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PLANNING FOR DROUGHT-RESILIENT COMMUNITIES: EVALUATING THE FASTEST GROWING COUNTIES' LOCAL COMPREHENSIVE PLANS

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by

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Recent drought events across the United States illustrate the country's changing and continuing vulnerability to drought. Drought impacts are often associated with unsustainable land use and poor water management practices, but research has been conducted on how well localities prepare for drought in building long-term resilience through land use planning and what jurisdictional factors correlate with their quality in drought planning. Targeting the fastest growing counties, due to their high possibility in increasing drought risk by making unwise land use decisions, this paper analyzes 61 selected county comprehensive plans from the research sample against a conceptualized drought-ready protocol, and examines whether jurisdictional variables relate to their higher drought preparedness through land use planning. The results indicate that lack of awareness, poor analysis, and weak actions in these localities' comprehensive plans render them unprepared for drought hazard in the long term. Large variations exist among their plan performance in terms of selected indicators and across jurisdictions. Also, none

of the nine contextual variables were found to be significantly correlated with plan quality in drought preparedness, suggesting a complex case for drought planning at the local levels. Finally, local land use planning obstacles are identified and policy recommendations are given.

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CHAPTER 1: INTRODUCTION

Drought is known as one of the most complex hazards, and it affects a large number of people across the globe (Wilhite and Buchanan, 2005). In fact, drought is a normal part of the climate and can occur in nearly every region on earth (Wilhite and Knutson, 2011). Although more than 150 definitions of drought exist, it is generally defined as a deficiency of precipitation over a substantial period of time (IPCC, 2012; Wilhite and Buchanan, 2005). Whether a drought hazard turns into a disaster depends on a region's social, economic, and environmental characteristics or, in other words, the region's vulnerability to drought (Wilhite 2011; Wilhite et al. 2007).

In the United States, the impacts of drought are considerable, and there has been increased frequency and severity of drought events that reveal the nation's increasing vulnerability to the hazard (Mishra and Singh, 2010). In a National Climatic Data Center (NCDC) study of U.S. severe weather disasters resulting in damage of $1 billion or more from 1980-2005, 11 drought events (16.7% of the total) alone accounted for $148 billion (28.6%) of the estimated total $507 billion (normalized to 2002 dollars) economic cost of all weather-related disasters (Lott and Ross, 2006). In 2011, the severe drought in Texas alone was estimated to cause $7.62 billion in agricultural losses (Fannin et al., 2012). The

2012 drought has been the most severe and extensive drought event in the past 25 years (USDA 2013). Drought is also the most destructive natural disaster from an economic perspective (Cook et al., 2007; Mishra and Singh, 2010). However, compared with more frequent and visual hazards such as floods, drought is insidious and hard to visualize, and drought planning has always been slow in the U.S. (Wilhite, 2002). Generally, droughts have not been prioritized on the planning agenda and, therefore, little money and resources are allocated to drought mitigation and preparedness (Wilhite et al., 2007). Given the fact that droughts are destructive and spatially extensive, there is an urgent need to enhance drought preparedness planning across the nation to meet the increasing challenges from droughts that are intensified by the growing population, changing climate, and urbanization.

Although there are increasingly growing number of hazard mitigation plans and state drought plans (Schwab, 2010; Wilhite, 2011), FEMA (1995) has stated that "all mitigation is local," and hence localities shall play an active role in hazard mitigation. Most local jurisdictions that sustain losses due to hazards like drought lack the capability to cope with severe disasters, and federal and state governmental programs provide financial and technical support in such events (Schwab, 2010; Wilhite, 2011). However, these local governments are capable of preparing, through planning for these hazards

before they become disasters (Burby et al., 2000; FEMA, 2008; Ivey et al., 2004; Godschalk, Kaiser and Berke, 1998). The local land use planning mechanism has long been encouraged in previous studies as an instrumental tool for hazard mitigation (Berke and Smith, 2009; Burby, 2005; Fu and Tang, 2013; Schwab, 2010; Tang et al., 2008, 2010).

Local comprehensive plans serve as policy documents that are developed through experts' analysis and public consensus building toward future development (Berke and Smith, 2009; Norton, 2008). Since hazard mitigation and local comprehensive planning are both future-oriented, integrating hazard mitigation into local comprehensive land use planning has been recognized as a principal tool to improve localities' coping capability, as well as reduce unnecessary hazard risks (Burby et al., 2000; FEMA, 2008; Fu and Tang, 2013; Schwab, 2010; Godschalk, Kaiser and Berke, 1998; Tang et al., 2011b). In addition, such integration was found to have reduced hazard losses (Burby, 2005; Nelson and French, 2002). Hence, states began to mandate local governments to address hazard mitigation in some way within their comprehensive plans, and this trend has continued (Schwab, 2010). However, the extent to which drought resilience planning is integrated into local comprehensive planning frameworks remains unknown and is believed to have substantial room for improvement because of intensifying drought impacts and increasing

losses.

Integrating drought preparedness into local land use planning is increasingly recognized as a key to reducing drought risk. Generally, maintaining the integration of watersheds and preventing urban sprawl by keeping smaller paved footprints will significantly improve local drought resilience. There is a growing body of research that examines the role of local land use planning in hazard mitigation (Burby et al., 2000; Fu and Tang, 2013; Schmidt and Garland, 2012; Schwab, 2010; Stevens, 2012; Tang et al., 2008, 2011a), but integrating drought preparedness into local land use planning is an emerging research area. Though much research has been conducted in improving local drought preparedness and reducing drought risk (Fu et al. 2013a; Knutson et al., 1998; Svoboda et al., 2010; Wilhite, 2002, 2011; Wilhite et al., 2000), the process for incorporating the drought resilience planning toolkit into local land use planning contexts is still unclear.

Therefore, this study develops an evaluation protocol that can be used to understand the extent to which drought preparedness planning is included in local comprehensive plans. The result provides insights for policy-makers and planners in improving local coping capability. Previous research provides a solid basis for plan content analysis (Brody, 2003; Berke and Conroy, 2000; Fu and Tang, 2013; Fu et al.

2013; Norton, 2008; Tang et al., 2008, 2010, 2011a, 2011b, 2013), but to date local drought preparedness through land use planning has not been analyzed, and what factors drives the localities to plan for such an insidious hazard is yet to be studied. To address these deficiencies, this research aims to answer the following questions:

1. How well are the fastest growing counties planning for drought through the land use planning mechanism?
2. What are the plan components and indicators associated with drought mitigation and adaptation that receive the greatest attention and are treated in the greatest depth in local comprehensive plans?
3. Are any of the nine jurisdictional variables directly correlating with the plan quality relative to drought preparedness?

CHAPTER 2: LITERATURE REVIEW

2.1 What is Drought?

Drought is recognized as the most complex, greatest recurring, and costliest natural disaster in North America (Cook et al. 2007; Mishra and Singh 2010). It is also considered to affect the most people among all natural disasters and nearly every region on earth (Hagman 1984, Wilhite and Buchanan 2005). Drought is actually a normal part of the climate that results from a lack of precipitation over a substantial period of time and, therefore, no region on earth can be immune (IPCC 2012). The hazard distinguishes itself from other natural hazards for its slow-onset, long-lasting, and wide-ranging characteristics. Also, there is no universal definition of drought, resulting in confusion about the onset and end of a drought and its degree of severity (Wilhite and Buchanan 2005).

Drought becomes a disaster once it produces social, economic, and/or environmental impacts (Wilhite and Buchanan 2005). Drought is always widely known for its tremendous impacts on the agricultural sector, while its impacts on other sectors (e.g. industrial, municipal water supply, tourism) are generally underestimated or even largely neglected (Fu et al. 2013b). Impacts of drought can directly reduce crop, range

land, and forest productivity, increase wildfire occurrence, reduce water availability, kill livestock and wildlife, deteriorate wildlife and fish habitat environment, and more (Wilhite et al. 2007). In addition, as consequences of the direct impacts, drought can cause even more significant indirect losses. For example, the reduction in crop productivity can bring significant economic impacts in terms of reduced income and government tax revenues, increased prices for food and food-related businesses, and increased budgets for disaster relief programs (Wilhite et al. 2007). Thus, how a region is affected by drought may vary widely from other regions because of variations in the social, economic, and environmental context. So, the drought risk or the vulnerability of the population to drought can be totally different from region to region.

The drought risk of a region is dynamic in response to the drought hazard and the societal vulnerability at the time (Wilhite et al. 2007). Drought hazard represents whether drought occurs and how often it occurs in the region. The societal vulnerability can be explained by how the region can be affected or, in other words, vulnerability is dependent on the regional social, economic, and environmental characteristics (Hayes et al. 2004). It was originally believed that risk was the sum of the hazard and vulnerability "(risk=hazard + vulnerability)", but the equation has been revised to be a product of the hazard and vulnerability "(risk=hazard * vulnerability)" due to the increasing magnitude

of drought impacts in recent drought scenarios (Knutson et al. 1998; Hayes et al. 2004).

Recent droughts in the United States have revealed the nation's continuing and changing vulnerability in terms of estimated economic losses. Severe drought episodes almost occurred every single year from 1996 to 2004, contributing to average annual losses of $6-8 billion (FEMA 1995). In 2002, the estimated losses were over $20 billion with a lack of national systematic analysis (Wilhite and Buchanan 2005). More recently, the 2011 and 2012 droughts are regarded as the worst in the U.S. history. Although drought in 2011 was more severe, with nearly 12% of the nation in exceptional drought conditions in late June, the 2012 drought became the costliest hazard of its kind due to the long-lasting impacts throughout that year (Folger et al. 2012). In 2011, drought in Texas resulted in over $7.62 billion of agricultural losses (Fannin et al. 2011). The following year, the economic loss of drought was estimated to exceed $35 billion (Aon Benfield 2012). As the drought impacts are both direct and indirect on various sectors and last for a substantial period of time, losses or impacts on other sectors (e.g. social stress, tourism, and environmental deterioration) are hardly ever observed and reported. As a result, the impacts and losses of each drought episode are believed to be more destructive and severe than it appears in terms of the estimated economic losses.

What is worse, it is believed the climate change, changing land use patterns,

population growth and many other factors all will intensify and aggravate drought impacts in the near future (IPCC 2012; Wilhite 2011). The changing climate, along with the increased variation of precipitation, will undoubtedly increase the probability of the occurrence of drought in some regions. In addition, urbanization and land use developments rely heavily relied on water resources for construction, and these developments can also disturb the integration of watersheds, which results in reduced water quality and quantity. Moreover, the growing population dramatically increases the water demand and, therefore, causes challenges for providing a sufficient water supply. Some other factors include changing government policies, advancing technology, increasing environmental awareness, and improving resources management practices. With such a trend toward increased drought, so are other natural hazards, the severe drought events increasingly demonstrate the urgent need for building communities' resilience, sustainability, and preparedness planning at all levels of government.

2.2 Drought Planning in the U.S.

Hazard mitigation planning is widely applied by various levels of governments and jurisdictions and is proven to be effective in reducing impacts and losses (Burby 2005, 2006; Godschalk, Kaiser and Berke, 1998; Nelson and French 2002; Schmidt and

Garland 2012; Schwab 2010; Wilhite et al. 2000; Wilhite 2011). The preferred approaches towards hazard planning are generally referred to as mitigation and adaptation, resilience planning, and risk management, which are proactive in nature. However, most existing hazard mitigation plans are largely reactive, mainly prepared by emergency managers and designed in response to emergencies (Schwab 2010). As planning for drought is not required by Federal Emergency Management Agency (FEMA), the existing generation of hazard mitigation plans is believed to address drought minimally or even mostly ignore it. In addition, the progress of drought planning, compared to planning for other natural hazards like floods and costal storms, is slow in the United States (Wilhite 2011).

Though drought planning has been slowly improving practically, the progress of drought planning in the theoretical sphere has been impressive. Wilhite (1991) published a 10-step drought planning process for state governments to develop a drought plan. The body of state drought plans grew dramatically, but these plans were found largely reactive and, therefore, a substantive revised 10-step process was established to urge states in their revision of, or in development of, drought plans toward a risk management approach (Wilhite et al. 2000). Since relying on state government for drought planning is largely insufficient, guides for reducing drought risks, as well as building resilience towards

drought readiness, have been established, aiming to enhance drought planning at multiple levels (Hayes et al. 2004; Knutson et al. 1998; Svoboda et al. 2010). Most recently, integrating drought planning into local water resources plans and comprehensive plans is increasingly advocated to build communities' resilience to drought (Schmidt and Garland 2012). To sum up, no matter how drought is addressed at the local level, planning officials are encouraged to cope with the hazard in a format of pre-disaster preparedness and post-disaster mitigation.

In general, the types of drought planning are classified into crisis management and risk management (Wilhite et al. 2000). The traditional approach to droughts, known as crisis management, is responding to ongoing drought that aims to maintain the status quo. It generally involves assessing ongoing impacts, responding to the impacts, recovering from the abnormal status, and reconstructing the damaged facilities and maintaining regular services (Wilhite et al. 2000). Relying heavily on such a reactive approach is not only largely ineffective and untimely, but also increases, to some extent, the societal vulnerability due to the growing locales' dependence on governmental programs (Wilhite 2011). By increasingly recognizing the fallacy of crisis management, governments are placing more weight on risk management to reduce societal vulnerability from its root. Risk management is aimed at building drought resilience through pre-disaster

preparedness planning, mitigation and adaptation, and early warming or monitoring. Preparedness planning intends to enhance operational and institutional capabilities by clarifying responsibilities, identifying potential impacts and responding actions, and facilitating implementation. Mitigation and adaptation (e.g., water conservation techniques) refers to programs and policies in both the short-term and long-term, which are implemented continuously to reduce drought risk. Prediction of future drought events is considered a key element of risk management since the effective, timely responses must rely on the accurate drought early warming or monitoring programs. Even though risk management is highly preferred, as the approach cannot eliminate all possible drought impacts and costs, the crisis management or emergency response shall always be a part of drought planning.

Planning for drought is quite unique compared with other natural hazards such as floods, costal storms, and earthquakes. The strategies of protecting vulnerable populations from hazardous areas, which is a significant approach in managing floods, storms, and hurricanes, will hardly reduce hazard risk associated with drought, as it occurs in both arid and humid areas and is always spatially extensive. In addition, once largely affecting the agricultural sector, droughts nowadays result in extreme social, economic, and environmental impacts. Drought’s lack of universal definition and

nonstructural impacts also hinder the progress of drought planning since governments can hardly identify a drought's onset and end, measure its degree of severity, and therefore provide specific actions to address the issues. Lastly, drought's complexity in terms of various impacts by regions and sectors render it even harder for governments to respond. Thus, a close coordination among all levels of governments is essential in coping with such an insidious hazard.

It is interesting to notice that the most active level of drought planning in the U.S. is at the state level (Wilhite 2011). Even though localities are always the victims for the disaster impacts and losses, local drought planning is believed to be minimal in the U.S.. With no national policies having been passed, there is no formal format for drought planning, and, therefore, the quality of drought planning varies widely at all levels.

2.3 Typical Forms of Drought Planning

As drought directly and indirectly affects almost all aspects of a community, it appears there is not a holistic way or form of planning framework for droughts. Drought should be considered in every planning endeavor so as to produce a fully coordinated framework for mitigating various drought impacts. This section identifies plans that are considered places where hazard mitigation shall be integrated. These forms of plans are

discussed for their suitability for drought planning and weaknesses and strengths of each plan framework are identified.

Land use planning is widely advocated for hazard mitigation and is increasingly recognized as an ideal place for building drought resilience (Burby et al. 2000; Godschalk, Kaiser and Berke, 1998; Stevens 2012; Schwab 2010; Schmidt and Garland 2012; Tang et al. 2011a). Integrating hazard mitigation into local comprehensive plans is preferable because mitigation and land use planning are both proactive in solving or preparing for and anticipating future problems. Further, local comprehensive plans always play a critical role at local levels (Burby et al. 2000; Godschalk, Kaiser and Berke, 1998). Comprehensive plans are particularly appropriate for identifying hazardous areas, retrofitting existing development, directing development towards less vulnerable areas, establishing development standards for hazards, and educating the population through public participation (Burby et al. 2000). Moreover, local land use plans mostly consider all significant sectors of their communities (e.g., land use, agriculture, economic development, and environmental quality) and, therefore, hazard can be addressed, if well established, through policies and actions in every possible affected sector. Although drought differs significantly from most other natural hazards (e.g., earthquake, flood, and coastal storm), local comprehensive plans are increasingly believed to be very beneficial

for building drought resilience as well as reducing future drought losses. Despite the benefits stated above, land use planning is especially suitable for drought mitigation because of its continuous process of planning with continuously monitoring, adapted implementation, and regularly updating. As drought is complex and less understood by most jurisdictions, such a continuous planning process enables the communities to learn and adapt their plans after each drought scenario, gradually enhance the communities' absorbing and persisting ability to address drought impacts (resilience), and make wiser decisions with limited information and knowledge (Schmidt and Garland 2012). Though the integration of drought mitigation and land use planning seems to be ideal, limitations still exist. An apparent one is that local comprehensive plans may not address the hazard in depth and, therefore, such integration may render the process of hazard mitigation weak and slow. In addition, as a standing document in envisioning a future to which communities aspire and solving anticipated problems, local comprehensive plans can hardly facilitate responses to emergencies. Last but not least, not all localities are required to establish a comprehensive plan, so that theory is not applicable anymore to jurisdictions with no comprehensive plans.

Another form of plan is known as the all-hazards plans or classified into a category of operational plans by Schwab (2010). These operational plans are always developed by

emergency managers in order to receive pre- and post-disaster funding for mitigation under the Disaster Mitigation Act (DMA) of 2000. Such plans aim to designate responsibilities of governmental agencies and private organizations and to facilitate coordination and implementation for mitigation actions in response to an emergency or disaster event. This type of plan remedies the lack of capability of a comprehensive plan in responding to emergencies and, thus, a well-established, closely-coordinated package of two plans will significantly enhance the coping capacity of a region, locality, and community. Even though emergency managers and planners are always encouraged to collaborate, their coordination appears to be weak at present (Schwab 2010). As drought is not a mandated element for funding by FEMA under the DMA of 2000, as is the case for other types of plans, few localities, though growing due to recent severe drought episodes, have drought plans. Also, local operational plans are believed to address drought minimally. Although to date almost all states have a drought plan, they are mainly considered in the category of operational plans since they typically address drought in a crisis management approach (Fortaine et al. 2012; Whilhite 2011). It is widely known that responding to a drought crisis is untimely, ineffective, and poorly coordinated (Wilhite 1997, 2011; Wilhite et al. 2000). Thus, the weakness of this type of drought planning is apparently its lack of mitigation and adaptation.

Two other types of plans that are considered places for hazard mitigation are referred to as area plans and functional plans (Schwab 2010). “Area plans are meant to address issues unique or specific to parts of a jurisdiction” and “Functional plans generally deal with the management and coordination of certain functions of local or regional government” (Schwab 2010, pp. 42 and 43). These two types of plans are discussed together because both are limited to a smaller scope in terms of territory and issue. Both types of plans can further enhance drought preparedness at smaller a scale, and these planning endeavors are expected to be more efficient, to some extent, since they better understand how the area or sector has been affected by the hazard and their need to cope with it than other comprehensive planning frameworks.

As discussed above, all the plans, if integrated with drought planning, have justified their strengths and weaknesses. Thus, a system with these complementary plans will enhance a state, region, locale, or community’s drought preparedness from almost all perspectives (see figure 1). To achieve this utopian idea, efforts must be made at all levels. However, the fact of lack of a national drought policy, splits in responses and responsibilities, weak awareness of drought planning at localities, and more, has resulted in the hardships for improving drought preparedness (Folger et al. 2012). There is still a large room for improvements ub the process of drought preparedness planning.

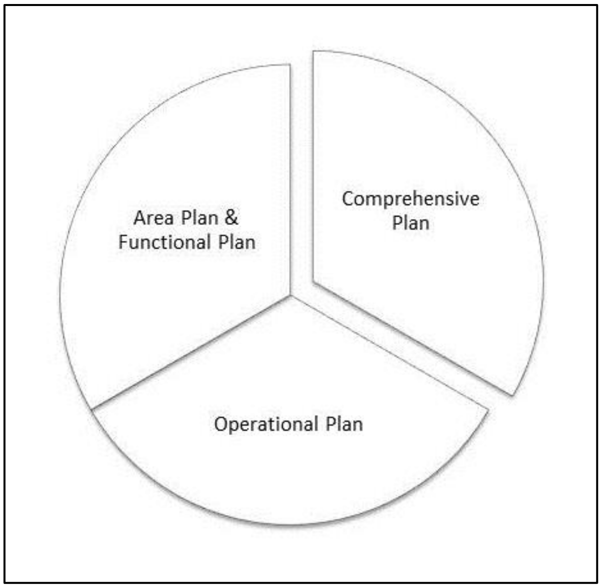

Figure 1 Forms of Drought Planning

2.4 Local Comprehensive Planning and Drought Preparedness Planning

Local comprehensive planning and drought preparedness planning should be integrated because they both share a future orientation, can be powerful tools in building drought resilience if integrated, and can maximize local planning capability by building connections between both planning processes with limited knowledge and resources. First, the comprehensive planning process gives a community the opportunity to get all stakeholders involved, gather information from the public, and search for other information that is necessary in a systematic and comprehensive way. In addition, since local comprehensive planning is an ongoing and continuous process, it can help facilitate the monitoring of drought conditions as well as the implementation of actions and

policies set forth to address hazards through consensus building if local planners recognize drought as an important issue in the community. Third, the planning process of public participation and information gathering educates the public and raises people's awareness by providing information on their drought vulnerability and the benefits of drought planning. Finally, the comprehensive plan documents the community's goals and objectives and can detail specific policies to address drought.

Another reason to support this argument is that comprehensive plans have already become a policy guide in most communities, and hence would encourage integrating drought planning goals with other ongoing community goals and programs (Godschalk, Kaiser and Berke, 1998). Stand-alone drought plans have typically been prepared because of a recent drought scenario in a locale; they are intended to address immediate needs and to respond to the next drought similar to the previous one (Wilhite and Knutson, 2011). These drought plans are always developed using a crisis management approach and have been proven to be untimely and ineffective (Wilhite et al., 2000). Therefore, as a long-range planning document, comprehensive plans can serve as a principal tool that incorporates drought preparedness planning and helps communities move from reactive crisis management to proactive risk management.

2.5 Scope of the Study

The scope of this study only focuses on local comprehensive land use planning capacity for drought mitigation and adaptation. Tang et al. (2008) categorized two major approaches of local hazard planning: one is the stand-alone plan, and the other is the integrated component in other types of plans. Regarding drought planning, localities can either develop their own stand-alone drought plans or integrate drought components into other planning framework (e.g., local all-hazards plan, emergency plan, water resources plan, climate action plan, watershed plan, etc.). Currently, only a few local jurisdictions have developed their own stand-alone drought mitigation or response plans. The most popular model is to integrate drought concepts into existing local plans, and this integrated model can enhance the community's overall drought preparedness to some extent. Local comprehensive plans are believed to an ideal place for drought preparedness plans (Schwab, 2010). Therefore, the scope of this study focuses on local comprehensive plans in drought mitigation and adaptations (Figure 2).

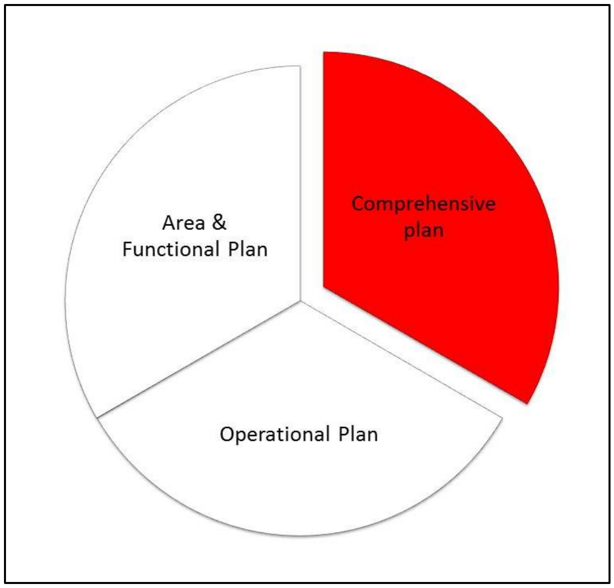

Figure 2 Scope of Study

CHAPTER 3: CONCEPTUALIZING DROUGHT PREPAREDNESS PLAN QUALITY

Tang et al. (2010) developed a Three Component Protocol termed "AAA" (Awareness, Analysis, and Action) that decision makers can employ to enhance society's preparedness for climate change to evaluate local plans. Like climate change, drought is insidious, difficult to quantify, and largely nonstructural and spatially extensive, which leads to the lack of comprehensive and quantitative impact assessments and inadequate loss estimates associated with drought. Therefore, policy and decision makers feel reluctant to allocate money and resources to drought planning (Wilhite et al. 2007). To achieve drought-ready communities, local comprehensive plans should demonstrate a holistic awareness of drought, make a systematic analysis of drought risk and impacts, and translate awareness and concerns into sound action. The "AAA" Protocol shares a strong correspondence with the five tasks that Svoboda et al. (2010) outlined to achieve drought-ready communities (see Figure 3). The five tasks are (1) getting started, (2) information gathering, (3) monitoring, (4) awareness and education, and (5) action plan.

The first, "*getting started,*" and fourth, "*awareness and education,*" tasks of drought-ready communities can be accomplished by strengthening the **awareness**

component of local comprehensive plans. The local land use planning mechanism provides a formal means to gather community perceptions of drought, identify the adequacy of public awareness, and create community vision for drought readiness; therefore, decision makers, officials, and stakeholders need to understand the extreme impacts and losses that drought poses, their community's vulnerability to drought, and the benefits of preparing for droughts. The second, "*information gathering,*" and third, "*monitoring,*" tasks can be achieved by enhancing the **analysis** component of local plans. Local comprehensive plans can serve as a systematic means to complete a thorough analysis of past drought events and impacts, as well as a community's vulnerable population and sectors-- factors that could intensify or reduce drought impacts, and thus develop a continuous drought monitoring system. For the last task, "*action*" plan, local comprehensive plans are generally, as standing policy documents, the most important planning mechanism in local jurisdictions, which can be used to implement drought mitigation and adaptation **actions**.

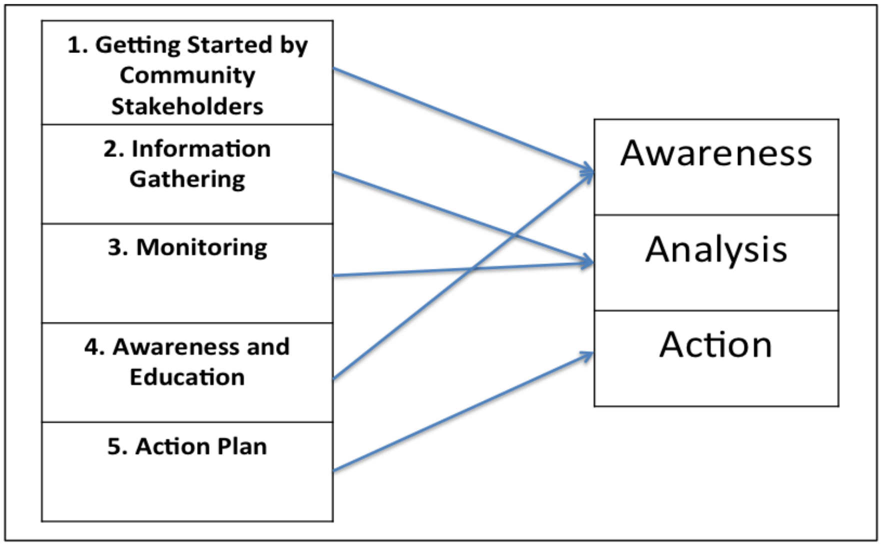

Figure 3 Plan Components' Relationships

This study develops a conceptual framework using the "AAA" to guide land use planners to address drought mitigation and adaptation in local comprehensive plans. The three critical plan components (awareness, analysis, and actions) are strengthened by including specific indicators in conformance with previous studies in drought planning, especially the Drought-Ready Communities (Svoboda et al. 2010), to measure local drought preparedness through land use planning.

The awareness component measures the degree to which local governments understand drought. Since drought impacts and their complexities vary from region to region, local jurisdictions need to be aware of community perceptions of drought, historical drought events, and their population growth so as to initially assess drought vulnerability as well as highlight community misperceptions (Svoboda et al. 2010;

Wilhite 2011). Moreover, local misperceptions regarding drought can be further addressed by public awareness and educational campaigns throughout the planning process (Svoboda et al. 2010). Recognition of existing state drought guidance and local water-related regulations and plans can help communities re-assess their effectiveness in drought mitigation and adaptation. Finally, long-term water conservation and efficiency goals should be clearly stated in local plans.

The analysis component should inventory water supply sources and water use, therefore providing a systematic analysis of water supplies and projected future water demand. In addition, the analysis component should also identify local climate conditions, previous drought impacts, and drought prone areas in order to understand their economic, environmental, and social vulnerability. Finally, to monitor drought locally, jurisdictions should conduct a thorough analysis to determine how communities recognize drought once it starts.

The action component represents the heart of the plan, because it is the means to assure that the plan’s goals and objectives are achieved (Brody 2003; Tang et al. 2008, 2011b). Local jurisdictions should fully extend their planning capacity to develop actions that address drought mitigation and adaptation in the natural and built environment, and human health. Actions should involve: (1) coordination strategies (Ivey et al. 2004;

Wilhite 2002; Wilhite et al. 2000); (2) land use policies (Burby et al. 2000; Schwab 2010); (3) water conservation regulations (APA 2002; Wilhite 2011); (4) financial tools (Campbell 2004; Tang et al., 2010); and (5) implementation strategies (Svoboda 2010; Wilhite 2011). See Appendix 2 for the detailed information for this plan coding protocol.

Chapter 4 Measuring Variations in Local Drought Preparedness

A correlation analysis is conducted to test if any of the nine selected jurisdictional factors affect local drought preparedness through land use planning (see Figure 4). The plan quality regarding drought preparedness, measured by the "3A" coding protocol, is to be tested with other nine jurisdictional characteristics to help understand whether these contextual variables influence local drought mitigation and adaptation.

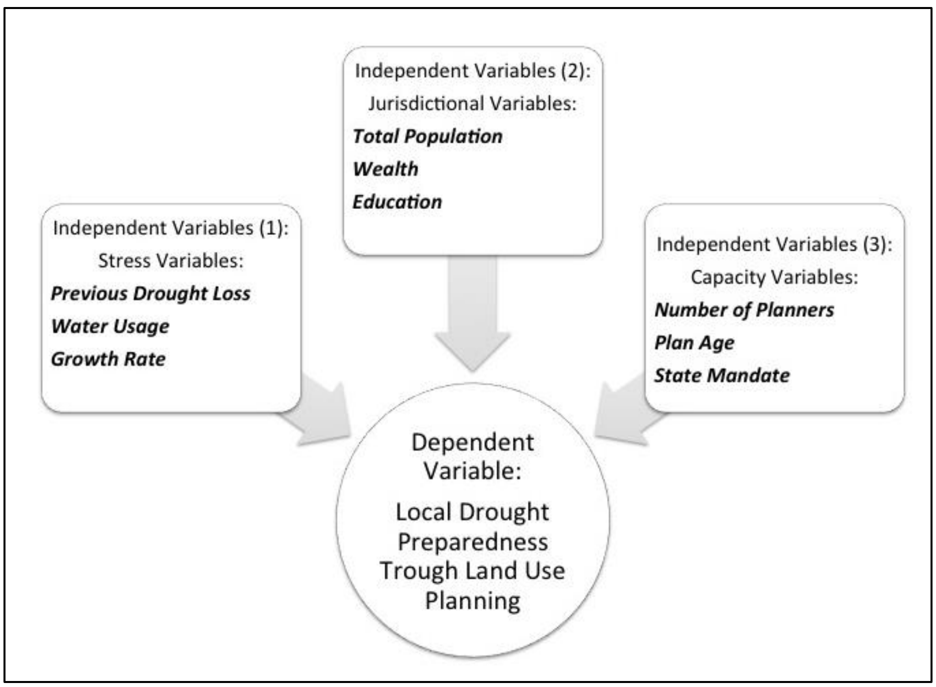

Figure 4 Dependent and Independent Variables

Previous studies on plan quality and drought planning identify numerous factors

influencing plan quality (Balling Jr. et al. 2007; Hayes et al. 2004; Ivey et al. 2004; Tang et al. 2010, 2011a, 2011b; Wilhite 2011; Wilhite et al. 2007). Since drought is, unlike other natural hazards, insidious and complex, planning for drought encounters more obstacles and is usually affected by many factors including jurisdictional framework, decision-makers' values and experiences, information resources, and awareness of alternatives (Tang et al. 2010). To date, little research has quantitatively measured the factors affecting local drought preparedness. Three sets of variables are utilized in this study to measure correlation with local comprehensive plan quality on drought mitigation and adapation. These are capacity variables, jurisdictional variables, and risk variables.

Capacity variables include the number of planners in the planning department, age of the plan, and state guidance. Local jurisdictions that hire more planners are expected to have greater planning capacity and thus develop better plans. The same is expected to hold true for planning for drought preparedness. Moreover, the age of a plan is also an important factor affecting plan quality because recently updated plans may have more current knowledge, information, regulation, and techniques to assure consistency with local changing conditions (Tang et al. 2011b). Finally, state mandates have been demonstrated to enhance local plan quality in several previous studies (Berke and French 1994; Burby 2005). Although drought mitigation and adaptation have not been mandated

at the state level across the U.S., states that have developed state drought plans are believed to motivate local governments to address drought, and these local jurisdictions would therefore establish better plans than others without state guidance.

Jurisdictional variables include population size, population income, and population education. Local jurisdictions that have a larger population size, higher population income and a higher level of education are expected to have more financial, human and technical resources with which to develop better quality plans (Tang et al. 2010, 2011b). In addition, drought hazards affecting a larger scale of population may increase public awareness of the significance of drought mitigation and adaptation; therefore, local governments will respond by protecting the public welfare with stronger local plans that address such hazards.

Risk variables include population growth, water usage, and previous drought losses. Population growth is relevant because it urges local governments to act so as to provide resources and services for future demands. Local jurisdictions experiencing higher growth rates are more likely to take efforts in drought preparedness. Moreover, water usage is another important factor relating to local drought awareness as well as preparedness. Jurisdictions with higher water usage may be better aware of future potential water shortages, as well as drought, and thus develop better quality plans.

Finally, local jurisdictions with more historical drought damage may have more motivation to develop higher quality plans to mitigate the risks. If jurisdictions have experienced drought damage and loss, they would be expected to be better prepared to cope with future potential drought events.

Chapter 5: Research Method

5.1 Sample Selection

The population of this research is the top 100 fastest growing U.S. counties with housing unit changes from April 1, 2000 to July 1, 2009. The housing unit estimates for the 100 fastest growing counties with 5,000 or more housing units in 2009 were released by the U.S. Census in September 2010. The 100 fastest growing counties in housing units in the U.S. were initially chosen as the research sample for two main reasons. *First*, these counties are faced with tremendous challenges from growth, such that their land use decisions could directly reduce or increase local drought vulnerability. For example, urbanization is accompanied by increasing impervious surfaces like roads, roofs, and driveways that generate polluted runoffs that are recognized as a leading threat to water quality (EPA 1992). Thus, it is imperative for them to address the conflict between development and environmental issues. In addition, with increasing pressure on water and other natural resources because of the growing population, local jurisdictions must protect and conserve their water resources to meet future demand. *Second,* along with various challenges from growth, these counties are also places for opportunities. These developing counties could adopt new policies and regulations and implement advanced

techniques to reduce hazard vulnerability as well as enhance hazard resilience in the long run. Also, the counties in the sample are scattered across 24 states in the U.S., making this sample body somewhat representative of the nation's local drought preparedness through land use planning.

Of the 100 counties, 81 counties' comprehensive plans are available on their official website and can be downloaded (Accessed May 1st, 2012). The remaining 19 counties either did not have a planning department at the local level or were still in the process of updating their plans so that only part of the plans was available (see Appendix 1). To ensure the validity of the research, the sample was narrowed down to 61 local plans by excluding counties with population of less than 50,000 or more than 1,000,000 people. According to the census data, nearly 60% of the population of the U.S. is living within these medium-sized counties, and these counties are generally believed to have similar contextual factors. As a result, 20 counties that did not meet the requirement of population size were excluded, because small communities and large cities that have very different contextual factors may skew the sample (Berke and French 1994; Brody 2003).

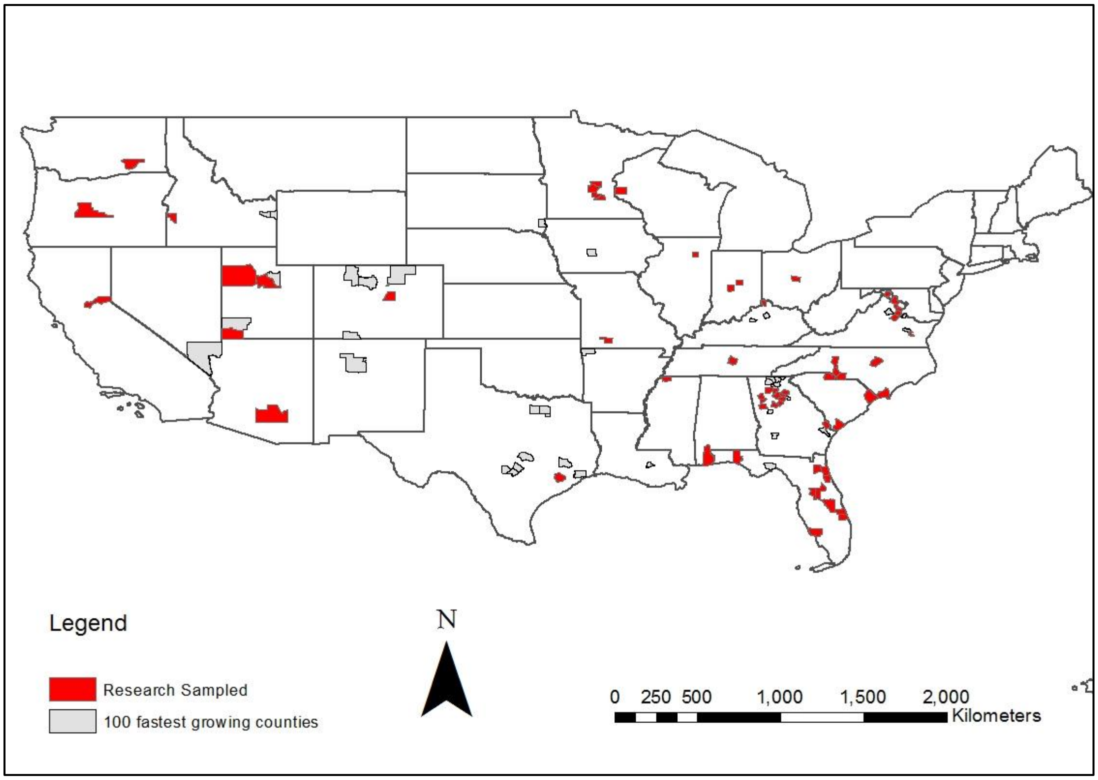

Figure 5 100 Fastest Growing Counties and Research Sampled

5.2 Data Sources

Local comprehensive plans were retrieved from each county's official planning website. Data for the contextual variables, including population, income, and education, were collected from the U.S. Census Bureau (Accessed June, 2012, http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t). Data on the number of planners and plan dates were collected either by e-mails or phone calls. Counties' water usage data were gathered from the U.S. Geological Survey (Accessed July, 2012, http://water.usgs.gov/watuse/data/2005/index.html). Data on previous drought

losses were collected from Spatial Hazards Events and Losses Database for the United States (SHELDUS) from 1960 through 2011 (Accessed August, 2012, http://webra.cas.sc.edu/hvri/products/sheldus.aspx). State guidance was measured by the state drought plans' status, established by the National Drought Mitigation Center (Accessed September, 2012, http://drought.unl.edu/Planning/ PlanningInfobyState.aspx). The population growth was calculated by subtracting a jurisdiction's population in 2000 from its population in 2010 (see Appendix 3 for all the details).

5.3 Evaluation Criteria

A plan coding protocol was developed according to the preceding conceptualization of plan quality for drought. In total, 33 indicators were included in the protocol to measure the coverage and depth at which local comprehensive plans address drought mitigation and adaptation. Within the three core components (awareness, analysis, and actions), each indicator is scored on a 0-2 scale. Such ordinal coding scheme was originally developed by Berke and French (1994) and is applied in this research to rate the plans. Any indicator that is not mentioned in the plan receives a score of "0." An indicator that is considered, but not thoroughly, is scored as "1". A score of "2" means the indicator is fully considered. Since this study focuses on local drought preparedness,

indicators that fail to address the drought hazard or water-related issues were considered to be not mentioned in the plan and therefore are scored as “0”.

The 61 counties’ comprehensive plans were evaluated following three steps independently to relatively reduce the effects of personal bias and to enable the assessment of reliability: First, the entire plan is read, and each indicator in the plan is located and scored according to the evaluation criteria. Then a key word search method is applied to confirm that each indicator’s score is accurate and to avoid skipping some information during the first scanning. The last step is reevaluating the sample one more time to improve the reliability of the results. After these steps, each plan receives a score on each indicator for further analysis.

5.4 Calculation Method

Based on previous research (Berke and French 1994), plan component quality and total plan quality can be calculated by the following equations:

$$PC_j = \frac{10}{2m_j} \sum_{i=1}^{m_j} I_i \qquad \text{(Equation 1)}$$

and

$$TPQ = \sum_{i=1}^{3} PC_j \qquad \text{(Equation 2)}$$

where PC_j indicates the quality of the *j*th plan component (ranging 0-10); m_j represents

the number of indicators within the *j*th plan component; I_i represents the *i*th indicator's score (ranging 0-2); and TPQ means the total score of a whole plan (ranging 0-30).

Indicator breadth equation:

$$IBS_j = \frac{P_j}{N} * 100 \quad \text{(Equation 3)}$$

Indicator depth equation:

$$IDS_j = \frac{\sum_{j=1}^{P_j} I_j}{2P_j} * 100 \quad \text{(Equation 4)}$$

IBS_j is the j^{th} indicator breadth score (scale 0-100%); P_j is the number of plans that address the j^{th} indicator; N is the total number of plans sampled in this study; IDS_j is the j^{th} indicators depth score (scale 50-100% if at least one plan addresses this indicator; the score is 0 if none of the plans address this indicator); and I_j is the j^{th} indicator received scores (scale 0-2).

5.5 Correlation analysis

To measure whether the selected jurisdictional variables correlate with their plan quality in drought planning, a correlation analysis was conducted after all the plans had been coded. The Pearson's product-moment correlation was conducted among plan quality and their standardized jurisdictional characteristics. Please go to Appendix 3 and 4 for detailed information regarding the data and results.

Chapter 6: Results

6.1 Overview

The results shown in Table 1 demonstrate the overall assessment of how well local jurisdictions addressed drought mitigation and adaptation in their comprehensive plans. The mean score of the 61 plans is only 9.4 (31% of the maximum possible score) on a scale of 0-30. Only 4 (7%) counties (Osceola, FL; Brunswick, NC; Indian River, FL; Kendall, IL) received more than half of the total points, indicating an overall weak drought preparedness through local land use planning. Moreover, plan quality in drought preparedness varies widely from the lowest 3.2 (10%) to the highest 20.1 (67%), revealing the huge capacity gap among these regions. There are large geographic variations among the quality of these plans.

Table 1 Plan Component Performance and Total Quality

County (Growth Ranked)	Awareness	Analysis	Actions	Total
Sherburne, MN (43)	1.4	0.6	1.1	3.2
Mecklengburg, NC (39)	1.4	0.0	1.9	3.4
DeSoto, MS (22)	2.1	0.0	1.4	3.5
Fort Bend, TX (42)	1.4	1.3	1.4	4.1
Utah, UT (51)	1.4	1.3	1.7	4.3
Washington, UT (13)	1.4	1.9	1.1	4.4
Wright, MN (37)	2.1	1.3	1.1	4.5
Hendricks,IN (32)	2.1	0.6	2.2	5.0
Canyon, ID (34)	1.4	1.3	2.5	5.2
Tooele, UT (55)	2.9	0.6	2.5	6.0

Delaware, OH (18)	2.9	1.3	2.5	6.6
Boone, KY (57)	3.6	1.3	1.9	6.8
Effingham, GA (50)	2.9	0.6	3.6	7.1
Henry, GA (7)	2.9	1.3	3.1	7.2
Franklin, WA (28)	2.9	1.9	2.5	7.2
Barrow, GA (14)	2.9	0.6	3.9	7.4
Rutherford, TN (25)	2.1	2.5	2.8	7.4
Hamilton, IN (19)	2.1	1.3	4.4	7.8
Baldwin, AL (36)	3.6	1.3	3.3	8.2
Prince William, VA (41)	2.1	3.1	3.1	8.3
Placer, CA (49)	2.1	3.1	3.1	8.3
Newton, GA (10)	3.6	1.9	3.1	8.5
Union, NC (15)	3.6	1.3	3.9	8.7
Spotsylvania, VA (60)	3.6	1.3	3.9	8.7
Horry, SC (31)	5.0	1.3	2.8	9.0
Stumer, FL (2)	3.6	1.9	3.6	9.1
Walton, FL (27)	2.9	1.3	5.0	9.1
Stafford, VA (48)	4.3	1.3	3.6	9.1
Walton, GA (29)	2.1	3.8	3.3	9.2
Loudoun, VA (8)	3.6	1.3	4.4	9.3
Wake, NC (45)	4.3	2.5	2.5	9.3
Lee, FL (23)	3.6	1.3	4.7	9.5
Carver, MN (54)	2.9	1.9	4.7	9.5
Clay, FL (58)	2.9	1.9	4.7	9.5
York, SC (53)	2.9	2.5	4.4	9.8
Jackson, GA (17)	3.6	1.9	4.4	9.9
Paulding, GA (4)	2.9	2.5	4.7	10.1
Cherokee, GA (12)	4.3	2.5	3.3	10.1
Douglas, CO (11)	3.6	1.9	5.0	10.4
St.Croix, WI (47)	4.3	3.1	3.1	10.5
Berkeley, WV (59)	4.3	1.9	4.4	10.6
Scott, MN (24)	5.0	1.9	3.9	10.8
Coweta, GA (33)	3.6	3.8	3.6	10.9
Pinal, AZ (3)	3.6	3.1	4.4	11.1
Deschutes, OR (30)	3.6	2.5	5.0	11.1

Iredeel, NC (56)	3.6	3.1	4.4	11.1
James City, VA (46)	4.3	1.9	5.0	11.2
Christian, MO (40)	2.9	6.3	2.2	11.3
Forsyth, GA (6)	4.3	4.4	3.1	11.7
Douglas, GA (35)	5.0	2.5	4.4	11.9
Broomfield, CO (20)	5.7	1.9	4.4	12.0
Flagler, FL (1)	4.3	2.5	5.3	12.1
Gwinnett, GA (52)	5.7	2.5	3.9	12.1
Lake, FL (38)	3.6	2.5	6.7	12.7
Beaufort, SC (44)	4.3	3.8	4.7	12.8
St.Johns, FL (21)	4.3	2.5	6.4	13.2
St.Lucie, FL (26)	5.7	4.4	4.7	14.8
Osceola, FL (9)	5.7	3.8	6.4	15.9
Brunswick, NC (16)	5.0	6.3	4.7	16.0
Indian River, FL (61)	5.7	3.8	7.2	16.7
Kendall, IL (5)	7.9	5.0	7.2	20.1

(The scale of each plan component-Awareness, analysis, action is 0-10. The scale of total score is 0-30.)

Of the three plan components (Table 2), analysis received the lowest average score: 2.2 (22% of a maximum score of 10). This score indicates that jurisdictions failed to provide systematic analysis of the drought hazard at the local level. Lack of information about how local communities were affected by drought renders them vulnerable to such hazard. The awareness and action components also received low average scores, 3.5 (35%) and 3.7 (37%), respectively, on a scale of 0-10, demonstrating that these jurisdictions tended to ignore drought and were less willing to take action to mitigate drought impacts in their local plans. These results show that local jurisdictions have not

realized the extreme impact and loss that drought could cause their communities and therefore fail to make a thorough analysis of such a hazard as well as take action to enhance local drought preparedness through land use planning.

Table 2 Summary of Plan Quality and Performance

Components [a]	Number of indicators	Minimum	Maximum	Mean	Std. Dev.
1. Awareness	7	1.4	7.9	3.5	1.31
2. Analysis	8	0	6.3	2.2	1.31
3. Actions	18	1.1	7.2	3.7	1.44
Total [b]	33	3.2	20.1	9.4	3.35

(a: component score range: 0-10; b: total score range: 0-30)

6.2 Analysis by Plan Component

6.2.1 Awareness Plan Component

Most (84% breadth) plans detailed local demographic data and identified an increasing demand for water from the growing population (Table 3). A majority (90% breadth) of jurisdictions had already established and implemented stand-alone plans, codes, or regulations to address water issues and mentioned these planning endeavors in their local comprehensive plans. Moreover, most (70% breadth) jurisdictions committed themselves to carry out awareness and education programs to conserve water. Forty (66% breadth) plans set water conservation goals but few (55% depth) articulated such goals to specify specific actions. Not surprisingly, drought remained overlooked by almost all

these jurisdictions, with barely 8% of the plans mentioning drought as a natural hazard, 15% of the plans mentioning previous drought experience, and only 3% of the plans recognizing their state's drought guidance.

Table 3 Indicator-Based Scores for the Awareness Component

Indicators	Breadth (%)	Depth (%)
Local perception of drought and water shortage	8	60
Historical records of drought	15	61
Population growth and impacts	84	88
Recognition of state drought plan	3	100
Existing water-related regulations/codes/plans	90	75
Water conservation/efficiency goals	66	55
Public awareness and education campaign	70	66

6.2.2 Analysis Plan Component

Almost all (97% breadth) of the plans inventoried their water sources by maps (Table 4). Approximately half (48% breadth) of the plans identified their water supply status and showed their concerns with meeting increasing water demand. A systematic analysis of local water information can help communities identify potential future impacts and provide a basis for comparison when a drought occurs (Svoboda et al. 2010). However, only 38% of the plans calculated their current water usage and projected future water demand and only 20% of the plans define their local water use. Also, only a few (2-3% breadth) plans addressed how their communities were affected by drought, how

they realized drought if it occurred, and which part of their communities is or was more vulnerable to drought. No more than 34% of plans addressed local climate moderately (62% depth). Such results indicate their overall weak capacity in providing a strong foundation to cope with future drought events.

Table 4 Indicator-Based Scores for Analysis Component

Indicators	Breadth (%)	Depth (%)
2.1 Water supply sources inventory	97	85
2.2 Identify water uses	20	62
2.3 Identify water supply status	48	64
2.4 Identify how previous drought affect local community	3	50
2.5 Identify drought prone areas and vulnerable sectors	3	50
2.6 Identify local climate	34	62
2.7 Identify local drought triggers and indicators	2	50
2.8 Current water usage and future demand projection	38	65

6.2.3 Action Plan Component

In the action component (Table 5), some of the traditional policies, tools, and strategies, e.g., land restrictions and land acquisitions, were well covered in the plans, while other newly emerged strategies, e.g., green infrastructure and water-saving building codes, received less attention. As droughts are a normal part of the climate in most areas, conserving water resources can be regarded as a means to mitigate drought impacts; most of the actions within this category receive points for their efforts in saving water rather

than preparing for the drought hazard.

Coordination

A majority (90%, 92% breadth) of plans seek coordination within and beyond jurisdictions to plan for trans-boundary issues such as water resources and drought hazards, but few listed specific programs, therefore rendering their comparably low score in depth.

Table 5 Indicator-Based Scores for Action Component

Indicators		Breadth (%)	Depth (%)
Coordination	Coordination within jurisdiction	92	67
	Coordination beyond jurisdiction	90	74
Land Use Policies	Land use restrictions from watersheds	95	78
	Land acquisitions to preserve integration of watersheds	89	64
	Green infrastructures	46	57
	Mix-used and compact development	93	72
Water Conservation Regulations	Water-saving building codes	41	62
	Water-efficient irrigation	49	52
	Drought-resilient landscaping	49	62
	Restrictions in some urban water uses	18	59
	Improve water system efficiency	61	58
	Wastewater recycle and reuse	43	56
Financial Tools	Water pricing	3	100
	Establish water conservation incentives	20	63
Implementation	Establish drought leadership team	2	50
	Prioritize water related programs	62	62
	Identify feasibility of actions	84	73

Strategies	Continuously monitor, assess, and update	82	67

Land Use Policies

Most jurisdictions adopted land use restrictions (95% breadth, 78% depth), land acquisition (89% breadth, 64% depth), and mix-use development (93% breadth, 72% depth) policies to preserve integration of watersheds, but their comparably low quality scores suggest there is room to improve these policies. Green infrastructure, a newly emerged policy, was commonly (46% breadth) and moderately (57% depth) addressed.

Water Conservation Regulations

Consistent with water conservation goals (66% breadth, 55% depth) stated in the plans, related regulations were also commonly and moderately covered. Approximately half of the plans mentioned water-saving building codes (41% breadth), water-efficient irrigation (49% breadth), and drought-resilient landscaping (49% breadth), but they did so in moderate quality, and few plans detailed related implementation strategies. Other indicators in this category were rarely or commonly addressed in the plans, indicating these jurisdictions' average performance in water conservation policies and their potential for further improvements.

Financial Tools

Only two regular financial tools are included in this category to initially measure how local jurisdictions incorporated this method into their planning toolkit. The results demonstrate that only 2 (3% breadth) plans mentioned control of water demand by modifying water prices and no more than 12 (20% breadth) of the sampled jurisdictions applied water conservation incentives.

Implementation

Most (84%, 82% breadth) of the jurisdictions committed themselves to implementing their local plans by strongly emphasizing feasibility, a clear schedule, and a measurable procedure for continuously updating and monitoring. Tables of responsibility, funding, and timelines for action were almost always given in detail, contributing to higher scores in depth. Over half (62% breadth) of the plans established implementation priorities for water-related programs, suggesting that local jurisdictions did realize the significance of their water resources. However, only one county (Lake, FL) out of 61 counties sampled, mentioned, to a moderate extent, their local drought leadership team in the comprehensive plan.

6.3 Correlation results

As Appendix 4 shows, none of the selected jurisdictional variables was statistically significantly correlated with the total plan scores generated from this study: number of planners (r= 0.073), plan age (r= -0.017), state leadership (r= 0.65), previous drought losses (r=-0.109), water usage (r= -0.117), population growth (r= 0.100), education level (r= -0.105), income (r= -0.113), and population (r= -0.151). The variables indicate either positive or negative relationship with the plan quality in drought planning but none of these relationship stand at a statistically significant level (as $P<0.05$).

Chapter 7: Discussion

7.1 Answer to the Research Questions

1. How well are the fastest growing counties planning for drought through land use planning mechanism?

As the results show, these fastest growing counties' comprehensive plans were weak in planning for droughts. Since droughts generally result from a deficiency of precipitation over a substantial period of time and are highly related with water resources, credit for the plan quality should almost always be given to those jurisdictions that have relatively better water resources management. If the plan evaluation method of Tang et al. (2008), in which plans that failed to mention the word "tsunami" were given a score of 0, was applied in this study, where the word "drought" would need to be used, all the local plans would receive much lower scores. The results also highlight these jurisdictions' continuing drought risks due to their ignorance of drought hazard in the comprehensive plans, which would most likely lead to the unwise land use decisions that unnecessarily increase drought risks.

2. What are the plan components and indicators associated with drought mitigation and adaptation that receive the greatest attention and are treated in the greatest depth in local comprehensive plans?

The results indicate that the jurisdictions' plans were comparably weak in actions (37%), weaker in awareness (35%), and weakest in analysis (22%). Even taking water-related actions into consideration, the strongest plan component of these counties received only a mean score of 3.7. As expected, local jurisdictions had a very weak awareness of drought in their comprehensive plans because of this hazard's insidious nature. Unlike flood management, drought management received far less attention in most of the local plans (Wilhite 2002). Also, as the concept of incorporating hazard mitigation into planning efforts is relatively new for droughts, local land use planners and decision-makers may be preoccupied with visual and immediate hazards like floods, rather than more abstract and slow-onset droughts (Hayes et al. 2004). It is not surprising that these counties had the weakest analysis component in their local plans because of the lack of a database for drought hazard at all levels of governments. Before the Drought Impact Reporter (DIR) was launched in 2005, no national drought impact database existed, and the lack of data that can render drought monitoring and predication, mitigation, and preparedness an arduous task (Wilhite et al. 2007). In addition, few

post-drought assessments were conducted and, therefore, caused hardship for planners, decision makers and the public to be aware of the tremendous economic losses and various impacts associated with droughts.

Indicators that addressed water related issues (e.g., existing water-related policies, water supply inventory, and land use restriction and land acquisition to preserve integration of watersheds) received higher scores, indicating that these counties realized the importance of water resources and had already started to take action. However, indicators regarding drought (e.g., historical records of drought, local drought impacts, and triggers) were always disregarded in local comprehensive plans and thus received the lowest scores.

3. Are any of the nine jurisdictional variables directly correlating with the plan quality in drought planning?

As the results indicate (see Appendix 4), the quality of these counties' plans in addressing droughts varied widely from region to region, and none of the contextual characteristics shows significant correlation with the plan quality and with the three plan components. The results of this study are partially consistent with previous studies on hazard plan quality (Tang, et al., 2008; Tang et al. 2011b). Like tsunami and climate

change, drought is either unpredictable or invisible for decision makers. Local decision makers tend to respond to urgent and immediate problems rather than uncertain, slow-going drought hazards. In these studies, they also found that plan quality was not significantly related to any of the jurisdictional characteristics. However, these findings are somewhat inconsistent with those of previous studies that found plan quality and other planning outcomes to be related to the jurisdictional characteristics (Berke and French 1994; Burby 2006; Tang et al. 2010). The inconsistencies in the relationship between plan quality and contextual conditions might be partially explained by previous studies that found community conditions had small (and marginally statistically significant) correlations with planning outcomes (Tang et al. 2011b). Therefore, the small sample size in this study might be limited to finding statistically significant correlations between community context and plan quality (Tang et al. 2008, 2011b). Additionally, these counties' plan quality scores in addressing drought are generally very low, and therefore less variance exists in the dependent variable. The restricted variance in this study may explain why there are no correlations between plan quality and other jurisdictional characteristics.

7.2 Theory and Policy Contributions

This study makes small but significant contributions to the theory and practice of drought mitigation and adaptation planning. By integrating the principles of a Drought-Ready Community (Svoboda et al. 2010), a leading document in drought planning, into the local comprehensive land use planning mechanism, this study develops a measurable model with specific indicators to enhance local jurisdictions' drought preparedness through land use planning. This application empirically documents the gaps between drought mitigation and adaptation and local land use planning and provides insights into how to improve these plans. Local jurisdictions can reduce drought hazard risk by understanding the areas in which their plans are deficient. Additionally, other local jurisdictions across the nation or even the globe can use this comprehensive model to assess their efforts in drought mitigation and adaptation so as to improve the quality of their local comprehensive plans.

The findings of this study have identified very low awareness of drought in these local comprehensive plans, and hence, the awareness must first be enhanced so as to improve local drought preparedness in the long term. The general low awareness might be due to drought's slow on-set characteristics, lack of universal definition, difficulty in quantifying severity, and largely nonstructural and spatially extensive impacts (Hayes et

al. 2004; Wilhite 2011). Therefore, local planners, emergency managers, and decision makers would be less willing to allocate money and resources for drought mitigation and adaptation. In addition, the lack of state mandates for drought mitigation throughout the U.S. could be another reason for local low awareness. Although FEMA established DMA 2000, which urged local jurisdictions to develop hazard mitigation plans in order to receive funds for disaster recovery, drought mitigation plans have not been mandated. Thus, it is imperative for all levels of government to fill the coordination gaps and clarify their responsibilities so as to enhance local drought awareness and preparedness.

This study found that local drought risks were minimally analyzed in existing local comprehensive plans. Since how droughts affect localities varies from region to region, local jurisdictions must identify impacts and indicators of drought to understand their local vulnerability and to predict future events so as to prepare and act beforehand. The extreme weakness of drought analysis in these local plans might be partially due to the availability of reliable information associated with drought being scattered across the Internet, such that local planners would be less likely to devote limited budgets and time resources to this effort. However, since the Drought Impact Reporter (DIR) and National Integrated Drought Information System (NIDIS) were launched in the 2005 and 2007 respectively, the lack of information gap has already been filled but none of these

counties have recognized such efforts in their newly adopted or revised comprehensive plans. Although previous study has developed a simplified model to conduct drought risk analysis for local planners, but little evidence was observed in these local comprehensive plans. Localities should move away from the current crisis management approach to drought management that heavily relies on the emergency management to respond to drought disasters toward a more proactive, risk-based approach that addresses droughts through comprehensive planning to build local drought resilience as well as reduce risks in the long term.

This study also found that current local comprehensive plans relied heavily on a narrow set of traditional regulations, such as land use restrictions and land acquisition. Nevertheless, other innovative practices are largely overlooked by the majority of the local jurisdictions sampled. Newer techniques such as water-conserving building codes, green infrastructures, and water-efficient landscaping and irrigation can effectively protect and preserve our water resources so that local jurisdictions increase their water availability as well as reduce their drought risks. Since most actions are water-oriented, local plans pay little attention to drought hazards. The lack of hazard-oriented actions may be significantly due to these counties' weak drought awareness and analysis. In addition, the poor coordination between multiple governmental agencies with

responsibilities for responding to drought conditions could have been enhanced to clarify localities' responsibility in drought planning (Wilhite 2011). Third, the local jurisdictions' dependence on government programs to rescue them by providing resources may also discourage local self-motivated actions (Wilhite 2011). These related issues regarding droughts must be seriously considered and it is imperative for all levels of governments to act before future losses and impacts arrive.

Chapter 8 Study Limitations and Future Studies

While this study provides a great understanding of local drought planning, it is just a start for the topic, and research limitations do exist.

The most obvious limitation in this study is the relatively small research sample. Only 61 local comprehensive plans were analyzed out of 100 fastest growing counties in the U.S. These plans, while being somewhat representative, are limited in fully understanding the capacity of jurisdictions in drought mitigation across the nation. Additionally, only one county (Fort Bend County) out of ten counties in Texas, which is regarded as the core component for its severity and frequency in drought, was analyzed in this study due to their lack of comprehensive plans in place. Future studies should explore more local jurisdictions and research the differences among these state planning laws and their influence on drought planning at local levels.

In addition, limitations do exist in the plan quality evaluation method. By using the same criteria within each plan component, the indicator-based scoring protocol ignored each plan's difference. Assuming all indicators to be equally significant might neglect the fact that some are more important and therefore influenced the overall scoring results. Future study should further explore the significance of each indicator. Moreover, since

this study is the first one in evaluating localities' capacity in drought mitigation and adaptation through land use planning on a national basis, only 33 general broad indicators were developed to examine local jurisdictions' drought preparedness through land use planning. Given the hypothesis that they are generally weak in drought preparedness in their land use plans and developing indicators that can hardly be found in the plans makes little sense; therefore, we do not develop indicators to measure their preparedness in specific sectors like agriculture and industry but broad indicators that can be applied in all sectors like water-conservation irrigation, identify drought prone areas and vulnerable sectors (could be agricultural lands if they are vulnerable to droughts at their regions), and establish water-conservation incentives to measure their plans' overall quality in drought planning preliminarily. With raised awareness, reliable analysis, and effective actions, local jurisdictions will be able to develop better plans and improve their drought preparedness through mitigation and adaptation efforts. As a result, future studies should include more specific indicators to precisely measure their capacity. Lastly, the readers of this paper shall notice that the protocol are mainly developed by the leading literatures in drought planning and adjusted to local land use planning frameworks to help local land use planners, stakeholders, and decision makers to understand their strength and weakness in drought preparedness through land use planning. All the indicators in the

protocol are not necessarily recommendations because not all ideas are appropriate in all cases. Therefore, only 33 general indicators were developed to preliminarily examine their drought preparedness through land use planning across the nation. Future studies could focus on specific regions to develop a more region-based protocol for evaluation and recommendations.

Third, the study only analyzed local comprehensive plans to measure their drought preparedness, while most local jurisdictions' efforts with drought mitigation and adaptation in other plans (e.g., hazard mitigation plans, climate action plans, water resources plans, watershed plans, and emergency management plans) could be ignored. In future studies, the authors will measure local drought preparedness from a broader perspective, which takes all the plans and efforts into consideration.

Fourth, although the three-step evaluation procedure was applied to increase the reliability of the study to great extent, personal bias may still exist. Although it is impossible to eliminate such personal bias in content analysis, future study could have more statistical evaluation to generate more accurate results as well as findings by comparing and revising the individual results.

Lastly, there might be some limitations on the selected jurisdictional variables in the correlation research that led to no significant findings. Local drought planning and its

comprehensive planning frameworks are subject to multiple factors and the selected data sets were limited and their data quality might also vary. Therefore, to further understand their planning processes and capabilities it may need to conduct a mail survey, online survey, or phone questionnaire to have an in-depth understanding on the issue.

Chapter 9 Conclusions

This study found that most local jurisdictions failed to incorporate drought mitigation and adaptation into their local comprehensive plans. The results demonstrated these fastest growing counties' continuing or even increasing vulnerability to droughts because of their unpreparedness for drought in the land use plans. Previous literature has provided a strong basis for localities to improve drought preparedness and identified various obstacles such as lack of awareness and a weak drought database that discouraged local actions. However, given the fact that people are starting to realize the serious impacts of droughts because of the recent drought disasters, as well as efforts to improve the drought database, little evidence was found in this study that these local jurisdictions were paying more attention to drought hazards in their comprehensive plans. From a top-down planning model, federal and state governments failed to provide incentives and guidance for local jurisdictions to act against drought hazards. Thus, as the first study in examining local drought preparedness through land use planning on a national basis, this paper found that the lack of federal and state efforts in drought mitigation and adaptation planning directly resulted in local jurisdictions' weak drought coping capacity through land use planning. Federal and state governments must clarify

their responsibilities in drought planning and enhance their planning capacity from reactive response-oriented emergency planning toward the proactive risk-oriented comprehensive planning. Their leading roles in coping with droughts will undoubtedly improve localities' awareness and thus result in developing better local lands use plans to enhance local drought preparedness.

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Appendices

Appendix 1 Research Sampled Information

Growth Rank	State	County	Adoption Year	Plan Name	Population
1	FL	Flagler	2010	Comprehensive Plan 2010-2035	95696
2	FL	Stumer	1992	Comprehensive Plan 2008	93420
3	AZ	Pinal	2009	Comprehensive Plan	375770
4	GA	Paulding	2007	Comprehensive Plan 2007-2027	142324
5	IL	Kendall	1994	Land Resources Management Plan 2011	114736
6	GA	Forsyth	2004	Comprehensive 2004-2025	175511
7	GA	Henry	2009	Comprehensive Land Use Plan 2030	203922
8	VA	Loudoun	2001	General Plan 2011	312311
9	FL	Osceola	2006	Comprehensive Plan 2025	268685
10	GA	Newton	2008	Comprehensive Plan Adopted in 2008	99958
11	CO	Douglas	2008	Comprehensive Master Plan 2030	285465
12	GA	Cherokee	2008	Comprehensive Plan adopted in 2008	214346
13	UT	Washington	2009	The General Plan	138115
14	GA	Barrow	2008	Comprehensive Plan 2007-2027	69367
15	NC	Union	2010	Comprehensive Plan 2025	201292
16	NC	Brunswick	2007	Land Use Plan	107431
17	GA	Jackson	2010	Comprehensive Plan 2030	60485

19	IN	Hamilton	2006	Comprehensive Plan	274569
20	CO	Broomfield	2005	Comprehensive Plan	55889
21	FL	St. Johns	1990	Comprehensive Plan 2025	190039
22	MS	DeSoto	2004	Comprehensive Plan	161252
23	FL	Lee	2011	The Lee Plan	618754
24	MN	Scott	2009	Comprehensive Plan 2030	129928
25	TN	Rutherford	2010	Comprehensive Plan adopted in 2011	262604
26	FL	St. Lucie	2010	Comprehensive Plan adopted in 2010	277789
27	FL	Walton	2011	Comprehensive Plan 2007	55043
28	WA	Franklin	2008	Comprehensive Plan	78163
29	GA	Walton	2007	Joint Comprehensive Plan	83768
30	OR	Deschutes	2011	Comprehensive Plan 2030	157733
31	SC	Horry	2008	Comprehensive Plan 2025	269291
32	IN	Hendricks	2006	Comprehensive Plan	145448
33	GA	Coweta	2006	Land Plan 2006-2026	127317
34	ID	Canyon	2005	Comprehensive Plan 2010	188923
35	GA	Douglas	2004	Comprehensive Land Use Plan	132403
36	AL	Baldwin	2009	Comphrehensive Plan 2008-2025	182265
37	MN	Wright	2009	Land Use Plan 2009	124700
38	FL	Lake	2010	Comprehensive Plan Planning Horizon 2030	297052
39	NC	Mecklengburg	1997	2015 Plan	919628
40	MO	Christian	1993	Comprehensive Plan 2009	77422
41	VA	Prince William	2008	Comprehensive Plan	402002

42	TX	Fort Bend	1998	Comprehensive Plan	585375
43	MN	Sherburne	2011	Comprehensive Land Use Plan 2010-2030	88499
44	SC	Beaufort	2007	Comprehensive Plan	162233
45	NC	Wake	2003	Land Use Plan	900993
46	VA	James City	2009	Comrehensive Plan	67009
47	WI	St. Croix	2008	Comprehenesive Plan	84345
48	VA	Stafford	2010	Comprehensive Plan 2010-2030	128961
49	CA	Placer	1994	General Plan	348432
50	GA	Effingham	2004	Comprehensive Plan	52250
51	UT	Utah	2006	General Plan	516564
52	GA	Gwinnett	2009	2030 Unifies Plan	805321
53	SC	York,	2009	2025 Comprehensive Plan	226073
54	MN	Carver	2010	Comprehensive Plan 2030	91042
55	UT	Tooele	1994	General Plan	58218
56	NC	Iredeel	2009	2030 Horizon Plan	159437
57	KY	Boone,	2005	2010 Comprehensive Plan	118811
58	FL	Clay	2009	2025 Comprehensive Plan	190865
59	WV	Berkeley	2006	Comprehensive Plan Update	104169
60	VA	Spotsylvania	2008	Comprehensive Plan	122397
61	FL	Indian River	2010	2030 Comprehensive Plan	138028

Appendix 2 Plan Coding Protocol

Plan Component	*Indicators*
1. Awareness	1.1 Local perception of drought and water shortage 1.2 Historical records of drought 1.3 Population growth and impacts 1.4 Recognition of state drought plans 1.5 Existing water-related regulations/codes/plans 1.6 Water conservation/efficiency goals 1.7 Public awareness and education campaign
2. Analysis	2.1 Water supply sources inventory 2.2 Identify water uses 2.3 Identify water supply status 2.4 Identify how previous drought affect local community 2.5 Identify drought prone areas and vulnerable sectors 2.6 Identify local climate 2.7 Identify local drought triggers and indicators 2.8 Current water usage and future demand projection

3. Actions	*3.1 Coordination*	3.1.1 Coordination within jurisdiction 3.1.2 Coordination beyond jurisdiction
	3.2 Land Use Policies	3.2.1 Land use restrictions from watersheds 3.2.2 Land acquisition to preserve integration of watersheds 3.2.3 Green infrastructures 3.2.4 Mix-used and compact development
	3.3 Water Conservation Regulations	3.3.1 Water-saving building codes 3.3.2 Water-efficient irrigation 3.3.3 Drought-resilient landscaping 3.3.4 Restrictions in some urban water uses 3.3.5 Improve water system efficiency 3.3.6 Wastewater recycle and reuse
	3.4 Financial Tools	3.4.1 Water Pricing 3.4.2 Establish water conservation incentives
	3.5 Implementation	3.5.1 Establish drought leadership team 3.5.2 Prioritize water related programs 3.5.3 Identify feasibility of actions 3.5.4 Continuously monitor, assess, and update

Appendix 3 Variables' Measurement

Variable	Measurement	Scale	Data sources
Dependent variables			
plan quality	The total score of each local plan quality	3.2-20.1	Evaluation and calculation
Capacity Variables			
Number of planners	All planners in the county planning department	1-38	Phone calls and E-mails
Plan age	The year that the plans was adopted (measured by the number of years passed since 1990)	0-21	Local comprehensive plans
State guidance	Measure by the form and status of the State drought plans: 0 (States with no drought plans); 1 (State drought plans still under development); 2 (States with response based drought plans); 3 (States with mitigation based drought plans).	0-3	http://drought.unl.edu/Planning/PlanningInfobyState.aspx
Risk Variables			
Previous drought losses	The total economic losses in US dollars (in 1000 units) for drought events from 1995-2011 (by 1000 units)	0-20139	Spatial hazard events and losses database for the United States (SHELDUS): http://webra.cas.sc.edu/hvri/products/sheldus.aspx
Water usage	Estimated use of water in the United States at the county level for 2005 in total (by 1000 units)	5-2664	US Geological Survey: http://water.usgs.gov/watuse/data/2005/index.html
Growth rate	Population growth from 2000 to 2010 (at percentages)	22-138	Calculation (Census 2000 and Census 2010)

Contextual Variables			
Education	Population 25 years or over that had a bachelor’s degree or higher (by 1000 units)	3.2-187.6	Census 2000
Income	Family median income (in 2000 inflation-adjusted dollars) (by 1000 units)	37.0-88.5	Census 2000
Population	Population in each county in 2010 (by 1000 units)	52.3-919.6	Census 2000

Appendix 4 Means (M), Standard Deviations (SD), and Correlations among Contextual Variables and Plan Quality

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1.Plan total	9.45	3.38	1.00												
2. Awareness	3.50	1.33	.869[b]	1.00											
3. Analysis	2.21	1.33	.755[b]	.487[b]	1.00										
4. Actions	3.74	1.45	.848[b]	.667[b]	.401[b]	1.00									
5. Planners	5.70	6.84	.073	.048	-.023	.147	1.00								
6. Plan age	15.97	5.22	-.017	.002	-.128	.076	-.119	1.00							
7. State leadership	2.20	.65	.004	-.034	.024	.018	-.058	.026	1.00						
8. Drought losses	2675.82	4187.69	-.109	-.084	-.022	-.157	-.008	-.004	.064	1.00					
9. Water usage	238.36	481.35	-.117	-.175	.051	-.159	.357[b]	-.173	.017	.076	1.00				
10. Growth rate	50.77	21.73	.100	.111	.110	.032	-.113	-.176	.099	-.085	-.014	1.00			
11. Education	30.01	39.03	-.105	.012	-.140	-.127	.442[b]	-.174	.117	.067	.373[b]	-.041	1.00		
12. Income	56.11	12.63	-.113	-.049	-.138	-.093	.171	-.094	.066	.183	-.150	-.007	.274[a]	1.00	
13. Population	217.93	194.33	-.151	-.103	-.111	-.156	.455[b]	-.116	.084	.133	.508[b]	-.074	.838[b]	.221	1.00

[a] Significant at the .001 level (2-tailed), [b] Significant at the .005 level (2-tailed).