.01	$3.01
	Emission Offset	$0.58	$1.85	$0.69	$2.17
	Federal Investment Tax Credit	$2.89	$2.89	$2.89	$2.89
	Job creation	$0.79	$0.79	$0.79	$0.79
	Total Benefits	**$6.94**	**$8.20**	**$7.38**	**$8.86**
NPV(3%) [Million $]	**Net Benefits**	**-$4.51**	**-$3.25**	**-$4.12**	**-$2.64**
BC Ratio(3%)		0.61	0.72	0.64	0.77

Values in 2012 USD[5]

As can be seen, the costs of the project always outweigh the benefits no matter which scenario we looked at. The net present value would be negative $4.51 million if the project operated for 25 years under a low carbon cost. Even if the project ran for 30 years under a high CO_2 cost, it would still cost $2.64 million for the state of Oregon.

[5] Note: money values were adjusted into 2012 USD by the CPI inflation rate. Calculation was done by the CPI Inflation Calculator on the website of US Bureau of Labor Statistics. Available at http://www.bls.gov/data/inflation_calculator.htm

IV. Discussion

4.1 Survey & Interview Results Implications

The survey and interviews that were conducted provide a very clear understanding of the current climate governance structures that are in place at different levels of government and the key challenges facing government officials working in this area. Details of current structures that exist and that are most effective can be used as a model for other governments. Many states or cities, specifically in the Midwest and Southeast, have not begun to fully incorporate climate change into their governance structures. Using the current structures as a model, these new governments could avoid the challenges that other governments have faced and set up a more effective structure to begin with. For example, organizational restructuring was proven to be one the biggest drivers for climate change achievements. Specifically, the integration of the sustainability department and urban planning departments led to an organization-wide increase in the implementation of climate related activities. By incorporating this change to begin with, organizations would avoid wasting limited budgetary resources on projects that are less likely to succeed.

By surveying government officials at all levels of government, there is also room for increased collaboration across government levels. Collaboration between government levels is rather minimal and therefore, these climate governance strategies are not shared. There are positive characteristics unique to each level of government that could be adapted and shared across levels. Specifically, climate change officials at the state and city governments are placed differently. At the state level, climate change is more often a smaller part of a large department. This means they have access to more resources and more employees but the chain of command is much larger than that of a city. In contrast, the city department working on climate change is usually a separate department that deals exclusively with climate change and sustainability related issues that reports directly to the mayor or city manager. The command chain is much shorter, but the department is usually comprised of less than five people and more susceptible to budgetary cuts. Advantages and disadvantages from these two unique structures could be shared between government levels to help develop a structure that works well at these levels in the future.

Finally, an area needing improvement was devoting more human resources to climate change. Currently, there are single employees working in different departments spending part of their time on climate change. Since climate change is an intricate problem that spans multiple departments and sectors, it is good to maintain a presence in each department but there is often little communication. Our results show the importance of coordination and therefore, a recommendation to solve this problem would be to hire a full-time climate change coordinator who would work across multiple departments. This helps minimize the workload and specific departmental changes but can increase the effectiveness of the current structure.

4.2 Factor Analysis Results Implications

Three main factors contributing to the effectiveness of climate change governance were identified from the analysis: 1) policy support and planning, 2) policy development, and 3) utility policies. The results have the following implications.

First, among the three factors, policy support and planning has the highest eigenvalue, meaning that it influenced climate governance effectiveness the most. Our finding suggests that the availability of a comprehensive strategic plan such as the Climate Action Plan, the level of disclosure of the strategic plan, and research support in producing the plan played a major role in developing effective policies. In addition, incorporating climate policies into the urban planning process also correlates with successful development of the strategic plan. Agreeing with previous findings, our result confirms that capacity building in the form of developing a well-informed and integrated strategic plan with sound research contribute most to effective climate change governance. All in all, policy support and planning should be prioritized in climate change governance.

Second, building efficiency policies and transportation policies are grouped with inter-department cooperation and budget under the second main factor: policy development. The eigenvalue for this factor is also high, implying that the four variables under the factor also capture a considerable amount of significant variance in climate change governance. This suggests that the level of budget correlates strongly with number of building efficiency policies and transportation policies, which confirms our hypothesis that budget and resources play important roles in policy development.

4.2.1 Effectiveness Index Robustness Check

In order to confirm the validity of our effectiveness index, we compared the ranking from the Factor Analysis to the 2013 ACEEE Energy Efficiency Scorecard. The ACEEE scorecard focuses on energy efficiency measures and the ranking is based on six main categories: utility & public benefit program, transportation policies, building energy codes, combined heat and power, state government initiatives, and appliance efficiency standards (ACEEE 2013). The weights of each category was based on their relative magnitude of energy savings (ACEEE 2013). While both indices measure government performance in dealing with climate change, ACEEE's is more focused on the energy sector while our study takes a more comprehensive approach focused on government organization structures as well as policies in specific sectors.

The effectiveness index is comparable to the ACEEE energy ranking. As shown in Figure 15 and Figure 16, the top tier states in both rankings are concentrated on the west coast and northeastern US. Massachusetts, California, Oregon, New York, Connecticut, and Rhode Island are all among the top 10 states on both rankings. Similarly, the states in the last tier are very similar on both rankings. North Dakota, South Dakota, Wyoming, West Virginia, Idaho, Nebraska are all in this category. The similarity in both indices presents us greater confidence in our results.

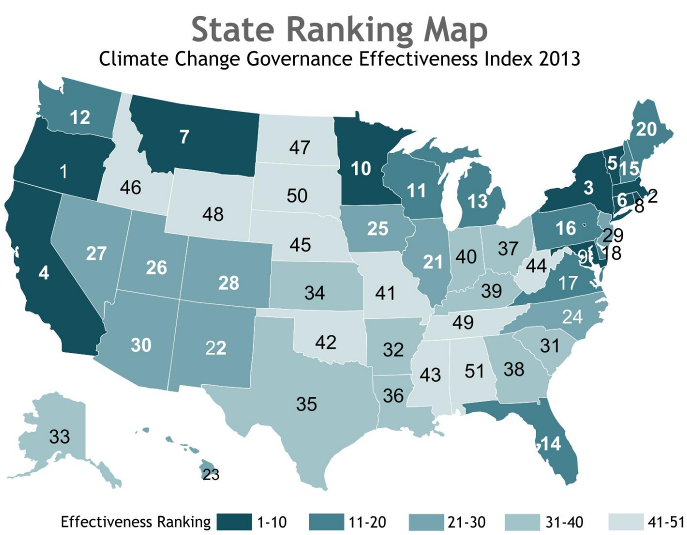

Figure 15. Effectiveness index ranking Map

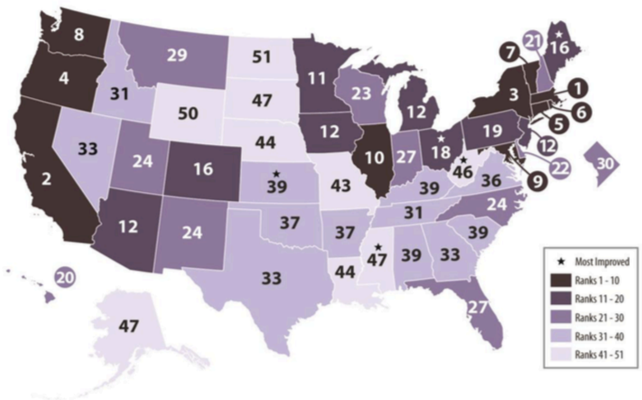

Figure 16. ACEEE Energy Efficiency ranking. ACEEE Energy Efficiency Scorecard 2013.

4.2.2 Effectiveness Index Implications

The climate change governance effectiveness index in this study has the following implications: First, it identifies key factors contributing to effective climate change governance and highlights the relative importance of the key factors. As discussed previously, developing a comprehensive climate action plan with sufficient research support and cooperation among departments contributes most to effective governance. This provides justification for prioritizing strategic planning, allocating research funding, and assigning appropriate responsibilities to staff members working on climate change governance. In other words, in order to improve the effectiveness of climate actions for a state government with limited resources, it is most efficient to allocate funding to developing a comprehensive climate action plan within the urban planning framework, among other activities such as developing sector-specific policies and creating utility programs.

Second, this study presents a novel model for measuring climate change governance performance. This is, according to our knowledge, the first index for US-specific governance performance. The only other index for climate change governance is the Climate Change Performance Index by Greenmatch, which measures country-level performance. Moreover, we took an analytical approach to try to justify our weighting selection while most of the performance indices are developed based on arbitrary weights. For example, the ACEEE energy efficiency index is based on percentage of contribution to energy savings. The weights in our study are derived from the eigenvalues based on the variance explained, according to factor analysis. In addition, this approach is particularly useful in dealing with a complicated issue, such as climate change, with numerous contributing factors. The factor analysis extracted the variables that explain the most variance from a large variable set. Therefore, this model serves as an alternative approach for indexing climate change governance effectiveness or climate change performance.

Third, the index provides a comprehensive measure of government climate change efforts. Greenhouse gas emissions reduction is a frequently used metric for indicating progress in dealing with climate change. However, each state faces different climate change impacts. Some states work more on mitigation while other states, particularly coastal cities, are more focused on adaptation. Therefore, emission reduction alone fails to represent all efforts the government is taking to tackle climate change and it is less fair to judge effectiveness based only on emissions. This index takes a holistic approach and considers the overall organizational structure in climate change governance, thus reflecting a more comprehensive climate change governance landscape.

Finally, the index provides a benchmark for state level climate governance and incentivizes states to improve their performance. Not only is peer pressure a powerful incentive for improvement, but better information sharing can also facilitate knowledge sharing and learning. For example, states can identify higher-ranking states with similar demographic, political, or environmental conditions and learn about their approaches to improve performance. In addition, the index can also serve as a benchmarking tool for states to track their performance over the years. This index is not intended to identify ‘good’ or ‘bad’ states in climate change governance. Rather, it should be used to identify key areas and opportunities to improve capacity to deal with climate change.

4.3 Case Studies

From previous sections, we identified three main factors contributing to effective climate change governance: 1) Policy Support and Planning, 2) Policy Development, 3) Utility Policy. Here we present a more detailed analysis on how factors influence governance. We selected the state with the highest factor score in factor 1 and factor 2, which are Florida and Oregon.

It should be noted that the recent political changes in Florida (banning the use of “climate change”, “global warming” and “sustainability” in official government documents) is likely to alter the effectiveness of climate change governance in the future. The purpose of the case study is to retrospectively investigate the performance of Florida in climate change governance prior to Mach 2015 and explore effective measures to recommend to other states.

4.3.1 Florida Case Study

Florida achieved the highest score in factor 1 (policy planning and support), which includes four specific variables: presence of a climate action plan, cooperation of climate initiatives and city planning actions, presence of climate research group, and publicity of climate action plan. Specifically, the four variables represent four key climate change dimensions: 1) strategic planning, 2) development decision incorporation, 3) research support, and 4) social education and mobilization. Florida has taken initiatives in all four areas.

Strategic planning

Florida developed its first Climate Action Plan (Phase 1 Report: Florida’s Energy and Climate Action Plan Pursuant to Executive Order 07-128) in 2007, outlining policy recommendations on climate change mitigation. It set short-term and long-term emission reduction goals and analyzed policy mechanisms in the power sector and transportation sector. The plan was energy focused and the recommendations were oriented towards ensuring energy security. The plan was updated in 2008 to become Florida’s official Energy and Climate Change Action Plan. Climate change adaptation is first proposed in the plan. Comprehensive planning, protection of ecosystem, water resources management, infrastructure and community protection, emergency response, human health concerns, coordination with other regulatory agencies and education were identified as key areas.

Since the release of the statewide action plan, strategic planning has been taken place on different levels of government: regional, county, and city levels. For example, the Southeast

Florida Regional Climate Change Compact was formed in 2009 to coordinate regional climate efforts among Broward County, Miami-Dade County, Monroe County, and Palm Beach County. They also established a regional climate action plan titled: A Region Responds to a Changing Climate. The plan especially facilitates collaboration on resiliency building and habitat protection through coordinating public outreach and conservation programs. Efforts are also burgeoning at the county level. Miami-Dade County, for instance, proposed its county-level action plan as well as a broader scale sustainability plan that incorporates climate change initiatives into other sustainability actions (Miami-Dade County Climate Action Plan, 2010, Miami-Dade GreenPrint Plan, 2010). On the city-level, city governments are targeting more specific strategic planning issues that relates to climate change adaptation. The City of Miami Beach, for example, established a stormwater management plan that addresses the flooding and stormwater issue considering sea-level rise impacts (City of Miami Beach Stormwater Master Plan, 2010). The layers of action plans helps governments at different levels to plan for climate initiatives with different goals and allows them to make informed decisions for resource allocation. This layered system is also helpful in avoiding general goal-setting without specific implementation plans, since the goals are more narrowed and well-defined at lower level of governments (e.g in cities).

Development decision incorporation

Similar to strategic planning, climate action coordination with urban planning is taking place at all levels of governance in Florida. On the state-level, the Florida Department of Economic Opportunity oversees climate adaptation planning under Florida Statutes section 163.3164(1) and section 163.3177 (6)(g)(10) (FloridaDisaster, 2014). Several adaptation planning tools are provided by the department (e.g Digital coast-National Oceanic and Atmospheric Administration; Coastal Inundation Toolkit and Ecosystem-Based Management Tools Networks). These toolkits and resources enable regional and local governments to proceed with more specific planning integration activities. For example, Lee County developed the Climate Change Resiliency Strategy that integrates climate change adaption strategies into multiple economic sectors to utilize potential economic development opportunities under the changing climate by strengthening building codes, reallocating high risk infrastructure, incorporating Low Impact Development Principles (LID), adjusting commercial and sport fishery harvesting strategies, etc. (Council, S. F. R. P., 2010). In a state with high vulnerability to climate change, especially sea-level rise, coordinating and incorporating climate adaptation strategies into development of key economic sectors can not only build resiliency, but also minimize the cost of adaptation.

Apart from functional coordination, Florida is also incorporating climate change into the planning division through organizational restructuring. For example, the Miami-Dade Office of Sustainability was moved from a separate department that directly reports to the mayor’s office into the planning division under the Department of Economic Resources. According to our interview with a staff member in the sustainably office, this creates both benefits in cooperation with the planning department and inconvenience in accessing the mayor’s office.

Research support

Understanding the impact of climate change on the economy and society can serve as a powerful incentive to effectively develop policies. With accurate predictions of impact and effective policy mechanisms, the policy solutions can also be more efficient. Therefore, research plays an important role in dealing with climate change. Florida has been an active state in researching climate change impacts, particularly sea-level rise modeling. Multiple research centers and institutes have been founded such as the Florida Climate Institute that developed multi-disciplinary evaluation responses to climate change, the Southeast Climate Consortium that conducts research on seasonal climate change and the impacts on agricultural systems and ecosystems, the Florida Climate Center that developed the interactive website AgroClimate to help farmers manage crops and optimize farming strategies based on climate simulations, and the Florida Climate Change Task Force and Miami-Dade Climate Change Advisory Task Force that researched economic and environmental risks specific to Florida and Miami-Dade County (Galindo-Gonzalez 2011).

Social education and mobilization

Research products wouldn’t be helpful if they are not made public to foster communication and public engagement. Social education and mobilization programs can serve as effective tools in communicating the impact of climate change and benefits of climate change policies to the public and gain public support in developing and implementing policies. This can also incentivize behavior changes in energy and water conservation on the individual-level. There have been numerous efforts in Florida in this area. For example, the Florida Fish and Wildlife Conservation Commission developed a professional development workshop in climate change to help participants gain basic understanding of climate change, improve communication skills in climate change issues, and provides a forum for adaptation strategy discussion (Galindo-Gonzalez 2011). Even though the program is encouraged but not required for employees, it is likely to promote climate literacy in the population, raise awareness, and could even foster innovative solutions to climate adaptation through the active forum discussion. This is not the only training program in government agencies: Florida Department of Environmental Protection, Department of Transportation, and Regional Planning Council also have similar education/ training programs (Galindo-Gonzalez 2011). Moreover, the Southeast Florida Regional Climate Change Compact also utilizes its coordination advantage and organized the Southeast Florida Climate Leadership Summit to promote climate awareness and knowledge in the general public. It is expected that such social education and mobilization efforts will promote public attention and may even alter priority on policy agenda due public pressure.

City of Miami Beach Stormwater Management Project

We found that the new projects are expected to produce significant benefits in avoided flooding damage, avoided property damage, and avoided revenue loss from tourism. The total net present value of the project is 129.43 million dollars.

It is clear that the most significant benefits are from avoided property damage from sea-level rise and avoided tourism revenue loss, which represent key component of the City of Miami Beach economy. Miami Beach is one of the most concentrated areas of luxury hotels and high value private properties in the US, which means that it is at high risk of property value loss with coastal condition changes. It is estimated that approximately half of Miami's property value is exposed to catastrophic coastal events, ranking second among all US cities. (Worldwide A. I. R., 2013). Similarly, there is significant negative impact on tourism from climate change. Tourism is the biggest economic sector of the City of Miami Beach with over 2.2 billion dollars of tourism spending, according to City of Miami Beach Comprehensive Annual Financial Report. It is expected that the signature tourism sites will not be able to attract visitors with sea-level rise and extreme weather conditions. This reflects the high vulnerability of coastal cities' key economic sector to climate change, particularly sea-level rise and extreme weather events such as hurricanes. In turn, measures that protect properties and key tourism sites from inundation are crucial to maintaining the local economy. Therefore, even though this study makes conservative assumptions the estimated damage from climate change, we still found significant benefit in avoided damage.

Compared to the significant net benefits from the new stormwater management projects, the status-quo case with old stormwater infrastructures does not generate benefits because they lack capacity to deal with increased levels of flooding from more frequent storm surges, sea-level rise, and hurricanes. Therefore, even though the stormwater infrastructure is still operating and creating maintenance costs and environmental costs (from electricity consumption), they produce a negative net benefit. This demonstrates that rather than separately implementing climate change adaptation strategies and treating them as add-ons to the current city infrastructure, incorporating these adaptation strategies in to the city planning projects will reduce the cost while realizing significant benefits.

It is also worth noting that the cost of the projects is close in magnitude in both low and high social cost of carbon scenarios. In fact the only difference is that the high cost scenario has higher CO2 emission cost. The main reason is that the new projects do not dramatically increase electricity consumption. This again suggests that the adaptation project is minimized when merged with city planning efforts. However, it is also possible that we did not model the level of increased operation times such as the pump stations operating more frequently during extreme conditions. Therefore, future studies should more accurately simulate the operation schedule of the new infrastructures to accurately measure their environmental impact.

4.3.2 Oregon Case Study

Oregon received the highest score for Factor 2, policy development, which includes number of transportation policies, number of building policies, number of departments working on climate change, and climate change budget. Those four elements represent (1) development decision integration, (2) inter-department cooperation, and (3) resources and funding. The Baldock Solar Highway project demonstrated Oregon's efforts on all three aspects.

The transportation sector is always a big emitter of greenhouse gases in the U.S. In 2012, the transportation sector was the second largest contributor to U.S. greenhouse gas emissions, responsible for about 28% of total U.S. GHG emissions behind 32% from the electricity sector. Between 1990 and 2012, GHG emissions in the transportation sector increased more in absolute terms than any other sector. (EPA, 2015) In Oregon, Transportation accounted for 34% of total CO_2 emission in 2010. (Oregon DOT, 2009) That was where the Oregon Legislature started to require "a statewide transportation strategy to help achieve the greenhouse gas emissions reduction goals set in ORS 468A.205 [a 75% reduction below 1990 levels by 2050]." (Oregon DOT, 2013)

In response to the transportation emission regulation, Oregon Department of Transportation (ODOT) worked closely with state, regional and local governments, as well as stakeholders in the private sector, and advocacy groups to develop the Statewide Transportation Strategy (STS). The STS provided a strategic framework for ODOT to examine every aspect of the transportation system for potential emission reductions. In detail, the STS looked at six categories: (1) Vehicle and Engine Technology Advancements, (2) Fuel Technology Advancements, (3) Enhanced System and Operation Performance, (4) Transportation Options, (5) Efficient Land Use, and (6) Pricing and Funding Mechanisms. (Oregon DOT, 2013)

In addition to programs like Clean Fuel, Low-emission Vehicles, and car-sharing that are universally adopted by other state DOTs, ODOT looked at the electricity consumption in the transportation system, in combination to make more efficient use of its territory (land use). The Solar Highway program, which was designed to install solar panels along the highway, and provide clean electricity for the transportation system, is a pilot strategy for this purpose. The Baldock Solar Highway project is a part of this program.

As mentioned above, the project was initialized through cooperation between ODOT and Portland General Electric. High capital costs used to impede the project from moving forward, but ODOT came up with an innovative financing strategy. It encouraged private entities like Portland General Electric and Bank of America to financially support this project, and had local solar companies to design, construct, and maintain the system. This public-private partnership also enabled the project to take advantage of federal and state tax incentives. As a result, the Baldock Solar Highway Project successfully utilized public and private resources and funding through cooperation with other entities, to incorporate CO_2 emission reduction into the ODOT strategic plan.

From the CBA report (Table 11) in the Results section, we found that the net present value for the project would always be negative no matter which scenario we looked at. That was mainly due to the high capital costs ($11.08 million). However, we should notice that not all benefits were quantified in the analysis. The spillover benefits listed below were not sufficiently accounted for due to the limitation of data availability.

- Promoting local economy: as stated above, the project was designed, constructed, and maintained all by local businesses, which would at least support nine local companies, and create hundreds of jobs
- Achieving policy goals: the project helped to meet Oregon's ambitious Renewable portfolio standard, and helped with emission reduction. Oregon needs to adopt similar renewable energy projects to meet strict environmental compliance regulations anyway
- Increasing land value: this project made additional use of the land owned by ODOT to generate clean electricity for the transportation system, which also meets the goals of Oregon's STS
- Leading the solar highway development: ODOT has the first and largest solar highway project in the nation, making it the leader for transportation solar projects. 36 states and 15 countries have requested information on solar highways from ODOT. (Oregon DOT, 2014) The "Solar Highway Program Manual" developed by ODOT in 2011 had been a successful technology transfer tool
- Establishing public-private partnership for public renewable projects: the public-private partnership adopted by the Solar Highway Program enabled the Baldock Project to utilize private funding, federal and state tax credits, which paved the way for huge capital

investment accumulation. It also provides a model for other state governments to develop renewable projects.

In addition, as the International Renewable Energy Agency suggested, the cost of Solar PV systems is expected to reduce by 25% by 2020, 45% by 2030, and 65% by 2050. The efficiency of solar system is expected to increase from 10%-13% to 17%-20% by 2020. (IRENA, 2012) As a result, the initial capital cost for a similar project will be much less than the Baldock Solar Highway project. Based on that, we would expect that although in the short run a solar highway project seems not cost-effective, the benefits could outweigh the costs in the long run.

Thus, even though the net present values in our CBA were negative for this project, we still believe the Solar Highway project is generalizable. It is a creative project for different state DOTs, as a complementary strategy for projects like clean fuel, and zero-emission vehicles. By looking at emission reduction potential from the entire transportation system, such a project can add value to the idle transportation territory, and contribute to the commonwealth with clean, renewable electricity. The innovative public-private-partnership business model could also be helpful for other renewable projects.

4.4 Limitations

4.4.1 Survey

Collectively, the results from the survey responses, interviews, and factor analysis provide a better understanding of climate change governance effectiveness and show the differences at each level of government. However, our sample size is relatively small compared to the number of climate change professionals there are working in the U.S. government, even though there is representation from officials across the nation. We only reached officials from 18 states and had lower response rates from states in the Midwest and Southeast regions. Future research should try to capture a greater number of participants to help strengthen results and overcome potential biases. Also, feedback from survey respondents indicated that the survey needed to be more applicable to all the levels of government being surveyed. In this case, separate survey questions would need to be crafted for each level of government rather than creating questions that attempt to encompass all levels and possible responses. Finally, another respondent suggestion was to differentiate between climate adaptation and mitigation policies.

Organizations are taking different approaches to deal with climate change not reflected in our study which could help strengthen the specific strategies of each government. Identifying leaders in each dominant strategy could ease the collaboration between governments seeking to pursue one particular strategy or another.

4.4.2 Effectiveness Index

Despite our best effort to build a comprehensive model for the effectiveness index, there are certainly opportunities to improve the model. First, climate change governance is a complicated process with a number of factors and interacting influences. The nine variables identified by the study are far from a complete list of influential factors. Additional factors such as public education, political dynamics, and interaction of sector-specific policies can also play a crucial role in the effectiveness of climate governance. Further research is needed to identify additional variables and collect more comprehensive data. Second, it was challenging for us to collect data on the specific number of departments working on climate change for each state. Despite our research on state administrative structures and department websites, it is still possible that we omitted some departments, especially if no reports or other online products were available. Therefore, it would be optimal to contact each state agency and verify the data used for this variable.

4.4.3 Case Studies

While the results from the CBAs are reasonable, there exists opportunities to improve the study.

Data limitation

In the CBA for the City of Miami Beach stormwater management project, almost all damage data was based on Florida or Miami-Dade County. Even though we applied weight adjustments according to the economic sector evaluated, the damage data was not an accurate representation of City of Miami Beach conditions. Future studies should specifically model City of Miami Beach sea level rise damage, tourism damage, and expected flooding frequency to capture the true avoided damage by the stormwater management projects. Moreover, due to data availability, it is likely that the stormwater management plan generates benefits in other areas that we did not include in our benefit estimation, such as job creation and ecosystem service protection. Therefore, a more complete CBA should take these factors into consideration as well.

In the CBA of the Oregon Baldock Solar Highway Project, we were not able to quantify the spillover benefits such as local economy promotion, policy goal achievements, land value increase, and clean transportation strategy leadership. Those benefits should be counted in a complete cost-benefit analysis. However, our only data sources were the Oregon DOT and the Baldock Solar Highway websites, which only covered some of the necessary data for analysis. If we could get more detailed parameters for this project, the CBA results would be more reliable.

Analysis based on many assumptions

For the City of Miami Beach stormwater management projects, despite our best efforts in benefit estimation, our estimates of avoided damage are based on estimates from different journal article sources, taking a benefit transfer approach. The benefit transfer approach assumes it is reasonable to extrapolate results across different studies, which might be problematic when some studies have generalizability issues or are based on specific assumptions. It is noted that the estimates might lack precision since they are not generated from formal benefit valuation methods such as hedonic pricing or econometric models. Future studies can improve by identifying specific observable factors that climate change has an impact on (asset value, hotel occupancy rates and pricing, ecosystem services, and etc) and build an econometric model to accurately estimate the damage in City of Miami Beach from climate change.

For the Solar Highway Project, we made assumptions on the shadow value of capital, the discount rate, and the percentage of and shadow wage for unskilled workers to calculate job creation benefits. Although we had those assumptions based on the most accurate estimates and research support we could get, the values were not specifically set for this project. As a result, slight changes in those values could easily change the net present values of the project. While our CBA analyses provide some insight on potential benefit from climate change adaption and mitigation projects, they are far from complete and perfect models.

Conclusion

Overall, this project has helped determine current trends among different government levels that are working to address climate change within the United States and Canada and developed an index to rank climate change actions at the state level based on their governance structures. Climate change projects within governments appeared to begin around the same time in the late 2000's and coincided with government restructuring and the election or appointment of new leadership. Also, states in the West and Northeastern United States appear to have the best governance structures for dealing with climate change.

Identifying the current trends in governance structures and combining this with the governance effectiveness index can help provide states that are not addressing climate change now with the best information for future structure and implementation. With current major challenges associated with climate change governance of inadequate budget and human resources, as well as low priority, knowing which states have been more successful and what they have done can help avoid problems others have faced previously and formulate the best strategies for dealing with known obstacles. Also, by exploring governance structures at different levels of government, there can be more collaboration and information sharing between levels such as city and state departments. Different levels are often working towards the same goal of emission reductions and greater overall sustainability, yet collaboration often only occurs between governments at the same city or state level. Finally, by looking at what made specific projects successful, states can replicate certain steps in structuring their own climate adaptation or mitigation projects to help increase the chances of having a successful project.

References

A Region Responds to a Changing Climate. Southeast Florida Regional Climate Change Compact. October 2012.

ACCO. (2014, April 11). *Core Competencies of Climate Change Officers and Professionals*. Retrieved from Association of Climate Change Officers: http://www.accoonline.org/competencies.html

Active Climate Legislative Commissions and Executive Branch Advisory Groups. http://www.c2es.org/sites/default/modules/usmap/pdf.php?file=5899 . July. 2012.

Aldy, J. E., & Pizer, W. A. (2009). Issues in designing US climate change policy. *The Energy Journal*, 179-209.

Aldy, J. E., & Stavins, R. N. (2012). The promise and problems of pricing carbon: theory and experience. The Journal of Environment & Development, 1070496512442508.

Arvai, J., Bridge, G., Dolsak, N., Franzese, R., Koontz, T., Luginbuhl, A., & Thompson, A. (2006). Adaptive management of the global climate problem: Bridging the gap between climate research and climate policy. *Climatic Change*, *78*(1), 217-225.

Betsill, M. M., & Bulkeley, H. (2006). Cities and the multilevel governance of global climate change. *Global Governance: A Review of Multilateralism and International Organizations*, *12*(2), 141-159.

Braun, D., & Giraud, O. (2009). Politikinstrumente im Kontext von Staat, Markt und Governance. In: K. Schubert & N. C. Bandelow (Eds.), Lehrbuch der Politikfeldanalyse 2.0 (pp. 159–187). Munich: Oldenbourg.

Bulkeley, H., & Betsill, M. (2005). Rethinking sustainable cities: multilevel governance and the 'urban' politics of climate change. *Environmental politics*,*14*(1), 42-63.

Bulkeley, H., & Moser, S. C. (2007). Responding to climate change: governance and social action beyond Kyoto. *Global Environmental Politics*,*7*(2), 1-10.

Bulkeley, H., & Schroeder, H. (2008). Governing climate change post-2012: The role of global cities–London. *Tyndall Center for Climate change research*.

Bulkeley, H. (2010). Cities and the governing of climate change. 229-253.

Bureau of Labor Statistics, 2014 State Occupational Employment and Wage Estimates-Oregon. Retrieved 4 22, 2015 from http://www.bls.gov/oes/current/oes_or.htm#47-0000

Burch, S., Schroeder, H., Rayner, S., & Wilson, J. (2013). Novel multisector networks and entrepreneurship: the role of small businesses in the multilevel governance of climate change. *Environment and Planning C: Government and Policy*, *31*(5), 822-840.

Carlson, A. E. (2008). Iterative federalism and climate change.103 (3): 1097–1161.

CDM Smith. (2011). The City of Miami Beach Stormwater Master Plan Final Report.

Chittum, A., Hayes, S., Neubauer, M., Nowak, S., Vaidyanathan, S., Farley, K., & Cui, C. (2013, November). The 2013 State Energy Efficiency Scorecard. American Council for an Energy-Efficient Economy.

City of Miami Beach Revenue from Tourism in 2012: Comprehensive Annual Financial Report, City of Miami Beach.

City of Miami Beach Stormwater Master Plan. 2010

Climate Change Action Plans. http://www.epa.gov/statelocalclimate/state/state-examples/action-plans.html#all

Climate Change Action Plan. Miami-Dade County, June 2010

Corfee-Morlot, Jan, Lamia Kamal-Chaoui, Michael G. Donovan, Ian Cochran, Alexis Robert and Pierre-Jonathan Teasdale (2009), "Cities, Climate Change and Multilevel Governance", OECD Environmental Working Papers N° 14, 2009, OECD publishing, © OECD.

Cote, M. (2011). Barriers to Implementing Climate Adaptation Plans: A Survey of Climate Professionals Across Sectors. Washington D.C.: Association of Climate Change Officers. Retrieved from http://www.accoonline.org/downloads/ACCO-Abstract-Adaptation-Nov2011.pdf

Council, S. F. R. P. (2010). Lee County Climate Change Resiliency Strategy (CCRS).

Creswell, J. & Clark, V. (2007). Designing and Conducting mixed methods research. Thousand Oaks, California: Sage Publications.

EIA Electricity Data. Retrieved 4 22, 2015 from http://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=vvvvvvvvvvvvo&endsec=vg&linechart=ELEC.PRICE.US-ALL.A&columnchart=ELEC.PRICE.US-ALL.A&map=ELEC.PRICE.US-ALL.A&freq=A&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0

Energy Information Administration. (2013). *International Energy Statistics: Total Carbon Dioxide Emissions*. Retrieved from EIA.gov: http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8

Energy Information Administration. (2014). International Energy Statistics: Total Carbon Dioxide Emissions. Retrieved from EIA.gov: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8

Environmental Protection Agency. (2015). Fast Facts U.S. Transportation Sector Greenhouse Gas Emissions 1990-2012. EPA Office of Transportation and Air Quality, March 2015. Retrieved from http://www.epa.gov/otaq/climate/documents/420f15002.pdf.

Executive Office of the President. (2013). The President's Climate Action Plan. Retrieved from http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

Federal Agency Benefit-Cost Analysis Principles and Standards for Social Programs. Retrieved 4 22, 2015, from http://evans.uw.edu/sites/default/files/public/Federal_Agency_BCA_PS_Social_Programs.pdf

FloridaDisaster. Adaptation Planning in Florida. Retrieved 4 22, 2015 from http://www.floridajobs.org/fdcp/dcp/AdaptationPlanning/AdaptationPlanninginFlorida.pdf

Florida's Energy & Climate Action Plan. October 15, 2008.

Fitzpatrick, M. (2011, October 4). Canada's Climate Change Goals Falling Short. CBC News. Retrieved from http://www.cbc.ca/news/politics/canada-s-climate-change-goals-falling-short-1.1001266

Friedman, B., Jordan, P., & Carrese, J. (2011). Solar Installation Labor Market Analysis. *Contract*, *303*, 275-3000.

Fröhlich, J., & Knieling, J. (2013). Conceptualising Climate Change Governance. In *Climate Change Governance* (pp. 9-26). Springer Berlin Heidelberg.

Galindo-Gonzalez, S., Florida climate change Education and Training: State University System Cooperative Plan. December 2011. State University System of Florida

Goulder, L. H., & Stavins, R. N. (2011). Challenges from state-federal interactions in US climate change policy. *The American Economic Review*,*101*(3), 253-257.

Goulder, L. H., Jacobsen, M. R., & Van Benthem, A. A. (2012). Unintended consequences from nested state and federal regulations: The case of the Pavley greenhouse-gas-per-mile limits. *Journal of Environmental Economics and Management*, *63*(2), 187-207.

Hamilton A. Spotlight on Solar Arrays[J]. Public Roads, 2012, 76(3).

HDR and CH2M Hill. (2011). Discounting Recommendations for Least Cost Planning in Oregon. Retrieved from http://www.oregon.gov/ODOT/TD/TP/docs/lcp/discount.pdf.

IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Group I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team: R.K. Pachauri and L.A. Meyer (eds)]. IPCC, Geneva, Switzerland, 151pp.

IRENA. (2012). Renewable energy technologies: Cost analysis series[J]. Concentrating solar power, 2012.

Junpeng Jia. (2011). Statistics. *Chapter 11 Principle Component and Factor Analysis*, 231-242.

Kingdon, John W. (2010). Agendas, Alternatives, and Public Policies, 2nd Edition. New York: Harper Collins.

Lutsey, N., & Sperling, D. (2008). America's bottom-up climate change mitigation policy. *Energy Policy*, *36*(2), 673-685.

Maike Rahn. (2013). Factor Analysis: A short Introduction, Part 1. Retrieved from http://www.theanalysisfactor.com/factor-analysis-1-introduction/

Mayntz, R. (2006). Governance Theory als fortentwicklelte Steuerungstheorie? In: G. F. Schuppert (Ed.), Governance-Forschung. Vergewisserung über Stand und Entwicklungslinien (pp. 11–20). Baden–Baden: Nomos-Verl.-Ges.

Miami-Dade County GreenPrint Plan. December 2010

Niles, R., (2006). "Robert Niles' Journalism Help: Statistics Every Writer Should Know," RobertNiles.com. Retrieved from http://www.robertniles.com/stats/.

Oregon Department of Transportation. (2009). Background Report: The Status of Oregon Greenhouse Gas Emissions and Analysis. Retrieved from http://www.oregon.gov/ODOT/TD/OSTI/docs/hb2186/background.pdf.

Oregon Department of Transportation. (2013). Oregon Statewide Transportation Strategy Oregon Department of Transportation: A 2050 Vision for Greenhouse Gas Emissions Reduction. Retrieved from http://www.camsys.com/pubs/STSReport.pdf.

Oregon Department of Transportation. (2014). Oregon's Solar Highways. Retrieved from http://www.oregon.gov/ODOT/HWY/OIPP/pages/inn_solarhighway.aspx

Ostrom, E. (2010). A multi-scale approach to coping with climate change and other collective action problems. *Solutions*, *1*(2), 27-36.

Phase 1 Report: Florida's Energy and Climate Action Plan Pursuant to Executive Order 07-128. November 1, 2007.

Pierre, J. (2002). Introduction: Understanding governance. In: J. Pierre (Ed.), Debating governance. Oxford: Oxford University Press (reprinted).

Rabe, B. G., Roman, M., & Dobelis, A. N. (2005). State competition as a source driving climate change mitigation. *NYU Envtl. LJ*, *14*, 1.

SERCTrade. Retrieved 4 22, 2015 from https://www.srectrade.com/srec_markets/california

Shellenberger, M., & Nordhaus, T. (2004). The death of environmentalism.*Global warming politics in a post-environmental world*, *28*.

Sijim, Jos, Jaap Jansen, and Asbjorn Torvanger. 2009. Differentiation of mitigation commitments: the multi-sector convergence overlap. *Climate Policy* 1(4) : 481-497.

Soltwedel, R. (2005). Marktwirtschaftliche Instrumente. In: ARL, Akademie für Raumforschung und Landesplanung (Ed.), Handwörterbuch der Raumordnung (pp. 625–631). Hannover: Akad. für Raumforschung und Landesplanung.

State and Local Government. http://www.statelocalgov.net/state-ma.cfm .

Terri L. Cruce (2009). *Adaptation Planning – What U.S. States and Localities are Doing.* Pew Center on Global Climate Change.

US EPA. (2012). Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2010.

VanDeveer, Stacy (2010). Multilevel Governance Perspectives from North America Climate Policies. Northeastern University, Boston.

Wiener, J. B. (2007). Think globally, act globally: The limits of local climate policies. *University of Pennsylvania Law Review*, 1961-1979.

Worldwide, A. I. R. (2013). The Coastline at Risk: 2013 Update to the Estimated Insured Value of US Coastal Properties.

Appendices

Appendix A. Responding Institutions

Region	State	Organizations
Midwest	Oklahoma	City of Oklahoma City
Midwest	Wisconsin	City of Madison
Midwest	Illinois	Lake County, Illinois
Midwest	Ohio	City of Columbus
Northeast	Connecticut	CT Department of Energy and Environmental Protection
Northeast	Massachusetts	Massachusetts Department of Environmental Protection
Northeast	Delaware	State of Delaware
Northeast	New York	City of Rochester
Northeast	Maine	Maine PUC
Northeast	Connecticut	CT Department of Energy and Environmental Protection
Northeast	Massachusetts	MA Executive Office of Energy and Environmental Affairs
South	North Carolina	North Carolina Department of Environment and Natural Resources
South	Louisiana	Louisiana Department of Environmental Quality
South	Tennessee	City of Knoxville, TN
South	North Carolina	Town of Cary
West	Oregon	City of Beaverton
West	Oregon	Oregon Department of Transportation
West	Oregon	Portland, Oregon
West	Montana	Montana Department of Environmental Quality
West	California	City of Hamilton
United States		USDA
United States		U.S. EPA Office of Sustainable Communities
Canada		City of Hayward
Canada		Regional Municipality of Peel, Ontario, Canada
Canada		The Regional Municipality of York
Canada		Peel
Canada		The Regional Municipality of York

Appendix B. Survey Questionnaire

Background

1. Survey Participation Guidelines: In an effort to disseminate potential lessons learned surrounding climate change governance in local and state governments, project managers will compile results from this survey to produce a series of academic and published reports. If you would like to exclude your institution from being identified or referenced in any related reports/publications, please select the “Opt Out” box below. NOTE: Selecting this box means that the answers provided in your response will only be used for aggregated information, and your response will remain completely anonymous.

2. Please identify a point of contact responsible for survey responses submitted. The project managers anticipate receiving responses to questions that may require clarification. We ask that survey respondents identify a point of contact responsible for the content submitted, and who can answer questions that may arise during the course of this survey. Project managers will not use any person’s name or contact information in published materials. This information will only be used to clarify content in the survey responses (and/or for future surveys on related topics)

Name: Job Title: Email:

3. At what level of government do you work?

1. City/ Municipality
2. County
3. State/Province
4. National/Federal

4. Please enter the name of your government entity:

5. Please identify affiliations your institution maintains related to climate change (check all that apply):

1. Member of Large Cities Climate Leadership Group (C40)
2. Member of the ICLEI
3. Member of Western Climate Initiative
4. Signatory to the Resilient Communities for America Agreement
5. Member of the EPA Climate Leaders Program
6. Signatory to The U.S. Conference of Mayors' Climate Protection Agreement
7. Membership in the World Mayors Council on Climate Change
8. Member of The Climate Registry
9. Member of Urban Sustainability Directors Network
10. Other, please specify

Governance Structure

1. What is the name of the department, division or agency in which you work?

2. What is the title of the individual (if not you) who is responsible for leading climate initiatives within your department/division/agency?

3. Is your department/division/agency the overall lead for climate response within your government?

- Yes
- No, please identify the lead entity:

4. List any other divisions/departments with whom you work on climate change initiatives (Note: please limit responses to within your government entity, as opposed to external stakeholders such as universities, private sector, etc.).

5. How many people are employed in your division/department?

1. 1-10
2. 10-25
3. 25-50
4. More than 50

6. How many of those individuals are tasked with working on climate change initiatives?

7. Which of the following activities are included in the daily responsibilities of the individual tasked with leading climate response in your agency? (Check all that apply)

1. Greenhouse gas accounting and management
2. Climate change vulnerability assessment and adaptation planning
3. Communicating and engaging with stakeholders
4. Policy design/ project evaluation
5. Compliance check
6. Intergovernmental relations
7. Emergency response
8. Energy management / renewable energy development
9. Supply chain / procurement
10. Budgeting climate management activities
11. Transportation, public transit and fleet management
12. Other, please specify

8. If the person answering this survey is the individual tasked with leading climate response, please indicate areas of professional experience (if not, please skip this question – check all that apply):

1. Government/Public Affairs
2. Environmental Management / Sustainability
3. Engineering
4. Climate Change Strategies
5. Communication
6. Business Administration and/or Financial Management
7. Public Administration

8. Facilities Management
9. Natural Resource Management
10. Other, please specify

9. Does your institution have a strategic plan (e.g. Climate Action Plan) to address climate change?
1. Yes
2. A plan is in development
3. No

10. **If YES or IN DEVELOPMENT to Q7**: Is the plan publicly available? If yes, please provide a link.

11. **If YES or IN DEVELOPMENT to Q7**: When did/will this climate plan go into effect?

12. **If YES or IN DEVELOPMENT to Q7**: List the job titles of up to three key contributors to the development of the plan

13. **If YES or IN DEVELOPMENT to Q7**: List the job titles of up to three key contributors to the implementation of the plan

14. **If YES or IN DEVELOPMENT to Q7**: List the job titles of any individuals that approved the adoption of the plan.

15. **If YES to Q7**: What was/were the primary climate related goal(s) of this action plan? (Check up to three that apply)

1. GHG Reduction
2. Adaptation Planning
3. Renewable Energy Development
4. Energy Efficiency
5. Community Engagement
6. Other, please specify

16. Does your department produce any other climate change related annual products or reports?
1. Yes
2. No

17. **If YES to Q14**: The yearly product(s) include:
1. Annual review/ internal report
2. Compliance report
3. White paper
4. Climate change awareness campaign
5. Other, please specify

18. **If YES or IN DEVELOPMENT to Q9 or Q16:** Please list any other departments your department/ agency collaborated with to produce the strategic plan or yearly product?

19. Who directly oversees your institution's response to climate change and is accountable (i.e. possesses the highest authority regarding climate change decisions) for addressing the economic, operational and environmental implications of climate change, potentially including directing strategies and/or overseeing budgetary considerations?

1. Mayor
2. Department Head
3. City Manager
4. Other, please specify job title
5. I don't know

20. **If Dept Head or Other to Q16:** In what department or division is this person located? (Check all that apply)

1. Department of Environment and Energy
2. Department of Air Quality
3. Department of Environmental Assessment
4. Department of Environmental Compliance
5. Department of Research and Development
6. Department of Sustainability
7. Other, please specify

21. **If Dept Head or Other to Q16:** To whom does this person report administratively? (Check all that apply)

1. Mayor
2. City Manager
3. City Council
4. Other, please specify
5. I don't know

22. What other governing bodies, groups or departments oversee the work of this person? (Check all that apply)

1. Mayor's Office
2. City Council
3. Environmental Department
4. Economic Development Council
5. Other, please specify
6. I don't know

23. Where did this person (the one who directly oversees your institution's response to climate change) work previously?

1. State government
2. Other city government within the same city
3. Other city government of a different city
4. Other (private sector, academia, non-profit)
5. Within your institution (hired from within)

24. Please choose the areas in which this person has professional experience (Check all that apply):

1. Government/Public Affairs
2. Environmental Management
3. Environmental Science/Engineering
4. Climate Change Strategies
5. Communication
6. Business Administration
7. Other, please specify
8. I don't know

25. Please indicate which topics are of importance to this person's job responsibilities particularly related to climate change (check the top 3):

1. Carbon offsets and related markets
2. Facilities management and design
3. Transportation, public transit and fleet management
4. Renewable energy projects
5. Stakeholder relations
6. Cost benefit analysis/life cycle analysis
7. GHG inventory development and/or identification of GHG reductions goals
8. Climate action planning/setting goals and strategies
9. Budgeting climate management activities
10. Coordinating climate change efforts across departments
11. Other, please specify
12. I don't know

26. Has your institution undergone any organizational restructuring related to climate change governance in the past 6-8 years?

1. Yes
2. No
3. I don't know

27. **If YES to Q28**, When did the restructuring take place?

28. **If YES to Q28**, What has changed after the restructuring?(check all that apply)

1. Creation of new position(s)
2. Creation of new department(s)
3. Eliminating position(s)
4. Reorganization of functions
5. Other, please specify

29. **If YES to Q28**, why did the restructuring happen?

30. **If YES to Q28**, what was the job title of the person that led the restructuring?

31. **If YES to Q28**, do you think the restructuring has improved the institution's ability to deal with climate change issues ?(Note: the answer will not be attributed to the respondent)

1. Yes
2. No
3. I don't know

Budget

1. Does institution you are working in have a specific budget to address climate change?

   1. Yes
   2. No

2. **If YES to Q1:** Where does the climate-specific funding come from? (Check all that apply)

   1. Grant
   2. Federal funding
   3. State funding
   4. Local tax
   5. External donors
   6. Other, please specify
   7. I don't know

3. Who has budgetary authority over implementation of climate change strategies in the institution you are working in? Please specify job title(s)

4. To whom does this person report administratively? (Check all that apply)

   1. Mayor
   2. Department Head
   3. City Council
   4. City Manager
   5. Other, please specify
   6. I don't know

5. Please choose the areas in which this person has professional experience (Check all that apply):

   1. Government/Public Affairs
   2. Environmental Management
   3. Climate Change Strategies
   4. Communication
   5. Business Administration
   6. Finance
   7. Accounting
   8. Other, please specify
   9. I don't know

6. Has the institution you are working in undergone any budgetary change related to climate change governance in the past 6-8 years?

1. Yes
2. No
3. I don't know

7. **If YES to Q6**: When did the change take place?

8. **If YES to Q6:** How did the budget related to climate change governance change?

1. Increase
2. Decrease
3. I don't know

9. **If YES to Q6:** Please specify any known reasons for the budgetary change.

10. Do the organization/ institution/ department you are working in coordinate with other departments in implementing climate change programs?

1. Yes
2. No

11. **If YES to Q10:** Do the organization/ institution/ department you are working in have a shared budget for these programs?

1. Yes
2. No

Others

1. What are some state regulations that limit your institution's ability to set or implement climate change plans? (please check all that apply)

1. Restrictions on power plant regulations
2. Preemption of transportation related policies
3. Climate related taxes
4. Renewable adoption incentives
5. Other, please specify
6. None

2. Please rank the challenges or organizational barriers to addressing climate change that the institution you are working in faces:

1. Budgetary Issues
2. Organizational structure issues
3. Educating and training staff
4. Lack of concern of the constituents/residents
5. Existing policy framework at the state level
6. Low priority placed on climate change within your institution

7. Other, please specify

3. How effectively do you feel the institution you are working in has dealt with climate change issues in your city/county? (1 being ineffective; 10 being highly effective) Note: this rating will not be attributed to the respondent or shared with anyone

4. Are there any aspects surrounding your institution's response to climate change issues that have not been addressed in the survey thus far? (i.e. any other arrangements unique to your institution) Please describe:

Appendix C. Assumptions for benefit estimation of City of Miami Beach Stormwater Management Projects

Capital cost:
Status-quo: none
New plan: construction cost of the project included in the new management plan,

Year	Capital Cost ($million/yr)
2012-2016	12.4
2017-2021	5.8
2022-2026	6.86
2027-2031	16.2

*Data Source: City of Miami Beach Stormwater Management Master Plan Executive Summary. Page ES-8.

Operation & Maintenance Cost:
Status-quo: maintenance of current stormwater management system: $0.63 million/year.
New plan: maintenance of the new stormwater management system: 0.9 million/year
*Data source: City of Miami Beach Citywide Comprehensive Stormwater Management Master Plan. Presentation to the Finance Committee. June 2012.
* Note: With limited available information, we assume pumping O&M cost is representative of system cost.

Environmental cost:

$$CO_2\ Emission\ Cost = Energy\ consumption\ of\ pump\ station\ each\ year \times CO2\ Emission\ Rate\ in\ Florida \times Social\ Cost\ of\ Carbon$$

Status-quo: energy consumption from 28 existing pump stations.
New plan: energy consumption from 17 new pump stations.
*Data source:
Energy consumption: assume 225kw motor running 90 hours per year.
*Storm Water Pumping Station Design Guide. Grundfos.

Social cost of carbon: low scenario: average 3% discount rate
High scenario: 95% percentile 3% discount rate

*Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. Interagency Working Group on Social Cost of Carbon, United States Government. November 2013.

Avoided Flooding Damage:

$$Avoided\ Flooding\ Damage_{2012} = Flooding\ Damage\ per\ Year\ in\ Florida \times State\ to\ City\ Weight$$

Flooding Damage per Year in Florida= 40 million/ year in 1997 * inflation adjustment to 2006 dollar =50 million/year

*Data Source: Climate Change in Coastal Areas in Florida: Sea Level Rise Estimation and Economic Analysis to Year 2080. Dr. Julie Harrington and Dr. Todd L. Walton, Jr. The Florida State University. August 2008.
State to City Weight: City of Miami Beach GDP in 2008/ Miami-Dade GDP in 2008= 7.2 billion/ 111.615 billion = 6.45%
*Data Source: Miami-Dade County: Current Economic Conditions. Greater Miami Chamber of Commerce Real Estate Committee Meeting.
City of Miami Beach: Miami Beach Economic Indicators.

Avoided Sea-level Rise Damage:
Sea-level rise damage is often predicted in the long-run and it is unlikely that the damage occurs now. Therefore, according to literature on sea-level rise modeling, we assume the damage start occurring in 2025. Moreover, we assume that the damage increase follows an exponential function. The following equation is used to solve for the annual growth rate from 2025 to 2031.

Miami-Dade County damage: every foot of increase result in 7.32 billion loss.
Miami-Dade County projected 0.5 feet by 2025: Damage in 2025= 7.32 billion * 0.5 = 3.66 billion
Cost of inaction is 5.5% (Florida and Climate Change: the Cost of Inaction).
Management plan remedy 5.5% of damage

$$Avoided\ Damage/year = Damage\ in\ one\ year \times 5.5\%$$

Avoided damage in 2025= 3.66 billion * 5.5% = 203.1 million
Miami-Dade County economic loss in 2060 = 27694 million (data obtained from Florida and Climate Change the Cost of Inaction)
Fit the exponential model:

$$Avoided\ Damage\ in\ 2060 = Avoided\ Damage\ in\ 2025 \times (1+r)^{35}$$

Growth rate is 15%

$$Avoided\ Damage\ per\ year = 203.1 \times county\ to\ city\ weight\ adjustment \times (1+0.15)\text{^}(t-2025)$$

$$County\ to\ city\ weight\ adjustment = \frac{City\ of\ Miami\ Beach\ Property\ Value_{2013}}{Miami-Dade\ County\ Property\ Value_{2013}} = \frac{24.07\ billion}{189\ billion} = 13\%$$

Data Source: Miami-Dade County property value in 2013: FY2014-2015 Property Tax Comparative Data Summary. Florida Association of Counties.
City of Miami Beach property value in 2013: Miami Beach Economic Indicators

Avoided Tourism Revenue Loss:
Similar to property value, tourism revenue loss from sea-level rise and extreme flooding is unlikely to happen immediately. It is assumed that the revenue loss start occurring in 2025 and follows an exponential growth trend with constant annual growth from 2025 to 2031.
Growth rate calculation:

$$Tourism\ Revenue\ Loss_{2050} = Tourism\ Revenue\ Loss_{2025} \times (1+r)^{25}$$

Florida State-wide Tourism revenue loss in 2050=40 billion.
Florida State-wide Tourism revenue loss in 2025= 9 billion.
Growth rate=6%

Assume the management plan remedy 5.5% of damage (avoid the cost of inaction).
*Data Source: Economic Impacts of Climate Change on Florida: Estimates from Two Studies

$$Avoided\ Revenue\ Loss\ per\ year = 4\ billion \times 5.5\% \times state\ to\ city\ weight\ adjustment \times (1+0.06)\hat{}(t-2025)$$

$$State\ to\ city\ weight\ adjustment = \frac{City\ of\ Miami\ Beach\ Revenue\ from\ Tourism_{2012}}{Florida\ Revenue\ from\ Tourism_{2012}} = \frac{2.2\ billion}{67\ billion} = 3.2\%$$

Data Source: City of Miami Beach Revenue from Tourism in 2012: Comprehensive Annual Financial Report, City of Miami Beach.
Florida Revenue from Tourism in 2012: Facts about Florida. State of Florida.com

Appendix D. **Social Cost of CO_2 (2007 dollar)**

Year (Discount rate = 3%)	Low CO_2 social cost	High CO_2 social cost
2010	32	89
2011	33	93
2012	34	97
2013	35	101
2014	36	105
2015	37	109
2016	38	112
2017	39	116
2018	40	120
2019	42	124
2020	43	128
2021	43	131
2022	44	134
2023	45	137
2024	46	140
2025	47	143
2026	48	146
2027	49	149
2028	50	152
2029	51	155
2030	52	159
2031	52	162
2032	53	165
2033	54	168
2034	55	172
2035	56	175
2036	57	178
2037	58	181
2038	59	185
2039	60	188
2040	61	191
2041	62	194

Appendix E. NVivo Matrix coding result

	California Department of Water Resources	Maine PUC	Delaware Department of Natural Resources and Environmental Control
Scale	2	2	1
Cooperation	5	1	4
Budget	7	3	5
Achievements	1	2	3
Challenges	5	2	7
Rating	2	2	0

Matrix Coding results_track back to sources

	California Department of Water Resources	Maine PUC	Delaware Department of Natural Resources and Environmental Control
Scale	12/3000, including an assistant deputy director, a program manager, a regional specialist in each of the regional office, a number of additional staffers	0 full time, 5-10 depending on climate change works	0 full time, 6 have some responsibility for climate change
Cooperation	1. Western Governors Association: agreements and information sharing; 2. California Air and Resources Control Board: develop policies and regulations.	1. Maine DEP; 2. RGGI: Energy efficiency	1. Coastal Programs Office and the Division of Energy and Climate; 2. NOAA; 3. local governments, agencies, and businesses; 4. state agencies and league of local governments to get the information needed
Budget	From: proposition funds, water/flood funds, general fund for certain projects; budget scale is uncertain, depending on funding sources	From: a fee on electrical rates, funding from RGGI, a small of the general fund revenue; 1%-2% of total budget	From: funding from RGGI on alternative energy; federal funding

Achievements	1. well coordinated among the climate group; 2. more efficient	1. huge carbon reductions; 2. successful climate initiative; 3. energy efficiency program; 4. working across the agency of energy and environment	1. two milestone documents and products—the vulnerability assessment and the adaptation plan; 2. work closely with local governments, agencies, business; 3. significant public engagement; successful workshops and meetings; 4. Delaware being the lead on sea level rise
Challenges	1. difficult for California agencies to travel out of state for meetings; 2. not effective to get climate change integrated across the department; 3. Climate change is not a priority; 4. Fund out of the department is not effectively used	1. budget is under tremendous pressure; 2. climate change work is not a priority; 3. short of resources and staff	1. Restriction in allocation of federal funding, no state general funds designated for energy and climate programs; 2. environmental regulations in the state do not yet incorporate climate or sea level rise concerns, and cannot because of the complicated regulatory process; 3. difficulty implementing plans and to make decisions; 4. diffused governance
Rating	8	Previous: 8-9; recent: 5	9

From the table, we can see seven similar themes as our findings from survey responses: (1) the group of people working on climate change was small, though in some cases there was part-time staff with responsibility for climate change issues; (2) a state would join regional climate initiatives for cooperation; (3) the department of environment and air quality worked on climate change issues; (4) funding for climate work depended on the type of the department, for example, the department of water resources got most funding from water/flood bonds, PUC got funding from electric rates. But the percentage of budget allocated for climate work was usually small; (5) the success of climate action plan was seen as big achievement, which was associated with significant emission reductions; (6) not seeing climate change as a priority was a primary challenge for all the three departments; (7) limited budget and resources restricted climate work.

Appendix F. Factor Analysis Results Tables and Figures

Table 1 Descriptive Statistics

Variables	Average	Standard Deviation	Sample Size
Climate Change Budget	0.60	0.33	51
Number of Utility Policy	0.51	0.23	51
Number of Transportation Policy	0.57	0.25	51
Number of Building Policy	0.62	0.26	51
Percentage of Number of Departments Working on Climate Change	0.43	0.21	51
Presence of Climate Research Advisory Committees	0.61	0.49	51
Presence of Climate Action Plan	0.75	0.44	51
Publicity of Climate Action Plan	0.69	0.47	51
Presence of Cooperation between Planning Division with Climate Department	0.49	0.51	51

Table 2 Total Variance Interpreted

Factor	Initial Eigenvalue			Sum of Squares			Sum of Squares with Rotation		
	Total	Variance %	Accumulation%	Total	Variance %	Accumulation%	Total	Variance %	Accumulation%
1	3.957	43.962	43.962	3.957	43.962	43.962	2.771	30.794	30.794
2	1.190	13.219	57.181	1.190	13.219	57.181	2.344	26.043	56.837
3	1.043	11.585	68.766	1.043	11.585	68.766	1.074	11.929	68.766
4	.822	9.139	77.905						
5	.694	7.709	85.614						
6	.486	5.398	91.012						
7	.445	4.941	95.953						
8	.248	2.757	98.710						
9	.116	1.290	100.000						

Extraction Method: Principle Components.

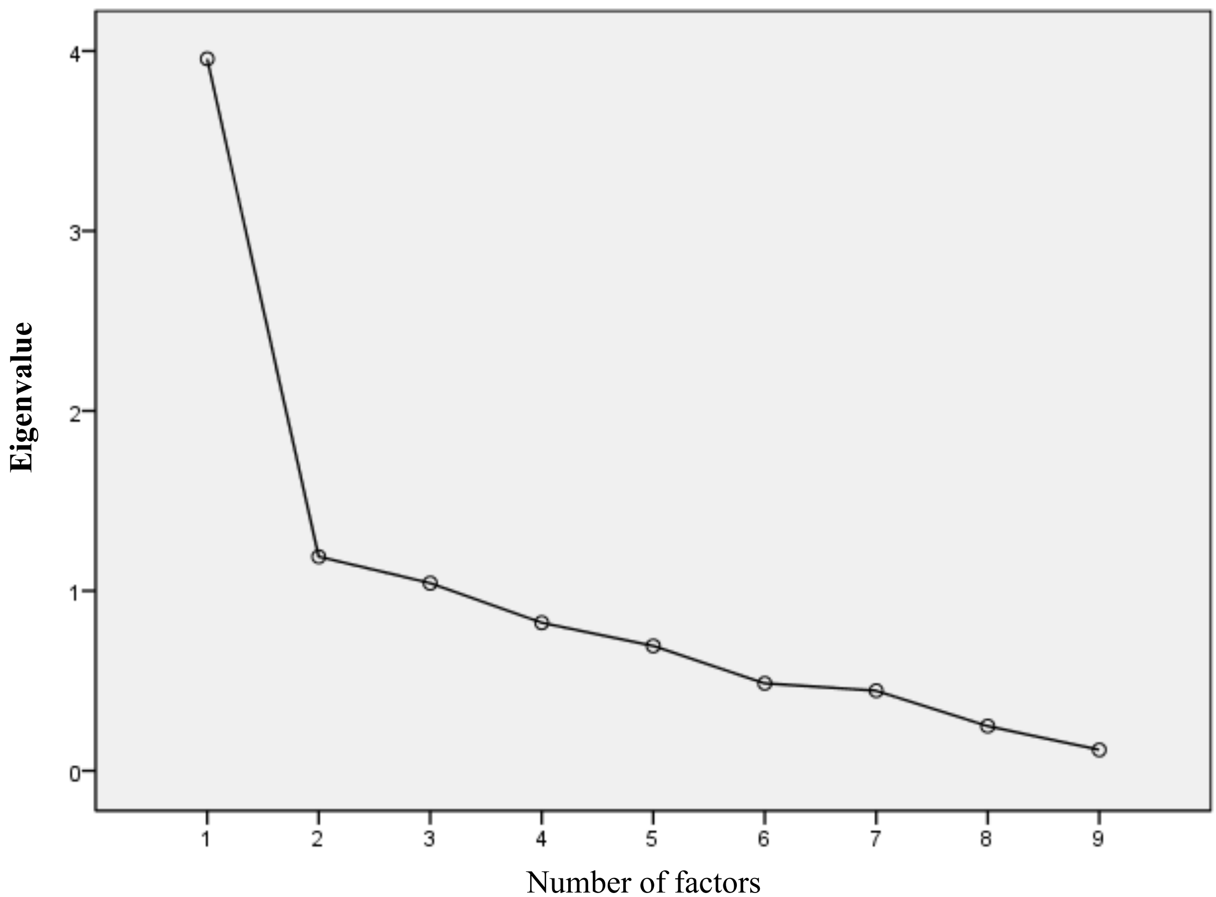

Figure 1 Scree Plot of Factor Analysis

Table 3 Rotated Factor Matrix

Variables	Factors		
	1	2	3
Climate Change Budget	0.055	0.553	-0.455
Number of Utility Policy	-0.051	0.118	0.912
Number of Transportation Policy	0.390	0.709	0.032
Number of Building Policy	0.245	0.740	0.102
Percentage of Number of Departments Working on Climate Change	0.105	0.728	0.002
Presence of Climate Research Advisory Committees	0.723	0.239	-0.036
Presence of Climate Action Plan	0.906	0.182	-0.036
Publicity of Climate Action Plan	0.915	0.150	-0.080
Presence of Cooperation between Planning Division with Climate Department	0.601	0.575	0.116

Table 4 Factor Scoring Matrix

Variables	Factors		
	1	2	3
Climate Change Budget	-0.159	0.329	-0.437
Number of Utility Policy	-0.021	0.064	0.848
Number of Transportation Policy	-0.012	0.310	0.030
Number of Building Policy	-0.093	0.370	0.089
Percentage of Number of Departments Working on Climate Change	-0.166	0.408	-0.011
Presence of Climate Research Advisory Committees	0.297	-0.073	-0.007
Presence of Climate Action Plan	0.408	-0.163	0.002
Publicity of Climate Action Plan	0.420	-0.183	-0.038
Presence of Cooperation between Planning Division with Climate Department	0.140	0.163	0.121