Drought Management Plans in
Major Cities of the Southeastern U.S. v. Western U.S.

by

Meredith Kaye Moore

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
May 5, 2019

Keywords: Drought management plans, Water policy, Sustainability,
Water supply, Southeastern United States

Approved by:

Dr. Philip Chaney, Associate Professor of Geosciences
Dr. Christopher Burton, Assistant Professor of Geosciences
Dr. Eve Brantley, Associate Professor and Extension Specialist of Crop, Soils, and Environmental Sciences

Abstract

The severe drought conditions impacting California and the Western United States over the last several years have led to greater awareness of the consequences of water scarcity and the need for effective drought policy. The Southeastern U.S. is not immune to this threat, as evidenced by the devastating droughts of 2007 and 2016. Without adequate management and effective planning, drought impacts and water scarcity issues are likely to become more severe. Few studies have critically analyzed local drought management plans and conceptualized the overall quality of the mitigation strategies. Characteristics of local management plans in the West and Southeast U.S. were evaluated on three levels for key elements of sustainable policy (i.e., social, environment, and economic), the stages of drought management (i.e., pre-drought, during drought, and post-drought), and the level of detail and overall quality. This study presents a multi-state policy analysis for 22 key cities in the Southeast (Alabama, Georgia, Mississippi), and the Western U.S. (California and Arizona). The results confirm the assumption that drought management plans are more comprehensive in the west and they provide a roadmap for how cities in the southeast can increase the level of preparedness. Recommendations for the development of successful local plans, particularly from the environmental pillar, pre-drought, and during-drought framework, are provided based on the higher scores of the western plans. These methods are a proactive approach to sustainably addressing water scarcity issues.

Acknowledgements

I would like to first thank Dr. Philip Chaney for serving as the chair of my committee and for his guidance throughout my graduate career. This research would also not have been possible without the support of Dr. Christopher Burton and Dr. Eve Brantley. The help provided by the members of my thesis committee made this work both possible and rewarding. Thank you to Dr. Chaney and the Geoscience Advisory Board for providing this opportunity and funding of my graduate assistantship and conference travel. A special thanks to the Geoscience faculty for the support and time they gave me.

I would also like to express gratitude to my fellow Auburn geoscientists, who started as strangers and turned into life-long friends, and whose constant encouragement and uplifting support helped shape my experience throughout this process. Lastly, thank you to my family. They helped instill a lifelong passion for learning and a mindset to always do my best, which will continue with me in my personal and professional experiences. To all whom I've mentioned above and countless others: I appreciate you all more than you will ever know.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Water security in urban areas is under threat for domestic, industrial, and municipal uses due to population growth and variable climate patterns, which leads to an imbalance between water supply and demand. This imbalance is magnified during periods of drought (McDonald 2014, Richter et al. 2013, Yigzaw et al. 2016). The severe water shortages that have recently threatened cities such as Cape Town, South Africa, and Sao Paolo, Brazil, raise concern about the reality of urban water crises (Welch 2018). Recent severe droughts in California and the Western United States have led to greater awareness of the consequences of water scarcity and the need for effective drought policy in major cities. Ensuring that there is an adequate supply of freshwater to satisfy these urban areas is one of the greatest issues facing the 21st century (McDonald et al. 2014, Padowski et al. 2012, Saejis 1995).

The Southeastern U.S. faces unprecedented challenges in sustainable water resource management as the imbalance between water supply and demand intensifies and climate patterns become more unpredictable (IPCC 2014, Campana et al. 2012). The relative abundance of precipitation and ground and surface water supplies in this region appears to have led to an unsustainable approach toward freshwater resources, which leads to uncertainty about future availability given the changing climate and variable environmental conditions (e.g. prolonged dry periods, frequent heavy rainfall events, etc.) (Campana et al. 2012, Fishman 2011, Padowski et al. 2012). Water-rich areas are likely to be as susceptible to the detrimental effects of droughts as water-scarce areas without considering these factors (Wada et al. 2013). The Southeastern

U.S. faces a unique opportunity to plan and mitigate the impact of water shortages before a major crisis occurs.

The purpose of this study is to evaluate the state of drought management plans (DMPs) of major cities of several states in the Southeast (i.e., Alabama, Georgia, and Mississippi). Drought has historically been a greater concern in the Western U.S. than the Southeast; so it is likely that major cities in the West have developed local DMPs that are both comprehensive in structure and highly detailed. Therefore, DMPs of major cities in the Western U.S. were used to develop a framework for evaluating the DMPs of major cities in the Southeast. The primary research questions for this study will be addressed on a city by city basis and are as follows:

1) Does the city have a DMP in place?
2) Does the DMP include the key components of sustainable policy (social, economic, and environmental factors)?
3) Does the DMP include pre-drought, during, and post-drought conservation strategies and implementable actions?
4) Does the DMP identify an enforcement strategy for regulating restrictions during drought, and are there goals identified to mitigate the effects of future droughts?
5) How do DMPs differ in their level of preparedness in the Southeast compared to the Western U.S.?

The findings of this study were used to develop a set of recommendations for the fundamental elements of a DMP for major cities in the Southeast.

Chapter 2: Drought Types and Management Strategies

Drought is a natural and anthropogenic phenomenon that affects nearly all areas of the world, with both short and long-term lingering impacts; however, there is no universal drought definition (Wilhite et al. 2007). It is generally characterized as a lack of precipitation over an extended period of time in which water availability deviates from normal conditions and detrimentally affects a particular activity, group, or environmental sector. There are several types of drought according to the National Drought Mitigation Center (2016) and Wilhite and Glantz (1985) (Maybank et al. 1995) (Table 1). Palmer indices, percentages of normal precipitation, and the Crop Moisture Index are the most common indices to measure drought (Campana 2012).

Each drought is in some way unprecedented due to the varying duration, likely causes, consequences, and spatial area affected (Lloyd-Hughes 2014). Each drought begins as a result of climatic variability and a lack of precipitation and has the potential to yield economic, environmental, and social impacts (Wilhite et al. 2014, Figure 1). The onset and impacts of droughts occur over a longer period compared to other hazards, and they are often unrecognized until human activity is affected (Maybank et al. 1995). Impacts in the United States cost an estimated $6-8 billion each year due to agricultural and crop damages, wildfires, and decline in thermoelectric power generation (Lloyd-Hughes 2014).

Disadvantaged and low-income communities are particularly at risk to the rising cost of food and water during water shortages. The costs associated with drought impacts are felt at the local level and extended to the public to increase water treatment for low-quality water, purchase freshwater supplies, or improve infrastructure (Feinstein 2017).

Table 1: Types of drought (National Drought Mitigation Center 2016; Wilhite et al. 1985).

Agricultural	Identifies precipitation deficits and evapotranspiration levels, lack of soil moisture, reduced groundwater and reservoir levels, hindering crop growth.
Ecological	The water stress across ecosystems; it includes any change in natural or managed hydrology based on a shortage of naturally available water supplies.
Hydrological	Precipitation deficits linked with the surface or subsurface water supply (streamflow, reservoir and lake levels, groundwater). These effects often take longer to become apparent.
Meteorological	The degree and duration of dry conditions compared to the average amount; number of days without precipitation compared to average amounts on monthly, seasonal, or annual time scales.
Socioeconomic	The supply of water resources and demand which vary over time and contribute to the overall vulnerability of societies to drought.

Droughts are often more recognized in arid regions of the United States such as the Great Plains and the western regions of the country; however, as evidenced by several devastating droughts since the early 2000s, the Southeast is not immune to its recurring consequences (Seager et al. 2009). Climatic oscillations such as La Nina (cold phase of El Nino Southern Oscillation) typically lead to drier winters in the Southeastern U.S., provoking dry conditions the following year (Fernando et al. 2016; Piechota et al. 1996). In addition to climate variability, an influx in population has increased pressure on freshwater resources over the past two decades, with increases in demand for public supply and irrigation as likely causes of freshwater over-consumption (Wada et al. 2013; Sun et al. 2008). Urban population growth, climate variability,

economic development, and lack of environmental regulation contribute to the rising pressure on freshwater supplies (Fishman 2011, Gilligan et al. 2018).

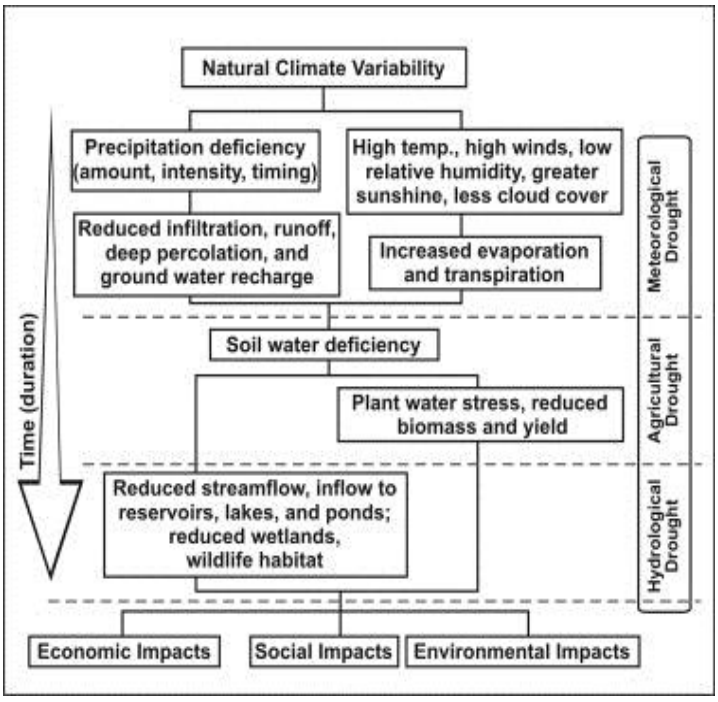

Figure 1: Model depicting the types of drought, causal factors, and sequence of occurrence (Wilhite et al. 2014)

The International Water Management Institute defines an area as "water scarce" if there is not enough clean water to satisfy the population's demand or if it is inaccessible due to contamination or lack of infrastructure (IMWI 2007). Population growth, declining infrastructure, environmental degradation, and poor governance are among the primary reasons for the increase in areas experiencing water shortages (IMWI 2007). Major cities in the Southeastern U.S. increased in population by approximately 9.4% between 2006 and 2010 and are expected to double by the year 2060 at the current rate of urban growth (Terando et al. 2014). Demand for freshwater increases with population growth due to the increase in household/domestic needs and economic development (Sun et al. 2008). When demand surpasses supply, low-flow and water-scarce conditions may be intensified (Wada et al. 2013).

The Southeastern U.S. is likely to become more vulnerable to water scarcity as urban populations increase if sustainable water policies are not implemented (Yigzaw et al. 2016).

Drought Impacts in Urban Areas

Water shortages have serious implications for urban areas where human demands exacerbate diminishing water quantities. Urban environments are particularly at risk as communities become more reliant on precipitation to fulfill the demand for freshwater, especially among areas that had been accustomed to ample freshwater supplies (Buytaert et al. 2012, Padowski et al. 2014). Current trends of population growth in cities reflect the increasing pressure of satisfying populations with adequate supplies of freshwater and increases the likelihood of future water stress or scarcity. In the U.S., water managers in 36 states predict that they will experience water shortages within the next decade at the local, regional, or state level (Fitzhugh et al. 2004).

Cape Town, South Africa, suffered from a water crisis in 2017-2018 and nearly reached "Day Zero," where water for a metropolitan city of four million people became nearly nonexistent. This urban water crisis developed as a result of a severe imbalance of water use and supply, overdevelopment, population growth, and climate change (Welch 2018). Local regulations were set in place in January 2018, after the onset of water shortages to limit water consumption to 50 liters per day, less than one-sixth of the daily amount that the average American uses (Welch 2018).

An assessment of water availability and vulnerability in U.S. cities suggests that 16% of the population was at risk of water scarcity in 2012, and 44% of cities worldwide are estimated to experience severe water shortages by 2040 at the current rate of growth (Padowski et al.,

2012). Approximately 50% of major global cities with populations greater than 100,000 are located in water-scarce regions (Richter et al. 2013). The average household cost in the U.S. for ten gallons of water is approximately three cents, which may lead to wasteful behavior and makes water scarcity a seemingly "invisible issue" (Fishman 2011).

Water scarcity affects every urban environment differently; severe drought impacts in the western U.S. led to the development of public policy to increase resilience to future water shortages; for example, in the San Joaquin Valley, California, the 2009 drought resulted in an estimated loss of 10,000 jobs and $340 million in economic revenue. Public water entities in California were mandated to reduce water consumption by 20% by 2020 as a result of increasing drought frequency (Schwabe et al 2012). Urban areas in particular have focused on water conservation and reuse strategies based on future water consumption goals outlined in the 2016 California Drought Contingency Plan (Chang et al. 2016).

Hydropower production was reduced by approximately 50% in California during the drought years of 2014-2015; it cost approximately $2 billion to shift to gas-turbine generation and additionally saw an increase in air pollution and greenhouse gasses (Gleick 2017). Electricity costs were substantially higher for residents during this time (Gleick 2017). Cities that rely on agriculture as a primary economic commodity also suffer during periods of water shortage. Studies suggest that communities suffer from the long-term health and social impacts even after a rainfall, or when a drought is no longer declared (Fresno Foundation 2015). Water shortages are particularly detrimental for urban industries because it has the potential to interrupt normal business operation and production, forcing businesses to minimize or cut production levels. The impact of water shortages becomes a local issue when it affects commercial entities and their ability to produce goods and services (Benotti 2015). Approximately seven percent of businesses

in Cape Town, South Africa, would have closed altogether if Day Zero arrived (Cohen 2018). In Brazil, Solvay's Rhodia chemical firm reduced production by 50% after closing four factories in the city of Paulinia during a drought in 2014. The world's largest beef producer, JBS, suspended production and cut 800 workers in Barretos, Brazil, due to the inaccessibility of freshwater to maintain the industry (Stauffer 2014).

Denim-based manufacturing companies in Southern California were forced to find alternative solutions to lower water usage during the recent long-term water shortage between 2010-2015. This industry in Southern California, a region that produces 75% of high-end denim products sold worldwide, minimized production in 2015 due to the lack of water supplies available for use (Quirk 2015). Some golf courses, which use approximately 90 million gallons of water per year, let the greens brown while other courses were forced to shut down (Lurie 2015).

A study conducted by Richter et al. (2013) investigated water use in four major municipalities: Adelaide (Australia), Phoenix (Arizona), San Antonio (Texas), and San Diego (California). In each of these cities, greater emphasis was placed on discovering new water supplies rather than managing demand. This finding parallels water use patterns observed in many urban areas; once the water supply is exhausted, municipalities turn to constructing water transfer systems and identifying new water sources (Richter et al. 2013). The four cities evaluated in this study attempted to secure additional water supplies to sustain their populations rather than managing demand, which yielded higher electrical and water bills, increased carbon emissions, and numerous negative social disruptions and consequences as a result of water importation. As groundwater and surface water depletion accelerates during water scarce conditions, electricity costs increased to combat the increased pressure on water systems (Richter

et al. 2013).

Urban Drought Impacts in the Southeast

The Southeast relies predominantly on precipitation to satisfy reservoir water levels to fulfill thermoelectric power generation, agricultural irrigation, and industrial, municipal, and domestic demands (Gavrilles 2010, Atkins et al. 2017). Similar to the West, the large urban areas of the Southeastern U.S. (e.g., Birmingham, AL and Atlanta, GA) are located inland with small watersheds and limited storage capacity, making these urban areas highly susceptible to declining levels of precipitation and overuse of freshwater resources (Gavrilles 2010).

Water scarcity does not only lead to water shortages impact drinking water supplies, but it also has significant implications for thermoelectric power generation and industrial use. In Alabama, water withdrawals for thermoelectric power generation and industry accounts for nearly 90% of total freshwater withdrawals (Harper et al. 2010). The cities of Decatur and Sheffield, Alabama, for example, rely solely on the Tennessee River to supply thermoelectric power generation and for industrial use. The paper and wood product industries in Alabama are primary users and rely on high levels of water, making them vulnerable to water shortages. Colbert and Lawrence Counties (Alabama) are two regions in the state that produce high volumes of pulp and paper, withdrawing between 60 and 70 million gallons of water daily (Harper et al. 2010).

Water scarcity is already a perceivable threat to certain areas of the Southeast (Sun et al. 2008; Seager et al. 2009). In 2007, approximately 60,000 people in Alexander City, AL and surrounding areas of Western Georgia experienced significant water shortages during the devastating drought that lasted nearly two years (NBC 2007). This year of drought is considered

the driest on record in Alabama. Mayor of Alexander City, Barbara Young, reported, "This is not just about recreation, it's not about washing cars, this is drinking water. We've got to have some rain" (NBC 2007). The primary drinking water source for residents in the area is Lake Martin. During the drought of 2007, water levels decreased so drastically that divers attempted to increase the depth around the pipe intake to drain more water from the lake. This drought prompted bans on outdoor watering in eastern Alabama in order to ensure that local residents had an adequate supply of drinking water (NBC 2007).

The city of Orme, Tennessee was forced to find alternative means to supply the population with freshwater after the local stream and groundwater well ran dry during the drought of 2007; via volunteer firefighters and the local fire truck, water was pumped from a fire hydrant in Bridgeport, Alabama, to fill the city's water tank (Fishman 2011). For three hours each evening, residents took advantage of the transported water supply to clean, cook, do laundry, and shower until the mayor turned off the supply valve. After four months of a three-hour-per-day water allotment, utility crews constructed a pipeline from Bridgeport and the Tennessee River to Orme's water tower (Fishman 2011; Bigg 2007). The city is located on the state line of Alabama and Georgia; it is approximately 150 miles northwest of Atlanta, which was estimated to have been within 90 days of losing its major water supply from Lake Lanier the same year as Orme's water crisis (Glennon 2009).

Nine years later, lake levels in Alabama once again recorded significantly lower-than-normal conditions during another devastating drought. In the summer of 2016, recreational activities were suspended along the Coosa River and Lake Martin, which recorded approximately one inch of water loss per day. Additionally, water releases by Alabama Power

from the hydroelectric dams were minimized or suspended. During this drought, Lake Magazine wrote that "hope and prayer may be the best strategy" (Lake Magazine 2016).

That same year, the City of Auburn, AL implemented voluntary water restrictions which included reduced landscape irrigation, discontinued vehicle washing, and reduced pressure washing (Woodham 2016). Farmers in the area reported that it was the worst drought they had witnessed; 74-year-old George Robertson commented that it was the driest conditions he had experienced: "You can walk out into the pastures where the cattle are, and it's like walking on toast. Everything is crunchy, everything is dead" (Mosbergen 2016).

The Birmingham Water Works implemented a 200% surcharge on households who consumed an excessive amount of water (considered more than 8,977 gallons per month) during the drought of 2016. This was as a result of the record-low levels of precipitation and water levels of Lake Purdy (located southeast of Birmingham, AL) and above-average household water consumption. The implementation of this surcharge occurred in November, approximately six months after the initial drought declaration (Pillion 2016).

The metropolitan city of Atlanta, Georgia supports nearly 5.7 million people and receives approximately 87% of its water from the Chattahoochee and Coosa River basins; 70% of this supply comes from Lake Lanier (Missimer et al. 2014). The growing urban population parallels a steadily increasing demand for water, which was severely compromised during the 2005-2009 water crisis when an estimated 35 to 90 days of water supply remained (Missimer et al. 2014). The two river basins are shared by Florida and Alabama and are under high demand to support a growing population, power generation, agriculture, and recreational interests (Jordan et al. 2006). Outdoor watering in the Atlanta area was restricted as a result of the unprecedented low levels of

Lake Lanier and public prayer events were held at the Capitol throughout the several years of drought (Glennon 2009).

Athens, Georgia imposed water restrictions established at the local and state level during the drought of 2007-2009, which resulted in a 20% reduction in overall water usage. During this time, hotels encouraged patrons to reuse towels, the University of Georgia installed water-saving devices in residence halls, and native plants that require less water reduced water used for landscaping (Campana 2012).

The ongoing "tri-state water wars" between Alabama, Florida, and Georgia largely began in the early 1900s as a result of the growing Atlanta metropolitan area and series of droughts, straining the water resources supplied by the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint river basins. Alabama and Florida are primarily concerned with the allocation of water as demand increases in Georgia, lessening the supply for the downstream users; each of the three states are concerned with the reliability of water quantity to meet their respective demands. Georgia and Tennessee are also in a border dispute as the search continues for new water supplies to satisfy the needs of the Atlanta metropolitan area (Jordan et al. 2006). Competition for freshwater resources will likely increase between individuals, communities, and ecosystems at the local, national, and global level especially if policies are not improved to sustainably utilize water resources (Postel 2005).

Drought Preparedness and Planning

There is no shortage of previous studies stating the difficulty of drought management and the complexity of developing policy to mitigate the impacts (e.g., Lloyd-Hughes 2014, Wilhite et al. 1985, 2007, 2014). Previous research suggests that current conservation planning and

mitigation strategies poorly address the various types of drought and the consequential impacts (Wilhite et al. 2014, IPCC 2014). While there is a growing number of state drought conservation and mitigation plans, these appear to be ineffective at preparing communities and urban areas for prolonged periods of aridity and water scarce conditions. The scale of state plans make it difficult to assess the most vulnerable water systems and enforce restrictions at the local level (Feinstein 2017). There is rising concern that the current drought management practices fall short of identifying long-term and sustainable techniques to mitigate the increasing frequency and intensity of drought events (Wilhite et al. 2014). The recurrence of droughts severely inhibits the development of mitigation and preparedness; the approach is often reactionary and crisis-based, which does little to reduce future risks to droughts and is not continued afterward to avoid future water crises (Wilhite et al. 2000, Wilhite et al. 2011, Rossi et al. 2007, Thornton et al. 2006).

McDonald et al. (2014) identify three main urban water management challenges that hinder effective water use: 1) rapidly growing cities have limited resources to maintain and improve infrastructure to deliver water resources to residents, 2) cities located in arid or semi-arid regions are limited by climatic constraints, 3) cities located along large waterbodies may suffer from poor water quality and quantity due to upstream users. Urban areas experiencing water stress often resort to expensive alternatives to meet the human demand of freshwater by constructing recycling or desalination plants or an inter-basin water transfer (Padowski et al. 2014).

The hydro-illogical cycle (Figure 2) is an example of a common process of managing and responding to drought conditions: hazard conditions arise followed by an initial awareness of the issue. People then become concerned and panicked about how to handle the crisis and are confronted with their lack of preparedness. Emergency measure and mitigation strategies are

addressed once the crisis has already begun, often resulting in the quick and wasteful depletion of water reserves and financial resources (Rossi et al. 2007). Drought fees and surcharges are common strategies for covering the costs associated with water shortages. This is a short-term fix that is revoked after the water shortage, which is especially detrimental to low-income households and for those who are already conservative in their water use (Feinstein 2017). The reactive approach may also include not making any improvements with the hope that the population at risk has enough resilience to withstand the impacts of the hazard.

Drought management plans and water conservation plans are terms often used interchangeably, and while they are similar, each outlines water resource management with slightly different approaches. It is important to address the differences in terminology in order to incorporate the best approach for the size and vulnerability of a particular water system. Drought management plans should outline planned, short-term responses to manage water during crises or shortages while water conservation plans aim to be a long-term approach of using water sustainably to support daily activities and demands (Finch 2012).

Public water supply agencies and environmentalist groups tend to encourage long-term actions to eliminate the need for infrastructure or environmental damages from additional water withdrawals, while government entities often focus on short-term and immediate actions, such as restricting residential water use (Rossi et al. 2007). Long-term drought mitigation strategies regularly include governmental entities offering economic incentives for reducing water consumption, promoting the reuse of treated wastewater, development of early warning systems, and providing educational activities for improving drought preparedness. Short-term drought mitigation strategies include improving existing water system efficiency, public information campaigns for water saving techniques, and restricting urban water uses (car washing, garden or

lawn watering, etc.) Short (immediate) and long-term actions should be incorporated to sustainably manage water resources before, during, and after a drought event (Finch 2012). In water-rich areas, there typically remains a discrepancy between water managers who accept that they have no control of external factors (precipitation patterns, climate change, etc.) and their responsibility to proactively and sustainably manage the water resources for current and future use.

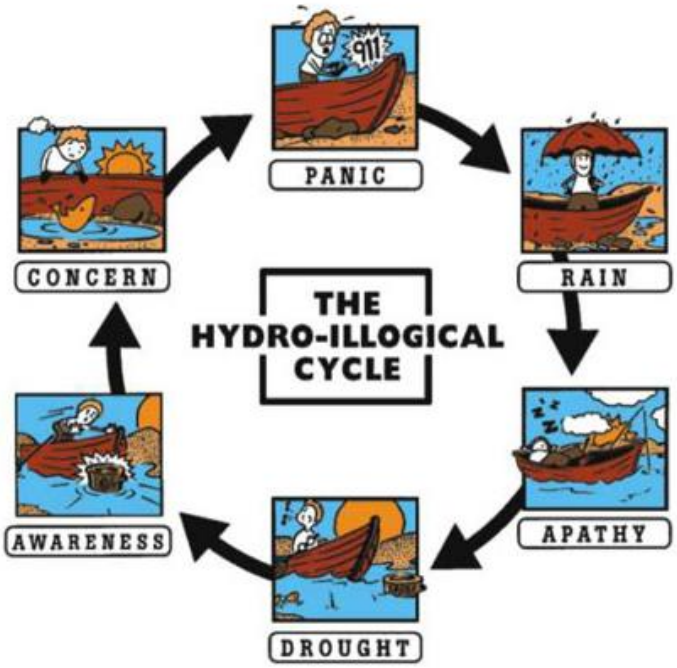

Figure 2: The hydro-illogical cycle of addressing droughts (Rossi et al. 2007).

Developing a local management plan is paramount to ensuring water availability in times of water scarcity (Wilhite et al. 2000). There are typically three approaches to water resource

management to optimize water availability during periods of water shortage: increase the water supply, decrease water demands, and minimize the impact of drought consequences (Table 2).

The first approach includes utilizing existing water supplies more effectively or tapping into new supplies. The second approach focuses on reducing the demand of water by implementing legal restrictions and water saving techniques. The third approach aims to detect drought onset and reduce the consequences caused by a drought event by forecasting the water reduction and likely impacts (Rossi et al. 2007). A comprehensive plan should address social, economic, and environmental pillars as well as the interconnectedness and trade-offs between human welfare, ecological needs, and desired human uses (recreation, transportation, irrigation, etc.) (Thornton et al. 2006).

Within this framework, there should be several key components including regular monitoring and early warning systems, risk assessment, and mitigation and response techniques. Specific verbiage indicating drought stages, thresholds, early warning drought detection, and resulting implementable actions reduces confusion and improves the cohesiveness of the plan. Terminology such as “alert”, “advisory”, and “emergency” is favorable to “level 1” or “phase 1” of drought policy (Wilhite et al. 2000).

Table 3 shows a ten-step drought management planning process developed by Wilhite et al. (2000) that incorporates key stakeholders, changing government policies, technologies, and natural resource management properties. The objectives of using this model at the local level are to identify the primary issues and individuals who must be involved to address drought planning to reduce the detrimental impacts. This ten-step planning process provides an overview of the necessary framework for implementing water conservation policy.

Table 2: Necessary components to include in a drought management plan using three different approaches (water supply increase, water demand reduction, and drought impact mitigation) (modified from Rossi et al. 2007).

Approaches to Water Management	
1. Water supply increase	
A. Existing supplies • Surface storage • Subsurface storage • Interbasin transfer • Water conservation	B. New supplies • Emergency use of lakes
2. Water demand reduction	
A. Active strategies • Legal restriction and public pressures • Economic incentives	B. Reactive strategies • User recycling systems • User production adjustments
3. Drought impact minimization	
A. Forecasting • Forecast and warning • Follow-up forecast and warning	B. Risk sharing • Insurance • Individual protection • Disaster aid

The lack of an entity or agency responsible for regulating water resources may be a cause of the extreme unpreparedness of most cities, counties, states, and regions to a drought event (Walker et al. 1991). Collaboration among regulatory entities, key stakeholders, and the public is

extremely important in mitigating the effects of drought to avoid policy duplication and/or gaps; in most instances, the lack of this authority to regulate water usage and enforce policies results in its ineffectiveness (Aither 2018).

If explicit actions taken before, during, and after drought conditions are not clearly outlined, minimizing the drought impacts is essentially impossible (Finch 2012). Since every state has experienced water shortages yet only a few have made drought planning a high priority, it would appear that societies are becoming increasingly vulnerable to the consequences, yet, only several are prepared (Wilhite et al. 2000).

Table 3: The ten-step planning process to develop drought policy (Wilhite et al. 2000)

Step One	Appoint a drought task force
Step Two	State the purpose and objectives of the drought preparedness plan
Step Three	Seek stakeholder participation and resolve conflict
Step Four	Inventory resources and identify groups at risk
Step Five	Develop organizational structure and prepare the drought plan
Step Six	Identify research needs and fill institutional gaps
Step Seven	Integrate science and policy
Step Eight	Publicize the drought preparedness plan and build public awareness
Step Nine	Teach people about drought
Step Ten	Evaluate and revise drought preparedness plan

Sustainable Water Policy

Sustainable policy is often structured across three primary domains; the social, economic, and environmental pillars are integrated at the foundation of sustainable policy in order to address a range of complex issues (Kua 2016). Incorporating each of these domains can be a challenging process for policy makers. As a result, they often react quickly to fix a problem rather than focus on preparation and mitigation before the problem arises and after the problem is resolved (Kua 2016, Searle 2011). Identifying specific actions to assess and manage drought risk not only during, but also before and after a drought, is imperative to optimizing freshwater availability while minimizing the social, economic, and environmental impacts in the long-term (Grobicki et al. 2015). A planning-based and proactive approach to mitigating drought impacts through sustainable policy therefore involves the combination of aspects within the three sustainability pillars and specific frameworks for before, during, and after a drought crisis (Grobicki et al. 2015). A list of major topics that are to be included in sustainable policy is presented in Table 4.

The three pillars of sustainability (social, economic, and environmental) and three drought frameworks (before, during, and after the crisis) each cover a diverse set of conditions and subsequent actions in sustainable policy development. Social sustainability includes elements that optimize the well-being and health of both individuals and the collective society (Moldan et al. 2012). This incorporates stakeholder involvement, public participation in reviewing and understanding the suggested policy, and in the case of water supply, an assessment of how much water is both available and needed (Kua 2016).

The economic pillar includes elements that allow for economic growth and development coupled with the consumption of natural resources in a way that does not deplete them for future

use. This incorporates establishing an enforcement entity to establish regulations without bias or discrimination and implement equitable pricing structures to encourage conservation (Moldan et al. 2012, Anand et al. 2000).

The environmental pillar includes elements that assess and maintain ecosystem services. Sustainable policies from this pillar include a summary of water sources and the diversity of these sources, identifying certain pressures or constraints on water supply, and indicators for various drought stages to maintain ecological systems (Wong et al. 2009, Moldan et al. 2012).

In addition to the three pillars of sustainability, sustainable water policy focuses on preparedness strategies against water shortages and future risk mitigation. Specific elements and actions should be described before, during, and after a water crisis to proactively optimize present and future water availability (Kampragou et al. 2011, Moldan et al. 2012, Kua 2016). In the case of drought policy, the pre-drought framework includes a description of historical drought events, early warning systems of drought, and specific actions which should be taken during non-drought periods. The during-drought framework includes actions taken during a water shortage and the process of monitoring water levels. The post-drought framework focuses on planning for future droughts by identifying potential water sources and updating the DMP (Wilhite et al. 2000, Wilhite et al. 2007).

Advancement in sustainable water resource management (particularly in water scarce areas) has recently developed from a modeling and prediction approach to incorporating societal and political factors into sustainable governance (Pahl-Wostl et al. 2008). Good governance and management practices are necessary components to exercise in developing and implementing sustainable water policy.

The term “governance” as applied to water resource management refers to the implementation of public policies that promote sustainable development and use of water sources based on policy accepted by the society (including various stakeholders involved in the process). This term assumes transparency and public participation in the development and implementation process of the sustainable policies in order to yield successful results (Solanes et al. 2006, Moore et al. 2014). Unlike the predictive or modeling approach to manage water resources, good water governance incorporates uncertainties, changing perspectives, community development, and stakeholder inputs into the public policies (Pahl-Wostl et al. 2008). It should ultimately be a factor incorporated within the primary pillars of sustainability and coupled with good management practices. Governance may be influenced by societal factors and constraints, while management places an emphasis on analyzing and implementing measures to optimize the current and future consumption of water (Knuppe et al. 2016).

An important component of sustainable water policy implementation is utilizing an adaptive management approach (Feldman 2007). This approach suggests social and political flexibility since natural resource systems and human demands continuously fluctuate. Environmental policy must be designed in a manner that encourages consistent review and adaptation to learn from mistakes or gaps in the plan (Feldman 2007). To sustainably develop and implement effective policy, stakeholders, nongovernmental organizations, policymakers, and citizens should all be involved in the process. Sustainable development ultimately requires effective policy and a fundamental change towards an adaptive and conservation approach to freshwater resources.

Table 4: Major topics of sustainable water policy

Sustainable Policy Topics	Description
Drought framework and definition	A clear definition of drought and the service area
Sustainability pillars (social, economic, environmental elements)	Identification of key elements within each of the sustainability pillars
Potential impacts	Evaluation of potential impacts on economy, community, and environment (forecasting future water supplies and demands) before, during, and after a drought crisis
Conservation actions	Conservation measures taken during non-drought periods (e.g. restricted watering during certain times of day, water reclamation and reuse practices, etc.)
Drought actions	Implementable actions during drought periods (e.g. over-consumption surcharges, restricted outdoor watering, use of car washes, refilling pools, etc.)
Enforcement	Clear enforcement agency or management team to monitor drought status and enforce violations of conservation and drought actions
Education	Community participation, education, and/or outreach methods identified
Mitigation goals	Goals for mitigating the impacts of future droughts
Reporting	Plan is regularly updated and revised

Drought Policy in the Southeast

Historically, the plentiful supply of surface and groundwater sources in the southeast have led to an unlimited renewability approach, whereas, conservation has not been viewed as a necessary priority. Of the southeastern states analyzed in this study, Alabama and Georgia have responded to past drought events by making steps to improve local water policies. All three states have water withdrawal permit requirements.

The Alabama Water Resources Act of 1993 established the Alabama Office of Water Resources as an administrative body that assigns a "certificate of use" to establish beneficial use of water, and has since worked to ensure sufficient freshwater resources in the state. Despite the current relative abundance of freshwater in Alabama coupled with vulnerability to recurring water shortage conditions, the ideal time to implement effective water policy is before an emergency. In November of 2018, the state released a Drought Management Plan which includes reservoir system management and drought contingency planning procedures at the state level. This plan is the result of several years of collaboration between stakeholders and organizations, including the Alabama Water Resources Commission, the Alabama Drought Assessment and Planning Team, and the Alabama Monitoring and Impacts Group. The state plan does not influence local drought policy, apart from designating the Alabama Office of Water Resources with the responsibility of managing the state's water resources.

At the local level, the Alabama Drought Planning and Response Act (2014) requires each community public water system to submit a Drought Management or Conservation plan every five years to the Alabama Office of Water Resources. The requirements state that each plan much include:

- A description of the service area
- Levels of voluntary or mandatory response actions during periods of water shortages
- Specific monitoring and measurements of available water supply and demand
- Implementation and enforcement mechanisms
- Public outreach and education procedures or programs
- Identification of staff or organization responsible for implementation and enforcement

The Georgia Drought Management Plan in conjunction with the Water Conservation Plan is arguably the most comprehensive state plan in the Southeastern United States. The Georgia Water Stewardship Act of 2010 requires local governments to establish and enforce water restrictions during drought and non-drought periods and complete annual water loss audits. During non-drought periods, all cities are required to enforce daily watering restrictions between 10 a.m. and 4 p.m. (Rule 391-3-30-.07). Each local water system is required to implement specific actions during a drought based on the stage of water shortage. State regulations require water restrictions and general surcharges for consuming excess water, though there is no requirement for each city to submit a DMP.

Mississippi does not have any specific policy in place pertaining to submitting a DMP or regulation during water shortage conditions. The Mississippi Department of Environmental Quality oversees the conservation and management of freshwater resources in the state, focusing their efforts on groundwater and surface water withdrawal permitting and source water assessments. The Delta Sustainable Water Resources Task Force includes key entities and stakeholders that focus on developing and implementing initiatives to ensure sustainable usage of

the Mississippi Delta water resources (MDEQ 2019). These organizations, however, are responsible for assessing the state's water resources and do not necessarily develop drought policy or implement water restrictions during shortages.

Chapter 3: Research Methods

The analysis of drought management and water conservation plans were performed in four stages: 1) collect data (acquire drought management plans), 2) analyze each plan for key elements of local water policy, 3) complete matrix by scoring the three levels of analysis for each drought plans (framework, presence of key elements, overall quality of elements), 4) identify the characteristics in stronger plans to develop recommendations for cities to create or revise an existing drought management plan.

Drought management and water conservation plans for 22 major cities were examined in this study, and were identified based on their mid-size population (Table 5, Figures 3-5). Major metropolitan cities (e.g., Atlanta, GA, and San Francisco, CA) were excluded due to a lack of cities in the Southeast of similar size. The major cities in the Western U.S. (Figure 4) were identified based on the similar population size compared to the southeastern cities (Figure 5).

Since most of the Alabama and Georgia DMPs are not accessible online, the Alabama Office of Water Resources and Georgia Environmental Protection Division (Watershed Protection Branch) agreed to provide access to the drought and/or water conservation plans submitted by each city. The Mississippi Department of Environmental Quality reported that there are no local drought restriction policies or DMPs currently in place.

Each city was first evaluated based on whether or not they had a DMP. The plans were scored based on three levels of analysis. The major categories and subcategories (Level 1 and Level 2 of analysis) for the framework of this study were based on categories that should be included in sustainable policies, as defined previously in Table 4 (Fraser Basin Council 2011).

The "Sustainability Water Policy" section in Chapter 2 identifies key elements of the three sustainability pillars and the three drought frameworks (pre-drought, during drought, and post-drought) which were used in conjunction to develop the major categories and subcategories.

Level 1 was evaluated based on seven major categories presented in Table 6. This level of analysis was scored based on the presence or absence of each major category (Not present=0, Present=1). The maximum score for Level 1 analysis is 7. Level 2 was evaluated based on 28 subcategories, which include the three key elements of sustainability (social, economic, and environmental pillars) and the three stages of drought management (pre-drought, during drought, and post-drought), presented in Table 7 (David et al. 2016, Fraser Basin Council 2011, Rossi et al. 2007). The maximum score for Level 2 analysis is 28.

Table 5: Population of major western and southeastern cities selected for study (U.S. Census Bureau, 2017)

City – Western U.S.	2017 Population	City – Southeastern U.S.	2017 Population
Anaheim, CA	352,497	Auburn, AL	63,973
Antioch, CA	111,674	Birmingham, AL	210,710
Azusa, CA	49,864	Columbus, GA	194,058
Glendale, AZ	246,709	Dothan, AL	68,202
Napa, CA	79,774	Huntsville, AL	194,585
Roseville, CA	135,329	Jackson, MS	166,965
Sacramento, CA	501,901	Macon, GA	152,663
Santa Barbara, CA	92,101	Mobile, AL	190,265
Scottsdale, AZ	249,950	Montgomery, AL	199,518
Tucson, AZ	535,677	Oxford, MS	23,639
Tulare, CA	63,855	Tuscaloosa, AL	100,287

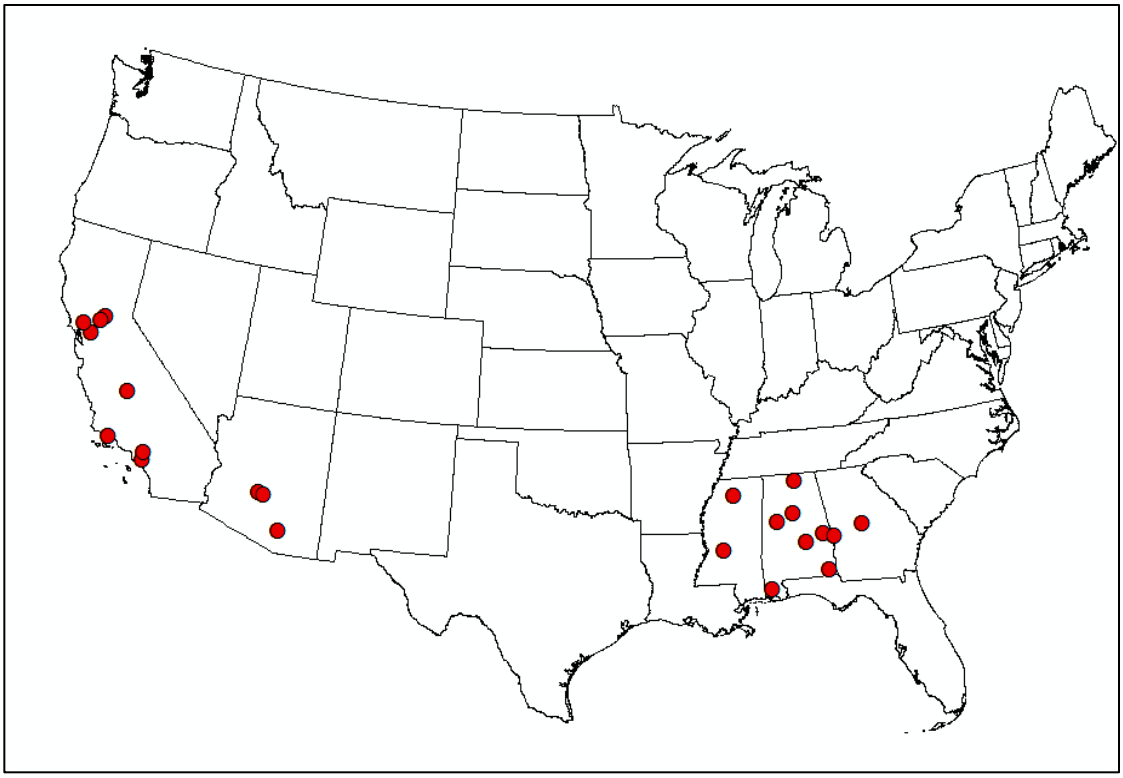

Figure 3: Major cities selected for study

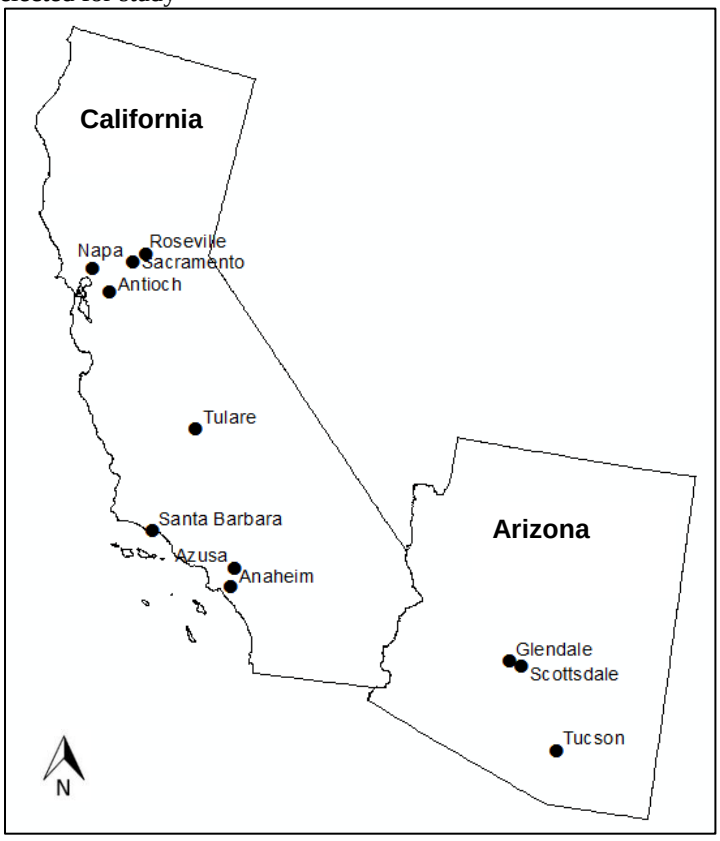

Figure 4: Western cities selected in this study

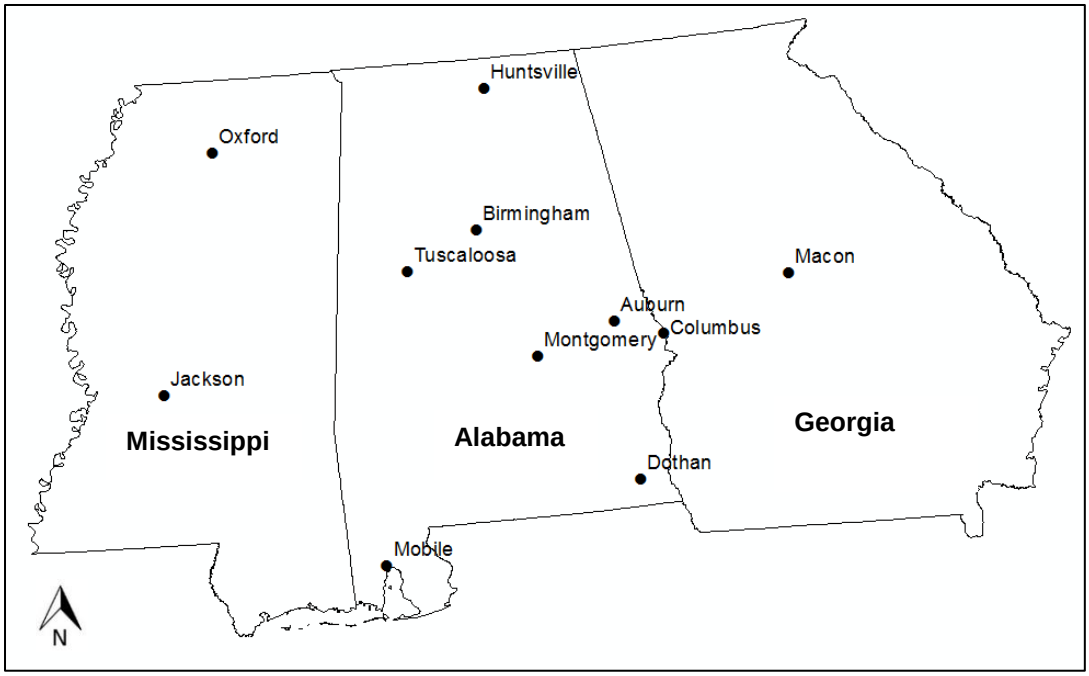

Figure 5: Southeastern cities selected in this study

Table 6: Major categories of a Drought Management Plan and definitions for Level 1 analysis

Major Category (Level 1 analysis)	Definition
1. Drought Plan Framework (DPF)	General description and overview of the purpose and scale of the plan
2. Social Pillar (SP)	The impact of both the plan and water shortages on the community, while encouraging public support and participation
3. Economic Pillar (EcP)	The impact of water shortages on the economy and an assessment of how to minimize the detrimental impacts
4. Environmental Pillar (EnP)	Aim to reduce impacts associated with environmental harm and the deterioration of natural resources
5. Pre-drought Framework (Pre-DF)	Measures taken before a drought occurs
6. During-drought Framework (DDF)	Measures taken during identified drought periods
7. Post-drought Framework (Post-DF)	Measures taken after a drought to ensure sufficient water supplies during future water shortages

Table 7: Major categories and subcategories of scoring matrix for Level 1 and Level 2 analysis

Major Categories (Level 1 Analysis)	**Subcategories** (Level 2 Analysis)
Drought Plan Framework	Definition of purpose/goals of the plan
	Definition of the service area
	Identify gaps and uncertainties
Social Pillar	Incorporation of public participation, public review component
	Describe population/demographics
	Supply and demand assessment
	Identify key stakeholders
Economic Pillar	Conservation pricing for reducing water used
	Established enforcement agency
	Define baseline and targeted water use data
Environmental Pillar	Define constraints/pressure on water sources
	Establish indicators and thresholds for drought stages
	Identify use of reclaimed, recycled, or non-potable water
	Summary of surface water sources
	Summary of ground water sources
Pre-drought Framework	Description of historical drought events
	Define early warning system of drought
	Conservation actions during non-drought periods
	Penalties imposed for violating restrictions
During-drought Framework	Description of public education and outreach
	Water level monitoring process
	Implementation of residential restrictions
	Implementation of commercial restrictions
	Penalties imposed for violating restrictions
	Identify future water sources
Post-drought Framework	Identify projected water use
	Post-drought assessment of impacts
	Evaluation and update of the drought/water plan

Level 3 evaluated the quality and detail of each subcategory based on the rubric in Table 8. This analysis scored the overall comprehensive nature of the subcategory on a scale of 0-5. An absent subcategory received the lowest score of 0, and a highly detailed and thoroughly

described subcategory received the highest score of 5. The maximum score for Level 3 analysis is 140. The plans with the highest score within each of the levels of analysis and overall score were used to provide a framework and recommendations for other cities to improve their drought policy and minimize the detrimental impacts of drought in the Southeast. The complete list of major categories and subcategories and their respective description is found in Appendix A. Table 9 shows an example of the matrix with the three levels of analysis for the major categories and subcategories. This study was conducted for comparative and exploratory purposes using a uniform rubric across each of the local DMPs.

Table 8: Description of scoring process for Quality/Detail of Plan (Level 3 analysis)

Quality/Detail of Plan -Score	**Description**
0	Absence of key element
1	Element is identified with very little description; lacks detail
2	Clearly identified element, vague/minimal detail provided
3	Additional details, specific examples, and some level of analysis provided but with gaps/limitations
4	Element is described in detail; examples and analysis are of higher quality but retains some ambiguity
5	Element is thoroughly described in great detail; very high quality description and the element is well-explained and supported

Table 9: Example of results of analysis for the first major category (DPF) showing Level 1,2, and 3 scores

Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	5
Definition of the service area		1	4
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**9**

Chapter 4: Results and Discussion

Each of the cities in the Western U.S. have a DMP in place, compared to the two cities from Mississippi included in this study (Jackson and Oxford) that do not have plans. A map of the location of these two cities is presented in Figure 6. Jackson and Oxford, MS received a zero for each level of analysis. Scores for each of the western and southeastern plans are provided in Appendix C and D respectively.

Scores for each level of analysis were computed based on the methods presented in the previous section. Table 10-12 show the average scores for Levels 1, 2, and 3 for each major category. The first level of analysis scored the presence of seven major categories within the DMP. The average score for Level 1 was 7 for the West and 4.8 for the Southeast (Figure 7). All the western plans included information for at least one component within each of the major categories. Nine of the 11 southeastern plans did not include any information for the pre-drought framework; the two plans with this information were Columbus and Macon, GA. Four southeastern plans also did not include any information for the components within the post-drought framework. The Hunstville, AL DMP did not include 3 of the 7 major categories (social pillar, pre-drought framework, and post-drought framework).

Level 2 analysis scored the presence or absence of each of the subcategories. The average score for Level 2 analysis was 23.9 for the West and 11.9 for the Southeast (Figure 8). The Sacramento, CA DMP received the highest score of 27 and in the Southeast, Columbus, GA received the highest score of 20. The lowest score among the western plans was 19 (Glendale, AZ) compared to the southeastern lowest score of 8 (Hunstville, AL). The western plans were

missing pre-drought and post-drought components on average. The southeastern plans lacked components among the environmental pillar, pre-drought, and post-drought framework.

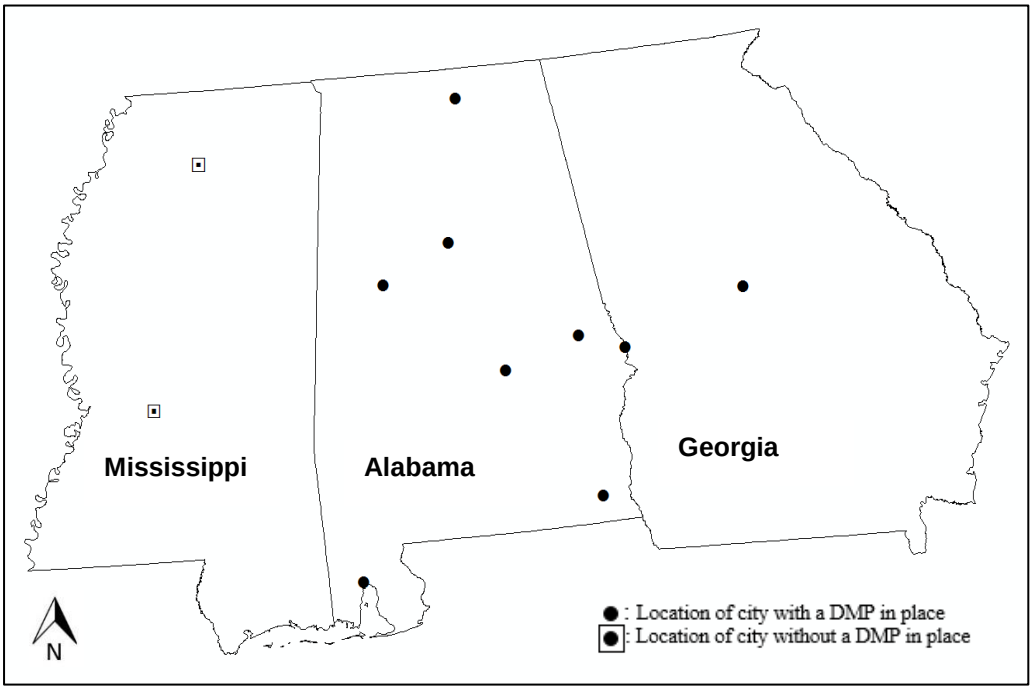

Figure 6: Presence of cities in the Southeast with a DMP in place. The two cities without a DMP are Jackson and Oxford, MS.

Table 10: Average scores for Level 1 Analysis (No=0, Yes=1) for the plans of major cities in the Western and Southeastern U.S. The maximum score for Level 1 analysis is 7.

	Major Category	Average Score for Level 1	
		Western U.S.	Southeastern U.S.
1	Drought Plan Framework	1	0.82
2	Social Pillar	1	0.73
3	Economic Pillar	1	0.82
4	Environmental Pillar	1	0.82
5	Pre-Drought Framework	1	0.18
6	During-Drought Framework	1	0.82
7	Post-Drought Framework	1	0.64
	Total	7	4.8

Table 11: Average total scores for Level 2 Analysis (No=0, Yes=1) for the drought plans of major cities in the Western and Southeastern U.S. The maximum score for Level 2 analysis is 28.

	Major Category (Range of possible scores)	Maximum score possible	Average Score for Level 2	
			Western U.S.	Southeastern U.S.
1	Drought Plan Framework (0-3)	3	2.27	1.64
2	Social Pillar (0-4)	4	3.27	1.64
3	Economic Pillar (0-3)	3	2.64	1.45
4	Environmental Pillar (0-5)	5	5	2.27
5	Pre-Drought Framework (0-4)	4	2.73	0.36
6	During-Drought Framework (0-5)	5	4.64	3.55
7	Post-Drought Framework (0-4)	4	3.36	1.00
	Total	28	23.9	11.9

Table 12: Average total scores for Level 3 Analysis (Comprehensive Score) for the drought plans of major cities in the Western and Southeastern U.S. The maximum score for Level 3 analysis is 140.

	Major Category (Range of possible scores)	Maximum score possible	Average Score for Level 3	
			Western U.S.	Southeastern U.S.
1	Drought Plan Framework (0-15)	15	8.91	4.45
2	Social Pillar (0-20)	20	13.00	3.55
3	Economic Pillar (0-15)	15	9.91	3.09
4	Environmental Pillar (0-25)	25	20.82	5.82
5	Pre-Drought Framework (0-20)	20	7.64	0.82
6	During-Drought Framework (0-25)	25	17.09	9.00
7	Post-Drought Framework (0-20)	20	10.27	1.45
	Total	140	87.64	28.2

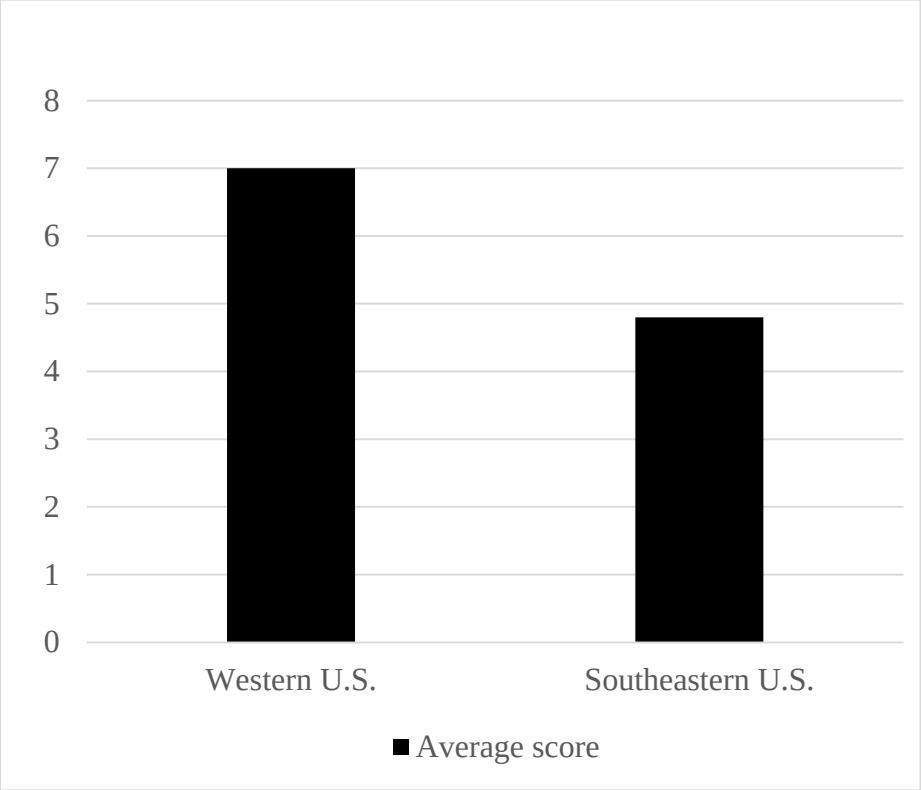

Figure 7: Average score for Level 1 analysis

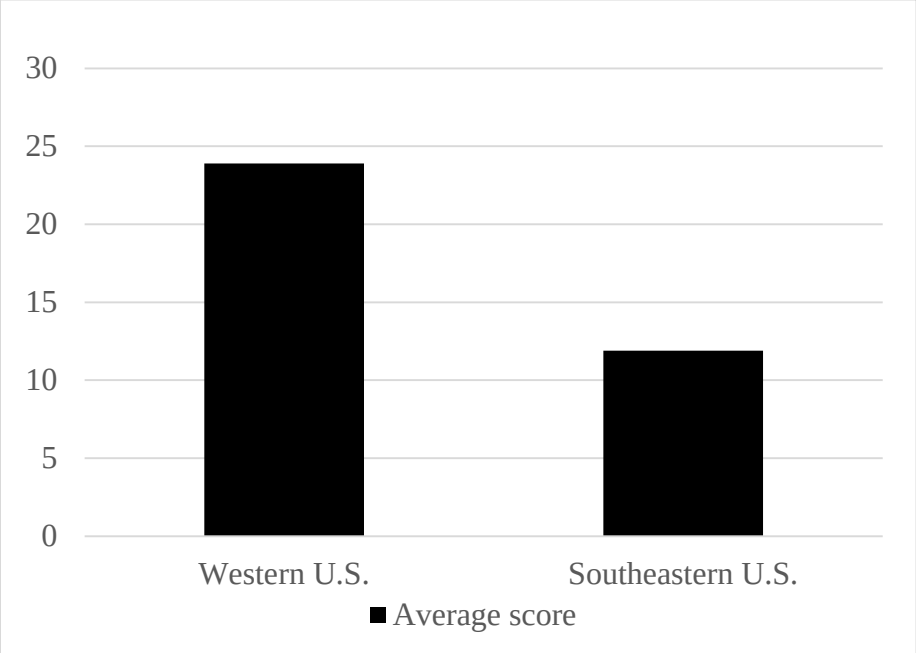

Figure 8: Average score for Level 2 analysis

The third level of analysis scored the level of detail and comprehensiveness for each subcategory. The average score for Level 3 analysis was 87.64 for the West and 28.2 for the Southeast. Sacramento, CA received the highest score of 110 compared to 55 in Columbus, GA. In the Western U.S., Glendale, AZ received the lowest score of 60 compared to Hunstville, AL whose plan scored an overall comprehensive score of 15. Very few plans from either region included information on early drought warning systems and the majority of southeastern plans did not include conservation actions during non-drought periods (pre-drought framework components).

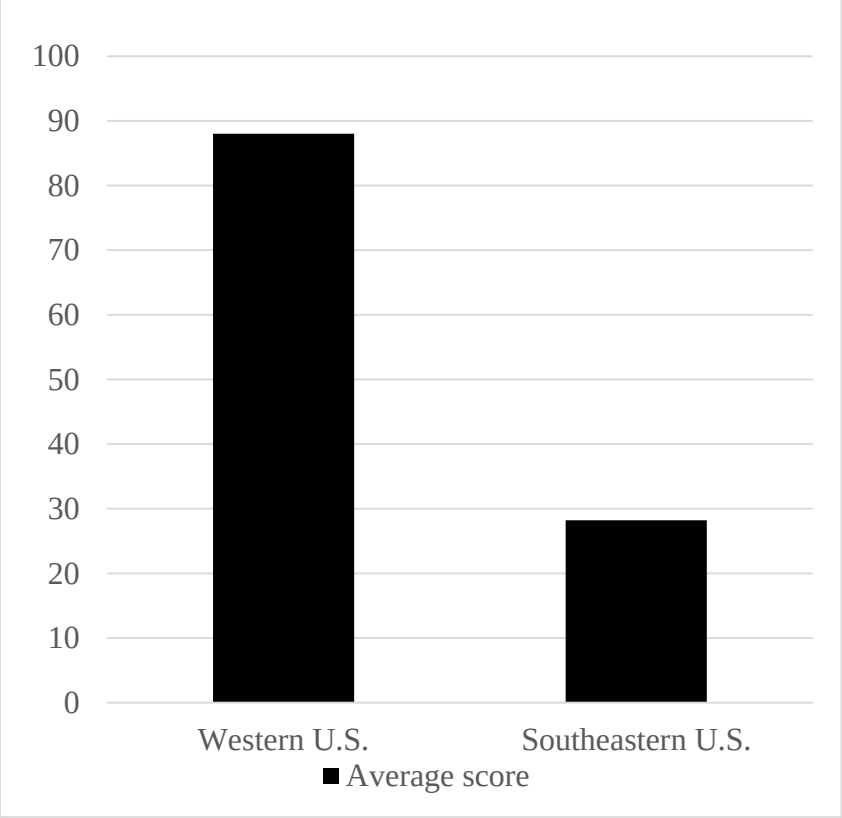

Figure 9: Average score for Level 3 analysis

As part of the social pillar, none of the southeastern DMPs require a public review component or public participation in the editing and initial draft stages of the drought policy. This is in contrast to the western plans, which were to be circulated in public buildings and offices for review and the opportunity to provide comments, and several hearings and town halls were held in each of the cities during the drafting phases. Additionally, all of the western plans were accessible online while none of the southeastern plans were available for download. The total scores for each level of analysis for the western and southeastern plans are presented in Appendix B.

The western plans each included a chapter on population and demographics with current and projected figures; these sections included historical data and growth trends in order to predict future supply requirements and demand. The description also included a breakdown of commercial, institutional, and residential customers. The plans additionally detail the involvement of major stakeholders and their respective responsibilities, including water conservation advisory groups, universities, and non-profit organizations. The Birmingham, AL DMP was the only southeastern plan to include this information. Major stakeholders that would likely be impacted by water shortages are listed in Table 13.

A common problem with establishing effective drought policy is the lack of strict enforcement of restrictions, which is a notable shortcoming of many of the southeastern plans. The more robust plans (e.g., Antioch, CA, Roseville, CA, and Santa Barbara, CA) require service discontinuation if over-consumption continues after several warnings, helping to ensure that the conservation measures are followed particularly during times of water scarcity. Previous work by Moore et al. (2014) and Pahl-Wostl et al. (2008) suggest that even with a highly comprehensive

plan in place, the lack of clear enforcement and regulation would likely hinder sustainable water use and conservation strategies.

Table 13: Stakeholders involved in a city impacted by water shortages (Benotti et al. 2010, Centers for Disease Control and Prevention 2017, Gazzar 2017, Office of Cyber and Infrastructure Analysis 2015)

Industry	Water use purposes
Hospital/medical services	Cleaning of surgical tools, devices, and surfaces, patient care and hygiene
Emergency public services/firefighting	Lack of water storage for putting out fires; not enough water available to pump from hydrants
Schools and community centers	Drinking water, cooking, and cleaning purposes
Community parks and recreation	Landscape, sports fields, pools, green space upkeep and drinking water fountains
Restaurants and food services	Cooking, sanitizing, and washing
Solid waste and wastewater systems	Decreasing flows for faucets, toilets, and showers, source water impacts, wastewater treatment technologies
Transportation systems	Closure of roadways, railways, and waterways due to extreme heat and deteriorating asphalt
Manufacturing, communication systems, and industry	Production, equipment cooling and ventilating
Food products and brewing industry	Food production, development, and beer production and distribution

The Sacramento, CA DMP received a top score for the clear establishment of an enforcement agency (subcategory of the economic pillar), and the extensive description of penalties, charges, and enforcement for any person that violates the water conservation measures

(subcategory of the during-drought framework). The western plans all specify that the penalty charges be used to fund the city water conservation programs. The findings of this study confirm previous research by Wilhite et al. (2007, 2014) that suggests among the key components of ensuring ample future water supplies is a drought early warning system and clear enforcement of water restrictions.

A study by Ozan et al. (2013) revealed that residents were less likely to decrease water use and disregard public watering ordinances altogether if there is no enforcement of the regulation or if the fee is minimal. Restrictions are likely only effective given the degree of enforcement mechanism (Ozan et al. 2013). It appears that when the public perceives the reality of a water shortage, coupled with high costs of violating water conservation regulations, this is more likely to lead to less water usage.

Voluntary restrictions were found to yield minimal water consumption decreases compared to mandatory restrictions (Kenney et al. 2004). Many cities in California and Arizona have designated staff members ("water cops") responsible for enforcing water restrictions, even during periods of non-drought (Sisser et al. 2016). Examples of water conservation restrictions are listed in Table 14. For violating these regulations, customers are often first issued a written notice, followed by increasing penalty charges, and in extreme situations (especially during a water shortage), the final violation may result in termination of water service. Several examples of these enforcement mechanisms and penalty costs are listed in Table 15.

As dry conditions and aridification become the "new normal" in the Western U.S., the Southeast continues to see fluctuating periods of drought followed by rainfall. This can perhaps explain the large differences between the scores of the Western U.S. to the Southeast. California experienced nearly 16 years of water shortages and drought conditions, which may have

motivated research and funding into drought forecasting, drought management plans, and short and long-term mitigation strategies (Folger 2017). The problem in the Southeast, however, is that current policies do not appear to reflect the persistence and consequences from the droughts that do arise. The lack of baseline data in the majority of the southeastern plans reflect that very little monitoring is taking place to track the change in water levels and usage.

With the exception of Macon, GA, the plans of the Southeast also lack early drought warning systems. Developing data networks that quickly provide climate data to assist in water system monitoring and collaborating with the state climatologist are two opportunities to proactively monitor and prepare for water shortage conditions before a drought occurs. Implementing sustainable water policy is a complex process, exacerbated during unpredictable weather patterns and periods of water shortages (Botterill et al. 2013).

Developing a comprehensive DMP is a time-consuming process that involves both physical and theoretical components across the pillars of sustainability and various timeframes (before, during, and after a drought crisis). Varying political beliefs and agendas, competing interests, and the multitude of invested organizations further complicate the process (Wilhite et al. 2000). However, a proactive approach to reduce drought impact is to create a plan before a crisis occurs (Wilhite et al. 2000).

Previous research indicates that communities who have experienced severe droughts are more likely to be concerned with future droughts (Dunn 2005). These studies suggest that more comprehensive drought plans and water policies seem to be developed in places that have suffered from severe droughts and water shortages. Therefore, areas that have yet to be significantly impacted, such as the Southeast, can benefit from the experience of these other communities and create comprehensive policy before an emergency.

Table 14: Examples of water conservation restrictions

City	Water use restriction
Auburn, AL	During declared water shortage, lawn irrigation limited to the hours of 8 p.m. – 8 a.m.
Birmingham, AL	Surcharge applied to water bills for customers who used excess water during a shortage
Cape Town, South Africa	Online map showing color-coded dots of major water wasters
Macon, GA	During declared water shortage, landscape watering may only occur two days a week between 4 p.m. and 10 a.m.; even-numbered addresses may water on Wednesday and Saturday, odd-numbered addresses may water on Thursday and Sunday
	Prohibit washing of hard surfaces (streets, gutters, sidewalks, driveways)
	Prohibit washing of vehicles
	Prohibit use of water for ornamental purposes (e.g., fountains and waterfalls)
Sacramento, CA	Irrigation restrictions to specific days; no outdoor watering on Monday, even-numbered addresses may water on Wednesday, Friday, and Sunday, odd-numbered addresses may water on Tuesday, Thursday, and Saturday
	During severe water shortages, all landscape irrigation prohibited
	Prohibited use of automatic sprinklers
	During severe shortages, restaurants permitted to only serve water upon request
	Hotels required to ask guests to skip daily laundering of towels and linens
Santa Barbara, CA	Any leakage or use causing excess runoff is subject to penalties if not repaired
	Watering landscapes within 48 hours of one-fourth of an inch or more of rainfall

Table 15: Examples of penalties for violating water use restrictions

City DMP	First Violation	Second Violation	Third Violation	Fourth and Subsequent Violations
Antioch, CA	Written notice	Penalty charge of $100	Penalty charge of $200	Penalty charge of $500
Azusa, CA	Penalty charge of $50	Penalty charge of $100	Penalty charge of $200	Penalty charge of $200 and flow-restrictor at customer's expense, potential termination of service
Napa, CA	Written notice	Penalty charge of $100	Penalty charge of $200	Penalty charge of $500
Sacramento, CA	Written notice	Penalty charge of $25 (May also attend a water conservation seminar)	Penalty charge of $100 (doubled during a water shortage)	Penalty charge of $500 (doubled during a water shortage)
Santa Barbara, CA	Written notice	Penalty charge of up to $250	Penalty charge of up to $250, possible installation of flow restrictor	Penalty charge of $250, possible installation of flow restrictor, possible termination of service
Tucson, AZ	Written notice	$250-$1000 depending on Court review of violation	$250-$1000 depending on Court review of violation	Potential termination of service

Given the variability in water supply and the periodic water shortage conditions, traditional water use and management approaches are no longer sustainable practices (Wilhite et al. 2000, Wilhite et al. 2011). It is imperative to understand the social and behavioral aspect to make positive change, rather than focus on the physical aspect of water supply and factors that limit its availability. A comprehensive drought management plan should therefore include the social, environmental, and physical aspects in order to address the underlying mechanisms that

promote change, even if these changes are not the most restrictive or extreme (Wilhite et al. 2014, Watanabe et al. 2017). The language used should be understood by the public, incorporate clear regulation, and be supported by centralized entities (Sivakumar et al. 2014).

It appears to be difficult to motivate interest groups, local government employees, political and environmental organizations due to the large number of involved parties, especially without the physical pressure of a drought crisis (Wilhite et al. 2000, Hayes et al. 2004). Previous studies by Glennon (2009) and Fishman (2011) state that major droughts generally lead to significant improvements in drought policy; however, the Southeastern U.S. so far does not appear to have made the necessary advancements to prepare for future droughts. The current study corroborates previous research that attest to the vulnerability of this region to future water shortages, which can be mitigated by implementing a comprehensive DMP to increase the level of preparedness for drought and ultimately help reduce potential impacts.

Chapter 5: Summary and Conclusions

Drought management plans for urban areas are important in order to proactively plan for water shortages and minimize the potential impacts of drought. A universal framework of what makes a comprehensive plan is imperative to ensure sufficient water resources in the future. This study used DMPs from the Western U.S., where droughts have historically been of greater concern, to evaluate the plans of the Southeast. The western plans were reviewed to design a scorecard that included major sustainability topics which was ultimately used to evaluate the DMPs of major cities in the Western and Southeastern U.S. Previous research has identified several key elements of a successful plan, but few studies have evaluated the state of drought management plans for urban areas to document the comprehensive framework of these plans. The purpose of this study was to evaluate the state of DMPs of major cities in the Southeast to identify the plans' comprehensive nature and provide a framework for cities to create or develop a new plan.

The scorecard used to evaluate each plan incorporates seven major categories: a drought plan overview, sustainable policy pillars (social, economic, and environmental pillars), and periods of drought management (before, during, and after drought actions). Overall scores for each city were determined based on analyzing the seven major categories (Level 1), 28 subcategories (Level 2), and overall level of detail (Level 3). Common characteristics from top plans were identified to serve as an example for cities developing drought management policies.

The Western plans scored higher in all three levels of analysis. They were scored 7, 23.9 and 87.64 for Levels 1, 2, and 3 respectively. The plans of the Southeastern U.S. scored 4.8, 11.9

and 28.2 for Levels 1, 2, and 3 respectively. The DMPs of the Western U.S. involved stakeholders and public review to develop and maximize the effectiveness of the plan and included drought mitigation strategies before and after a drought crisis. The Southeast appears to be less organized in terms of unifying the stakeholders, enforcement entities, and various levels of government. These plans also lack detailed subcategories particularly within the pre-drought and post-drought frameworks.

DMPs of both regions did not include extensive information pertaining to early warning systems of drought. The results of this study contribute to sustainable water policy research by compiling key elements from comprehensive drought plans to assess and improve DMPs of major cities in the Southeastern U.S. The resulting framework and recommendations additionally highlight areas for improvement of plans in this region. These results were also used to address five major questions.

1. Does the selected city have a DMP in place?

All the cities in Alabama and Georgia have a DMP in place. Mississippi does not have any regulation in place requiring cities to have a DMP; of the 22 selected cities, Jackson and Oxford were the only two without any drought contingency policies. The major recommendation of this study is for states to require DMPs with specific requirements of components, and an enforced penalty if the plans are not complete.

2. Does the DMP include the key components of sustainable policy (social, economic, and environmental pillars)?

All of the western plans included information for each of the sustainability pillars, and six of the 11 included information for all of the subcategories for each of the pillars. Macon, GA was

the only southeastern plan, out of 11, to include all categories for the key components of sustainable policy, but this city failed to include information for each of the subcategories. The western plans scored particularly strongly in the presence of subcategories of sustainable policy (Level 2). The average Level 2 score for the social, economic, and environmental pillars for the western plans is 3.64 and for the southeastern plans is 1.79. The average Level 3 score for these three pillars for the western plans is 13.97 and for the southeastern plans is 4.15.

3. Does the DMP include pre-drought, during, and post-drought conservation strategies and implementable actions?

All the western plans included information for pre-drought, during, and post-drought conservation strategies and implementable actions compared to only 1 of 11 southeastern plans that included information for each of the three drought frameworks. Macon, GA was the only plan to include pre-drought, during-drought, and post-drought conservation strategies. Overall, the southeastern plans scored particularly low among the presence of subcategories in pre-drought and post-drought frameworks. The average Level 2 score for the pre-drought, during, and post-drought frameworks for the western plans is 3.57 and for the southeastern plans is 1.64. The average Level 3 score for these three frameworks for the western plans is 11.77 and for the southeastern plans is 3.76.

4. Does the DMP identify an enforcement strategy for regulating restrictions during drought, and are there goals identified to mitigate the effects of future droughts?

Each of the western plans included significantly more comprehensive enforcement strategies and regulations for restricting residential and commercial water-use during periods of water shortages. Several additionally included detailed information regarding regulation and restrictions during non-droughts which is a highly sustainable practice to mitigating the effects of

future droughts. Most of the southeastern plans included enforcement strategies for regulating restrictions; however, they could be more restrictive (especially during non-drought periods) to ensure future water availability. Unlike the western plans, none of the southeastern plans identified projected water use data in order to establish goals to decrease water use.

5. How do DMPs differ in their level of preparedness in the Southeast compared to the Western United States?

Level 3 scores revealed very low overall levels of detail for each of the subcategories in the southeastern plans (averaging 28.2 out of 140). While most cities evaluated in this study include several of the key components of sustainable water policy, very few include detailed actions across all the pillars and frameworks. The plans of the Western U.S. were far more accessible and comprehensive compared to the southeast; allowing the public to review and become familiar with the policies, especially during non-emergency periods, increases the level of preparedness and reduces confusion once a crisis occurs. The southeastern plans included documents and information compiled by either the city or public water entity with seemingly no collaboration between the two. This appeared to result in confusion of policies, enforcement, and the lack of uniformity in information presented to the public.

Recommendations for Future Research

Following the major drought that struck the southeast in 2012, the Alliance for Water Efficiency published "The Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies". Alabama and Mississippi received the lowest score for state water policies (2 out of a possible 40), tied with several other states. Georgia received a score of 18.5 (Alliance for Water Efficiency 2012). Each of the Alabama DMPs evaluated in this study meet

the basic requirements for the Alabama Drought Planning and Response Act (2014); however, this study indicates that the requirements established by the state are not robust enough to adequately plan for long-term sustainability. Georgia and Mississippi should consider implementing similar legislation requiring each city to develop a comprehensive DMP using the proposed framework in this study as a guide for the necessary components.

Previous research identified the importance of stakeholder involvement, though few studies have focused on the collaboration between scientists, policy-makers, and the public, particularly in the Southeastern U.S. The framework developed in this study could be expanded to include categories relevant to small or large cities (e.g., potential for water conflict or intergovernmental participation). Additional analysis could be conducted to determine the effectiveness of each major category and subcategory. Ongoing research is necessary to understand and assess the effectiveness of the critical elements of sustainable policy.

The findings in this study will help cities to evaluate changes to existing plans and cities interested in developing a new plan and the framework should be used to evaluate the comprehensiveness of DMPs of additional cities to provide further recommendations and specific details that should be included in local water policy. The matrix developed in this study should be used to evaluate the comprehensiveness of DMPs of additional cities to provide further recommendations and specific details that should be included in local water policy.

The Southeastern U.S. has not yet witnessed the same levels of drought and water scarcity as other regions in the country; therefore, we are at a pivotal time to revise and implement comprehensive DMPs to preclude irreparable damage to freshwater supplies. The findings will help cities to evaluate changes to existing plans and cities interested in developing a

new plan. Developing a universal framework of what makes successful drought policy is imperative to ensuring sufficient water resources in the future.

Without adequate management and proactive planning, drought impacts are likely to become longer lasting and more severe. Each water system has varying degrees of vulnerability to drought and water scarcity, yet they would all benefit from taking proactive measures to diminish the severity of potential impacts. Each city in the Southeast has a unique opportunity to improve water conservation policies due to its historical abundancy of water and can look to other regions and cities that received higher scores as strong examples. The resulting framework of recommendations for effective local management of water resources provides this opportunity to improve the resiliency of communities to depleting freshwater supplies and proactively mitigate drought impacts before a crisis occurs.

Literature Cited

Aither, 2018. A Guide to Managing Water for the Environment (a framing paper for the High Level Panel on Water). Australian Water Partnership, Canberra.

Alliance for Water Efficiency, 2012. The Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies. http://www.allianceforwaterefficiency.org/finalscorecard.aspx

Anand, S. and A. Sen. 2000. Human Development and Economic Sustainability. *World Development.* 28(12): 2029-2049.

Atkins, J.B., M.J. Harper, D.D. Johnston, and T.M. Littlepage. 2017. An Assessment of the Surface Water Resources of Alabama. Alabama Office of Water Resources. http://adeca.alabama.gov/Divisions/owr/watermanagement/2017%20OWR%20Surface%20Water%20Assessment/OWR%20Surface%20Water%20Assessment%20Main%20Report.pdf

Benotti, M.J., B.D. Stanford, S.A Snyder. 2010. Impact of Drought on Wastewater Contaminants in an Urban Water Supply. Journal of Environmental Quality. 39: 1196-1200.

Bigg, M. (21 November, 2007). Water runs dry in rural Tennessee town. Reuters. https://www.reuters.com/article/us-usa-drought-town/water-runs-dry-in-rural-tennesseetownidUSN0934565720071122

Botterill, L.C. and G. Cockfield. 2013. Drought, Risk Management, and Policy: Decision-Making Under Uncertainty. Boca Raton, Florida: CRC Press.

Buytaert, W. and B. De Bievre. 2012. Water for cities: The impact of climate change and demographic growth in the tropical Andes. *Water Resources Research* 48 (8): 1-13.

Campana, P., J. Knox, A. Grundstein, J. Dowd. 2012. The 2007-2009 Drought in Athens, Georgia, United States: A Climatological Analysis and an Assessment of Future Water Availability. *Journal of the American Water Resources Association.* 48(2): 379-390.

Centers for Disease Control and Prevention. 2017. Other Uses of Water: Policy and Recommendations. https://www.cdc.gov/healthywater/other/policy.html

Chang, H. and M.R. Bonnette. 2016. Climate change and water-related ecosystem services: impacts of drought in California, USA. *Ecosystem Health and Sustainability.* 2(12).

Cohen, M. (1 February, 2018). Cape Town Companies Threatened by Water Shortages After Record Drought. Insurance Journal. https://www.insurancejournal.com/news/international/2018/02/01/479213.htm

David, R.B. and G.A. Tobin. 2016. Addressing the Sustainability of Austin, Texas, Water Policy. *Papers in Applied Geography.* 2 (1):

Ding, Y., M.J. Hayes, M. Widhalm. 2010. Measuring Economic Impacts of drought: A Review and Discussion. *Papers in Natural Resources.* 196. Elliott, H. 2017. The Failings of Alabama Water Law. *Alabama Law Review:* 68 (3): 760-792.

Dunn, B., A. Smart, and R. Gates. 2005. Barriers to Successful Drought Management: Why Do Some Ranchers Fail to Take Action? *Rangelands.* 27(2): 13-16.

Feinstein, L., R. Phurisamban, A. Ford, C. Tyler, A. Crawford. 2017. Drought and Equity in California. Pacific Institute, Oakland, CA.

Feldman, D. 2007. *Water Policy for Sustainable Development*. Baltimore, Maryland: The John Hopkins University Press.

The Federal Emergency Management Agency. 2013. *Local Mitigation Planning Handbook.* https://www.fema.gov/media-library-data/20130726-1910-25045-9160/fema_local_mitigation_handbook.pdf

Fernando, D.N., K.C. Mo, R. Fu, B. Pu, A. Bowerman, B.R. Scanlon, R.S. Solis, L. Yin, R.E. Mace, J.R. Mioduszewski, T. Ren, K. Zhang. 2016. What caused the sprin intensification and winter demise of the 2011 drought over Texas? *Climate Dynamics:* 47 (9-11): 3077-3090.

Finch, C. 2012. Conservation and drought management. Texas Water Resources Institute. *txH20.* http://twri.tamu.edu/publications/txh2o/fall-2012/conservation-and-drought management/

Fitzhugh, T.W. and B.D. Richter. 2004. Quenching Urban Thirst: Growing Cities and Their Impacts of Freshwater Ecosystems. *BioScience.* 54(8): 741-754.

Fishman, C. 2011. *The Big Thirst: The Secret Life and Turbulent Future of Water*. New York, New York: Free Press; A Division of Simon & Schuster, Inc.

Folger, P. 2017. Drought in the United States: Causes and Current Understanding. Congressional Research Service 7-5700.

Ford, T. and C.F. Labosier. 2014. Spatial patterns of drought persistence in the Southeastern United States. *International Journal of Climatology* 34: 2229-2240.

Fraser Basin Council. 2011. *Rethinking Our Water Ways: a guide to water and watershed planning for BC communities in the face of climate change and other challenges*. https://www.rethinkingwater.ca/index.html

Fresno Foundation. 2015. Beyond almonds and brown lawns. https://www.centralvalleycf.org/wp-content/uploads/2016/09/CVCF-Drought-Report.pdf

Gavrilles, B. 2010. Southeastern U.S., with exception of Florida, likely to have serious water scarcity issues. ScienceDaily. https://www.sciencedaily.com/releases/2010/12/101213184436.htm

Gazzar, B. (17 December, 2017). How firefighters get their water, and why it's sometimes tricky to get enough. Los Angeles Daily News. https://www.dailynews.com/2017/12/17/how-firefighters-get-their-water-and-why-its-sometimes-tricky-to-get-enough/

Gilligan, J.M., C.A. Wold, S.C. Worland, J.J. Nay, D.J. Hess, G.M. Hornberger. 2018. Urban Water Conservation Policies in the United States. *Earth's Future:* 6 (7): 955-967.

Gleick, P. 2017. Impacts of California's Five Year (2012-2016) Drought on Hydroelectricity Generation. Pacific Institute. Oakland, CA.

Glennon, R. 2009. America's Water Crisis and What to Do About It. *Office of Research and Economic Development-Publications.* 9.

Grobicki, A., F. MacLeod, and F. Pischke. 2015. Integrated policies and practices for flood and drought risk management. *Water Policy.* 17: 180-194.

Harper, M.J. and B.G. Turner. 2010. Estimated Use of Water in Alabama in 2010. Alabama Office of Water Resources. http://adeca.alabama.gov/Divisions/owr/Documents/AL2010Report.pdf

Hayes, M.J., O.V. Wilhelmi, and C.L. Knutson. 2004. Reducing Drought Risk: Bridging Theory and Practice. *Natural Hazards Review.* 5(2).

Hoerling, M., A. Kumar, R. Dole, J.W. Nielsen-Gammon, J. Eischeid, J. Perlwitz, X.W. Quan, T. Zhang, P. Pegion, and M. Chen. 2013. Anatomy of an Extreme Event. *Journal of Climate*: 26: 2811 2832.

IPCC, 2014b. Climate change 2014: Impacts, Adaptation and Vulnerability. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. In: Barros, V.R., C.B. Field, D. Jon Dokken, M.D. Mastrandrea, K.J. Mach (Eds.), Cambridge University Press, Cambridge, UK, and New York, USA.

IWMI, 2007. A Comprehensive Assessment of Water Management in Agriculture, International Water Management Institute.

Jordan, J.L. and A.T. Wolf. Interstate Water Allocation in Alabama, Florida, and Georgia. 2006. University Press of Florida. Gainesville, FL.

Kampragou, E., S. Apostolaki, E. Manoli, J. Froebrich, and D. Assimacopoulos. Towards the harmonization of water-related policies for managing drought risks across the EU. *Environmental Science & Policy.* 14(7): 815-824.

Knuppe, Kathrin and R. Meisnner. 2016. Drivers and barriers towards sustainable water and land management in the Olifants-Doorn water management area, South Africa. *Environmental Development.* 20: 3-14.

Kua, H.W. 2015. A New Integrated Framework for Stakeholder Involvement in Sustainability Policymaking – A Multidisciplinary Approach. *Sustainable Development.* 24(5): 281-297.

Lake Magazine (8 December, 2016). Surviving the drought: Hope and prayer may be the best strategy. http://www.alexcityoutlook.com/2016/12/08/surviving-the-drought-hope-and prayer-may-be-the best-strategy/

Lloyd-Hughes, B. 2014. The impracticality of a universal drought definition. *Theoretical & Applied Climatology.* 117:607-611.

Lurie, J. (3 August, 2015). Here's How Much Water Golf Courses, Ski Resorts, and Pools are Using in California. Mother Jones. https://www.motherjones.com/environment/2015/08/golf-pools-water-drought-california/

Maybank, J. B. Bonsai, K. Jones, R. Lawford, E.G. O'Brien, E.A. Ripley, and E. Wheaton. 1995. Drought as a natural disaster. *Atmosphere-Ocean.* 33 (2): 195-222.

McDonald, R.I., K. Weber, J. Padowski, M. Florke, C. Schneider, P.A. Green, T. Gleeson, S. Eckman, B. Lehner, D. Balk, T. Boucher, G. Grill, M. Montgomery. 2014. Water on an urban plant: Urbanization and the reach of urban water infrastructure. *Global Environmental Change.* 27: 96-105.

MDEQ: Mississippi Department of Environmental Quality. 2019. https://www.mdeq.ms.gov/

Missimer, T.M., P.A. Danser, G. Amy, T. Pankratz. 2014. Water crisis: the metropolitan Atlanta, Georgia, regional water supply conflict. *Water Policy* 16 (4): 669-689.

Moldan, B., S. Janouskova, and T. Hak. 2012. How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators.* 17: 4-13.

Moore, M.L., S. von der Porten, R. Plummer, O. Brandes, and J. Baird. 2014. Water policy reform and innovation: A systematic review. *Environmental Science & Policy.* 38: 263 271.

Mosbergen, D. (28 October, 2016). Alabama's 'Worst Drought in Memory' Is About To Get Even Worse. Huffington Post. https://www.huffingtonpost.com/entry/alabama-drought 2016_us_5812b8fee4b0990edc303fb7

National Drought Mitigation Center. 2016. Types of Drought. https://drought.unl.edu/Education/DroughtIn-depth/TypesofDrought.aspx

NBC News. (1 October, 2007). Parts of Ala., Ga. Curb water use due to drought. http://www.nbcnews.com/id/21079563/ns/weather/t/parts-ala-ga-curb-water-use-due drought/#.W7za9PZRdhE

Office of Cyber and Infrastructure Analysis. Operational Analysis Division. 2015. Drought Impacts to Critical Infrastructure. U.S. Department of Homeland Security.

Padowski, J.C. and S.M. Gorelick. 2014. Global analysis of urban surface water supply vulnerability. *Environmental Research Letters.* 9: 1-8.

Padowski, J.C. and J.W. Jawitz. 2012. Water availability and vulnerability of 225 large cities in the United States. *Water Resources Research.* 48 (12): 1-16.

Pahl-Wostl, C., E. Mostert, and D. Tabara. 2008. The Growing Importance of Social Learning in Water Resources Management and Sustainability Science. *Ecology and Society.* 13(1): 24.

Piechota, T.C., J.A. Dracup. 1996. Drought and regional hydrologic variation in the United States: Associations with the El Nino-Southern Oscillation. *Water Resources Research.* 32 (5): 1359-1373.

Pillion, D. (19 October, 2016). Birmingham Water Works Implements Drought Surcharges for Excess Water Use. https://www.al.com/news/birmingham/index.ssf/2016/10/birmingham_water_works_impeme_1 html

Postel, S. 2005. From the Headwaters to the Sea. *Environment*, 47(10), 8-21.

Quirk, M.B. (10 April, 2015). California's Denim Industry Trying To Get That Distressed Look Without Using Water During Drought. Consumer Reports. (https://consumerist.com/2015/04/10/californias-denim-industry-trying-to-get-that-distressed-look-without-using-water-during-drought/

Richter, B.D., D. Abell, E. Bacha, K. Brauman, S. Calos, A. Cohn, C. Disla, S. Friedlander O'Brien, D. Hodges, S. Kaiser, M. Loughran, C. Mestre, M. Reardon, E. Siegried. 2013. Tapped out: how can cities secure their water future? *Water Policy* 15: 335-363.

Rogers, P. 2018. Drought or no drought: Jerry Brown sets permanent water conservation rules for Californians. *The Mercury News.* 31 May 2018.

Rossi, G., T. Vega, B. Bonaccorso. 2007. Methods and Tools for Drought Analysis and Management (Chapter 16: 325-347). Guides for Planning and Implementing Drought Mitigation Measures. Springer Publishing: Dordrecht, The Netherlands.

Saejis, H.L., Van Berkel, M.J. 1995. Global water crisis: the major issue of the 21st century, a growing and explosive problem. *Eur Water Pollut Control* 5 (4): 26-40.

Schwabe, K.A. and J.D. Connor. 2012. Drought Issues in a Semi-arid and Arid Environments. *Choices.* 27(3).

Seager, R., A. Tzanova, and J. Nakamura. 2009. Drought in the Southeastern United States: Causes, Variability over the Last Millennium, and the Potential for Future Hydroclimate Change. Journal of Climate 22: 5021-5045.

Searle, G. and B. Head. 2011. Urban drought, infrastructure crisis, and governance centralization in Sydney, Melbourne and SE Queensland. *State of Australian Cities Conference (2011).*

Sivakumar, M.V.K., R. Stefanski, M. Bazza, S. Zelaya, D. Wilhite, and A.R. Magalhaes. 2014. High Level Meeting on National Drought Policy: Summary and Major Outcomes. *Weather and Climate Extremes.* 3: 126-132.

Solanes, M. and A. Jouravlev. 2006. Water governance for development and sustainability. *Recursos naturales e infraestructura.* United Nations, June 2006.

Stauffer, C. (31 October, 2014). Brazil's Water Crisis is Crippling Its Economy. Business Insider. https://www.businessinsider.com/r-election-year-water-crisis-taking-a-toll-on-brazils-economy-2014-10

Stein, Ulf, G. Ozerol, J. Troltzsch, R. Landgrebe, A. Szendrenyi, and R. Vidaurre. 2016. Chapter 2: European Drought and Water Scarcity Policies. *Governance for Drought Resilience,* H. Bressers et al. Berlin, Germany.

Sun, G. S.G. McNulty, J.A. Moore Myers, E.C. Cohen. 2008. Impacts of multiple stresses on water demand and supply across the Southeastern United States. *American Water Resources Association.* 44(6): 1441-1457.

Terando, A., A. McKerrow, J.A. Collazo, J. Costanza, C. Belyea, R. Dunn. 2014. *Scientists PredictMassive Urban Growth, Creation of "Megalopolis" in Southeast in Next 45 Years.* USGS. https://www.usgs.gov/news/scientists-predict-massive-urban-growth-creation-megalopolis southeast-next-45-years.

Thornton, K.W., C. Laurin, J. Shortle, A. Fisher, J. Sobrinho, and M. Stewart. 2006. A Framework and Guidelines for Moving Toward Sustainable Water Resources Management. Water Environment Foundation.

U.S. Census Bureau. 2017. Population estimates. https://www.census.gov/quickfacts/fact/table/US/PST045217#PST045217

Wada, Y., L.P.H. Van Beek, N. Wanders, M.F.P. Bierkens. 2013. Human water consumption intensifies hydrological drought worldwide. *Environmental Research Letters.* 8: 1-15.

Walker, W.R., M.S. Hzero, C.J. Haley. 1991. Management of Water Resources for Drought Conditions. Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply (Paper 2375): 147-156.

Watanabe, T., J. Cullmann, C.S. Pathak, M. Turunen, K.Emami, G. Ghinassi, and Y. Siddiqi. 2017. Management of Climatic Extremes with Focus on Floods and Droughts in Agriculture. *Irrigation and Drainage.* 67(1): 29-42.

Welch, C. (5 March, 2018). Why Cape Town is Running Out of Water, and Who's Next. National Geographic. https://news.nationalgeographic.com/2018/02/cape-town-running-out-of-water-drought-taps-shutoff-other-cities/

Wilhite, D.A. and M.H. Glantz. 1985. Understanding the Drought Phenomenon: The Role of Definitions. Water International. 10(3): 111-120.

Wilhite, D.A., M.D. Svoboda, M.J. Hayes. 2007. Understanding the Complex Impacts of Drought A Key to Enhancing Drought Mitigation and Preparedness. Water Resources Management. 21: 763-774.

Wilhite, D.A. 2011. Breaking the Hydro-Illogical Cycle: Progress or Status Quo for Drought Management in the United States. *European Water.* 34: 5-18.

Wilhite, D.A., M.V.K. Sivakumar, R. Pulwarty. 2014. Managing drought risk in a changing climate: The role of national drought policy. Weather and Climate Extremes. 3: 4-13.

Wilhite, D.A., M.V.K. Sivakumar, D.A. Wood. 2000. Early Warning Systems for Drought Preparedness and Drought Management. Proceedings of an Expert Group Meeting held in Lisbon, Portugal, 5-7 September 2000. Geneva, Switzerland: World Meteorological Organization.

Wong, T.H.F. and R.R. Brown. 2009. The water sensitive city: principles for practice. *Water Science and Technology.* 60(3).

Woodham, B. (19 October, 2016). Auburn Water Works Board to consider drought restrictions. Auburn Villager. https://www.auburnvillager.com/news/auburn-water-works-board-to-consider-droughtrestrictions/article_5fffa7cc-9612-11e6-9892-3bdf881b6b89.html

Yigzaw, W. and F. Hossain. 2016. Water sustainability of large cities in the Untied States from the perspectives of population increase, anthropogenic activities, and climate change. *Earth's Future*, 4(12): 603-617.

Appendix A: Major categories and subcategories of drought management plan matrix

List of major categories (7) and subcategories (28) and their respective descriptions. The major categories and subcategories make up the scoring matrix developed for evaluating DMPs of major cities in study.

A1. Drought Plan Framework

A2. Social Pillar

A3. Economic Pillar

A4. Environmental Pillar

A5. Pre-drought Framework

A6. During-drought Framework

A7. Post-drought Framework

A1. Drought Plan Framework

Subcategory (Level 2)	Description
Definition of purpose/goals of the plan	Identify why it is important to have a drought management/water conservation plan in place and what the objectives are of the document
Definition of the service area	Identify the physical area that is subject to the components of the plan
Identify gaps and uncertainties	Identify missing components of the plan and any potential limitations

A2. Social Pillar

Subcategory (Level 2)	Description
Incorporation of public participation, public review component	It is important to note how the community is involved in the planning and review process of the plan (i.e. town hall meetings, working groups, etc.)
Describe population/demographics	How many people are affected by the plan; what is the makeup of the community
Supply and demand assessment	How much water is available and how much water is required for industrial, agricultural, public, and municipal use
Identify key stakeholders	Identify involved institutions, entities, or institutions (i.e. farmers, households, energy companies, fishers, etc.)

A3. Economic Pillar

Subcategory (Level 2)	Description
Conservation pricing for reducing water used	Identify an increase in water prices for over-consumption or a decrease in pricing for reduced water usage
Established enforcement agency	Reliable enforcement of preventative and mitigation measures for non-compliance
Define baseline and targeted use data	Identify water use to determine how much water is used and to adjust reduction goals

A4. Environmental Pillar

Subcategory (Level 2)	Description
Define constraints/pressure on water sources	What are the main pressures and/or constraints to the water supply (i.e. agricultural usage, industries, pollution, etc.)
Establish indicators and thresholds for drought stages	Clearly identify the drought classifications and stages of a drought based on specific indices (dry conditions, alert, emergency, etc.)
Identify use of reclaimed, recycled, or nonpotable water	Options identified to optimize all water supplies
Penalties imposed for violating restrictions	Clearly defined consequences for non-compliance (i.e. surcharges, fines, etc.)
Summary of surface water sources	Identify the surface water sources and what aspects of the community depend on surface water
Summary of ground water sources	Identify the ground water sources and what aspects of the community depend on ground water

A5. Pre-drought framework

Subcategory (Level 2)	Description
Description of historical drought events	Identify how the area has been impacted by droughts in the past; describe if there has been any significant drought events
Define early warning system of drought	Identify the onset of drought conditions; what system is in place for determining drier-than-normal conditions
Conservation actions during non-drought periods	Regulations in place during normal conditions (i.e. water restrictions for car washes, irrigation, etc.)

A6. During-drought framework

Subcategory (Level 2)	Description
Description of public education and outreach	Description of how the public is notified of the drought stage and associated restrictions and/or general best water management practices
Water level monitoring process	Identify how water levels and drought status is monitored
Implementation of residential restrictions	Identify the water restrictions associated with residential purposes (i.e. landscape irrigation)
Implementation of commercial restrictions	Identify the water restrictions associated with commercial purposes (i.e. landscape irrigation, vehicle washing, etc.)

A7. Post-drought framework

Subcategory (Level 2)	Description
Identify future water sources	Description of alternative water sources given the diminishment of the current supply
Identified projected water use	Identify the estimated amount of water that will be demanded given changes in population, climate, land use, etc.
Post-drought assessment of impacts	Describe the assessment process for analyzing post-drought impacts (find, recognize and describe future risks and severity of future droughts)
Evaluation and update of the drought/water plan	Identify system to evaluate and update the drought management/water conservation plan in a timely manner to ensure that the information is up-to-date

Appendix B: Condensed display of scores for Levels 1, 2, and 3

Condensed display of scores for Levels 1, 2, and 3 of analysis from the DMPs for cities included in study. The seven major categories evaluated in this study: Drought Plan Framework (DPF); Social Pillar (SP); Economic Pillar (EcP); Environmental Pillar (EnP); Pre-drought Framework (Pre-DF); During-drought Framework (DDF); Post-drought Framework (Post-DF). See Table 6 for a description of each major category.

B1. Scores of Western U.S.

B2. Scores of Southeastern U.S.

B1. Scores of Western U.S.

	Anaheim			Antioch			Azusa			Glendale			Napa			Roseville		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
DPF	1	2	9	1	2	10	1	2	8	1	2	7	1	2	8	1	2	9
SP	1	4	13	1	4	18	1	4	16	1	2	6	1	2	11	1	4	20
EcP	1	3	9	1	3	11	1	3	12	1	2	6	1	3	10	1	3	12
EnP	1	5	23	1	5	22	1	5	24	1	5	15	1	5	23	1	5	21
Pre-DF	1	2	5	1	2	6	1	4	14	1	2	7	1	3	8	1	3	10
DDF	1	4	14	1	5	17	1	4	19	1	4	16	1	5	17	1	5	20
Post-DF	1	3	11	1	3	10	1	4	13	1	2	3	1	3	11	1	4	13
Total	**7**	**23**	**84**	**7**	**24**	**94**	**7**	**26**	**106**	**7**	**19**	**60**	**7**	**23**	**88**	**7**	**26**	**105**

	Sacramento			Santa Barbara			Scottsdale			Tucson			Tulare		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
DPF	1	3	13	1	2	9	1	3	8	1	3	9	1	2	8
SP	1	4	18	1	4	13	1	2	6	1	2	6	1	4	16
EcP	1	3	16	1	1	7	1	3	10	1	2	6	1	3	10
EnP	1	5	24	1	5	23	1	5	18	1	5	19	1	5	17
Pre-DF	1	3	9	1	3	7	1	3	8	1	2	4	1	3	6
DDF	1	5	20	1	5	16	1	5	18	1	5	17	1	4	14
Post-DF	1	4	10	1	4	14	1	3	8	1	4	11	1	3	9
Total	**7**	**27**	**110**	**7**	**24**	**89**	**7**	**24**	**76**	**7**	**23**	**72**	**7**	**24**	**80**

B2. Scores of Southeastern U.S.

	Auburn			Birmingham			Columbus			Dothan			Huntsville			Jackson		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
DPF	1	2	6	1	2	6	1	2	7	1	2	6	1	2	3	0	0	0
SP	1	2	4	1	4	8	1	2	7	1	3	5	0	0	0	0	0	0
EcP	1	1	3	1	2	4	1	3	8	1	3	6	1	1	2	0	0	0
EnP	1	3	7	1	2	7	1	4	9	1	2	6	1	1	2	0	0	0
Pre-DF	0	0	0	0	0	0	1	2	6	0	0	0	0	0	0	0	0	0
DDF	1	5	11	1	4	11	1	5	14	1	4	12	1	4	8	0	0	0
Post-DF	1	1	1	1	2	3	1	2	4	1	1	2	0	0	0	0	0	0
Total	**6**	**14**	**32**	**6**	**16**	**39**	**7**	**20**	**55**	**6**	**15**	**37**	**4**	**8**	**15**	**0**	**0**	**0**

	Macon			Mobile			Montgomery			Oxford			Tuscaloosa		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
DPF	1	2	4	1	2	6	1	2	5	0	0	0	1	2	6
SP	1	1	2	1	2	5	1	2	4	0	0	0	1	2	4
EcP	1	2	4	1	1	2	1	1	3	0	0	0	1	2	2
EnP	1	4	11	1	4	9	1	3	7	0	0	0	1	2	6
Pre-DF	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0
DDF	1	2	7	1	5	11	1	5	13	0	0	0	1	5	12
Post-DF	0	0	0	1	1	1	1	2	3	0	0	0	1	2	2
Total	**6**	**13**	**31**	**6**	**15**	**34**	**6**	**15**	**35**	**0**	**0**	**0**	**6**	**15**	**32**

Appendix C: Scores of Selected Western Drought Management Plans

The final scoring results for Levels 1, 2, and 3 of analysis for DMPs of major cities in the Western U.S. See Figure 4 for a map of city locations.

C1: Anaheim, CA

C2: Antioch, CA

C3: Azusa, CA

C4: Glendale, AZ

C5: Napa, CA

C6: Roseville, CA

C7: Sacramento, CA

C8: Santa Barbara, CA

C9: Scottsdale, AZ

C10: Tulare, CA

C11: Tucson, AZ

C1. Anaheim, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	5
Definition of the service area		1	4
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**9**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	3
Describe population/demographics		1	5
Supply and demand assessment		1	5
Identify key stakeholders		1	3
TOTAL	**1**	**4**	**13**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	2
Established enforcement agency		1	3
Define baseline and targeted water use data		1	4
TOTAL	**1**	**3**	**9**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	4
Establish indicators and thresholds for drought stages		1	4
Identify use of reclaimed, recycled, or non-potable water		1	5
Summary of surface water sources		1	5
Summary of ground water sources		1	5
TOTAL	**1**	**5**	**23**
5. Pre-drought Framework	1		
Description of historical drought events		1	1
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	4
Penalties imposed for violating restrictions		0	0
TOTAL	**1**	**2**	**5**
6. During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		0	0
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**4**	**14**
7. Post-drought Framework	1		
Identify future water sources		1	4
Identify projected water use		1	4
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**3**	**11**
Total Overall Score	**7**	**23**	**84**

C2. Antioch, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	5
Definition of the service area		1	5
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**10**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	5
Describe population/demographics		1	5
Supply and demand assessment		1	5
Identify key stakeholders		1	3
TOTAL	**1**	**4**	**18**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	3
Define baseline and targeted water use data		1	5
TOTAL	**1**	**3**	**11**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	4
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	5
Summary of surface water sources		1	5
Summary of ground water sources		1	3
TOTAL	**1**	**5**	**22**
5. Pre-drought Framework	1		
Description of historical drought events		1	3
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		0	0
TOTAL	**1**	**2**	**6**
6. During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		1	2
Implementation of residential restrictions		1	4
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**5**	**17**
7. Post-drought Framework	1		
Identify future water sources		1	3
Identify projected water use		1	4
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**3**	**10**
Total Overall Score	**7**	**24**	**94**

C3. Azusa, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	4
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**8**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	3
Describe population/demographics		1	5
Supply and demand assessment		1	5
Identify key stakeholders		1	3
TOTAL	**1**	**4**	**16**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	4
Define baseline and targeted water use data		1	5
TOTAL	**1**	**3**	**12**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	4
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	5
Summary of surface water sources		1	5
Summary of ground water sources		1	5
TOTAL	**1**	**5**	**24**
5. Pre-drought Framework	1		
Description of historical drought events		1	5
Define early warning system of drought		1	1
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		1	5
TOTAL	**1**	**4**	**14**
6. During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		1	4
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**4**	**19**
7. Post-drought Framework	1		
Identify future water sources		1	3
Identify projected water use		1	4
Post-drought assessment of impacts		1	3
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**4**	**13**
Total Overall Score	**7**	**26**	**106**

C4. Glendale, AZ Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	3
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**7**
Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		0	0
Supply and demand assessment		1	3
Identify key stakeholders		1	3
TOTAL	**1**	**2**	**6**
Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	3
Define baseline and targeted water use data		0	0
TOTAL	**1**	**2**	**6**
Environmental Pillar	1		
Define constraints/pressure on water sources		1	1
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	3
Summary of surface water sources		1	3
Summary of ground water sources		1	3
TOTAL	**1**	**5**	**15**
Pre-drought Framework	1		
Description of historical drought events		0	0
Define early warning system of drought		1	2
Conservation actions during non-drought periods		1	5
Penalties imposed for violating restrictions		0	0
TOTAL	**1**	**2**	**7**
During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		0	0
Implementation of residential restrictions		1	4
Implementation of commercial restrictions		1	4
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**4**	**16**
Post-drought Framework	1		
Identify future water sources		1	2
Identify projected water use		1	1
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**1**	**2**	**3**
Total Overall Score	**7**	**19**	**60**

C5. Napa, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	4
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**8**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	5
Supply and demand assessment		1	5
Identify key stakeholders		0	1
TOTAL	**1**	**2**	**11**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	2
Define baseline and targeted water use data		1	5
TOTAL	**1**	**3**	**10**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	5
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	3
Summary of surface water sources		1	5
Summary of ground water sources		1	5
TOTAL	**1**	**5**	**23**
5. Pre-drought Framework	1		
Description of historical drought events		1	1
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**3**	**8**
6. During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		1	2
Implementation of residential restrictions		1	4
Implementation of commercial restrictions		1	2
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**5**	**17**
7. Post-drought Framework	1		
Identify future water sources		1	3
Identify projected water use		1	5
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**3**	**11**
Total Overall Score	**7**	**23**	**88**

C6. Roseville, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	5
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**9**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	4
Describe population/demographics		1	5
Supply and demand assessment		1	5
Identify key stakeholders		1	4
TOTAL	**1**	**4**	**20**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	5
Define baseline and targeted water use data		1	4
TOTAL	**1**	**3**	**12**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	4
Establish indicators and thresholds for drought stages		1	4
Identify use of reclaimed, recycled, or non-potable water		1	4
Summary of surface water sources		1	5
Summary of ground water sources		1	4
TOTAL	**1**	**5**	**21**
5. Pre-drought Framework	1		
Description of historical drought events		1	3
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	4
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**3**	**10**
6. During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		1	3
Implementation of residential restrictions		1	4
Implementation of commercial restrictions		1	4
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**5**	**20**
7. Post-drought Framework	1		
Identify future water sources		1	4
Identify projected water use		1	4
Post-drought assessment of impacts		1	2
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**4**	**13**
Total Overall Score	**7**	**26**	**105**

C7. Sacramento, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	5
Definition of the service area		1	5
Identify gaps and uncertainties		1	3
TOTAL	**1**	**3**	**13**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	4
Describe population/demographics		1	4
Supply and demand assessment		1	5
Identify key stakeholders		1	5
TOTAL	**1**	**4**	**18**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	4
Established enforcement agency		1	4
Define baseline and targeted water use data		1	5
TOTAL	**1**	**3**	**16**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	4
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	5
Summary of surface water sources		1	5
Summary of ground water sources		1	5
TOTAL	**1**	**5**	**24**
5. Pre-drought Framework	1		
Description of historical drought events		1	3
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**3**	**9**
6. During-drought Framework	1		
Description of public education and outreach		1	5
Water level monitoring process		1	2
Implementation of residential restrictions		1	5
Implementation of commercial restrictions		1	4
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**5**	**20**
7. Post-drought Framework	1		
Identify future water sources		1	2
Identify projected water use		1	3
Post-drought assessment of impacts		1	2
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**4**	**10**
Total Overall Score	**7**	**27**	**110**

C8. Santa Barbara, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	5
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**9**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	3
Describe population/demographics		1	5
Supply and demand assessment		1	5
Identify key stakeholders		1	2
TOTAL	**1**	**4**	**13**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	3
Define baseline and targeted water use data		0	4
TOTAL	**1**	**1**	**7**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	4
Establish indicators and thresholds for drought stages		1	4
Identify use of reclaimed, recycled, or non-potable water		1	5
Summary of surface water sources		1	5
Summary of ground water sources		1	5
TOTAL	**1**	**5**	**23**
5. Pre-drought Framework	1		
Description of historical drought events		1	3
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	2
Penalties imposed for violating restrictions		1	2
TOTAL	**1**	**3**	**7**
6. During-drought Framework	1		
Description of public education and outreach		1	4
Water level monitoring process		1	1
Implementation of residential restrictions		1	5
Implementation of commercial restrictions		1	2
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**5**	**16**
7. Post-drought Framework	1		
Identify future water sources		1	5
Identify projected water use		1	5
Post-drought assessment of impacts		1	1
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**4**	**14**
Total Overall Score	**7**	**24**	**89**

C9. Scottsdale, AZ Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	3
Identify gaps and uncertainties		1	1
TOTAL	**1**	**3**	**8**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		0	0
Supply and demand assessment		1	3
Identify key stakeholders		1	3
TOTAL	**1**	**2**	**6**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	4
Define baseline and targeted water use data		1	3
TOTAL	**1**	**3**	**10**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	2
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	3
Summary of surface water sources		1	4
Summary of ground water sources		1	4
TOTAL	**1**	**5**	**18**
5. Pre-drought Framework	1		
Description of historical drought events		1	3
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		1	2
TOTAL	**1**	**3**	**8**
6. During-drought Framework	1		
Description of public education and outreach		1	3
Water level monitoring process		1	2
Implementation of residential restrictions		1	5
Implementation of commercial restrictions		1	5
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**5**	**18**
7. Post-drought Framework	1		
Identify future water sources		1	1
Identify projected water use		1	4
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**3**	**8**
Total Overall Score	**7**	**24**	**76**

C10. Tulare, CA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	4
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**8**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	3
Describe population/demographics		1	4
Supply and demand assessment		1	4
Identify key stakeholders		1	5
TOTAL	**1**	**4**	**16**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	3
Established enforcement agency		1	3
Define baseline and targeted water use data		1	4
TOTAL	**1**	**3**	**10**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	3
Establish indicators and thresholds for drought stages		1	4
Identify use of reclaimed, recycled, or non-potable water		1	3
Summary of surface water sources		1	3
Summary of ground water sources		1	4
TOTAL	**1**	**5**	**17**
5. Pre-drought Framework	1		
Description of historical drought events		1	2
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	1
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**3**	**6**
6. During-drought Framework	1		
Description of public education and outreach		1	4
Water level monitoring process		0	0
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**4**	**14**
7. Post-drought Framework	1		
Identify future water sources		1	3
Identify projected water use		1	4
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	2
TOTAL	**1**	**3**	**9**
Total Overall Score	**7**	**24**	**80**

C11. Tucson, AZ Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	4
Definition of the service area		1	3
Identify gaps and uncertainties		1	2
TOTAL	**1**	**3**	**9**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	2
Supply and demand assessment		1	4
Identify key stakeholders		0	0
TOTAL	**1**	**2**	**6**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	3
Define baseline and targeted water use data		1	3
TOTAL	**1**	**2**	**6**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	3
Establish indicators and thresholds for drought stages		1	5
Identify use of reclaimed, recycled, or non-potable water		1	3
Summary of surface water sources		1	4
Summary of ground water sources		1	4
TOTAL	**1**	**5**	**19**
5. Pre-drought Framework	1		
Description of historical drought events		1	1
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		0	0
TOTAL	**1**	**2**	**4**
6. During-drought Framework	1		
Description of public education and outreach		1	4
Water level monitoring process		1	1
Implementation of residential restrictions		1	4
Implementation of commercial restrictions		1	4
Penalties imposed for violating restrictions		1	4
TOTAL	**1**	**5**	**17**
7. Post-drought Framework	1		
Identify future water sources		1	3
Identify projected water use		1	3
Post-drought assessment of impacts		1	2
Evaluation and update of the drought/water plan		1	3
TOTAL	**1**	**4**	**11**
Total Overall Score	**7**	**23**	**72**

Appendix D: Scores of Selected Southeastern Drought Management Plans

The final scoring results for Levels 1, 2, and 3 of analysis for DMPs of major cities in the Southeastern U.S. See Figure 5 for a map of city locations.

D1: Auburn, AL

D2: Birmingham, AL

D3: Columbus, GA

D4: Dothan, AL

D5: Huntsville, AL

D6: Jackson, MS

D7: Macon, GA

D8: Mobile, AL

D9: Montgomery, AL

D10: Oxford, MS

D11: Tuscaloosa, AL

D1. Auburn, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	3
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**6**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	1
Supply and demand assessment		1	3
Identify key stakeholders		0	0
TOTAL	**1**	**2**	**4**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	3
Define baseline and targeted water use data		0	0
TOTAL	**1**	**1**	**3**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	3
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		1	2
Summary of ground water sources		1	2
TOTAL	**1**	**3**	**7**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	1		
Description of public education and outreach		1	2
Water level monitoring process		1	2
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	2
Penalties imposed for violating restrictions		1	2
TOTAL	**1**	**5**	**11**
7. Post-drought Framework	1		
Identify future water sources		1	1
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**1**	**1**	**1**
Total Overall Score	**6**	**14**	**32**

D2. Birmingham, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	3
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**6**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	2
Describe population/demographics		1	2
Supply and demand assessment		1	3
Identify key stakeholders		1	1
TOTAL	**1**	**4**	**8**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	3
Define baseline and targeted water use data		1	1
TOTAL	**1**	**2**	**4**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	4
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		1	3
Summary of ground water sources		0	0
TOTAL	**1**	**2**	**7**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	1		
Description of public education and outreach		1	3
Water level monitoring process		0	0
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	2
TOTAL	**1**	**4**	**11**
7. Post-drought Framework	1		
Identify future water sources		1	2
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	1
TOTAL	**1**	**2**	**3**
Total Overall Score	**6**	**16**	**39**

D3. Columbus, GA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	4
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**7**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	4
Supply and demand assessment		1	3
Identify key stakeholders		0	0
TOTAL	**1**	**2**	**7**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	2
Established enforcement agency		1	3
Define baseline and targeted water use data		1	3
TOTAL	**1**	**3**	**8**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	4
Identify use of reclaimed, recycled, or non-potable water		1	1
Summary of surface water sources		1	3
Summary of ground water sources		1	1
TOTAL	**1**	**4**	**9**
5. Pre-drought Framework	1		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**2**	**6**
6. During-drought Framework	1		
Description of public education and outreach		1	4
Water level monitoring process		1	1
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**5**	**14**
7. Post-drought Framework	1		
Identify future water sources		1	2
Identify projected water use		1	2
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**1**	**2**	**4**
Total Overall Score	**7**	**20**	**55**

D4. Dothan, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	3
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**6**
2. Social Pillar	1		
Incorporation of public participation, public review component		1	1
Describe population/demographics		1	2
Supply and demand assessment		1	2
Identify key stakeholders		0	0
TOTAL	**1**	**3**	**5**
3. Economic Pillar	1		
Conservation pricing for reducing water used		1	1
Established enforcement agency		1	4
Define baseline and targeted water use data		1	1
TOTAL	**1**	**3**	**6**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	3
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		0	0
Summary of ground water sources		1	3
TOTAL	**1**	**2**	**6**
5. Pre-drought Framework	1		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**2**	**6**
6. During-drought Framework	1		
Description of public education and outreach		1	3
Water level monitoring process		0	0
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**4**	**12**
7. Post-drought Framework	1		
Identify future water sources		1	2
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**1**	**1**	**2**
Total Overall Score	**6**	**15**	**37**

D5. Huntsville, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	2
Definition of the service area		1	1
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**3**
2. Social Pillar	0		
Incorporation of public participation, public review component		0	0
Describe population/demographics		0	0
Supply and demand assessment		0	0
Identify key stakeholders		0	0
TOTAL	**0**	**0**	**0**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	2
Define baseline and targeted water use data		0	0
TOTAL	**1**	**1**	**2**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	2
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		0	0
Summary of ground water sources		0	0
TOTAL	**1**	**1**	**2**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	1		
Description of public education and outreach		1	1
Water level monitoring process		0	0
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	1
TOTAL	**1**	**4**	**8**
7. Post-drought Framework	0		
Identify future water sources		0	0
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**0**	**0**	**0**
Total Overall Score	**4**	**8**	**15**

D6. Jackson, MS Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	0		
Definition of purpose/goals of the plan		0	0
Definition of the service area		0	0
Identify gaps and uncertainties		0	0
TOTAL	**0**	**0**	**0**
2. Social Pillar	0		
Incorporation of public participation, public review component		0	0
Describe population/demographics		0	0
Supply and demand assessment		0	0
Identify key stakeholders		0	0
TOTAL	**0**	**0**	**0**
3. Economic Pillar	0		
Conservation pricing for reducing water used		0	0
Established enforcement agency		0	0
Define baseline and targeted water use data		0	0
TOTAL	**0**	**0**	**0**
4. Environmental Pillar	0		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		0	0
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		0	0
Summary of ground water sources		0	0
TOTAL	**0**	**0**	**0**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	0		
Description of public education and outreach		0	0
Water level monitoring process		0	0
Implementation of residential restrictions		0	0
Implementation of commercial restrictions		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
7. Post-drought Framework	0		
Identify future water sources		0	0
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**0**	**0**	**0**
Total Overall Score	**0**	**0**	**0**

D7. Macon, GA Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	2
Definition of the service area		1	2
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**4**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		0	0
Supply and demand assessment		1	2
Identify key stakeholders		0	0
TOTAL	**1**	**1**	**2**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	1
Define baseline and targeted water use data		1	3
TOTAL	**1**	**2**	**4**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	2
Establish indicators and thresholds for drought stages		1	3
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		1	3
Summary of ground water sources		1	3
TOTAL	**1**	**4**	**11**
5. Pre-drought Framework	1		
Description of historical drought events		1	2
Define early warning system of drought		1	1
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**1**	**2**	**3**
6. During-drought Framework	1		
Description of public education and outreach		0	0
Water level monitoring process		1	4
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**1**	**2**	**7**
7. Post-drought Framework	0		
Identify future water sources		0	0
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**0**	**0**	**0**
Total Overall Score	**6**	**13**	**31**

D8. Mobile, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	3
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**6**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	2
Supply and demand assessment		1	3
Identify key stakeholders		0	0
TOTAL	**1**	**2**	**5**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	2
Define baseline and targeted water use data		0	0
TOTAL	**1**	**1**	**2**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		1	1
Establish indicators and thresholds for drought stages		1	2
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		1	3
Summary of ground water sources		1	3
TOTAL	**1**	**4**	**9**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	1		
Description of public education and outreach		1	3
Water level monitoring process		1	1
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	1
TOTAL	**1**	**5**	**11**
7. Post-drought Framework	1		
Identify future water sources		0	0
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	1
TOTAL	**1**	**1**	**1**
Total Overall Score	**6**	**15**	**34**

D9. Montgomery, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	2
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**5**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	3
Supply and demand assessment		1	1
Identify key stakeholders		0	0
TOTAL	**1**	**2**	**4**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	3
Define baseline and targeted water use data		0	0
TOTAL	**1**	**1**	**3**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	3
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		1	2
Summary of ground water sources		1	2
TOTAL	**1**	**3**	**7**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	1		
Description of public education and outreach		1	3
Water level monitoring process		1	1
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**5**	**13**
7. Post-drought Framework	1		
Identify future water sources		0	0
Identify projected water use		0	0
Post-drought assessment of impacts		1	1
Evaluation and update of the drought/water plan		1	2
TOTAL	**1**	**2**	**3**
Total Overall Score	**6**	**15**	**35**

D10. Oxford, MS Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	0		
Definition of purpose/goals of the plan		0	0
Definition of the service area		0	0
Identify gaps and uncertainties		0	0
TOTAL	**0**	**0**	**0**
2. Social Pillar	0		
Incorporation of public participation, public review component		0	0
Describe population/demographics		0	0
Supply and demand assessment		0	0
Identify key stakeholders		0	0
TOTAL	**0**	**0**	**0**
3. Economic Pillar	0		
Conservation pricing for reducing water used		0	0
Established enforcement agency		0	0
Define baseline and targeted water use data		0	0
TOTAL	**0**	**0**	**0**
4. Environmental Pillar	0		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		0	0
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		0	0
Summary of ground water sources		0	0
TOTAL	**0**	**0**	**0**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	0		
Description of public education and outreach		0	0
Water level monitoring process		0	0
Implementation of residential restrictions		0	0
Implementation of commercial restrictions		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
7. Post-drought Framework	0		
Identify future water sources		0	0
Identify projected water use		0	0
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		0	0
TOTAL	**0**	**0**	**0**
Total Overall Score	**0**	**0**	**0**

D11. Tuscaloosa, AL Major Categories (7) and Subcategories (28)	**Level 1 (0,1)**	**Level 2 (0,1)**	**Level 3 (0-5)**
1. Drought Plan Framework	1		
Definition of purpose/goals of the plan		1	3
Definition of the service area		1	3
Identify gaps and uncertainties		0	0
TOTAL	**1**	**2**	**6**
2. Social Pillar	1		
Incorporation of public participation, public review component		0	0
Describe population/demographics		1	2
Supply and demand assessment		1	2
Identify key stakeholders		0	0
TOTAL	**1**	**2**	**4**
3. Economic Pillar	1		
Conservation pricing for reducing water used		0	0
Established enforcement agency		1	1
Define baseline and targeted water use data		1	1
TOTAL	**1**	**2**	**2**
4. Environmental Pillar	1		
Define constraints/pressure on water sources		0	0
Establish indicators and thresholds for drought stages		1	3
Identify use of reclaimed, recycled, or non-potable water		0	0
Summary of surface water sources		1	3
Summary of ground water sources		0	0
TOTAL	**1**	**2**	**6**
5. Pre-drought Framework	0		
Description of historical drought events		0	0
Define early warning system of drought		0	0
Conservation actions during non-drought periods		0	0
Penalties imposed for violating restrictions		0	0
TOTAL	**0**	**0**	**0**
6. During-drought Framework	1		
Description of public education and outreach		1	2
Water level monitoring process		1	1
Implementation of residential restrictions		1	3
Implementation of commercial restrictions		1	3
Penalties imposed for violating restrictions		1	3
TOTAL	**1**	**5**	**12**
7. Post-drought Framework	1		
Identify future water sources		0	0
Identify projected water use		1	1
Post-drought assessment of impacts		0	0
Evaluation and update of the drought/water plan		1	1
TOTAL	**1**	**2**	**2**
Total Overall Score	**6**	**15**	**32**