University of Massachusetts Amherst
ScholarWorks@UMass Amherst

Masters Theses 1911 - February 2014

2013

Water Plans and Climate Change Plans in the Northeast and the Southwest

An Pham
University of Massachusetts Amherst

Follow this and additional works at: https://scholarworks.umass.edu/theses

 Part of the Industrial Engineering Commons

Pham, An, "Water Plans and Climate Change Plans in the Northeast and the Southwest" (2013). *Masters Theses 1911 - February 2014*. 1077.
Retrieved from https://scholarworks.umass.edu/theses/1077

This thesis is brought to you for free and open access by ScholarWorks@UMass Amherst. It has been accepted for inclusion in Masters Theses 1911 - February 2014 by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact scholarworks@library.umass.edu.

WATER PLANS AND CLIMATE CHANGE PLANS IN THE NORTHEAST AND THE SOUTHWEST

A Thesis Presented

By

AN PHAM

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN
INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH

May 2013

Mechanical and Industrial Engineering

WATER PLANS AND CLIMATE CHANGE PLANS IN THE NORTHEAST AND THE SOUTHWEST

A Thesis Presented

by

AN PHAM

Approved as to style and content by:

_____
Erin Baker, Co-chair

_____
Jenna Marquard, Co-chair

_____
Casey Brown, Member

_____
Donald Fisher, Department Head
Mechanical and Industrial Engineering

ABSTRACT

WATER PLANS AND CLIMATE CHANGE PLANS IN THE NORTHEAST AND THE SOUTHWEST

MAY 2013

AN PHAM, B.S., COE COLLEGE
M.S., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Erin Baker and professor Jenna Marquard

To what degree are water managers in different regions in the United States thinking about and planning for climate change? To answer this question we reviewed water plans and climate change plans in all the cities with populations over 50,000 in the Northeastern and Southwestern regions of the United with the inclusion of the city of Burlington (VT). By locating and reviewing water and climate change plans in the described cities in the two regions, we found that of the 101 cities with over 50,000 people in the Northeast, 83 cities had water plans and/or climate change plans that could be found online; only 20 had plans that discussed climate change in the context of water. Of the 56 cities with over 50,000 people in the Southwest, 42 cities had water plans and climate change plans that could be found online; 22 cities had plans that discussed climate change in the context of water. Our initial analysis shows that in the Northeast population and whether a city is on the coast may be the main factors driving whether a city considers water and climate change jointly and in the Southwest population and political leaning may be the main factors, while the median income of the city, and average rainfall level appear to be irrelevant. We compare the current status of water-related climate

change decision making in these regions before summarizing the types of water-related climate change mitigation and adaptation actions that these cities are currently undertaking or considering. Many of these plans mention both climate change mitigation and climate change adaptation actions, indicating that water managers who are thinking about and planning for climate change are approaching this issue broadly. These results provide a foundation for understanding the impacts of climate change on water-related decision-making.

TABLE OF CONTENTS

Page

LIST OF TABLES

Tables Page

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

In our research, we addressed the question of whether and how cities in the United States (U.S) are thinking about climate change mitigation and adaptation with respect to water. In order to do so, we focused our study on two regions in the U.S that have very different hydrology and political inclinations: the Northeast and the Southwest. The disparity in the two regions' hydrology might lead to significant differences in water-related climate change planning and actions. We consider the Northeast to include Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont and the Southwest to include Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. We reviewed water and climate change plans from all cities and towns (hereafter referred to as cities) of population over 50,000 in the Northeast (plus the city of Burlington, VT, the largest city in VT) and the Southwest and studied how water managers in the two regions are planning for climate change compared to one another.

To avoid bias, we excluded all the cities whose plans cannot be found on the internet in both regions from our analysis. Therefore, we only focus our analysis on 83 cities in the Northeast and 42 cities in the Southwest, which left us a total of 125 cities in both regions.

We found 20 water-climate change plans in the Northeast (24%) out of 83 cities and 22 water-climate change plans in the Southwest (52%) out of 42 cities. Of 20 cities with relevant plans in the Northeast, 10 cities have climate change related water plans and 18 cities have water related climate change plans. Among these 20 cities, 15 cities have mitigation actions and 19 cities have adaptation actions. Of 22 cities with relevant plans in the Southwest, 10 cities have climate change related water plans and 16 cities have water related climate change plans. Among these 22 cities, only 5 cities have mitigation actions and 21 cities have adaptation actions.

Population and whether a city is on the coast are the drivers we found for a city in the Northeast to have water-climate change planning. Both population and political leaning are found to play important roles in whether or not a city has a relevant plan in the Southwest. When the two regions are combined, population and political leaning are found to be driving factors to whether a city has a climate change-water plan.

The planning activities are very different between the two regions, with the Southwest focusing on water conservation and improving water system and quality, while the Northeast's planning varies among different cities due to different priorities and concerns of water managers in each city. While both regions have many specific adaptation actions, the Southwest only has a few mitigation actions and these actions are not as specific or diverse as the Northeast's.

To-date, we have yet to find any literature comprehensively reviewing or analyzing the water and climate change plans for these cities; therefore, the results from this research will serve as a reference for future climate change research in the Northeast and the Southwest regions.

We define **climate change mitigation** as any action taken in order to reduce the build-up of greenhouse gasses (GHG) in the atmosphere, to reduce the effects of climate change. Most often this action involves reducing greenhouse gas emissions. Mitigation could, however, involve actions such as afforestation that lead to more sequestration of GHG. We define **climate change adaptation** as any action taken in order to adjust to and cope with the effects of climate change, and to reduce natural and human vulnerabilities to these effects.

The rest of the thesis is organized as follows. In the next section we will review literature relevant to water-related climate change planning. Section 3 discusses our methodology for collecting data, reviewing and analyzing the relevant plans in both regions, as well as how we conducted binary regressions on the data gathered. In section 4, we show the results of our research from the Northeast and the Southwest, including regression results for both regions. Finally section 5 concludes our research.

CHAPTER 2

LITERATURE REVIEW

There is a significant amount of research dealing generally with water-related climate change planning. This research can be classified according to three broad categories: reports on climate change in large cities, surveys and interviews with water managers on the effects of climate change, and suggested strategies to adapt to climate change for different sectors (agriculture, costal zones, health, housing, water resources, etc.)

2.1 City reports on the impacts of climate change and climate change planning

Several papers report on climate change in large cities across the U.S. [1,9,10,14,20,21, 22]. These reports review the impacts of climate change in these cities and/or strategies the cities have taken to mitigate and adapt to climate change. The impacts of climate change on these cities and their adaptation approaches vary. Several reports have investigated climate change's effects on various factors, including infrastructures, water system, air quality and human health [1,14]. Many of the large cities across the country have specific strategies to adapt to climate change. For instance, New York City (NYC) has developed a climate risk management framework, whose approach focuses on the city's water supply, sewer, and wastewater treatment systems, to ensure that the NYC Department of Environment Protection (DEP)'s capital planning takes into account the potential risks of climate change on NYC's water system [20]. None of the reports, however,

focus on water-related climate change planning for each city in any specific region of the U.S.; nor do they discuss which cities do and do not have relevant plans. Rather, they go into details about climate change planning and impacts for specific large cities across the country.

2.2 Surveys and Interviews with Water Managers about climate change

Some researchers have surveyed and interviewed individuals who directly work in the water-planning sector. These articles question water managers on their perceptions of climate change as well as climate events that have the most effect on their water systems [3,6,15,16,17,18]. The results largely fall into the following categories:

- Some water managers expect more severe problems from climate events associated with variations in stream flow, such as droughts and floods, than from other types of climate events [3,15,16]
- Managers of surface water systems are more likely to expect problems from climate events than are managers of ground water systems [15]
- Mangers of smaller water systems are more likely to expect problems from climate events than are managers of larger water systems due to more limited resources [6]
- Water managers from different regions show different concerns towards climate change. For example, water managers from Pennsylvania report that

droughts are the most commonly experienced problem, but in South Carolina droughts rank 7th out of 10 most influential climate change events [3].

- Ninety percent of water managers who had experienced climate change events in the past would expect climate change in the future [18]

2.3 Suggested strategies for climate change planning in different sectors

Several articles discuss strategies and/or policy options for adapting to and abating climate change in different sectors (e.g., the water resources sector) [2,4,5,7,8,12,13]. The objective of these articles is to find the best strategies for these sectors, given uncertainties in climate change and the adaptation options available to them. These articles offer a wide range of suggestions on climate change adaptation approaches. For example, in the water resource sector some of the best adaptation actions include leak control and institutionalization of long-term perspectives, which are water-related strategies that can be applied to reduce climate change impacts in the long-term [13]. In another article, the authors discuss the assessment of the adaptation options available for the water resource sector in light of proposed strategies (for example: reversible strategies, safety margin strategies, etc.) [8].

CHAPTER 3

METHODOLOGY

To study how water managers in the U.S. are thinking about climate change, we reviewed water plans and climate change plans in each city of population more than 50,000 in the Northeast and the Southwest. Specifically, we wanted to see in each city, any activities of planning water in response to climate change or any climate activities that were related to water. To find these activities, we reviewed water plans, climate plans and all the available city or state plans that have something to do with either water or climate. We consider the Northeast to include Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont. While we primarily consider Northeastern cities of more than 50,000 residents, we also include the city of Burlington, VT, the largest city in Vermont, as Vermont has no cities over 50,000 residents. The regional plans produced by the Massachusetts Water Resources Authority (MWRA) serving the Boston, MA metropolitan area and the Department of Environmental Protection (DEP) serving New York City are also included. For purposes of this study, we consider the Southwest to include Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming.

3.1 Data Collection

The water plans, climate plans and city plans were found on the Internet. We searched for a wide range of water and climate plans to make sure no water or

climate plans in a subjected city were left un-reviewed. The types of water plans we used in our plan searching process are: General water plans, storm water plans, water management plans, wastewater plans, watershed plans, hazard mitigation plans, water sewer and infrastructure plans and water conservation plans (especially for the Southwest). The types of climate plans we used in our plan searching process are: Climate change action plans, climate action plans, climate change plans, climate protection plans, and environmental plans). In addition, we searched for city plans to look for any actions related to water or climate change. We located either the water section (if found) of a city plan to find mention of climate change or the climate change section (if found) of a city plan to find mention of water. In some cities we located multiple plans, therefore we combined and reported all the relevant activities from all these plans. In order to be considered relevant, a plan must fall into one of the following: 1) The plan is a water plan that mentions planning in response to climate change, 2) The plan is a climate plan that mention climate actions that are related to water, 3) The plan is consolidated city plan that mentions water in the climate change portion or mentions climate change in the water portion. Note that the research is based completely on information we found on the internet, therefore there might be some cities that would have a water plan, a climate plan or even a relevant plan that is not found online. For accuracy in data analysis, we only concentrate on studying the cities whose water plan or climate change plan can be found online. The rest of the cities would need further investigation to whether or not they have a water plan, a climate plan or a relevant plan (by calling the city's planning committee) which we don't do in this research.

In order to review water plans, we break down the water plans into big plans and smaller plans. The big plans usually have many sections and therefore tables of contents, so we first looked at the table of contents of each plan, searched for climate/environment and strategies/planning sections. We carefully read these sections to find actions in response to climate change. If a big plan with a table of contents did not have these types of sections, we searched the entire plan for keywords “climate change”, “global warming”, “climate” and “environment” to see any mention of climate change. If a plan also did not have those keywords, we searched for any mention of the following weather events “drought”, “flood”, “hurricane”, “storm”, “temperature change”, “temperature rising”, “sea level change”, “sea level rising”. If none of these keywords was found, we then assumed that the plan did not have any water-related climate change planning. On the other hand, if there were mentions of any of the climate events above, we carefully considered if mention of the events was to respond to climate change or not. In smaller plans where there were no tables of content or upfront summaries of the plans, we only searched for the keywords “climate change”, “global warming”, “climate” and “environment”. If none of those were to be found, we read the entire plans and noted any relevant mention of those weather events above and decided whether or not there was any action relevant to our study the same way as with the bigger plans. The plans that are relevant to our study must contain climate change related water planning actions.

We reviewed climate change plans similar to the way we reviewed water plans. We looked at the bigger plans with tables of contents or upfront summaries first. In those plans we searched for and read carefully any specific sections that address water or any strategies/planning sections to find mitigation and adaptation actions related to water. In addition to that, we searched for the keyword "water" through the entire plans to detect any mention of relevant climate change planning. If a plan did not contain the word "water" we concluded that the plan did not have any water-related climate change planning. On the other hand, if the plan did mention water, we carefully read the plan to ascertain that the water-related actions were relevant. After reviewing the big plans, we reviewed the smaller plans where there were not tables of contents; in this case we had to read the plan entirely to detect any relevant mention of water. The plans relevant to our study must contain the water-relate climate change actions.

Finally we reviewed city plans. If a city plan had a water section, we treated it as a water plan and reviewed it as a water plan like above. If a city plan had a climate/environment section, we treated it as a climate plan and reviewed it as above. If a city plan did not have a water section or climate section, we read through the entire plan to detect any actions that are water/climate change relevant. The relevant plans are those that mentioned climate change in the context of water or water in the context of climate change. A city plan is considered both a water plan and a climate change plan if it has both water and climate/environment sections.

Elements driving a city to have a relevant plan

There are various elements that might be drivers to whether or not a city has water-related climate change planning such as the size of their cities, the income levels, water resources available, climatic conditions, influences from close cities, politics, etc. However, data on many of these elements are hard to collect. As a first step, we focus on the elements easily found online that we think of importance to climate change planning. They are: population, median income, political leaning, average rainfall, and whether or not a city lies directly on the coast (for cities in the Northeast). Here we discuss the reasons why we include each of the elements in our regional and regression analysis:

- **Population:** Resources serve as an important factor for deciding whether a municipal government of a city or country plans for climate variability effectively [20]. In more developed countries, planning for climate change is more probable because there are more resources available for assessments that could provide inputs into planning [11]. Since bigger cities would have more resources, we expect to see more climate change planning in the bigger cities than in smaller cities. Moreover, since the planning cost is fixed regardless for a big city or a small one, it would likely be more beneficial planning in bigger cities, as more people would benefit from it. Our hypothesis is that the bigger a city is, the more likely that the city has some climate change planning.
- **Median Household income:** Median household income might influence a

city's planning. The richer a city is, the more likely that city would have available funding for planning for climate change as it does not have to worry about poverty remediation or other issues related to poverty. Also as mentioned above, richer cities would have more resources that are necessary to provide input into planning [11]. Another reason to consider median household income as proxy would be that richer areas might worry more about the ever-increasing damages from climate change. Our hypothesis is that the richer a city is, the more likely that the city has climate change planning activities.

- **Political Leaning:** In the U.S. the existence of climate change and its effects are still under discussion in the popular media. Only 49% of people in the US think climate change is a serious problem, compared to 90% of the rest of the world (Larger, 2006). Similarly, only 49% of the people in the U.S. believe climate change is a man-made problem, compared to 79% internationally, as stated in a BBC poll in 2007 (BBC, Man causing climate change-poll, February 25, 2007). Given this controversy, many cities might not have any planning for climate change or might not include directly the issue of climate change in their plans. Therefore in this paper, we address an element of political leaning. Our hypothesis is that the more liberal a city is, the more likely it is that the city might have some policies and planning on climate change.
- **Average Rainfall***:* Average rainfall level is a proxy for potential problem due to water in both regions: flooding in the Northeast and drought in the Southwest. In one report by the Intergovernmental Panel on Climate Change

(IPCC 2007), a concern over extreme weather events and their impacts on climate change was expressed. It has been observed that wet extremes are to become more severe in areas where mean precipitation is expected to increase and dry extremes are to become more severe in areas where mean precipitation is expected to decrease [25]. Given the problem with the Northeast's struggling with flooding issues and the Southwest's with water conservation, we believe rainfall level is a reasonable indicator to be considered in our model. The two regions are very likely to have very different approaches towards water planning and climate change. The Southwest might be likely to have more planning activities than the Northeast because of the issue of lacking water supply. We have two hypothesis concerning average rainfall: 1) The more extreme a city's average rainfall level (the difference between a city' average rainfall level and the national average level) is, the more likely that the city has water or climate change planning. 2) The lower a city's average rainfall level is, the more likely that city has planning on water and climate change.

- **Location of the city***:* One of the most salient threats of climate change is that of sea-level rise. Thus, cities that lie on the coast may be generally more aware and more likely to think about climate change. Thus, we include a dummy variable for whether a city lies on the coast (1) or not (0).

Population and income data were gathered from census.gov, with the exception of income data for Hamden and Manchester (CT), which were gathered from city-

data.com. Data by city for the 2008 presidential election results in the Northeast were taken from boston.com, with the exception of cities in New York, New Jersey, and Pennsylvania. For these states, data by county for the 2008 presidential election results were taken directly from the state websites. In the Southwest, data by county for the 2008 presidential election were gathered from counties' official websites. We assume the county-level results represent very well the cities of interest because we believe that cities of more than 50,000 are likely to strongly influence the voting results of the county. Political leaning is measured on scale of 100% (with 100% being completely liberal and 0% being completely conservative), based on the percentage of people voting for Obama in the 2008 presidential election. Data on average rainfall (1981-2010) for each city in the Northeast and Southwest, and for the U.S., were gathered from the NOAA website. Since the NOAA website didn't have rainfall data for all of the cities included in our research, we used data for the closest available city.

3.2 Regional Comparison

We compared the water-related climate change planning strategies and activities in the two regions to identify similarities and differences in the ways water managers in the two regions are thinking about climate change. We compared the percentages of cities that have relevant plans (water-related climate change plans and/or climate change-related water plans), the distributions and types of mitigation and adaptation actions, and the factors driving whether or not a city has a relevant plan. We anticipated to see a great deal of disparity in climate change decision making

related to water in the two regions because of their significant differences in hydrology and political leaning.

Though we are interested in studying how water managers are thinking about climate change and their concerns related to climate change planning, we are not conducting surveys or interviews with water managers. The current research is instead an internet-based review of plans, which we consider a proxy for water managers' mitigation and adaptation strategies and activities. Additionally, we don't suggest which adaptation actions are more appropriate for implementation in any city. We instead review the actions that are being or considered to be taken in the Northeast and the Southwest.

3.3 Regression Analysis

To statistically study the relationships between whether or not a city has a relevant plan and the factors we consider in this research (population, income, political leaning, rainfall, and city location from the coast), we used binary regression. We ran three binary regressions: one each for the Northeastern and Southwestern cities separately, and one for all cities in both regions together. In the regressions, we only consider cities whose water plans or climate change plans can be found online (83 cities in the Northeast and 42 cities in the Southwest). That is, we do not account for cities for which we have been unable to locate any kind of plan.

We used STATA to run binary regressions to determine the correlations between the independent variables (cities' populations, incomes, political leanings, rainfall amounts, and, in the case of the Northeast, dummy variable of whether a city lies on the coast), and the region (for the combined regression) and the dependent variable (whether or not there exists a relevant plan). STATA displays results from logit and probit regressions. However, since the results from the logit and probit models are very similar, we only present our results from the logit model because in most cases, the logit model is preferred over the probit model due to having wider variety of fit statistics and better mathematical tractability (Kleinbaum, 1997).

Our dependent variable takes a value of 1 when the city has a relevant plan and 0 when the city does not have a relevant plan. The independent variables in our model are, respectively:

- Population,
- Median household income,
- Political leaning,
- Average City Rainfall,
- Whether a city is on the coast (For the Northeast) and
- Location (For the combined regression)

The binary regression model is formulated as followed:

$$\mathbf{Y = a_0 + a_1(population) + a_2(income) + a_3(political) + a_4(location) + a_5(rainfall) + a_6(region) + u_i}$$

In which:

Y is the respondent variable, equal to 1 if the city has a relevant plan, 0 otherwise;

population is population in ten thousands of people

income is median household income in thousands of dollars

political is political leaning, measured as the percentage of people voting for Obama in the 2008 presidential election;

location is location of the city, equal to 1 if the city is on the coast and 0 if the city is not on the coast (for the Northeast regression)

rainfall is average rainfall (1981-2010) in inches

region is a region indicator, equal to 1 if the city is in the Northeast; 0 if the city is in the Southwest.

$\mathbf{u_i}$ is an error term

The aim of this regression is to fit the equation below (a converted linear equation from the binary regression equation) to the data we gathered:

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1(\text{population}) + \beta_2(\text{income}) + \beta_3(\text{political}) + \beta_4(\text{location}) + \beta_5(\text{rainfall}) + \beta_6(\text{region}) + e_i$$

In which, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are coefficients for independent variables p, I, pl, d, r, and l as explained above and π is the probability of a city with these characteristics having a relevant plan. In the case of the Northeast and the Southwest as a whole, π is 0.24 (20/83) and 0.524 (22/42) respectively, as 20 cities in the Northeast had relevant plans out of 83 and 22 cities in the Southwest had relevant plans out of 42. However, the probability of any given city having a water plan may be larger or smaller than 0.24 and 0.524.

CHAPTER 4

RESULTS

4.1 Water Plans and Climate Change Plans in the Northeast

4.1.1 Overview of Water Plans and Climate Change Plans in the Northeast

We found 101 cities in the Northeast with population over 50,000. There are, however, only 83 cities whose plans we found online. We only focused on analyzing those. Of the 83 cities in the Northeast with population over 50,000, we found 70 cities (84%) with either water plans or city plans that mention water. Among these 83 plans, 10 plans (12%) mention climate change, all of which include some mention of adaptation and 8 include some mention of mitigation. In other words, 12% of all included cities mention climate change in their water plans or water-related city plans.

Of these 83 cities, 27 (33%) have either climate change plans or city plans mentioning climate change, of which 18 plans (22%) mention water. Among these 18 climate change plans, 17 include some mention of adaptation, and 15 include some mention of mitigation. In other words, 26% of all the included cities mention water in their climate change plans or climate-related city plans.

There is some overlap among 70 cities with water plans and 27 cities with climate change plans that could be located on the Internet. To summarize, of 83 cities in the Northeast, we found 10 cities (12%) have climate change related water plan and 18 cities (22%) have water-related climate change plans.

The map following visually summarizes the above overview.

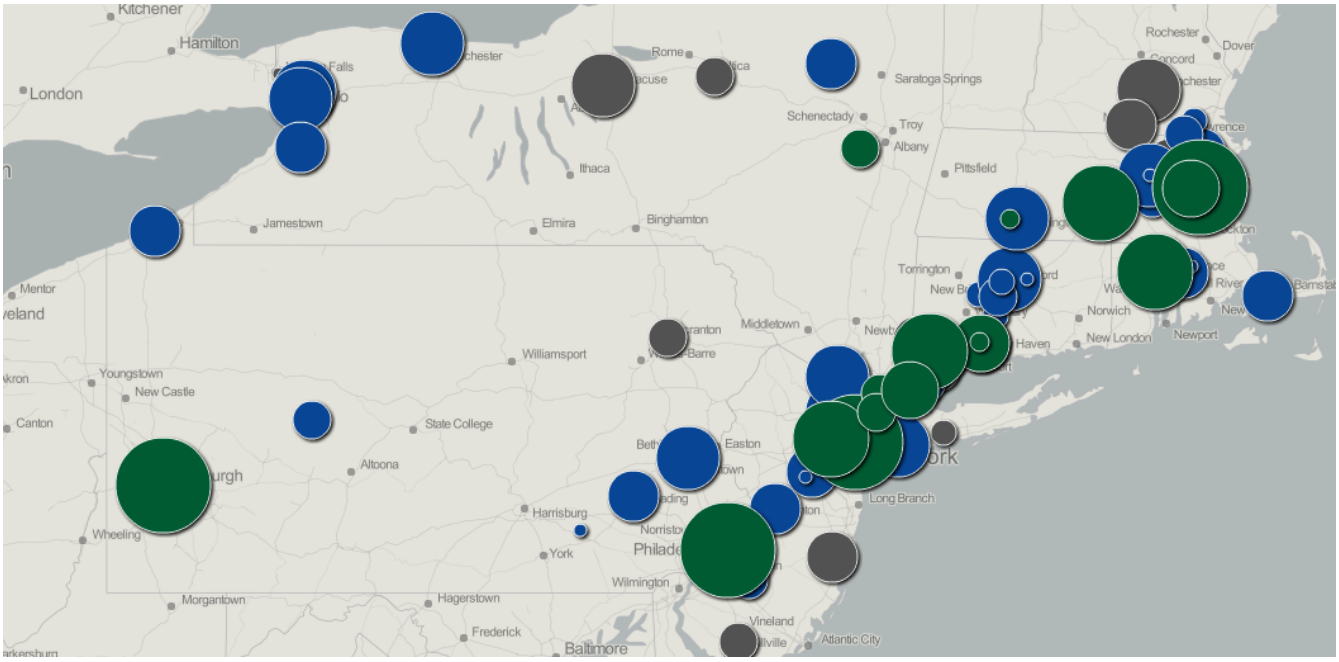

Figure 1: Map of 101 cities with more than 50,000 residents in the Northeast

Cities that have relevant plans

Cities that have non-relevant plans

Cities whose plans cannot be found on the internet

There is also overlap among the cities with climate change related water plans and water related climate change plans: 8 of the above cities have both water plans that mention climate and climate plans that mention water. This leaves a total of 20 cities that consider climate change mitigation and adaptation with respect to water.

4.1.2 Water Plans in the Northeast that mention Climate Change

In this section we summarize the data on cities that have relevant plans. Table 1 lists the cities in order of population from the most populated to the least populated. The table also lists the population rankings within the Northeast, the cities' median household income levels and income level rankings within the Northeast, the cities' political leaning and rankings within the Northeast, the city's distances from the East Coast and rankings within the Northeast, average rainfall levels and rankings within the Northeast, the water plan types, and the types of climate change action mentioned in their water plans (adaptation and/or mitigation). Note that because some of the political leaning data are by county, multiple cities in the same county have the same political ranking within the Northeast region. We denote A as adaptation and M as mitigation. The plan types are coded as:

- **HMP**: Hazard Mitigation Plan.
- **SWP:** Storm Water Plan.
- **WWP:** Waste Water Plan
- **CP:** City Plan.

As noted above, we consider city plans that mention climate change in their water subsections to be water plans and therefore these city plans are included in this section.

City	State	Population	Ranking	Income	Ranking	Political Leaning	Ranking	Rainfall	Ranking	Coastal Distance	Ranking	Plan Type	Climate Change Actions
New York	NY	8391881	1	50,285	40	86	1	46	30	28	49	SWP	A+M
Boston	MA	645169	3	52,433	38	80	3	43.8	48	1	1	CP	A+M
Newark	NJ	278154	5	35,659	48	76	4	46.3	21	22	41	MP	A+M
Providence	RI	171909	11	37,273	62	62	13	47.2	9	25	48	CP	A
New Haven	CT	123330	16	37,823	60	60	34	47.1	13	2	6	CP	A+M
Stamford	CT	121026	18	76,134	10	59	50	53.2	1	2	6	WWP	A+M
Cambridge	MA	108780	22	64,420	22	64	21	43.8	48	6	18	SWP	A+M
Waterbury	CT	107143	23	39,832	58	61	34	47.1	13	22	41	SWP	A
Warwick	RI	84760	33	65,317	26	63	59	48.5	6	17	31	CP	A+M
New Rochelle	NY	74323	45	61,114	19	58	30	46	30	1	1	HMP	A

Table 1: Cities in the Northeast whose water plans mention climate change

Of the 10 cities in the table, 9 are in the first and second quintile of population (rankings 1-33 out of 83), and half fall in the top quintile (rankings 1-16 out of 83) of population. This strongly suggests that population is an important driver of whether cities consider climate change in their water planning.

Similar to population, political leaning appears strongly correlated with whether cities included climate change in their water plans: of the 10 cities above, 6 cities fall into the first and second quintiles in terms of liberal leanings. However, there appears to be a correlation between population and political leaning, making it hard to say which may be the driver.

No such pattern emerges related to median household income, coastal distance, and average rainfall with a fairly even number falling into each quintile.

4.1.3 Climate Change Plans in the Northeast that mention Water

Similar to the analysis of water plans, we analyzed the cities with climate change plans that include water. Table 2 lists the same types of information as Table 1. The climate change plan types are denoted as shown below.

- **CCP:** Climate Change Plan.
- **EP:** Environmental Plan.
- **SP:** Sustainability Plan.
- **CP:** City Plan.

We consider city plans that mention water in their climate change subsections to be climate change plans and thus these city plans are included in this section.

City	State	Population	Ranking	Median Income	Ranking	Political Leaning	Ranking	Rainfall	Ranking	Coastal Distance	Ranking	Plan Type	Climate Change Actions
New York	NY	8,391,881	1	50,285	40	86	1	46	36	28	49	CCP	A+M
Philadelphia	PA	1,547,296	2	36,669	63	83	2	41.5	69	57	62	CCP	A+M
Boston	MA	645,169	3	52,433	38	77	3	43.8	48	1	1	CCP	A+M
Pittsburgh	PA	311,647	4	35,732	67	57	67	32.8	79	304	75	CCP	A+M
Newark	NJ	278,154	5	35,695	48	76	4	46.3	25	22	41	CP	A+M
Worcester	MA	182,421	10	45,944	46	55	71	48.1	7	40	59	CCP	A+M
Bridgeport	CT	137,298	14	40,530	55	59	50	42	67	2	6	SP	A+M
New Haven	CT	123,330	16	37,823	60	61	34	47.1	15	2	6	CCP	A +M
Stamford	CT	121,026	18	76,134	10	59	50	53.2	1	2	6	CP	A+M
Cambridge	MA	108,780	22	64,420	22	64	21	43.8	54	6	18	CCP	A+M
Waterbury	CT	107,143	23	39,832	58	61	34	47.1	18	22	41	EP	A
Albany	NY	93,836	27	55,603	31	64	21	39.4	75	158	71	CP	A+M
New Rochelle	NY	74,323	45	65,371	19	63	30	46	30	1	1	SP	A+M
Mount Vernon	NY	68,878	49	49,862	42	63	30	46	37	32	51	CP	A+M
Portland	ME	63,008	54	43,601	50	61	34	47.3	9	1	1	CCP	A+M
Hamden	CT	58,119	64	64,965	20	61	34	47.1	16	10	23	CP	A
Chicopee	MA	55,994	67	42,788	51	62	33	46	38	62	63	CP	A
Burlington	VT	38,647	79	38,598	59	68	10	36.8	76	158	71	CCP	M

Table 2: Cities in the Northeast whose climate change plans mention water

While the pattern for population here is not quite as strong as for the water plans, we can still see that 12 of the 18 plans fall in the first and second quintile of population, and nearly half are in the top quintile, suggesting again that population is a key driver. Political leaning is slightly stronger than in the water plans, with 14 of the 18 plans falling within the 34 most liberal leaning cities.

Income, coastal distance, and rainfall are clearly not drivers for including water in climate change plans as there are a fair number of cities falling into each quintile.

4.1.4 Mitigation and Adaptation Actions in the Northeast

In this section, we summarize the types of mitigation and adaptation actions being taken or considered in all of the plans listed in the tables above. There are 20 cities in total that consider climate change mitigation and adaptation with respect to water; of these 15 mention water-related mitigation actions and 19 mention water-related adaptation actions.

While all of the climate change plans include some mitigation actions, we only consider those mitigation actions that are related to water.

4.1.4.1 Mitigation Actions in the Northeast

We categorized the 15 cities that have mitigation actions in their climate/water related plans into three categories. The first category is *building energy conservation*, which includes plans that focus primary on green building or building energy and water conservation. The second category is *awareness and planning*. This category includes plans that don't detail any specific actions or strategies towards mitigation at the moment, but have acknowledged the impacts of climate change on their water sources and water quality and thus have been considering or preparing comprehensive plans with mitigation actions. The third category is *specific actions*, which includes plans that currently have very specific water-related actions towards mitigation with respect to climate change. Note that cities may fall into multiple categories.

4.1.4.1.1 Building energy conservation

There are 13 cities that fall in this category: Bridgeport (CT), New Haven (CT) Stamford (CT), Boston (MA), Cambridge (MA), Worcester (MA), Portland (ME), Albany (NY), Mount Vernon (NY), New York (NY), Philadelphia (PA), Pittsburgh (PA) and Burlington (VT). These plans typically contain policies related to adopting green building standards and reducing energy used inside the buildings. We count these actions for the purposes of our paper only if the plans include some specific mention of reducing water use in order to reduce energy use. The common water-related mitigation actions mentioned in these plans are:

- Acknowledging the impact of green building on the climate and therefore encouraging and targeting every building in the city to be constructed based on green building standard (Burlington, Cambridge, Mount Vernon, Portland, and Stamford).
- Designing city buildings based on green building standards (this includes considering installing and updating technologies and appliances to achieve green building standards, including water conservation) (Albany, Cambridge, Mount Vernon, Philadelphia, Pittsburgh, Portland, Stamford, and Worcester).
- Passing green building policies for other buildings in the city (Albany, Cambridge, Mount Vernon, New Haven, Philadelphia, Pittsburgh, Portland, Stamford, and Worcester).

4.1.4.1.2 Mitigation awareness and planning

There are 6 cities that include mitigation awareness and planning in their water or climate change plans: Cambridge (MA), New Haven (CT), Newark (NJ), Mount Vernon (NY), New Rochelle (NY), and Pittsburgh (PA). The common mitigation actions mentioned in these plans are as follows:

- Improving carbon sequestration (New Haven, Pittsburgh).
- Encouraging the use of local, non-polluting renewable and recycled resources (water, energy) (New Rochelle, Mount Vernon, Newark).
- Reducing water energy usage, possibly through modernizing plumbing and improving practices in water conservation in municipal government and community-wide (New Haven, Pittsburgh, Cambridge, New Rochelle).

4.1.4.1.3 Specific actions to reduce GHG emissions

Of the 14 cities that have climate change mitigation actions, 8 cities mention very specific actions to reduce greenhouse gas emissions related to water: New Haven (CT), Stamford (CT), Boston (MA), Worcester (MA), Portland (ME), New York (NY), Philadelphia (PA), and Pittsburgh (PA). Their actions, can be categorized into three different themes similar to those of mitigation awareness and planning, as following:

- **Energy reduction via water conservation:**

- Reducing energy consumption by making water energy improvements at 63 developments with 14,300 apartments (Boston).

- **Renewable energy:**
  - Processing the organic residuals generated through the wastewater treatment process into renewable energy (Stamford).
  - Purchasing 10% of energy from green power sources, (the Pittsburgh Water and Sewage Authority purchased 5,600,000 Kwh of renewable energy) (Pittsburgh).
  - Constructing a digester gas treatment facility at its Northeast Water Pollution Control Plant (Philadelphia).
  - Utilizing a waste treatment process that produces substantial quantities of digester gas, 43% of which is currently captured and used to displace 185,000 MCF of interstate pipeline gas (Philadelphia).
  - Installing a 200 kW fuel cell to supply electricity and heat for the fats, oils and grease processing system for the New Haven Water Pollution Control Authority (New Haven).
  - Installing a 100 kW hydro-power turbine at a water filtration plant (Worcester).

- **Updating or modernizing technologies in the systems to better control water energy consumption:**

- Upgrading pumps and pump station buildings and replacing existing pumps with energy efficient variable flow drive technology (Portland).
- Upgrading water pollution control plants and constructing new drinking water treatment plants to reduce energy (New York).

4.1.4.2 Adaptation Actions in the Northeast

We categorized the 19 cities in the Northeast that have adaptation actions in their climate change/water related plans into two categories. The first category we call *adaptation planning*. This category includes plans that don't have any specific actions or strategies towards adaptation at the moment, but have acknowledged the impacts of climate change and therefore have been considering or preparing comprehensive climate change plans with adaptation actions or hazard mitigation plans (such as flood or storm-water mitigation) related to climate change. The second category is *specific adaptation actions*. This category includes plans that currently have very specific water-related actions related to adaptation as a response to climate change. Some cities fall into both categories.

We also discuss the difference between adaptation actions of New York City and the City of Boston, as these cities have very different approaches towards climate change which show different concerns of water-related decision makers in response to the impacts of climate change.

4.1.4.2.1 Adaptation planning

There are 13 cities that fall into this category: Bridgeport (CT), Hamden (CT), New Haven (CT), Stamford (CT), Waterbury (CT), Cambridge (MA), Chicopee (MA), Worcester (MA), Portland (ME), Newark (NJ), Albany (NY), New Rochelle (NY), Philadelphia (PA), and Warwick (RI). These plans mention the impacts of climate change on their water systems, and indicate the importance of taking action in the future. The common water-related adaptations in these plans are:

- **Acknowledging the impacts of climate change on drinking water quality:**
    - Calculating the impacts of saltwater contamination of drinking water and flooding due to sea level rise and the cumulative costs to protect the coastline (Stamford, Worcester, Chicopee).
    - Preparing a comprehensive plan to improve water quality as climate change affects freshwater supplies (New Haven).

- **Flood reduction and storm-water mitigation:**
    - Designing a comprehensive storm-water management plan to define problem areas, create maintenance schedules, and incorporate run-off conditions from new and proposed developments into a watershed framework in response to inland flooding and repeated drainage problems in the city (Waterbury).
    - Developing water conservation/run-off techniques to capture water run-off (such as grey-water systems for watering plantings). (Hamden).

- Developing a capital improvement plan to reduce flood natural hazards (Chicopee).
- Developing vulnerability assessments and identifying and addressing projected local impacts and responses to climate change including increased risk of flooding (Albany, Bridgeport).
- Developing long-term recovery planning efforts utilizing Community Development Block Grant-Disaster Recovery (CDBG-DR) funds and focusing on mitigation and prevention of damage due to future flooding events (Warwick).
- Increasing cooperation between departments to control growth and developments in flooding zones (Waterbury).

- **Reduction of stress on the water system:**
    - Integrating green solutions into infrastructure planning to reduce stress on the sewer system and upgrading the city's storm and wastewater management system (e.g., Landscaping requirements, reflective and green roofs) (Newark).

4.1.4.2.2 Specific adaptation actions

There are 8 cities that have specific water-related actions towards adaptation in response to climate change: Boston (MA), Cambridge (MA), Mount Vernon (NY), New Rochelle (NY), New York (NY), Pittsburgh (PA), Providence (RI), and Warwick (RI). We categorize these actions into four categories. The first category is *green*

roofs and rooftop gardens, which specifies adaptation actions that reduce water runoff by installing green roofs or rooftops. The second category is *storm-water mitigation and flood control*. This category contains plans that have specific actions towards mitigating storm-water and/or controlling flooding levels as a response to the effects of climate change-induced extreme storms, floods, and droughts. The third category is *maintaining water supply*. This category includes plans that have actions to maintain water supply for their cities as the demand for water increases due to climate change. The last category is *protection from damages*, which contains actions to minimize water-related damages from climate change. The common water-related actions in these plans are:

- **Green roofs and rooftop gardens:**
    - Installing rooftop gardens and green roofs on buildings of all types to reduce storm-water run-off (Cambridge, Mount Vernon, New Rochelle, and Pittsburgh).

- **Storm-water mitigation and flood control:**
    - Having comprehensive storm-water management plans to understand and study the down-gradient effects of water run-off (Albany, Providence, and Waterbury).
    - Minimizing impervious surfaces such as driveways, parking lots, roadways, sidewalks and curbs to help minimize surface flooding, and

constructing rain gardens to reduce storm-water and manage water-runoff (Mount Vernon).

- Implementing targeted stream, forest, storm, and snow management programs to reduce storm flows and soil erosion (New York).
- Implementing practices to capture storm-water (rain barrels, blue roofs, and other integrated storm-water capturing methods to attenuate burden of high intensity rain on conveyance and treatment infrastructure) (New York).
- Developing effective vegetation management, which requires good on-site water management to help mitigate some of the anticipated changes in the weather due to climate change – more extreme storms, floods, and droughts (Cambridge).
- Reusing on-site water and maintaining healthy vegetation that increases water infiltration and absorption, and reducing storm runoff into the storm-water system by the Department of Public Work (Cambridge).
- Starting a 25- year asset management plan for the waste water and storm drain system (Boston).

- **Maintaining water supply:**
    - Expanding existing water conservation program to adjust to increasing water demand and population (New York).

- Considering aqueduct interconnections between turbidity prone Catskill system and turbidity resistant Delaware system (New York).

- **Protection from damages:**
    - Protecting and maintaining floodplains and undertaking stream stabilization efforts and updating floodplain management activities to exceed minimum thresholds established by the National Flood Insurance Program and applying for certification under the Community Rating system to reduce flood insurance premiums (Providence).
    - Installing flood gates at facility entryways (New York).
    - Protecting and preserving open spaces and other natural areas, including wetlands (this includes managing existing wetland resource areas, and designing long range plans in light of sea-level rise projections) (Boston).
    - Preventing pollution and storm damages (Boston).

Of the climate change adaptation plans mentioned, New York City and the City of Boston have the most in-depth adaptation actions in the Northeast region. However, their specific adaptation priorities differ. While New York has a long-range plan to manage climate change risk for both their water supply system and wastewater treatment system, Boston emphasizes mainly their waste water system. New York is concerned about maintaining water supply quantity and quality to satisfy the

increasing water demand within New York City and in watershed supply areas, while Boston is greatly concerned with the effect of increased precipitation and flooding which may strain the city's pipe systems. Therefore, these cities' near and long-term strategies towards climate change adaptation are different. In the long run, Boston focuses on asset management plans for wastewater and storm-water systems to address the systems' ability to discharge waste water and storm-water, and pump water to protect areas prone to flooding. New York looks to collaborate with NYC Climate Change Adaptation Task Force as it develops a city-wide adaptation strategy as well as with partners at the Water Utility Climate Alliance (WUCA) to advance their climate change science research and further develop adaptation methodologies.

4.1.5 Mitigation And Adaptation Summary

Table 3 summarizes how many cities had plans with actions in each category.

	Mitigation Actions (of 15 cities)	Adaptation Actions (of 19 cities)
Building energy conservation	10 (67%)	
Awareness and planning	6 (40%)	12 (63%)
Specific actions	8 (53%)	8 (42%)

Table 3: Number of cities in the Northeast falling into each category, out of all cities with plans. Note that some cities mention multiple types of actions in their plans

Even though there are more cities addressing adaptation actions than mitigation actions (19 versus 15 cities), more cities mention multiple mitigation actions (8 cities) than multiple adaptation actions (1 city).

4.2 Water Plans and Climate Change Plans in the Southwest

4.2.1 Overview of Water Plans and Climate Change Plans in the Southwest

There are 55 cities in the Southwest with population over 50,000. Among these cities, we found 42 cities have plans online. Of these 42 plans, there are 40 plans that mention water (95%). Among these 40 plans, 10 plans (25%) mention climate change, all of which include some mention of adaptation, while only one includes some mention of mitigation. In other words, 20% of all included cities mention climate change in their water plans or water-related city plans.

Of these 42 cities, 20 (48%) have either climate change plans or city plans mentioning climate change, of which 16 plans (80%) mention water. Among these 16 climate change plans, 14 include some mention of adaptation, and 10 include some mention of mitigation. In other words, 38% of all the included cities mention water in their climate change plans or climate-related city plans.

To summarize, of 42 cities in the Southwest, we found 11 cities (26%) have climate change related water plans and 16 cities (38%) have water related climate change plans.

The map below shows the locations of the 55 cities mentioned in the Southwest

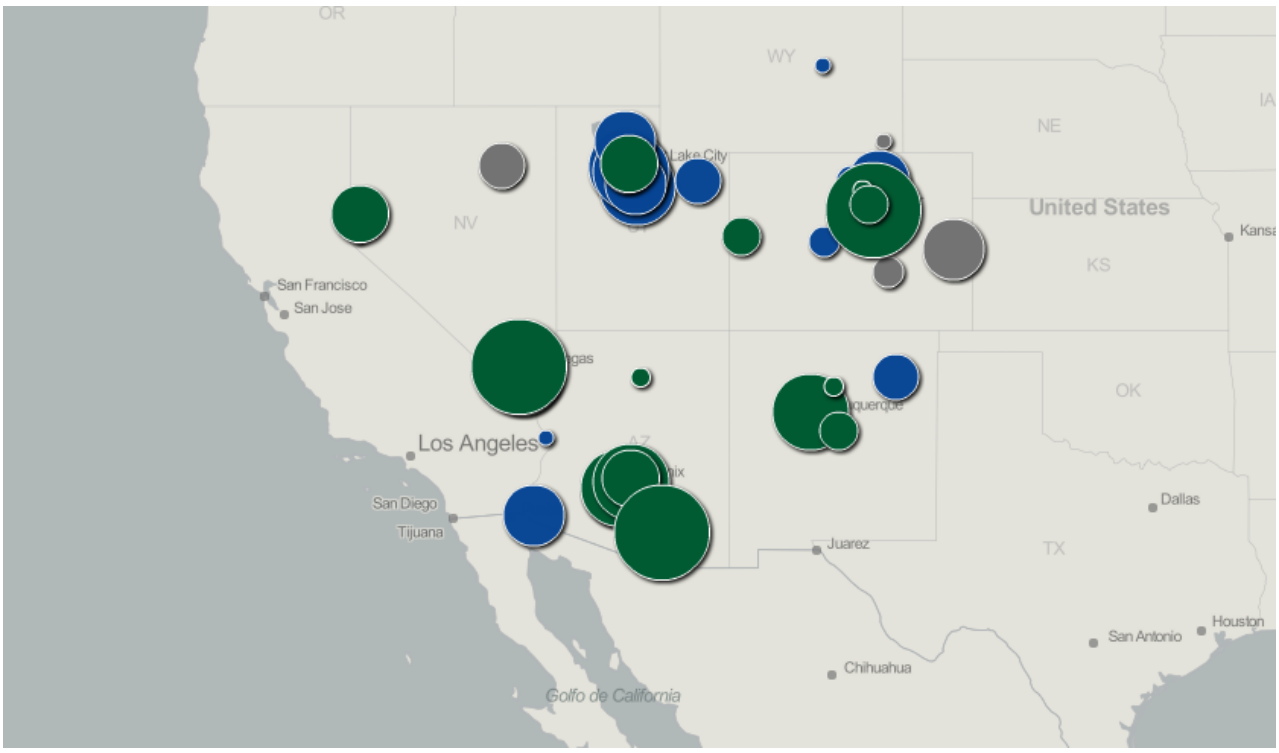

Figure 2: Map of 55 cities with more than 50,000 residents in the Southwest

Cities that have relevant plans

Cities that have non-relevant plans

Cities whose plans cannot be found on the internet

There is some overlap among the cities with relevant water and climate change plans mentioned above: 4 of the above cities have both water plans that mention climate and climate plans that mention water. This leaves a total of 22 cities, or 52%, that consider climate change mitigation and adaptation with respect to water.

The cities evenly locate around Colorado River in no particular pattern. We can say that distance from Colorado River does not seem to be a driver to whether or not a city in the Southwest has a relevant plan.

4.2.1 Water Plans in the Southwest that mention Climate Change

In this section, as in Section 4.1.1 we summarize the data on cities that have relevant plans. Table 4 lists the cities in order of population.. The table also lists the population rankings within the Southwest, the cities' median household income levels and income level rankings within the Southwest, the cities' political leaning and rankings with the Southwest, the cities' rainfall was the cities' average rainfall from 1981 to 2010 and the U.S. average, the water plan types, and the types of climate change action mentioned in their water plans (adaptation and/or mitigation). The political leaning data are by county; therefore, cities in the same county have the same political ranking within the region. Also note that some cities don't have data on average rainfall in that timeframe mentioned above; in these cases, their rainfall data are from the closest cities that have this data. We also denote A as adaptation and M as mitigation. The plan types are coded as:

- **DP**: Drought Plan
- **FMP:** Flood Management Plan
- **WCP**: Water Conservation Plan
- **WRP:** Water Resource Plan
- **WSP:** Watershed Plan
- **WUTP:** Water Utilities Treatment Plan

City	State	Population	Ranking	Income	Ranking	Political Leaning	Ranking	Rainfall	Ranking	Plan Type	Climate Change Type
Phoenix	AZ	1,601,587	1	47,085	30	43.6	18	8.2	30	WRP	A
Tucson	AZ	548,555	4	35,565	41	51.9	16	11.6	22	WRP	A
Reno	NV	219,636	10	47,856	28	55.4	12	7.4	37	FMP	A
Salt Lake City	UT	183,171	12	45,754	33	34.6	35	16.1	8	WCP	A
Fort Collins	CO	138,736	14	50,562	21	55.1	14	15	18	WCP	A
Thornton	CO	117,003	17	58,670	12	39.4	30	15.6	15	WCP	A
Boulder	CO	100,160	18	47,967	27	73.5	2	20.7	2	WUTP	A
Longmont	CO	88,424	24	52,076	16	73.5	2	20.7	3	DP	A
Avondale	AZ	84,914	25	58,159	13	43.6	18	8.7	35	WCP	A+M
Santa Fe	NM	73,720	29	52,045	17	60.7	7	14,2	20	WSP	A

Table 4: Cities in the Southwest whose water plans mention climate change

Of the 10 cities in the table above, 7 are in the first and second quintile of population (rankings 1-16 out of 42) of population and 8 are in the first 3 quintiles. This suggests that population may be an important driver of whether cities consider climate change in their water planning.

Median household income seems to suggest a negative correlation. No city lies in the first quintile (ranking 1-8 out of 42) and 8 out of 10 cities lie in the bottom half (16-42) of the 42 cities.

There are an even amount of cities lying in each quintile in terms of political leaning and rainfall, indicating that political leaning and rainfall do not appear to be drivers to whether or not a city considers climate change in their water plan.

4.2.3 Climate Change Plans in the Southwest that mention Water

In this section, as in Section 4.1.3, we analyzed the cities with climate change plans that include water. Table 5 lists the same type of information as Table 3. The climate change plan types are denoted as shown below.

- **CAP:** Climate Action Plan
- **SP**: Sustainability Plan
- **HMP**: Hazard Mitigation Plan
- **GBP**: Green Building Plan

City	State	Population	Ranking	Income	Ranking	Political Leaning	Ranking	Average Rainfall	Ranking	Plan Type	Climate Change Type
Phoenix	AZ	1,601,587	1	47,085	31	43.6	19	8.2	31	CAP	A
Denver	CO	610,345	2	46,410	32	76.5	1	15.6	14	CAP	A+M
Las Vegas	NV	567,641	3	50,935	21	63.7	5	4,2	39	SP	A
Tucson	AZ	548,555	4	35,565	42	51.9	17	11.6	23	CAP	A
Albuquerque	NM	528,497	5	44,594	36	60.7	7	9.5	26	CAP	M
Mesa	AZ	462,486	6	49,446	27	43.6	19	9.5	27	CAP	A+M
Henderson	NV	256,445	7	64,431	8	55.4	15	4.2	40	SP	A
Glendale	AZ	252,188	8	50,053	24	43.6	19	8.2	32	CAP	A
Scottsdale	AZ	238,715	9	71,658	6	43.6	19	8.2	33	GBP	A
Gilbert	AZ	217,285	11	74,957	3	43.6	19	8.2	34	CP	A
Fort Collins	CO	138,736	14	50,562	22	55.1	15	15	19	CAP	A+M
Arvada	CO	106,433	18	66,378	7	56.82	10	15.6	14	CAP	M
Boulder	CO	100,160	19	47,967	28	73.5	2	20.7	2	CAP	A
Las Cruces	NM	93,570	20	37,471	40	56.6	11	9.7	24	SP	A
Flagstaff	AZ	60,611	35	49,861	26	57.3	9	21.9	1	HMP	A
Broomfield	CO	55,990	38	76,380	2	56.1	12	15.6	18	CP	A

Table 5: Cities in the Southwest whose climate change plans mention water

Note that the 9 largest cities in the Southwest all have water-related climate change plans. Half of the cities (8 out of 16) are in the first quintile of population. Almost three quarters of the cities (11 cities out of 16) are in the first 2 quintiles of

population. These results indicate that population may be an important driver to whether or not a city has a water-related climate change plan.

For median household income, almost three quarters of the cities (11 out of 16) with relevant plans are in the bottom half (ranking 20-42) of household income out of 42 cities. Therefore, median income might have a negative correlation with whether or not a city has a water-related climate change plan.

For political leaning, 10 cities out of the 16 belong to the first 2 quintiles and no cities are in the 2 bottom quintiles. It appears that political leaning might be a driver of whether or not a city has a relevant plan, but the evidence is not obvious.

For rainfall, only 4 cities out of 16 that have plans are in the first 2 quintiles and 7 out of 16 are in the first 3 quintiles. We also have an even number of cities belong in the bottom 2 quintiles. Rainfall does not show evidence of affecting whether a city in the Southwest has a relevant plan.

Average city rainfall levels

To study the correlation between pure rainfall and whether or not a city has a relevant plan, we visually illustrated the rainfall levels and number of cities (with and without plans) with these levels of rainfall in both the Northeast and the Southwest. Figure 5 displays this information.

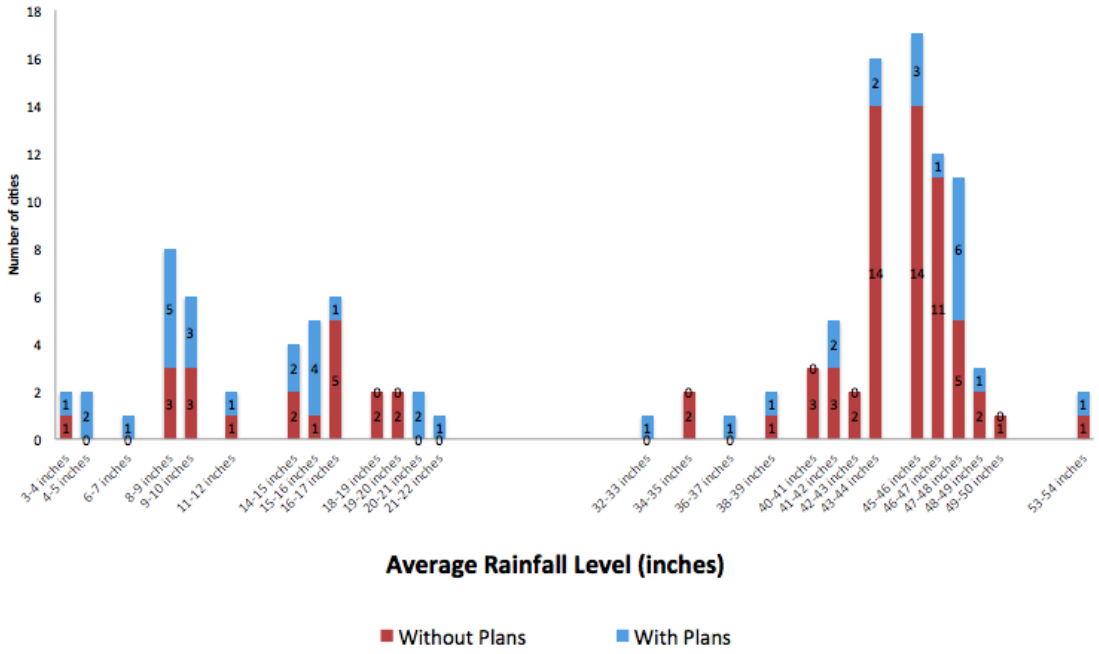

Figure 3: Average rainfall levels in 125 cities in the Northeast and the Southwest

Based on the graph of rainfall in the two regions above, there's no correlation between average rainfall levels in each city and whether or not a city has relevant plan. The Southwest appears to have about the same number of cities with and without relevant plans with the same levels of rainfall. While in the Northeast there are cities with and without relevant plans at each level of rainfall, only there are more cities without plans.

4.2.4 Mitigation and Adaptation Actions in the Southwest

Here we summarize the types of mitigation and adaptation actions being taken or considered in the Southwest. There are 21 cities in total in the Southwest that consider climate change mitigation and adaptation with respect to water; of these only 5 cities mention relevant mitigation actions and 20 mention relevant

adaptation actions.

4.2.4.1 Mitigation Actions in the Southwest

Unlike the Northeast, the Southwest has few mitigation actions. There are only 5 cities in the Southwest that have mitigation actions related to water. They are: Albuquerque(MN), Arvada(CO), Denver(CO), Fort Collins(CO) and Mesa(AZ). The mitigation actions we found are:

- Installing low-flow shower heads in order to use less hot water (Mesa)
- Installing Photovoltaic system at the Water Treatment Plant that powers 80-85% of the facility (Arvada)
- Designing green building to save water energy (Arvada, Denver)
- Water conservation upgrades at City LEED Buildings (Fort Collins)
- Increasing energy efficiency incentives for ENERGY STAR appliances such as refrigerators and washers (Albuquerque)
- Expanding existing incentive programs for energy efficient lighting and water conservation washers (Albuquerque).

4.2.4.2 Adaptation Actions in the Southwest

We categorized the 22 cities in the Southwest that have adaptation actions in their water and climate plans into two categories, as we did in the Northeast. The first category we call *adaptation planning*. This category includes plans that don't currently have any specific actions or strategies towards adaptation, but have acknowledged the impacts of climate change and therefore have been planning to

have adaptation actions. The second category is *specific adaptation actions*. This category includes plans that currently have very specific relevant adaptation actions to face with climate change. There are five cities that have both mitigation and adaptation actions.

4.2.4.2.1 Adaptation planning

There are 12 that cities fall into this category. They are Avondale (AZ), Boulder (CO), Denver (CO), Fort Collins (CO), Gilbert (AZ), Glendale (AZ), Las Cruces (MN), Longmont (CO), Phoenix (AZ), Salt Lake City (UT), Thornton (CO), and Tucson (AZ). These are the cities that have some planning or programs on reducing the impacts of climate change on their water systems, but don't currently have specific adaptation actions; or they only briefly mention water conservation actions in their relevant plans. The common adaptation actions in these plans are:

- **Evaluating water standards or other requirements:**
    - Reevaluation of flood irrigation water requirements (Avondale, Fort Collins)
    - Assuring that water quality meets all applicable Federal and State water quality standards (Gilbert)
    - Establishing an industrial institutional audit to manage the amount of water used (Phoenix)
    - Developing a Salinity Management Program to manage potential salinity impacts and methods of treatment of wastewater (Tucson, Boulder)

- Establishing Utility Water Loss Program (Fort Collins)
- Evaluate emerging contaminants in water system (Tucson)

- **Mentioning establishing Water Plans or Programs without stating any specific actions:**
  - Planning a Water Conservation Program to target per capita usage rate (Tucson, Boulder, Gilbert)
  - Planning on implementing a Storm-water Pollution Program focusing on reducing water pollution at the watershed level (Las Cruces)
  - Implementing Facility Plan to encourage the preservation of natural drainage ways (Glendale)

- **General water conservation actions:**
  - Encouraging Sewer Connection to provide more wastewater effluent for potential reuse (Tucson)
  - Reducing lost and unaccounted for water (Tucson, Denver)
  - Constructing new Reclaimed Supply sources to meet future water demand (Tucson)
  - Upgrading water distribution system (Tucson)
  - Developing and adopting ordinance prohibiting wasting of water (Salt Lake City, Thornton, Denver)
  - Adopting irrigation efficiency standards (Salt Lake City, Longmont, Denver)

4.2.4.2.2 Specific Adaptation Actions

These are the cities that have very specific water-related actions towards adaptation in response to climate change in the Southwest. There are 9 cities that fall into this category. They are Avondale(AZ), Gilbert(AZ), Glendale(AZ), Henderson (NV), Longmont(CO), Phoenix(AZ), Thornton(CO), Tucson(AZ), and Scottsdale(AZ). We sort these actions into 2 categories: *Conservation of water* and *protecting water system:*

- **Conserve water and reduce water use because of concern for water supply shortage**:
    - Reduce water lost due to leaks and expand system leak detection and controlling activities (Avondale, Phoenix, Thornton)
    - Attain additional water supplies from other sources (Phoenix, Gilbert, Tucson)
    - Capture and collect rainwater, storm-water run-off, wastewater (Scottsdale, Thornton, Henderson)
    - Use low-flow plumbing fixtures and water efficient appliances (Scottsdale, Avondale)
    - Strengthening the city's plumbing efficiency standard from the national plumbing standard to reduce per-unit water use (Phoenix)
    - Convert "non-recreational" turf to desert landscaping (Henderson, Longmont, Scottsdale)

- Exempt groundwater pumping from replenishment obligations (Gilbert)
- Designing and/or improving water delivery system (Tucson, Thornton)
- Partner with universities and agencies in modeling a better climate models (Phoenix)

- **Protect the water system and water quality:**
  - Install drainage system monitoring program to reduce excess pollutants that may obstruct flow or be transported in stormwater (Glendale, Santa Fe)
  - Evaluate water system and identify significant deficiencies (Gilbert)
  - Install technology to treat drinking water or to remove virus in drinking water (Gilbert)

4.2.5 Mitigation And Adaptation Summary

Table 6 summarizes how many cities had plans with actions in each category in the Southwest.

	Mitigation Actions (of 5 cities)	Adaptation Actions (of 20 cities)
Awareness and planning		12 (60%)
Specific actions	5 (100%)	9 (45%)

Table 6: Number of cities in the Southwest falling into each category, out of all cities with plans. Note that some cities mention multiple types of actions in their plans

4.3 Regression Results

To make sure the regression model fits our actual data well, we decided to omit the all the outliers in terms of population among the observations we used. In the Northeast, we excluded New York City out of our observation list and in the Southwest, we excluded Phoenix out of our observation list.

4.3.1 Cities in the Northeast

Table 7 shows the summary of the data for 82 cities in the Northeast (with the exception of NYC) with mean and standard deviation values for each independent variable: population, income, political leaning, coastal distance and difference between average city and U.S rainfall and the results from the logit binary regression for these 82 cities with values of the coefficients and p-values for each of the independent variables a and the model's constant

Predictor	Mean	StDev	Coeff	P-value
Population (10,000s)	12.11	17.85	0.145	**0.005**
Median Income (1,000s)	54.04	20.08	-0.015	0.381
Political Leaning (%)	61.77	6.1	0.045	0.443
Coastal Distance (dummy)	0.21	0.41	1.643	**0.02**
Average City Rainfall (inches)	44.79	3.43	0.068	0.474
Constant			-8.278	0.113

Table 7: Summary data and regression results for 82 cities in the Northeast (without NYC)

The binary regression shows that population and coastal distance are drivers among our independent variables for whether a city has a relevant plan ($p < 0.05$). Rainfall and political leaning appear to be irrelevant.

The coefficients can be interpreted as following: one unit change in the variable of interest results in a change of the amount of the coefficient of that variable in the log-odds of the dependent variable. The log-odds ratio is the ratio of the probability of having a relevant plan for a city given its characteristics to the probability of not having a relevant plan for the same city.

In the case of the Northeast, for an average city (a city with all its characteristics held at mean values), we have:

$$ln(\frac{\pi}{1-\pi}) = -8.278 + 0.145(population) - 0.015(income) + 0.045(political) + 1.643(location) + 0.068(rainfall)$$
$$= -8.278+0.145*12.11-0.015*54.04+0.045*61.77+1.643*0.21+0.068*44.79$$
$$=-1.16$$

Therefore,

$$\left(\frac{\pi}{1-\pi}\right) = e^{-1.16} = 0.31$$

$$\pi = 23.7\%.$$

We conclude from our regression result that for an average city in the Northeast, the probability of having a relevant water-climate change plan is 23.7%.

Using the same method of calculation as above, we found out that:

- If population increases by 10,000 people from the population mean, in an average city, the probability of having a relevant plan increases from 23.7% to 26.6% (2.9 percentage point).
- If population increases by 100,000 people from the population mean, in an average city, the probability of having a relevant plan increases from 23.7% to 57.1% (33.4 percentage point)

To calculate the change in probability of having a relevant plan when we move from a non-coastal city to a coastal city, we solved for π when location is 0 and 1:

If a city is not on the coast (location = 0):

$$ln\left(\frac{\pi}{1-\pi}\right) = -8.278 + 0.145(population) - 0.015(income) + 0.045(political) + 1.643(0) + 0.068(rainfall)$$

$$= -8.278+0.145*12.11-0.015*54.04+0.045*61.77+0.068*44.79$$

$$=-1.5$$

Therefore, **π = 18.2%**

If a city is on the coast (location = 1):

$$ln(\frac{\pi}{1-\pi}) = -8.278 + 0.145(population) - 0.015(income) + 0.045(political) + 1.643(1) + 0.068(rainfall)$$

= -8.278+0.145*12.11-0.015*54.04+0.045*61.77+ 1.643 + 0.068*44.79

=0.143.

Therefore, **π = 53.5%**

- If we move from a non-coastal city to a coastal city, all other characteristics held at mean values, the probability of having a relevant plan increases by **35.3% (increases from 18.2% to 53.5%)**

4.3.2 Cities in the Southwest

Table 8 shows the summary of the data for 41 cities in the Southwest (with the exception of Phoenix), with mean and standard deviation values for each independent variable: population, income, political leaning and rainfall, and the results from running logit regression in these 42 cities, compared to 82 cities in the Northeast

Predictor	Mean (SW)	Mean (NE)	StDev (SW)	StDev (NE)	Coeff (SW)	Coeff (NE)	P-value (SW)	P-value (NE)
Population (10,000s)	14.00	12.11	12.39	17.85	0.359	0.145	**0.01**	**0.005**
Median Income (1,000s)	53.00	54.04	14.34	20.08	-0.0028	-0.015	0.939	0.381
Political Leaning (%)	45.26	61.77	14.16	6.1	0.133	0.045	**0.01**	0.443
Average City Rainfall (inches)	12.83	44.79	5.02	3.43	0.15	0.068	0.261	0.474
Constant					-12.07	-8.287	**0.018**	0.113

Table 8: Summary data and regression results for 42 cities in Southwest and the Northeast

The regression shows that population and political leaning appear to be important drivers to whether or not a city in the Southwest has a relevant plan. All the other variables are irrelevant.

Applying the same method to calculate the increase in probability of having a plan in the Southwest as population increase by 10,000 and political leaning increases by 1% from their means, in an average city in the Southwest, we have:

- As population increases by 10,000 from the population mean (140,000), in an average city, the probability of having a relevant plan increases from 67% to 75% (8 percentage points)
- As population increases by 100,000 from the population mean (140,000), in an average city, the probability of having a relevant plan increases from 67% to 98.6% (31.6 percentage points)
- As political leaning increases by 1% from political leaning mean (45.26%), in a average city, the probability of having a relevant plan increases from 67% to 70.4% (3.4 percentage point)
- As political leaning increases by 10% from political leaning mean (45.26%), in a average city, the probability of having a relevant plan increases from 67% to 88.8% (21.8 percentage point)

4.3.3 Cities in both the Northeast and the Southwest

Table 9 shows the summary of the pooled data for 123 cities in the Northeast and the Southwest (with the exception of NYC and Phoenix) with mean and standard

deviation values for each independent variable: population, income, political leaning, average rainfall, and location as a dummy variable and the results from logit regression for these said cities:

Predictor	Mean	StDev	Coeff	P-value
Population (10,000s)	14.58	21.63	0.166	**0.0001**
Median Income (1,000s)	53.57	18.26	-0.0047	0.727
Political Leaning (%)	56.56	12.26	0.085	**0.005**
Average City Rainfall (inches)	33.88	15.83	0.086	0.198
Region (dummy)	0.66	0.48	-5.11	**0.024**
Constant			-6.84	**0.002**

Table 9: Summary data and regression results for 123 cities in the Northeast and the Southwest

For both regions pooled together, population, political leaning and location appear to be drivers to whether or not a city has a relevant plan.

- As population increases by 10,000 from the population mean (145,800), in an average city the probability of having a relevant plan increases from 37.8% to 41.8% (4 percentage points)
- As population increases by 100,000 from the population mean (145,800), in an average city the probability of having a relevant plan increases from 37.8% to 76.5% (38.7 percentage points)

- As political leaning increases by 1% from political leaning mean (56.56%), in an average city, the probability of having a relevant plan increases from 37.8%% to 39.7% (2.1 percentage points).
- As political leaning increases by 1% from the political leaning mean (56.56%), in an average city, the probability of having a relevant plan increases from 37.8%% to 58.7% (20.9 percentage points).

We notice in the two previous regressions that an average city in the Northeast has probability of 23.7% of having a relevant plan, while an average city in the Southwest has probability of 67% of having a relevant plan. An average city in the Southwest has 43% higher probability of having a relevant plan than an average city in the Northeast.

We found in the combined regression that population, political leaning and location appear to be the main drivers to whether or not a city has a relevant plan. All the other elements are not significant. Since average rainfall is strongly correlated to location (all the cities in the Southwest have average rainfall level below the average U.S level and all the cities in the Northeast have average rainfall level above the average US. level) and since we expected that the amount of rainfall was important for a city to plan their water resources accordingly, we thought rainfall would likely be a significant driver as well. But the regression suggests otherwise. When we run the regression without average rainfall data, location still appears to be significant; while without location in the model, rainfall is still insignificant. This suggests that

some other element other than rainfall is the reason for why there is more climate change related water planning in the Southwest.

CHAPTER 5

CONCLUSION

5.1 The Northeast

In the Northeast, only 20 of the 83 cities (24%) whose water plans or climate change plans are available online (out of 101 cities in total in the Northeast with population more than 50,000) are thinking enough about climate change with respect to water to include relevant information in their water, climate change, or city plans. Our results indicate that larger cities are more likely to include such information, so we would expect the percentage across all cities in the Northeast to be even lower than our result, if we include cities with population less than 50,000. Future research should aim to understand whether cities are thinking about climate change with respect to water but are not including this information in their plans, and should address where one might find other evidence of their thinking (i.e., city council meeting minutes).

Of the 20 cities with relevant plans, 10 have water-related plans mentioning climate change and 18 have climate change-related plans mentioning water (8 cities have both). Of the 10 water plans, 8 include some mention of mitigation and all include some mention of adaptation. Among the 18 climate change plans, 15 include some mention of mitigation and 16 include some mention of adaptation. This finding was non-intuitive, in that we expected a larger percentage of the cities to be thinking about mitigation than adaptation; instead, more cities included adaptation actions in

their plans. Adaptation actions tend to be implemented over a longer time frame, so it may be more likely that adaptation actions are included in formal plans than mitigation actions. However, 62% of the adaptation actions mention by cities only suggested a broad level of adaptation awareness and planning. By identifying other sources of information regarding cities' thinking about climate change with respect to water, we can confirm whether cities are, in fact, more likely to be thinking about adaptation actions than mitigation actions.

In the Northeast, even though we find more evidence of adaptation actions than mitigation actions, most of the mitigation actions are very specific ones while the bigger proportion of adaptation actions are at a general planning and awareness level. A significant portion of the cities with relevant plans included very specific mitigation and/or adaptation actions. 53% of those plans that included water-related mitigation actions discussed *specific mitigation actions* they are or will be taking. 42% of those plans that included water-related adaptation action discussed *specific adaptation actions* they are or will be taking. Our findings from our review of the plans are consistent with other literature indicating that floods and droughts are the main concerns of water managers in the Northeast, with flood-related actions being more common.

5.2 The Southwest

The proportion of cities in the Southwest with relevant plans is nearly double that in the Northwest. In case of the Southwest, 22 of the 42 cities (52%) whose water

plans or climate change plans are available online (out of 56 cities with population of more than 50,000) are thinking about climate change with related to water.

Of these 22 cities, 10 are climate change related water plans and 15 are water-related climate change plans, which leaves us with 4 cites with both relevant water plans and climate change plans. Among 10 cities that have relevant water plans, only 5 cities mentions mitigation actions while all 10 cities mention adaptation actions. Similarly among 15 cities that have water-related climate change plans, 4 cities mention mitigation while 14 cities mention adaptation actions. This shows that the Southwest has much less specific mitigation actions than the Northeast.

Looking at the mitigation actions in both regions, the Northeast has more specific and planning mitigation actions than the Southwest. Also, the mitigation actions in the Northeast are more diverse. While in the Southwest, most of the cities are concerned about water supply and how to conserve water and reduce water use to meet future water demand, the Northeast, with the exception of New York City, doesn't mention about maintaining their water supply and water quality in their published plans. Instead, water-related adaptation actions in the Northeast vary in different cities, showing diverse priorities and concerns of Northeastern water managers in response to climate change. Southwestern water managers, on the other hand, focus mostly on maintaining water supply and in a fewer cities, water system and water quality, which are all the water concerns of the entire region.

We find that our results are consistent with a body of earlier literature we reviewed on climate change planning and water planning. The mitigation and adaptation activities show different approaches to climate change planning by water managers of both regions.

This work is a first step in identifying the cities that are thinking about water planning and climate change in the Northeast and the Southwest, with some results about what drives cities' thinking. The data we have presented can be used to look more deeply into the reasons that cities plan for climate change, as well as the effectiveness of this planning in both regions.

APPENDIX

CITIES IN THE NORTHEAST AND THE SOUTHWEST

1 Cities and towns that have no relevant plans or have no plans that can be found on the Internet

1.1 Cities and towns in the Northeast that either have no relevant plans or have no plans that can be found on the Internet

Cities/Towns	Water Plan			Climate Change Plan		
	Plan	**CC**	**Date**	**Plan**	**Water**	**Date**
Allentown	SWPP	X	2011			
Amherst	SWP	X	2010	CP	X	2004
Bayonne	UP	X	2010			
Bethlehem	CP	X	2010			
Brentwood						
Bristol	WAP	X	2004			
Brockton	WMP	X	2009			
Brookline				CCAP	X	2002
Buffalo	SWP	X	2007			
Camden	MP	X	2010			
Cheektogawa	CP	X	2009			
Clarkstown	CP	X	2007			
Clay						
Clifton	MP	X	2008			
Cranston	WAP	X	2003	HMP	X	2010
Danbury						
East Hartfort	CP	X	2003			
East Orange	MP	X	2004			
Edison	MP	X	2003			
Elizabeth						
Erie	CP	X	2010			
Fairfield						
Fall River	WAP	X	2006			
Framingham	WmP	X	2006			
Greenburgh				CAP	X	2008
Greenwich	CP	X	2009			
Hartfort	CP	X	2011			
Haverhill	SMP	X	2010			

Hempstead						
Irondequoit	CP	X	2009			
Irvington	TP	X	2007			
Jersey City	CP	X	2000			
Lancaster	WRP	X	1996			
Lawrence	WWP	X	2009			
Levittown						
Levittown	SP	X	2002			
Lowell	WWP	X	2007			
Lynn	WWP	X	2001			
Malden						
Manchester	WWP	X	2010			
Manchester						
Medford				CAP	X	2001
Meriden	CP	X	2010			
Milfort	WWP	X	2009			
Nashua						
New Bedford						
New Britain	CP	X	2010			
New Brunswick	MP	X	2008			
Newton	WmP	X	2011			
Niagra Falls						
North Hempstead	CP	X				
Norwalk	CP	X	2006			
Passaic	MP	X	2005	HMP	X	2010
Paterson	CP	X	2005			
Pawtucket	CP	X	2011			
Peabody	CP	X	2002			
Quincy	CP	X	2011			
Ramapo	SWP	X	2010			
Reading	CoP	X	2009			
Revere						
Rochester	CP	X	2005			
Schenectady	SWPPP	X	2009			
Scranton						
Somerville	CP	X	2011	EP	X	2007
Springfield	CP	X	2010			
Stratford	CP	X	2003			
Syracuse						
Taunton	CP	X	2009			

Toms River						
Trenton				CCAP	X	2010
Union						
Union City	MP	X	2010			
Utica						
Vineland						
Waltham	CP	X	2010			
Wayne						
West Hartford	SWP	X	2004	CCAP	*	
West Haven	CP	X	2010			
Weymouth	CP	X	2010			
White Plains						
Yonkers						

1.2 Cities and towns in Southwest that either have no relevant plans or have no plans that can be found on the Internet

City/Town	Water Plan			Climate Change Plan		
	Plan	CC	Date	Plan	Water	Date
Arivaca						
Chandler	DMP	X	2003			
Goodyear	WP	X	2012			
Lake Havasu	WCP	X	2011			
Peoria	WMP	X	2008			
Surprise						
Temple						
Yuma	WCP	X	2009			
Aurora						
Grand Junction	GWP	X	2012			
Greeley	WMP	X	2003			
Lakewood						
Loveland	WMP	X	2005			
Pueblo						
West Adams						
Westminster						
Carson City	WCP	X	2011	GHGP	X	2011
Paradise						
Sparks						
Spring Valley						

Surprise Manor						
Rio Rancho	WRMP	X	2004			
Casper	SPPP	X	2008			
Cheyenne						
Layton	SWP	X	2011			
Ogden	SWP	X	2011			
Orem	SWPPP	X	2010			
Provo	WCP	X	2011			
Sandy	SWP	X	2009			
South Jordan	SWP	X	2010			
St.George	CP	X	2012			
Taylorsville				CP	X	2011
West Jordan	WCP	X	2012			
West Valley City	CP	X	2011	CP	X	2011

2 Cities and towns that have relevant plans

In this appendix we give the references for the plans that have some discussion of climate change.

2.1 Cities and towns that have relevant plans in the Northeast

nyc.gov. 2010. *Sustainable Stormwater Management Plan*. Retrieved June, 9th,2012 from:
http://www.nyc.gov/html/dep/html/watershed_protection/stormwater_management.shtml

nyc.gov. 2010. *Climate Change Plan*. Retrieved June, 9th, 2012 from:
http://www.nyc.gov/html/planyc2030/html/theplan/climate-change.shtml

phila.gov. 2007. *Philadelphia Local Action Climate Change Plan*. Retrieved June, 9th, 2012 from:
http://www.phila.gov/green/PDFs/Attachment1_Philadelphia_Local_Action_Plan_Climate_Change.pdf

cityofboston.gov. 2008. *Boston City Plan*. Retrieve June 9th,2012 from:
http://www.cityofboston.gov/climate/pdfs/CAPJan08.pdf

mwra.com. 2011. *Climate Change Adaptation*. Retrieved June 9th, 2012 from:
http://www.mwra.com/monthly/wscac/2011/102911-eoea.pdf

planning.ri.gov.2009. *Providence City Plan*. Retrieved June 9th, 2012 from: www.planning.ri.gov/comp/**Providence**.pdf

cityofpittsurgh.pa.us. 2008. *Pittsburgh Climate Change Action Plan*. Retrieved June 9th, 2012 from: http://www.city.pittsburgh.pa.us/district8/assets/08_pgh_climate_action_plan.pdf

sustainabilitynewark.com. 2009. *Newark's Master Plan*. Retrieved June 9th,2012 from: http://sustainablenewarknj.com/category/sustainability-action-plan/

worcesterma.gov. 2010. Climate Change Action Plan. Retrieved June 9th,2012 from: http://www.worcesterma.gov/city-manager/energy-task-force/climate-action-plan

rpa.org. 2010. Bridgeport Sustainability Plan. Retrieved June 9th,2012 from: www.rpa.org/bgreen/BGreen-2020.pdf

cityofnewhaven.com. 2007. Climate Change Action Plan. Retrieved June 9th,2012 from: http://www.cityofnewhaven.com/cityplan/pdfs/New%20Haven%20Climate%20Change%20Action%20Plan.pdf

cityofstamford.gov.2009. Wastewater Plan. Retrieved June 9th, 2012 from: www.ci.stamford.ct.us/content/25/52/138/164/166/.../default.aspx

cityofstamford.gov. 2009. Green House Gas Emission Reduction Plan. Retrieved June 9th,2012 from http://www.cityofstamford.org/filestorage/25/52/138/164/202/Stamford_Local_Action_Plan.pdf

cambridgema.gov. 2010. Climate Protection Plan. Retrieved June 9th, 2012 from: http://www.cambridgema.gov/CDD/climateandenergy/~/media/Files/CDD/Climate/climate_plan.ashx

cambridgema.gov.2010. Stormwater Plan. Retrieved June 9th, 2012 from: http://www.cambridgema.gov/theworks/ourservices/stormwatermanagement/stormwaterresources.aspx

albanysustainability.org.2010. *Comprehensive Plan*. Retrieved June 9th, 2012 from: http://www.albanysustainability.org/climate.asp

cogcnz.org.2007. *Hazard Mitigation Plan*. Retrieved June 9th, 2012 from: www.cogcnv.org/PDM/Waterbury_NHPDMP.pdf

warwick.gov. 2007. *Hazard Mitigation Plan*. Retrieved June 9th, 2012 from:

http://www.warwickri.gov/pdfs/EMA/Warwick%20Hazard%20Mitigation%20Plan.pdf

newrochelleny.gov. 2006. *Sustainability Plan*. Retrieved June 9th, 2012 from: http://www.newrochelleny.com/DocumentCenter/Home/View/444

mountvernonny.gov. 2008. *Comprehensive Plan*. Retrieved June 9th, 2012 from: http://cmvny.com/comprehensive-plan/

portlandmaine.gov. 2010. *Sustainability Plan.* Retrieved June 9th, 2012 from: http://www.portlandmaine.gov/planning/sustainableportlandbrochure.pdf

hamden.com. 2009. *Local Action Plan*. Retrieved June 9th 2012 from: http://www.hamden.com/filestorage/43/1286/Local_Action_Plan.pdf

burlingtonvt.gov. 2007. *Climate Action Plan*. Retrieved June 9th, 2012 from: www.burlingtonvt.gov/cap/

2.2 Cities and towns that have relevant plans in the Southwest

Phoenix.gov, 2011. Water Resource Plan. Retrieved November, 12th, 2012 from: http://phoenix.gov/webcms/groups/internet/@inter/@dept/@wsd/documents/web_content/wsd2011wrp.pdf

tucsonaz.gov, 2011. Water Resource Plan. Retrieved November 12th, 2012 from: http://cms3.tucsonaz.gov/water/waterplan

reno.gov, 2010. Flood Management Plan. Retrieved November 12th, 2012 from: http://www.reno.gov/Index.aspx?page=1675

slcclassic.com, 2009. Master Water Conservation Plan. Retrieved November 12th, 2012 from: http://www.slcclassic.com/utilities/PDF%20Files/2009%20Water%20Conservation%20Master%20Plan%20-%2011-03-2009.pdf

fcgov.com, 2012. Water Conservation Plan. Retrieved November 12th, 2012 from: http://www.fcgov.com/utilities/img/site_specific/uploads/conservation-plan.pdf

thorntonwater.com, 2009. Water Conservation Plan. Retrieved November 12th, 2012 from: http://www.thorntonwater.com/PDFs/COT_Conservation_Plan.pdf

bouldercolorado.gov, 2011. Water Utility Treatment Plan. Retrieved November 12th, 2012 from:

http://www.bouldercolorado.gov/index.php?option=com_content&view=article&id=14242&Itemid=4785

Longmont.co.us, 2011. Drought Response Plan. Retrieved November 12th, 2012 from:
http://www.ci.longmont.co.us/pwwu/water/conservation/droughtresponseplan.htm

az-avondale.civicplus.com, 2012. Water Conservation Program. Retrieved November 12th, 2012 from:
http://az-avondale.civicplus.com/index.aspx?NID=203

santafenm.gov, 2010. Watershed Plan. Retrieved November 12th, 2012 from:
http://www.santafenm.gov/DocumentCenter/Home/View/4354

ase.tufts.edu, 2009. Climate Action Plan. Retrieved November, 12th, 2012 from:
http://ase.tufts.edu/polsci/faculty/portney/climatePlan/PhoenixClimateActionPlan2009.pdf

greenprintdenver.org, 2007. Climate Action Plan. Retrieved November 12th, 2012 from:
http://www.greenprintdenver.org/docs/DenverClimateActionPlan.pdf
lasvegasnevada.org, 2007. Sustainability Plan. Retrieved November 12th, 2012 from:
http://lasvegasnevada.gov/files/Sustainable_Las_Vegas.pdf

tucsonaz.gov, 2012. Climate Action Plan. Retrieved November 12th, 2012 from:
http://cms3.tucsonaz.gov/ocsd/act

cabq.gov, 2009. Climate Action Plan. Retrieved November 12th, 2012 from:
http://www.cabq.gov/cap/CAPREV11forWEB.pdf

mesaaz.gov, 2012. Climate Change Action Plan. Retrieved November 12th, 2012 from:
http://www.mesaaz.gov/sustainability/pdf/ClimateExtension.pdf

cityofhenderson.com, 2012. Sustainability Plan. Retrieved November 12th 2012 from:
http://www.cityofhenderson.com/sustainability/

glendaleaz.com, 2008. Sustainability Plan. Retrieved November 12th 2012 from:
http://www.glendaleaz.com/CommunityPartnerships/documents/FiscalYear2008-09NSPThirdSubstantialAmendmenttotheAAP.pdf

scottsdaleaz.gov, 2012. Green Building Plan. Retrieved November 12th 2012 from:
http://www.scottsdaleaz.gov/greenbuilding

gilbertaz.gov, 2009. City Plan. Retrieved November 12th 2012 from: http://www.gilbertaz.gov/planning/pdf/GenPlan2011/draft-chapters/11%20GP%20Chapter%207%20FINAL%20edit%20-%20Nov%202010.pdf

fcgov.com, 2008. Climate Action Plan. Retrieved November 12th 2012 from: http://www.fcgov.com/climateprotection/pdf/climate_action_plan.pdf

bouldercolorado.gov, 2012. Climate Action Plan. Retrieve November 12th 2012 from: http://www.bouldercolorado.gov/files/LEAD/climate%20and%20energy/cap_final_25sept06.pdf

las-cruces.org, 2011. Sustainability Plan. Retrieved November 12th 2012 from: http://www.las-cruces.org/en/Departments/Public%20Works/Services/Facilities%20Management/Sustainability/Sustainability%20Action%20Plan.aspx

flagstaff.az.gov, 2005. Hazard Mitigation Plan. Retrieved November 12th 2012 from: http://www.flagstaff.az.gov/DocumentCenter/Home/View/1078

broomfield.org, 2005. City Plan. Retrieved November 12th 2012 from: http://www.broomfield.org/planning/masterplan/FINAL_COMP_PLAN.pdf

REFERENCES

1. Bell, L., Michelle, Goldberg, Richard, Hogrefe, Christian, Kinney, L., Patrick, Knowlton, Kim, Lynn, Barry, Rosenthal, Joyce, Rosenzweig, Cynthia & A. Patz, Jonathan. 2009. Climate change, ambient ozone, and health in 50 US cities. *Climatic Change,* V.82(1-2), 61-76.

2. Collins, MT & Lempert, RJ. 2007. Managing the risk of uncertain thresholds responses: comparison of robust, optimum and precautionary approaches. *Risk Analysis, 27*(4), 1009-1026.

3. Dow, Kirstin, O'Connor, E., Robert, Yarnal, Brent, Carbone, J., Gregory & Jocoy, L., Christine. 2007. Why worry? Community water system managers' perceptions of climate vulnerability. *Global Environment Change, 17*, 228–237.

4. Duong, Ha, Minh. 2000. Quasi-option value and climate policy choices. *Energy Economics, V.20(5-6), 46*(5), 599-620.

5. Frankhauser, Samuel, Smith, B., Joel, & Tol, S.J., Richard. 1999. Weathering climate change: some simple rules to guide adaptation decisions. *Ecological Economics, V.3(1)*, 67-78.

6. Groves, G., David, Knopman, Debra, Lempert, J., Robert, Berry, H., Sandra & Wainfan, Lynne. 2000. Presenting uncertainty about climate change to water resource managers.

7. Groves, G., David & Lempert, J., Robert. 2007. A new analytic method for finding policy-relevant scenarios. *Global Environmental Change,* V.17(1), 73-85.

8. Hallegate, Stephane. 2009. Strategies to adapt to an uncertain climate change. *Global Environment Change, V.19,* 240-247.

9. Hanak, Ellen & R. Lund., Jay. 2008. Adapting California's water management to climate change. *Climatic Change, 55*, 125–154.

10. Ivey, L., Janet, Smithers, John, Loë, de, C., Rob, & Kreutzwiser, D., Reid. 2000. Community Capacity for Adaptation to Climate-Induced Water Shortages: Linking Institutional Complexity and Local Actors. *Management Science, 46*(5), 626–643.

11. Lebel, L., L. Li, C. Krittasudthacheewa, et al., 2012. Mainstreaming climate change adaptation into development planning. Bangkok: Adaptation Knowledge Platform and Stockholm Environment Institute. 32 pp

12. Lempert, J., Robert & Schlesinger, E., Michael. 2000. Robust strategies for abating climate change. *Climatic Change, 45(*3-4), 387-401.

13. Lempert, J., Robert, Groves, G., David, Popper, W., Steven & Bankes C., Steve. 2006. A general, analytic method for generating robust strategies and narrative scenarios. *Management Science, 52*(4), 514-528.

14. Loë, de, C., Rob & Kreutzwiser, D., Reid, ..Climate Variability, Climate Change and Water Resource Management in the Great Lakes. *Climatic Change, 45*(1), 163-179.

15. O'Connor, E., Robert, Bord, J., Richard, Dow, Kirstin & Yarnal, Brent. 2004. Risk perceptions of natural hazards: community water system managers in Pennsylvania and South Carolina. *American Society of Civil Engineering,* 87-95.

16. O'Connor, E., Robert, Yarnal, Brent, Kristin, Dow, Jocoy, L., Christine & Carbone, J., Gregory. 2005. Feeling at risk matters: Water managers and the decision to use forecasts. *Risk Analysis, V.25*, 1265-1275.

17. Rayner, S. & Lach, D. , et al. 2005. Weather forecasts are for wimps: why water resources managers don't use climate forecasts. *Climatic Change, 69*(2-3), 197-277.

18. Romsdahl, J.,Rebecca. 2011. Decision support for climate change adaptation planning in the US: why it needs a coordinated internet-based practitioners' network. *Climatic Change, 106*, 507–536.

19. Rosenzweig, Cynthia, Solecki, Willian, Hammer, Stephen & Mehrotra, Shagun. 2002. Climate Change and Cities: First assessment report of the urban climate change research network.

20. Rosenzweig, Cynthia, David C. Major, Demong, Kate, Stanton, Christina, Horton, Radley & Stults, Melissa. 2007. Managing climate change risks in New York City's water system: assessment and adaptation planning. *Mitigation and adaptation strategies for global change,* V.12(8), 1391-1409.

21. Sharma, Divya & Tomar, Sanjay. 2010. Mainstreaming climate change adaptation in Indian cities . *Environment and Urbanization,* V.22(2), 451-465.

22. Vorosmarty, J., Charles, Green, Pamela, Salisbury, Joseph & Lammers, B., Richard. 2000. Global water resources: Vulnerability from Climate Change and Population Growth. *Science, V.289*, 284–288.

23. West,M., Jordan, Julius, H., Susan, Kareiva, Peter, Enquist, Carolyn, Lawler, J.,Joshua, Petersen, Brian, Johnson, E., Ayana & Shaw, M., Rebecca. 2009. U.S. Natural Resources and Climate Change: Concepts and Approaches for Management Adaptation. *Management Science,* 44(6), 1001-1021.

24. news.bbc.co.uk, 2007. Man causes climate change. Retrieved December 5th 2012 from: http://news.bbc.co.uk/2/hi/7010522.stm

25. ipcc.ch, 2007. IPCC Fourth Assessment Report: Climate Change 2007. Retrieved March 5th 2013 from: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

26. Hamin, Elisabeth. 2012. By Stealth or by spotlight: Matching Barriers to Adaptation Approaches. *Unpublished Manuscript*.