Local Planning Response for Enhancing Resilience in Drought-prone Small Cities and Towns

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Abstract

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Intensifying droughts due to climate change are increasing competition for water among different uses in communities. This growing competition will have implications for local development and sustainability. Among all actions related to water-sensitive growth, water conservation is most indicative of local response to drought risk, and its consideration in comprehensive plans suggests the community's commitment towards building resilience to future water shortages. This research focuses on planning response for building resilience to droughts in the context of small cities and towns. It includes a study of water conservation consideration in comprehensive plans from a representative sample of 114 drought-prone small cities and towns in the contiguous US. It uses content analysis comprising of alternate approaches to resource-intensive manual-based coding for identifying water conservation discussion in local plans and includes a descriptive analysis of the nature of this discussion. It

also applies inferential analysis to determine potential factors that can inform the level of water conservation consideration in the plans.

Analyses in this research demonstrate the utility of *Efficiency* and *Convergence* measures to compare alternate coding methods and to determine the most suitable approach for identifying references related to a concept in plans. These findings will facilitate the use of less resource-intensive coding approaches in plan analysis, allowing larger sample sizes to improve the generalizability of results. Examination of the nature of water conservation discussion reveals a much higher proportion of references related to policies and implementation mechanisms than supporting information, with a potential disconnect between policies/implementation discussion and supporting information for some water conservation concepts indicating implications for plan quality. The analysis also reveals patterns in the utilization of implementation mechanisms and provision of implementation details for water conservation strategies that can affect their application in smaller jurisdictions. Finally, findings from regression analysis suggest economic vulnerability, local capacity, and the state's focus on drought mitigation as potential factors that affect the level of water conservation consideration in the plans. These findings have implications for how long-term planning for water conservation should be approached and enabled in smaller jurisdictions to improve resilience in the face of growing water scarcity.

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DEDICATION

Dedicated to my family

Chapter 1. INTRODUCTION

1.1 BACKGROUND OF THE PROBLEM

Drought is characterized by prolonged periods of below-average precipitation. It is responsible for diminished productivity and economic losses across various sectors, making it one of the costliest natural disasters in the US (Smith, 2020). The consequences of drought extend beyond immediate agricultural concerns, affecting diverse sectors, such as water supply, energy production, tourism, infrastructure, and even public health (NDMC, n.d.). Furthermore, droughts can foster conditions leading to other environmental issues, such as wildfires (Merzdorf, 2019), habitat degradation (Drought.gov, n.d.), and saltwater intrusion (USDA, 2020).

Climate change has been identified by scientists as a critical factor in exacerbating the negative impacts of extreme natural events (Calvin et al., 2023). In the case of droughts, climate change can intensify water scarcity due to increasing temperatures that affect precipitation, soil moisture, and snowpack (Parker, 2023). Such intensifying droughts can increase the competition for water among different uses in a community and will have implications for its development and sustainability. Consequently, there is an urgent need for local jurisdictions to pursue water-sensitive growth. Improving resilience to droughts through local development planning provides a key opportunity to manifest such growth.

In the US, most municipal jurisdictions create comprehensive plans to determine strategies to fulfil their collective vision for long-term development. Consideration of resilience to droughts in these plans provides an understanding of community's intentions towards managing its drought risk. Building resilience to drought involves actions related to water conservation, preserving water quality, drought preparedness, compact development, and considering climate change impacts.

Among these actions, water conservation is most indicative of a community's response to drought risk in its long-term development plans. While other strategies are either related to multiple planning objectives (as in the case of water quality, compact development, and consideration of climate change impacts) or are more likely part of strategic planning efforts (as in the case of drought preparedness). Hence, this research focusses on observing water conservation consideration in comprehensive plans to study local planning response for building resilience in drought-prone communities.

Additionally, the study of resilience consideration in local planning of small cities and towns is most lacking among all jurisdictions. For this research, small cities and towns are defined as smaller and nonprimary (when considering metropolitan regions) incorporated areas with powers to conduct long-term planning and comprising of urban or suburban context. Only a few case studies or regional studies discuss how these jurisdictions around the world are gearing up to tackle extreme natural events. These jurisdictions typically lack planning capacity and resources, which can act as significant barriers for improving their resilience (Cross, 2001; Hamin et al., 2014). Their economic dependance on natural resources can also make them more vulnerable to droughts. Hence, there is a pressing need to analyze approaches for building resilience to droughts in small cities and towns. Such analyses should consider the unique context of these jurisdictions, which is different from large metropolitan cities.

1.2 PURPOSE OF THE STUDY

This research lies in the overlapping domain of three topics: 1) Planning for drought impacts; 2) Resilience in small cities and towns; 3) Content analysis of plans. These topics highlight the issue, context, and methodology of this research (Figure 1.1).

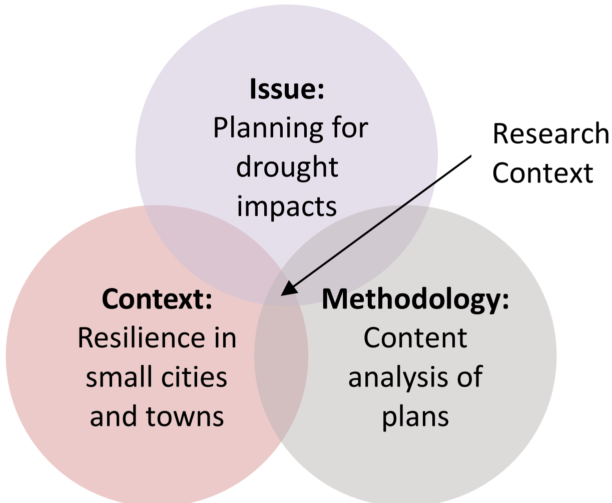


Figure 1.1. Three core domains for this research (Author's diagram)

This research aims to address a crucial knowledge gap by providing insights related to planning for resilience in long-term development of drought-prone small cities and towns. This study specifically focuses on analyzing consideration water conservation in comprehensive plans of these jurisdictions. To achieve this, content analysis of development plans from drought-prone jurisdictions has been used to assess the nature of water conservation consideration. This research also explores the application of alternate methods to the traditional manual coding-based method for content analysis and reports on the suitability of their use in plan evaluation based on coding protocols. Furthermore, using regression modelling the research unveils potential factors that can influence the level of water conservation consideration in plans of these jurisdictions.

1.3 Statement of the Problem

The primary goal of this research is to analyze water conservation consideration in long-term development planning of drought-prone small cities and towns of US. This will be achieved through the following objectives:

1. Examining comprehensive plans of these jurisdictions to study the nature of discussion on water conservation consideration using context-based themes inspired by plan analysis literature.
2. Studying a larger sample of plans by using alternate coding methods for identifying references related to water conservation.
3. Identifying potential factors that can influence the level of water conservation consideration in comprehensive plans of these jurisdictions using inferential analysis.

1.4 Research Questions

This research aims to answer the following questions:

1. What is the nature of water conservation consideration in drought-prone small cities and towns.
   a) In what context(s) has water conservation been discussed in comprehensive plans of these jurisdictions? How are the discussions under different types of contexts related?
   b) What are the types of mechanisms used for implementing water conservation strategies in these plans? To what extent are implementation details provided? What potential reasons can explain the type of implementation mechanisms used and the provision of implementation details?
2. How to use plan analysis themes to study discussion of concepts under a specific topic?
3. How to judge the performance of alternate coding methods and determine the most suitable method for a plan evaluation study?
4. What are the local characteristics that can affect the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns?

5. What are the regional setting characteristics that can affect the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns?

1.5 SIGNIFICANCE OF THE STUDY

Drought losses are accrued gradually and can have a high price tag over time. In fact, droughts have the second highest cumulative losses from disasters that costed more than a billion dollars since 1980, which is second only to losses from tropical cyclones (A. B. Smith, 2020). These losses are increasing with time due to warmer temperatures and higher variability in precipitation due to climate change. Increasing water scarcity during droughts also intensifies competition for water resources across all sectors, which leads to higher exposure of non-agriculture uses to droughts. Additionally, increasing population in urban areas exacerbates the impact of water scarcity due to droughts. As urban areas expand, the demand for water increases, and water resources become even more scarce. This leads to a further increase in competition for water resources between different sectors.

For addressing a community's risk to droughts, it is important to consider its impact on water availability in development planning. Resilience to droughts should be mainstreamed in different planning areas, such as land use, infrastructure development, and environmental planning. Comprehensive plans have a unique role to play in guiding future development in a jurisdiction and in considering long-term sustainability of its operations. This research will explore how resilience to droughts is incorporated into local comprehensive plans.

While the impact of droughts in US is becoming increasingly apparent, the extent to which small cities and towns are considering resilience to these events in their long-term development plans is largely unknown. Existing analyses of resilience considerations in planning have mostly focused on larger cities or counties, leaving small communities underrepresented. Better understanding related to consideration of water conservation strategies for mitigating, managing, and adapting to water shortages in drought-prone small cities and towns can help policy makers comprehend the applicability of these measures in the context of smaller jurisdictions. Furthermore, knowledge related to factors behind consideration of water conservation strategies can help policymakers at regional levels take more informed decisions for fostering resilience to droughts in small cities and towns. Findings from this research may also help engineers, designers, and planners to develop water conservation strategies that are more suitable for managing water resources and demand in small cities and towns to address increasing drought severity.

Lastly, in terms of methodology, this research uses content analysis to study consideration of resilience to droughts in local comprehensive plans. Traditionally, content analysis of plans is completely dependent on manual coding, which makes it extremely resource-intensive. This is the main reason why studies that involve content analysis are usually limited to small samples. Also, increased dependance on manual coding leads to a high level of subjectivity in identification of relevant references and their categorization in plans, which may introduce bias and errors in the analysis. Researchers typically address these issues by using inter-coder reliability measures, which require even more resources. Therefore, there is a need for methodological advancements to make reliable content analysis less resource-intensive. To address this gap, alternate methods to the traditional manual coding-based method will be used in this research to explore their performance and suitability for plan evaluation.

1.6 Definition of Key Terms

- 5A themes: These themes refer to the 5As, including Awareness, Analysis, Aspirations, Actions, and Application. These themes are related to different discussion contexts and are inspired from plan analysis literature. For more details see Section 3.6.3
- Alternate coding method: Alternate methods to manual-based coding (or labelling) of data. For example, Machine Learning (ML) and Boolean Query-based coding methods that were applied in this research.
- Comprehensive plans: A documentation of a jurisdiction's goals and policies (usually for the next 20-years) along with supporting information to realize its collective vision for development. The plan addresses development under different physical, social, and economic aspects of community life in the jurisdiction.
- Content analysis: A methodology used to study plans and other types of qualitative data based on coding (or labelling) of data under key concepts (or codes).
- Codes: Concepts related to the area of interest. In this research codes depict concepts related to water conservation defined as per the protocol for content analysis.
- Coding: Labelling of data under concepts (or codes). In this research, deductive coding has been used to label data based on a predefined protocol.
- Development plans: Plans outlining goals and policies for growth and improvement of living conditions in a jurisdiction.
- Droughts: Conditions characterized by prolonged periods of below-average precipitation.
- Drought risk: Potential future impact of droughts for a jurisdiction characterized by a combination of severity of droughts, exposure and vulnerability of the jurisdiction to drought conditions, and its capacity to plan and prepare for such conditions.

- Drought-prone jurisdictions: Jurisdictions that have experienced high drought severity and those anticipated to experience a decrease in precipitation in future.
- Long-term development plans: Growth of an area over a longer period of time. Comprehensive plans are a type of long-term development plans for the next 20-years (usually) to fulfil a community's vision.
- Level of water conservation consideration: The extent on water conservation in plans depicted by the aggregated value of scored references.
- Nature of water conservation consideration: Qualitative aspects of water conservation discussion in the plans (such as the context of references and implementation of strategies).
- References: Excerpts from the data
- Relevant references: Excerpts from the data labelled (or coded) under a concept (or code) related to the area of interest, which in this case is water conservation
- Resilience: Ability of a community to endure extreme events. Resilience to droughts has been defined for this study as a community's ability to endure extended periods of water shortages without lasting effects on its everyday operations and growth.
- Small cities and towns: Smaller (with population below 50,000) and nonprimary (when considering metropolitan regions) incorporated areas with powers to conduct long-term planning and comprising of urban or suburban context.

1.7 Dissertation Chapter Details

This dissertation is structured into five chapters, each addressing a key aspect of the research problem and contributing to the overall analysis of resilience development in drought-prone small cities and towns. This section outlines the main focus and content of each chapter:

- Chapter 1: Introduction – This chapter provides a brief background on the impacts of drought and research related to resilience in the context of small cities and towns. It lists the main goals of this study and the research questions that will be addressed. It also summarizes the potential broader impacts of this research and notes key definitions and assumptions applicable for this research.
- Chapter 2: Literature Review – This chapter includes description existing theories that will be used to study and understand planning response of drought-prone small cities and towns. Using existing research, it briefly addresses consideration of resilience in local planning and approaches used to study this phenomenon. It discusses the use content analysis for plan evaluation and research gaps associated with it. It also describes planning and resilience in the context of small cities and towns and the lack of scholarly works in urban planning addressing this context.
- Chapter 3: Research Methods – This chapter explains the key tasks undertaken to address research questions posed for this study. It illustrates the operationalization of the theoretical framework to collect and analyze data for this study. It provides an overview of the content analysis approach adopted for this study, which includes application of alternate methods to the traditional manual coding-based method. It also describes how qualitative analysis of discussion on water conservation consideration was performed and the modelling approach that was adopted to explain the level of water conservation consideration in comprehensive plans.
- Chapter 4: Results and Discussion – This chapter includes a description and discussion of results from analyses conducted in this study: 1) Performance evaluation of alternate coding methods (Section 4.1); 2) Examining discussion on water conservation consideration in

sampled plans (Section 4.2); 3) Determining potential factors that influence the level of water conservation consideration in the plans (Section 4.3).

- Chapter 5: Summary, Implications, and Outcomes – This chapter summarizes the key findings from this research and discusses their broader impacts on planning for resilience in small cities and towns and plan evaluation methodology. It also discusses assumptions from the research methodology that have implications for validity and reliability of results from analyses undertaken in this study and includes recommendations on how these issues can be circumvented in future research.

Chapter 2. LITERATURE REVIEW

This chapter provides a brief description of existing theories related to resilience concept and process, policy diffusion, and risk determinants that will be applied to study the planning response in drought-prone small cities and towns. It illustrates the connections between these theories and how they can be used to study resilience consideration. It also provides a review of existing research related to drought risk and the role of climate change in exacerbating its impacts, key strategies recommended for water conservation, incorporating resilience in long-term development plans of local jurisdictions, use of content analysis in plan evaluations, application of alternate coding methods in content analysis, and resilience in the context of drought-prone small cities and towns. The chapter emphasizes gaps in existing literature that will be the focus of this study.

2.1 Theoretical Framework

2.1.1 *Resilience Conceptualization and Contextualization*

There is no single universal definition of resilience. Resilience to external stressors has been studied by scholars from infrastructure systems, ecology/complex-systems, psychology, and emergency management field perspectives. There are nuanced differences between these different field perspectives in terms of their focus on spatial, political, and temporal aspects related to resilience. Resilience conceptualization can be studied in terms of these aspects to understand its application and potential outcomes. Scholars have previously used the different aspects of resilience to contextualize resilience perspectives, especially to discuss power dynamics and inequity behind developing resilience ("resilience of whom") (Cretney, 2014; Cutter, 2016a). Meerow et al. (2016) and Meerow & Newell (2019) proposed a framework involving the five Ws ("resilience for whom, what, when, where, and why?"). This framework considers who influences the decisions, resilience to what disturbances is considered, whether resilience (short-term or long-term) to sudden or gradual events is being studied, resilience of which entity is prioritized, and what is the main purpose behind building resilience. This framework adds multiple considerations to study resilience and can be very useful in contextualizing resilience application for a problem setting, but it lacks comprehensiveness in terms of reflection on the resilience perspective being used, such as how resilience is perceived and manifested.

From an emergency management perspective, resilience is a holistic approach that can be used to understand a community's ability to endure extreme events. Mileti (1999) defines "local resiliency" as the ability of an area "to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life and without a large amount of assistance from outside the community." Building community resilience to an extreme event includes improving a community's physical, social, economic, environmental, cultural, and institutional aspects that influence its ability to plan for, respond to, and recover from its impact. Overall, resilience provides an optimistic outlook by moving the focus away from community's vulnerabilities to an extreme event towards building its capacity for managing impact and recovery. It is an action-based approach that allows communities to build their ability to endure extreme conditions. In this research, resilience has been used to characterize the endurance of local communities to drought conditions. An augmented version of five Ws framework has been utilized later in this chapter to contextualize resilience application in this study.

2.1.2 *Embeddedness of Resilience Process*

Communities exist in the larger global, national, and regional contexts that have an impact on their functions. At the same time, individuals and households are the building blocks of a community and collectively determine its performance. Gunderson & Holling (2002) describe this “nestedness” of functions at different scales as “Panarchy.” Due to this interconnectedness between scales, resilience at community level depends on both internal and external factors (Berkes & Ross, 2016). In the case of community resilience at municipal level, we can imagine the cities and towns as a socio-ecological system with its adaptive cycle going through the four stages of growth (“exploitation”), stabilization (“conservation”), collapse (“release”) and rebirth (“reorganization”) (Figure 2.1a). Cities are connected to systems functioning at larger scales (Figure 2.1b), such as at regional (eg: transportation systems), national (eg: foreign policies), and global (eg: climate change) levels. Cities also comprise of systems functioning at smaller scales, such as at neighborhoods (eg: community organizations), household and individual (eg: lifestyle choices) levels. Links between community resilience to systems at different levels should be kept in mind to understand how communities can withstand extreme events since the adaptive process of the community depends on the feedback from both larger scale and smaller scale systems. Literature from psychology/social work has focused on how resilience at community level supports individual and household well-being and vice-versa (Van Breda, 2001). Based on the theory of *Panarchy*, while studying resilience to extreme events such as droughts, scholars should consider that communities operate within broader contexts and that their functioning is determined by the individuals and households that comprise them (Figure 2.2).

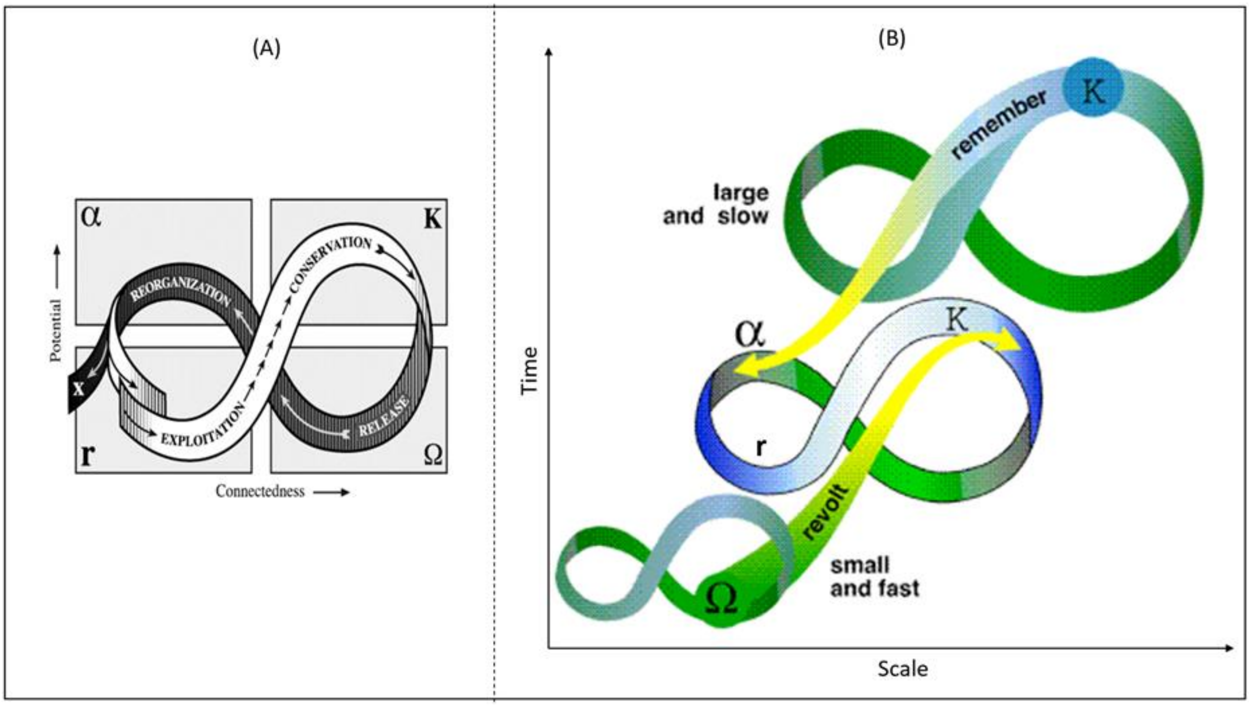


Figure 2.1. (a) Adaptive cycles (Gunderson & Holling, 2002, pp 34) (b) Impact of adaptive cycles of systems operating at different time and scales (Resilience Alliance, 2010)

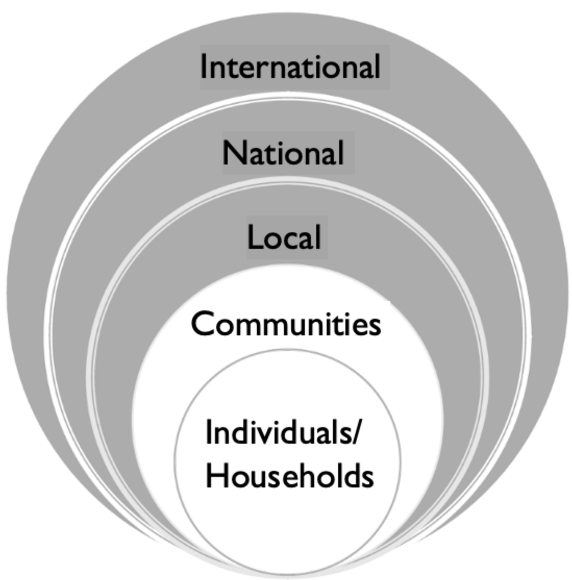


Figure 2.2. Resilience process structure. Image showing resilient societies using systems perspective (Shimizu & L. Clark, 2019, pp 94) adapted by the author

The embeddedness of resilience processes has implications for developing resilience at the local level to extreme events, especially since these impacts transcend jurisdiction boundaries. Top-down policies and actions from global/national/regional level can affect local resilience. For example, international climate agreements or federal climate action policies can promote or impede local/regional climate adaptation and mitigation. Policy actions at higher levels are usually addressed at community level by adaptation (Berkes & Ross, 2016) or by revolt. These implications suggest a power imbalance in the form of limitations experienced by local agencies in influencing top-town actions for their resilience. Communities particularly lack power and agency to affect policies and actions at the global level (Robards & Greenberg, 2007). Similarly, small cities and towns lack influence on regional policies as they are not involved in policy-making processes at the regional level to the same extent as other jurisdictions (Dobbin & Lubell, 2021), even though, they are disproportionately impacted by top-down policies due to their lack of capacity. Hence, considering the implications of top-down policies and actions on resilience to extreme events in these jurisdictions is particularly important. In this research, the concept of embeddedness of resilience process has been used to understand the influence of external factors (such as state level policies and planning) on resilience development in smaller jurisdictions. The bottom-up implications for resilience at the community level have been used to understand the role of internal factors (such as economic dependance on natural resource sector and planning capacity) that capture the combined individual/household vulnerability and capacity to plan for droughts as a community.

2.1.3 *Policy Diffusion for Improving Resilience*

Policy diffusion is a phenomenon to understand policy adoption by government entities. The phenomenon has its roots in the field of political science and can be defined as “when one government's decision about whether to adopt a policy innovation is influenced by previous choices by other governments" (Graham et al., 2013). This phenomenon has been studied for a long time with foundational literature based in late 1960s, which was inspired by theories of "interpersonal influence" on innovation and diffusion of ideas among individuals (Crain, 1966) and organizations. Since then, this phenomenon has been used to study adoption of policies (Walker, 1969). It is specifically useful in studying adoption of policies at the local level to understand how policy ideas get propagated across cities and towns or from higher to lower levels of government.

Shipan & Volden (2008) have identified four key "mechanisms" of local policy diffusion in literature: 1) Learning; 2) Competition; 3) Imitating; 4) Coercion. It can be difficult to differentiate between the role of some of these mechanisms towards policy adoption. Hence, it is important to clearly define the differentiating factors to parse the mechanism behind a policy adoption. Furthermore, in certain cases a single mechanism is not enough to explain policy adoption and therefore multiple mechanisms may be used to understand adoption dynamics.

The first mechanism of "learning" describes when cities and towns get to know about successful policies adopted by other jurisdictions to address an issue of interest. For example: Case studies of GSI (green stormwater infrastructure) contributing towards flood management in similar or nearby jurisdiction. Learning can transcend geographical boundaries. Cities and towns learn from both nearby and far off places, though the role of neighboring jurisdictions in influencing learning has been emphasized in existing literature (Berry & Berry, 1990). Diffusion through learning can be more likely if the policy in question is successful (measured through impact or continued application) in addressing an issue (Shipan & Volden, 2008). The second mechanism of "competition" can co-occur with learning. It refers to policy adoption by a jurisdiction in fear of losing its value (or attractiveness) to another. Geography is considered as a key distinguishing factor between learning and competition, with competition being described as an influence mostly from nearby jurisdictions (Berry & Baybeck, 2005). For example: a city or town fearing negative consequences may offer similar tax rebates as nearby jurisdictions to attract businesses. Both learning and competition are related to the concept of "horizontal diffusion" that denotes the "inter-governmental pressure" affecting policy adoption by a jurisdiction (Daley & Garand, 2005). Previous studies on environmental policy adoption at the state level have operationalized learning and competition by identifying potentially influential neighbors. These include nearby states that have adopted similar policies (Matisoff, 2008) or are members of organizations that facilitates peer to peer learning (Dolšak & Sampson, 2012). The third mechanism of "imitation" is also difficult to differentiate from learning and competition. It refers to adoption of policies followed by other jurisdictions to simply be like them, without deliberating on its process or consequences (Shipan & Volden, 2008). For example, when a jurisdiction decides of adopt policies being followed by a regional leader (usually a larger city), without thinking about its potential for success based on its own context. A key motivation for imitation is to improve a jurisdiction's competitiveness or attractiveness in the region. Imitation can be distinguished from competition, when there is a clear leader and follower when comparing policy adoption among jurisdictions. The fourth mechanism of "coercion" has a clearer distinction from other mechanisms. It refers to policy adoption in response to actions at higher levels of government or more powerful government entities. This mechanism taps into the concept of "vertical diffusion" of policies that denotes the "external pressure" due to top-down government actions, which plays an important role in policy adoption at the lower levels of government (Daley & Garand, 2005). Coercive policy adoption can be observed from local jurisdictions' response to state mandates or federal acts. For example: local jurisdictions prepare and adopt hazard mitigation plans to satisfy requirements set by FEMA to get non-emergency aid (FEMA, 2024). Essentially, these four policy mechanisms provide conceptual basis for discussing the nuance behind policy adoption. Researchers can use them to understand and describe the dynamics behind local decision-making.

There is a rich body of literature on adoption of policies by local jurisdictions for developing resilience. Scholars have previously studied policy adoption to develop resilience at local level as a result of programs or mandates at state or federal levels in the US (Butler et al., 2021; Berke et al., 2012). They have also discussed policy adoption, specifically related to climate change mitigation, as a result of participating in Trans-municipal networks (TMNs) (Krause, 2012; Rashidi & Patt, 2018). These studies do not use the policy diffusion framework, but discuss mechanisms similar to coercion and learning. At the same time, some scholars have used the policy diffusion framework to study how external influence can play a role in a jurisdiction's planning for resilience (Nohrstedt & Nyberg, 2015; Noonan et al., 2018). More recently, multiple scholars have studied policy diffusion of climate change adaptation across jurisdictions at different levels of government (An et al., 2022; Schoenefeld et al., 2022; Kang et al., 2023). These studies have used policy diffusion theory to explain adoption of hazard mitigation and climate adaptation strategies. However, these studies are confined to a particular state, international context, or focus only on larger cities. In this research, policy diffusion theory has been used to specifically understand the influence of external factors on consideration of resilience to droughts in smaller jurisdictions. The role of coercion (vertical diffusion) has been studied using variables related to state level planning and policies. Whereas, the role of learning/competition/imitation (horizontal diffusion) has been studied using regional location-based variables.

2.1.4 *Risk Determinants and Resilience*

For developing resilience to an extreme event, such as drought, the planning response by a jurisdiction needs to be proportional to its risk associated with that event. The United Nations Office for Disaster Risk Reduction (UNDRR) defines disaster risk as “The potential loss of life, injury, or destroyed or damaged assets (due to an extreme event) which could occur to a system, society or a community in a specific period of time” (UNDRR, n.d.). The Intergovernmental Panel on Climate Change (IPCC) defines risks in the context of climate change impacts as “The potential for adverse consequences (of climate change impacts or human response to climate change) for human or ecological systems, recognizing the diversity of values and objectives associated with such systems” (Reisinger et al., 2020). They explain "adverse consequences” as how climate change impacts may affect “lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species” (ibid). Based on these definitions, there are multiple dimensions of how an extreme event may affect a community. These dimensions are related to determinants of risk from that event.

In emergency management, risk to a jurisdiction (from an extreme event) is typically represented as the interaction between the severity of the hazard, jurisdiction’s exposure, its vulnerability or susceptibility to the event, and its capacity to withstand the event (UNDRR, 2017). Severity of the hazard represents the intensity of the “process, phenomenon, or human activity” (ibid) associated with an extreme event that can cause losses and disruptions. Exposure represents the potential impact on physical and natural assets due to an extreme event. Vulnerability of a jurisdiction is represented by its socio-economic characteristics that make it inherently more predisposed to the adverse impacts of an extreme event (ibid). Whereas, capacity of a community is represented by its assets or resources (such as institutional and community resources) or by its population characteristics that indicate its ability to manage and recover from an extreme event (ibid). Given this information, to understand a jurisdiction's planning response for building resilience to an extreme event, it is important to consider the different determinants of its risk associated to that event.

Community attributes that affect a jurisdiction's risk can help explain their level of planning response to improve resilience. These attributes are related to the local built and natural environment, social and economic characteristics, and municipal capacity (Cardona et al., 2012). Some of these attributes are similar to the internal factors discussed in Section 2.1.2. Incorporating risk determinants to understand resilience has some advantages (Logan et al., 2022). This is because the risk perspective includes a comprehensive set of attributes to explain potential loss that includes the community and population vulnerability and capacity, as well as hazard severity and physical exposure. Whereas, resilience is a capacity-oriented perspective and does not have a high emphasis on physical exposure and hazard severity. Planning response by a jurisdiction to build resilience is influenced by the potential severity of extreme event and its exposure (Smit & Pilifosova, 2003), along with its ability to absorb and manage impacts of that event. Hence, all determinants of risk should be included to understand local planning response for building resilience. In this research, risk determinants have been used to understand the influence of internal factors on consideration of resilience to droughts in smaller jurisdictions. Based on this theory, hazard and exposure was included along with economic vulnerability and planning capacity (identified under embeddedness of resilience process) to study the role local characteristics on resilience consideration.

2.2 Review of Existing Research

2.2.1 *Drought Impacts and Role of Climate Change*

Drought is typically characterized by the nature of its impact. There are five different kinds of droughts (Drought.gov, 2021): 1) Metrological; 2) Hydrological; 3) Agricultural; 4) Socio-economic; and 5) Ecological. Metrological drought is characterized by prevailing dry conditions in an area, hydrological droughts are associated with low water levels and supply, agricultural droughts are connected with the impact of dry conditions on crop yield, socio-economic droughts describe a phenomenon where demand and supply of goods are affected by water availability, and, lastly, ecological droughts are conditions where habitat degradation occurs due to dry conditions and low water levels. This impact-based classification of drought also has a temporal aspect, i.e. how long an area has been under drought (Wilhite et al., 2014). All droughts tend to start with lower precipitation, and gradually progress into different forms with time as certain community functions are affected by them. To assess drought-prone jurisdictions, this research will mainly focus on metrological and hydrological droughts.

Location-wise, drought is a wide-spread issue in contiguous US. The map in Figure 2.3 illustrates the number of weeks during which counties in lower 48 states have experienced extreme (D3) or exceptional (D4) droughts from 2000-2019. A D3 drought can be characterized by high crop damage and water shortages that result in major use restrictions in a community, while a D4 drought describes situations when communities face extraordinary crop damage and water emergencies due to intense water shortages (Drought.gov, n.d.). According to Figure 2.3, a number of inland counties in western, central, and southern US experience these severe drought conditions for a long period of time. But such severe droughts are also a concern for coastal counties along the central and southern portions of the west coast and the Gulf coast.

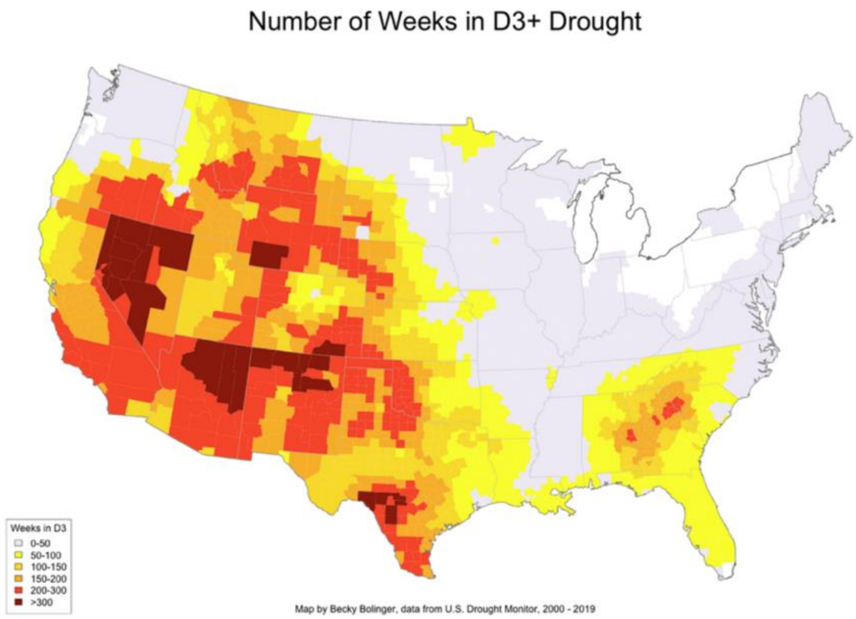


Figure 2.3. Number of weeks US counties experienced severe (D3/D4) drought (2000 – 2019) (Bolinger, 2019)

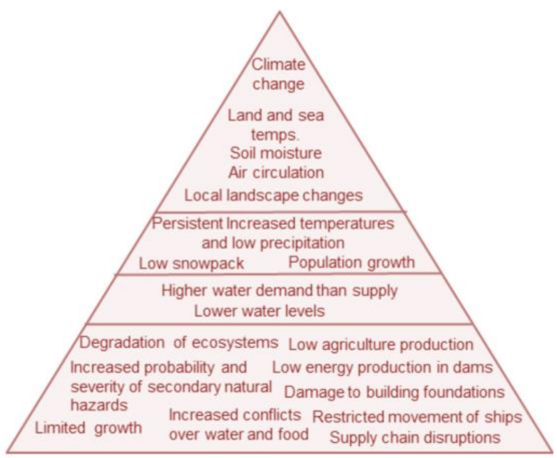


Figure 2.4. Effect of climate change-intensified droughts on different systems (author's diagram)

The assessment of drought losses in the US typically includes its impact on agricultural productivity for a community (FEMA, 2021a). This is likely because irrigation constitutes for 37% (as of 2015) of the total water withdrawal in the country (Maupin, M.A., 2018). This illustrates the high dependence of the agriculture sector on water availability and the likely cause of high losses in this sector due to droughts. The increasing frequency and severity of droughts due to climate change is expected to intensify other natural hazards and the competition for water among different uses, amplifying its impact on different sectors (Figure 2.4). This will significantly increase the repercussions of droughts, affecting not just on agricultural practices but also residential and industrial water usage, resulting in cascading social and economic impacts for communities (Naumann et al., 2021). Figure 2.5 illustrates the change in % share of losses across multiple sectors from 2015 to 2100, accounting for future rise in temperature due to climate change in different regions of Europe. It highlights the increasing share of losses for sectors apart from agriculture in these regions by 2100 due to climate change intensification of droughts, which signifies the importance of expanding the scope of assessing and addressing drought losses beyond agriculture.

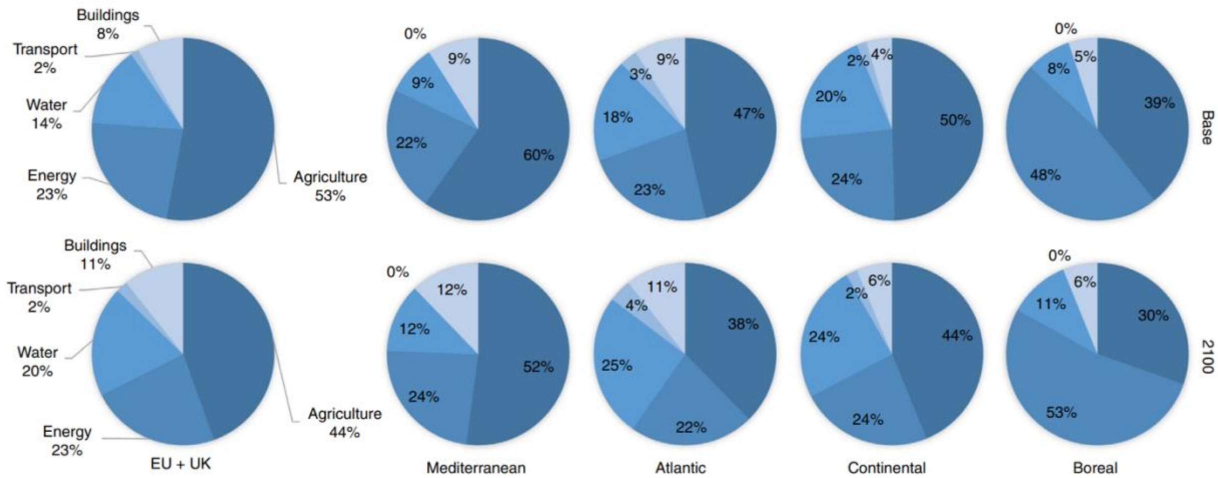


Figure 2.5. Change in sector-wise distribution of drought losses for different regions of Europe. Top pie charts represent base conditions in 2015, Bottom represents projected sector-wise share in 2100 based on impact due to average global warming expected by 2100. Source: (Naumann et al., 2021, pp 489)

The increasing share of drought losses on non-agricultural uses due to climate change should be addressed in community planning and operations. Long-term planning is an important venue for consideration of drought impacts since water availability has implications for the future growth of a city or town. In growing urban areas, water scarcity can be further exacerbated by increasing population. Hence, it is imperative for cities and towns with limited water resources to plan for future water needs in a way that takes into account the increasingly severe impacts of droughts.

Furthermore, it is important to consider the social and economic implications of water scarcity. Water shortages can have a significant impact on the well-being of individuals and communities, including their health, and livelihoods. For example: water shortages can impact tourism activities (Thomas et al., 2013). Low water levels also affect the ecosystem of water resources, which can lead to water contamination and water borne diseases (CDC, 2024). Given these implications, communities should adjust their water use behavior and businesses should re-evaluate their operations to ensure they are resilient to prolonged water shortages.

2.2.2 *Planning for Water Conservation*

Considering impacts of increasingly severe droughts in long-term community development planning by including water-sensitive growth and management is an important step for improving resilience to future water shortages. Multiple scholars have researched strategies and a number of public and non-profit organizations provide guidance to incorporate water-sensitive growth and management in local planning. Overall, strategies for building resilience to drought are related to water conservation, preserving water quality, drought preparedness, compact development, and considering climate change impact on water availability. Among all these actions, water conservation is most indicative of a community's response to drought risk in its long-term development plans. Other actions are either related to multiple planning objectives (as in the case of water quality, compact development, and consideration of climate change impacts), or are likely, to be a part of strategic planning efforts (as in the case of drought preparedness). Hence, in this research, we focus on observing water conservation consideration in long-term plans to study local planning response for improving resilience in drought-prone communities.

To successfully manage water requirements of different uses in areas with frequent water shortages, long-term planning of cities and towns should manage water demand of future development by including measures that reduce water consumption and diversify water resources. To achieve this objective, communities may invest in public water conveyance infrastructure to improve its efficiency, promote conservation practices such as low-flow fixtures, water-efficient appliances and landscaping practices, and diversify water resources through water reuse systems. Existing literature recommends strategies to promote water conservation that are usually related to five key concepts:

1. Water efficient landscaping and irrigation – This concept involves using drought-tolerant plant species and landscape design (known as xeriscape) for public and private green spaces (Wade et al., 2010; Fu, 2013). These plant species tend to be resistant to dry conditions and have low irrigation needs. Native species in drought-prone areas have similar properties and are recommended for landscaping in dry areas. Water efficient irrigation is also a key strategy to reduce outdoor water consumption. This includes using drip irrigation systems, or non-potable/reclaimed water for irrigation (Hilaire et al., 2008). Along with landscaping, these water-efficient irrigation practices can be useful in reducing water consumption in agricultural practices (Stubbs, 2016).
2. Water efficiency in buildings – This concept includes strategies for reducing indoor water consumption and improving building water system efficiency. Recommended practices include inspecting and reducing leaks and use of water-efficient fixtures and appliances (Eppig et al., 2022) and change in water use behavior (such as using less water while washing

and bathing) to be adopted even in non-emergent conditions (Rugland, 2020; O'Grady et al., 2023). A number of agencies also recommend pursuing Leadership in Energy and Environmental Design (LEED) or similar green building certifications and Water Efficiency Rating System standards for integrating water conservation in building design and operations (Rugland, 2020).

3. Water reuse – Strategies under this concept are related to diversification of water resources by reclaiming and reusing water. They are related to identifying potential uses for reclaimed water (AMEC, 2010; O'Grady et al., 2023) and developing community level water reclamation infrastructure (Cupps, 2000). Reclaimed water is often used for irrigation requirements when deemed feasible.
4. Water efficiency in public system – Strategies under this concept are related to reducing water losses in the conveyance system. This involves regular assessment of leaks in the public water system (APA, 2019) and managing pressure in the system (EPA, 2013).
5. General water conservation - This concept includes the goals related to water conservation (Schwab, 2013). It may also involve strategies that mention water conservation without pinpointing detailed actions for achieving this objective.

Existing literature also mentions multiple mechanisms for implementing water conservation strategies. These include: a) Adopting regulations such as ordinances and codes that contribute towards reducing water demand (APA, 2019; Rugland, 2020; Miller, 2019); b) Incentive and programs that encourage voluntary adoption of practices for efficient water use (APA, 2019; Rugland, 2020; O'Grady et al., 2023); c) Developing public education and awareness regarding water conservation (Schwab, 2013; APA, 2019; O'Grady et al., 2023; Khatibi et al., 2021); d) Coordination among agencies for improving water efficiency (Fu, 2013); e) Integration of water conservation (APA, 2019; FEMA, 2021b) and climate change consideration in water availability (Schwarz et al., 2011; Asinas et al., 2022) in different plans. Apart from these mechanisms, existing literature also highlights considering funding, prioritization, monitoring and other details related to implementation of these strategies (Miller, 2019; Schwab, 2013). These concepts and mechanisms for implementation from existing literature were used to develop criteria for analyzing water conservation consideration in local comprehensive plans.

2.2.3 *Consideration of Resilience in Development Plans*

Development plans play a crucial role in shaping the future growth of a community. In the US, development planning and implementation in different sectors at the municipal level is guided by local comprehensive plans, also known as general or master plans in some states (Kelly, 2012). Local communities also prepare different functional plans that can be long-term or strategic in nature. These plans tend to focus on a particular planning sector, such as transportation, housing, and economic development. At the same time, communities may also create sub-area plans, such as neighborhood master plans or corridor plans, to focus on future development of a particular area. Among these different types of plans, comprehensive plans tend to be most influential in steering the overall development of a community to achieve its long-term vision. These plans act as indispensable guidebooks for policy makers and resource managers, clearly outlining the community's priorities to inform their decision-making processes (MRSC, 2024). In practice, comprehensive plan policies steer development of local ordinances, functional plans, subarea master plans and land-use decisions (Seattle.gov, 2020, pp 18).

Comprehensive plans are an important instrument to align goals, objectives, and actions for different planning areas (Figure 2.6), which also makes these plans uniquely placed in mainstreaming consideration of issues in different planning fields. For example, consideration of water conservation in land-use planning, community facilities, critical and sensitive areas, and housing. Furthermore, these plans are usually developed keeping in mind a time horizon of around 20 years (Kelly, 2012), which makes them particularly suitable for studying resilience consideration in local policies. The impact of extreme natural events and climate change on community operations and living conditions is an important driver for future scenarios being considered in long-term planning. A wide-ranging consideration of these impacts across different planning areas can help promote sustainability and resilience in community development (Rouse & Piro, 2022).

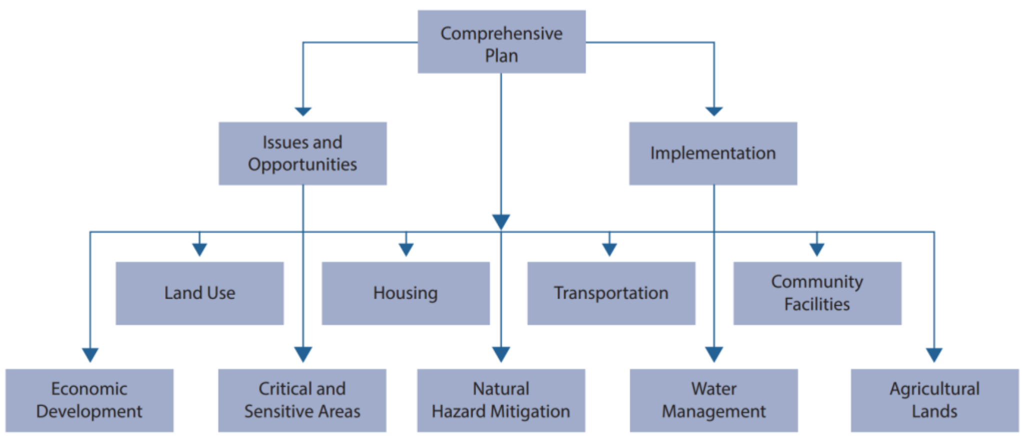


Figure 2.6. Consideration of issues across different planning areas during the comprehensive planning process facilitates integration of these issues in other local plans and policies (APA, 2019, pp 15)

Some states have passed laws that define requirements for local comprehensive plans. Local jurisdictions tend to shape their comprehensive planning process based on the state's legislative framework. Nationwide, local jurisdictions plan for resilience to extreme natural events in a separate regional level exercise at county level to prepare Hazard Mitigation Plans that are required by FEMA under the Disaster Mitigation Act of 2000 (FEMA, 2024). At the same time, most jurisdictions, especially larger municipalities develop separate Climate Action or Climate

Adaptation Plans to consider climate change impacts. Recently, a number of states, such as California, Florida and Washington, have passed laws requiring consideration of resilience to natural hazards and climate change impacts in local comprehensive plans (California SB 379, 2015; Florida SB 1094, 2015; Washington HB 1181, 2023). Multiple states require or suggest creation of specific comprehensive plan elements that address resilience to hazards and climate change by some or all local jurisdictions (APA, 2022). Some states may also require consideration of resilience in other elements of the plans (such as land use and transportation in the case of Washington). Overall, the consideration of resilience to extreme events and climate change impacts in local comprehensive plans is a growing phenomenon to help mainstream resilience across planning sectors

At present, planning for drought is addressed at the local level in comprehensive plans, functional plans (such as drought plans, hazard mitigation plans, and climate adaptation or resilience plans), and operations plans (such as emergency operations plans) (Fu et al., 2013). Not all jurisdictions develop a drought or climate adaptation/resilience plans. At the same time, policy discussion related to developing resilience to water shortages is not prevalent in local comprehensive plans (Fu & Tang, 2013). However, water management is a critical issue for drought-prone local jurisdictions due to the dominant nature of drought conditions and related challenges. Hence, it can be assumed that local comprehensive plans of such jurisdictions are more likely to address drought in development planning.

2.2.4 *Analysis of Local Planning Response for Building Resilience*

Municipal planning response for building resilience has been traditionally studied by focusing on specific functional plans. Hazard mitigation plans have been typically used to analyze resilience of local communities to extreme natural events (Frazier et al., 2013; Lyles et al., 2014; Horney et al., 2017). Whereas, planning for climate change impacts by local jurisdictions has mostly been studied by analyzing climate adaptation plans (Poyar & Beller-Simms, 2010; Tang et al., 2010; Salon et al., 2014; Shi et al., 2015; Woodruff & Stults, 2016). Mainstreaming of resilience or its integration in other planning areas has been emphasized by multiple scholars and agencies to improve implementation and increase co-benefits (Godschalk, D. R et al., 1998; Mogelgaard, K. et al., 2018; Runhaar et al., 2018; Mosso, D. et al., 2019). Despite this emphasis, very few empirical studies have analyzed local plans and policies from different planning areas to study consideration of resilience development.

Planning to improve resilience to droughts (like all hazards) should be integrated with different plans and policy sectors (Fu et al., 2013). However, studies that analyze consideration of drought risk in future development planning of local communities are rare. To address this gap, this research will focus on studying local comprehensive plans for consideration of resilience to droughts. Comprehensive plans define the long-term (10-20 year) vision for a local community and include multiple "elements" that address issues and potential actions (policies) from different planning sectors. Examination of these plans will help in improving our understanding about mainstreaming of resilience to droughts in different planning sectors related to future development.

Existing research on planning response to natural hazards risk and climate change impacts at the municipal level typically employs four types of approaches. The first approach involves surveying or interviewing municipal staff to gather data on consideration of hazard risk and climate change impacts in local plans and policies (Tang et al., 2012; Hamin et al., 2014; Shi et al., 2015; Horney et al., 2017; Gonick & Errett, 2018; Li et al., 2020). While this approach provides valuable insight, it is subject to variation in knowledge and interpretation among participants, potentially leading to less reliable findings. The second approach includes case studies that provide much deeper analysis of resilience building efforts to extreme natural events (Godschalk et al., 2003; Poyar & Beller-Simms, 2010). However, findings from these studies are usually context-specific and cannot be generalized. The third approach involves conducting content analysis of local plans by employing manual coding, which includes reading of plans by multiple researchers for identifying relevant references related to resilience themes (Tang et al., 2010; Frazier et al., 2013; Lyles et al., 2014; Woodruff & Stults, 2016; Horney et al., 2017; Lyles et al., 2018; Feinberg & Ryan, 2020). This approach tends to be more reliable than surveys and interviews but can be influenced by the researcher's perception of the issues and human errors in identification of references while reading the plans. These analyses are also resource intensive, resulting in small sample sizes that can limit the generalizability of the findings. Based on the pros and cons of different approaches, this study will apply alternate methods to manual coding that use human-assisted machine learning and Boolean search queries. These methods can help identify references related to consideration of resilience with consistent logic in a larger sample of plans than the studies that use manual coding.

2.2.5 *Content Analysis to Study Plan Quality*

Content analysis is frequently used to analyze text data. It has been particularly useful in studying plans based on pre-defined protocols (Norton, 2008). Scholars have tried to develop protocols for plan assessment for more than two decades (Baer, 1997, ibid). Plan content analysis involves developing an evaluation protocol with codes (concepts) and analyzing plans for their quality by applying the protocol. The quality is assessed based on the frequency and information depth of references identified for the codes in evaluation protocol. The use of content analysis to study the overall plan quality has a rich history. The plan quality framework developed by Berke & Godschalk (2009) forms the basis or inspiration for many studies using this methodology. This approach has been applied to study plan quality of comprehensive plans (Brody, 2003), climate adaptation plans (Woodruff & Stults, 2016) and hazard mitigation plans (Lyles et al., 2014). More recently, this methodology was also applied to study integration of issues and consistency across multiple plans (Berke et al., 2015; Keith et al., 2023).

Furthermore, content analysis is used to study the consideration of different issues in a plan document. For example, it has been previously used by scholars to study climate action in land-use plans (Tang et al., 2009; Grover, 2010) and to analyze consideration of climate change in Hazard Mitigation Plans (Stults, 2017). Scholars have also used content analysis to study integration of resilience to extreme events in comprehensive plans, such as for consideration of droughts (Fu & Tang, 2013) and flood mitigation (Kang, J.E., 2009). Overall, application of content analysis for plan quality assessment or resilience consideration has provided a systematic technique to compare plans based on evaluation criteria. It is a tested qualitative methods approach to study plans and convey consideration of a planning issue.

2.2.6 *Alternate Coding Methods*

One of the key challenges of plan content analysis is its resource-intensive nature. This is because it traditionally involves a manual coding-based method that requires researchers to read plan documents (often multiple times) to identify references and classify them under a code or a concept. Local comprehensive and other strategic plans are lengthy documents, hence manual coding based on a protocol takes considerable effort. All studies discussed in the previous section have used manual coding method and have a small sample size, which is likely due to the resource-intensive nature of this approach. Use of machine learning (ML) for studying plans provides a potential way to increase sample size by allowing targeted reading of plan documents that requires less effort than manual coding.

ML for coding qualitative data has been adopted in other fields such as communication and education. Recently, scholars have also started testing these tools for analysis of planning documents. For example, (Fu et al., 2023) applied Natural Language Processing (NLP) technique of "topic modelling" (a technique that depends on cluster of words to identify topics or themes from the qualitative data, similar to inductive coding in qualitative analysis) for determining key themes in 78 resilience plans from the 100 Resilient Cities Network. They compared the convergence of these themes with traditional method that involves manual identification of themes and found that topic modelling using NLP was more efficient than the traditional method and is successful in finding major themes, but not very useful for finding subtle themes in the plans. Similarly, Brinkley & Stahmer (2021) use topic modelling to analyze 461 general plans from California. They use the Latent Dirichlet Allocation (LDA) algorithm to conduct thematic analysis of these plans. Later, Deslatte et al. (2023) use the same tools to conduct thematic analysis of 159 comprehensive plans from Indiana. Overall, the knowledge base for using ML to analyze plans is rapidly evolving with studies that illustrate applicability of ML tools for thematic analysis. However, there are still gaps in knowledge related to the applicability of ML tools for conducting content analysis based on a pre-defined protocol.

Using NLP techniques, NVivo (a qualitative analysis software) provides an in-built feature that uses manually coded data based on pre-defined codes for "autocoding" large datasets of documents. This feature uses "term frequency-inverse document frequency" (tf-idf) vectors identified from manually coded data to look for similar vectors in other (uncoded) documents to determine relevant references (qsrinternational.com, 2014). Essentially, it tries to replicate the logic used by manual coders behind identification of references for a pre-defined code (by comparing tf-idf vectors) to automate reference identification in the whole dataset. This tool has potential for reducing resource-intensiveness of the coding process. At present, there are no studies that have applied NVivo's autocoding feature for plan content analysis. But, NVivo autocoding has been used by researchers in other fields, such as communication and education to automate identification of themes in large qualitative datasets. For example, Wright (2022) used NVivo autocoding to determine themes and sentiment in student feedback to determine patterns for informing decisions in higher education. Similarly, Pudaruth et al. (2018) use NVivo autocoding for sentiment analysis of twitter "Opposing Views" comments. Both these studies illustrate the usability and efficiency of the autocoding feature in NVivo for text data analysis. At the same time, Blaney et al., (2014) used text queries (instead of the autocoding feature) to determine key themes in student reflection essays and found that a more structured response based on prompts can improve the accuracy of coding using their approach.

Use of ML-based coding can also potentially reduce researcher bias and errors in multiple ways. This method can ensure consistent coding of documents for a single code by applying the same logic (based on training data) to each document. Specifically, the ML-based coding tool in NVivo that uses tf-idf does not learn or adapt during coding, ensuring that coding decisions for a particular code remain consistent. However, use of this tool is not completely devoid of manual coding. This tool requires manually coded dataset for pattern recognition in each code. To improve accuracy, it is recommended that the training dataset should be at least 10% of the complete dataset that is to be coded (Hai-Jew, 2014; qsrinternational.com, 2019). The quality of manual coding in the training dataset can also affect the quality of subsequent coding using this ML-based tool. Traditional methods, such as the using multiple coders, to improve coding consistency may be employed at this stage as the size of the training dataset requiring manual coding is small. This will help in reducing individual researcher bias while still minimizing resource-intensiveness of the manual coding process. Furthermore, references identified using this ML-based tool should be checked manually to ensure their relevance, as there can be many false positives. While this review allows an additional layer of supervision and reduces errors, it can also attract individual bias. Specific description defining codes in the protocol can help prevent such a bias to a certain extent. Overall, the use of ML-based tools for coding has potential for reducing the need for human resource to code large datasets. It can also help improve the reliability of the coding process as it enables consistent coding decisions and helps incorporate methods to reduce individual biases and errors in the coding process.

2.2.7 *Small Cities and Towns*

Scholarly works in urban studies have been mostly centered on large cities. There is a need for research on small cities and towns to develop a more nuanced understanding of their urban phenomena (Bell & Jayne, 2009). Small cities and towns are quite diverse in terms of their functions and context (Atkinson, 2019; Grossmann & Mallach, 2021). In the US, these jurisdictions can be municipalities in metropolitan areas that are not the primary centers, municipalities in micropolitan areas that may or may not be primary centers, or municipalities that are not located in a Core-Based Statistical Area (CBSA). Small cities and towns can also have different levels of urbanization in terms of their physical context and population agglomeration. Based on these differences, it is important to consider both regional connections and jurisdictional characteristics to define small cities and towns.

In this research, small cities and towns are defined as smaller and nonprimary (when considering metropolitan regions) incorporated areas with powers to conduct long-term planning and comprising of urban or suburban context. Based on Census Bureau data for 2021, there are 7,675 jurisdictions that fit this definition of small cities and towns. Out of these, 74.8% (5,741) of small cities and towns were located in the metropolitan areas, 17.7% (1,360) are located in micropolitan areas, and 7.5% (574) in non-CBSA areas.

a) Resilience in Small Cities and Towns

Compared to large metropolitan cities, small cities and towns are at a higher risk from extreme natural events. Multiple attributes of these jurisdictions are responsible for this higher risk. First, they typically have a higher exposure in terms of percentage area i.e., a large proportion of small cities and towns can be overwhelmed by extreme natural events (Cross, 2001). On the other hand, in larger cities exposure to natural hazard is concentrated to a comparatively smaller portion. Second, small cities and towns tend to have low capacity to manage disaster risk. They usually have low emergency response and medical services capabilities and outdated physical infrastructure (such as dykes, floodways, or culverts) to manage extreme natural events (ibid, Rumbach, 2016). Third, larger cities have better physical connectivity and have more political influence (due to their higher population and visibility to policy-makers) than small cities and towns. This is probably why larger cities are usually able to receive relief from higher levels of government more rapidly than smaller cities and towns when major disasters overwhelm these jurisdictions (Cross, 2001). Overall, higher exposure, lower institutional capabilities to manage the impact of extreme events, and lower political influence puts small cities and towns at a higher risk of experiencing catastrophic losses from natural disasters than larger cities. Hence, it is important to focus on resilience development of these jurisdictions.

When considering scholarly works on resilience, most studies have focused on larger cities (Haase et al., 2021) and urban areas (Cutter et al., 2016). These jurisdictions are more likely to plan for resilience development as they tend to have political support and higher planning capacity to assist deliberation and integration of resilience in their policies. Resilience to extreme natural events has been largely analyzed by scholars using county level hazard mitigation plans (Frazier et al., 2013; Lyles et al., 2014; Feinberg & Ryan, 2020). There are also a few studies that specifically focus on resilience assessment and planning in rural areas (Cox & Hamlen, 2015; Horney et al., 2017). However, studies focusing on consideration of resilience in smaller cities and towns in any regional context are rare. While, climate adaptation planning in coastal small cities and towns have received some attention (Hamin et al., 2014; Lehmann et al., 2021; Levesque et al., 2021), research looking at this issue in small inland cities and towns of US is almost non-existent. Additionally, existing studies on resilience of small cities and towns in US have only considered jurisdictions from a particular state or region (Hamin et al., 2014; Levesque et al., 2021) or a small sample of cities and towns (Homsy, 2018; Da Cunha & Lioubimtseva, 2021; Lehmann et al., 2021). For a better and more applicable understanding of risks and planning response of these jurisdictions to extreme natural events, a larger and more representative sample of small cities and towns needs to be considered.

b) Influence of Multi-level Actions and Risk Determinants on Resilience of Small Cities and Towns

Small cities and towns do not have high institutional capacity for managing extreme events (Cross, 2001). Literature on governance in small cities and towns indicates that local agencies in these jurisdictions have significant resource constraints (Grossmann & Mallach, 2021). Mattson & Solano (1986) provide an account of the nature of planning and professionalism followed in small towns. They explain the concept of free-standing cities traditions, which is still prevalent in the small-town political context in the US. These small towns usually have very few full-time staff, just enough to manage everyday operations. They argue that policy innovation rarely happens in small towns mainly due to less professional capacity as well as a commonly held "traditionalindividualist political outlook" that believes in less government intervention. This outlook is also applied when considering resilience to potential environmental concerns.

In the absence of resources for planning and local support for managing potential environmental concerns, external policies (such as state mandates and regional actions) can propel small cities and towns to plan for these issues. A number of research scholars have studied the impact of federal and state planning mandates and other policies on local response related to hazard mitigation and climate action planning (Lyles et al., 2014; Feinberg & Ryan, 2020; Butler et al., 2021). For example, Butler et al. (2021) found that the mandate for sea-level rise adaptation in Florida (Perils of Flood Act) promotes consideration of sea-level rise (SLR) impacts in local comprehensive planning. They argue that such mandates provide a "starting point" and a "political cover" to pursue adaptation actions. Building on this study, Holmes & Butler (2021) argue that implementation of such mandates requires actions at all levels. When coupled with local political will and commitment, and regional partnership and information sharing these mandates can drive adaptation response. Based on this discussion, potential impact of external "nudges," such as state mandates and regional climate action on the planning response of small cities and towns should be considered.

Furthermore, as mentioned in section 2.1.2, resilience of communities also depends on the ability of their residents to adapt or prepare for extreme events. This is particularly applicable in the case of rural small communities where residents tend to be more self-reliant and informed about their natural environment (Cutter et al., 2016). A few scholars have discussed cases of small cities and towns that use social capital to support planning capacity in these jurisdictions (Leetmaa et al., 2015; Meijer & Syssner, 2017). Moreover, a number of inherent attributes have also been recommended by scholars to measure community resilience to extreme events (Cimellaro, 2016;

Cutter, 2016b; Cai et al., 2018). Commonly used indicators of resilience include socio-economic attributes of the population (such as income and education) and political and institutional aspects related to the community (such as emergency response capacity, nature of local leadership, and social capital). Hence, the role of these inherent characteristics in shaping a community's collective adaptive capacity should also be kept in mind while analyzing their resilience to extreme events.

Risk determinants (section 2.1.4) are also inherent characteristics related to a community that can influence its planning response to improve resilience. The implications of these determinants can vary for small cities and towns across US. For example, in the case of jurisdictions with old downtowns and industrial areas, smaller densely populated zones are often concentrated in hazard prone locations leading to higher exposure. These higher density zones are also supported by aged infrastructure that is highly susceptible to extreme events. When observing other risk determinants, the severity of hazards can differ depending on the geographical location and natural environment of a particular jurisdiction, or due to human activities (UNDRR, 2017). At the same time, socio-economic vulnerability and community capacity can vary among different types of small cities and towns as they are influenced by population demographics, economic activities, and political and institutional dynamics. Based on this discussion, the overall level of risk will also vary across different small cities and towns, which can explain the disparity in the level of planning response in these jurisdictions.

c) Drought Impacts in Small Cities and Towns

Small cities and towns face significant challenges related to water conservation. One of the major issues is their aging infrastructure, as these communities often lack the resources to keep up with maintenance and upgrades. This can result in water loss due to leaks and less efficient water delivery systems. Additionally, the low development density context of these jurisdictions implies that each user will require more water for irrigation and maintenance purposes (Driver et al., 2003; Shandas & Parandvash, 2010), which can be further intensified by aging buildings that have less efficient indoor water system. At the same time, population pressure in small cities and towns located in growing regions can lead to outward growth of low density development, which will further stress its water resources. Overall, these inherent characteristics of small cities and towns can lead to higher water usage per capita than in larger cities that consist of comparatively smaller and newer homes and more efficient infrastructure.

Small cities and towns are also more vulnerable to severe droughts due to three key aspects. Firstly, these jurisdictions have less diversified water supplies than larger cities. They typically rely on a single water source such as a river or groundwater aquifer. This is mainly because they do not have the resources to invest in developing or maintaining multiple water sources (such as reclaimed water) or to implement backup systems in the case of an emergency. Importing water can be costly for small cities and towns (Fuller, 2021), particularly those in more remote areas, making it more difficult for such jurisdictions to ensure a reliable and affordable water supply for their residents. Secondly, economic activities in small cities and towns may be greatly affected by water scarcity as a number of these jurisdictions rely on agriculture or tourism for their sustenance. These industries are highly dependent on water availability and lack of water can lead to economic losses in these communities as well as pose significant challenges for residents who rely on these industries for their livelihoods (NIDIS/NOAA, 2021). Lastly, small cities and towns tend to have less capacity for water management. Hence, developing and implementing water conservation practices for improving resilience to water shortages can be extremely difficult for these jurisdictions.

d) Planning for Enhancing Resilience in Drought-prone Small Cities and Towns

Planning for drought risks, particularly in the context of small cities and towns, has traditionally not received much attention. The role of sprawl or low-density development that are prevalent practices in these jurisdictions on water use and quality has been studied by some scholars and agencies (Richards, 2006; Hill & Polsky, 2007; Shandas & Parandvash, 2010). More recently, scholarly works have emerged that focus on climate adaptation in smaller and mid-size cities that address water management (Özerol & Bressers, 2023). There is a need for more focused studies to understand planning for droughts in the context of small cities and towns, especially, since these jurisdictions have much higher susceptibility to prolonged water shortages than large cities. Application of the 5W resilience framework (Section 2.1.1) can be a useful way for studying this phenomenon

As resilience is a metaphorical concept, it is important to clarify its application in long-term planning of drought-prone small cities and towns. Table 2.1 illustrates how resilience can be contextualized for this problem using the 5Ws framework (Meerow et al., 2016; Meerow & Newell, 2019) supplemented with additional aspects as discussed in Section 2.1.1. Based on this framework, community members and systems are the key entities (subject) whose resilience will be studied to future droughts, which has been characterized by prevalence of dry conditions and water shortages for extended period of time (ideally for a season or more) (threat). The main purpose behind improving resilience to droughts is to conserve water resources of a community that are vital for its everyday functions and long-term sustainability (intent). Resilience over long-term to increasingly severe dry conditions and water shortages due to climate change will be observed (time), and planning for resilience in drought-prone small cities and towns from contiguous US will be the focus area for this study (context). Lastly, beyond the aspects of 5W framework, resilience to droughts has been defined as a community's ability to endure extended water shortages without lasting effects on its everyday operations and growth (perspective). Building upon this definition, planning to improve resilience to droughts in this research will include consideration of water conservation strategies in long-term development plans of a community (manifestation).

Table 2.1. Application of a supplemented 5 Ws Framework (Meerow et al., 2016; Meerow & Newell, 2019) to contextualize resilience in long-term planning of drought-prone small cities and towns

Elements	Research Context
Resilience for whom? (subject)	Community members and systems in drought-prone small cities and towns
What disturbance? (threat)	Future droughts characterized by dry conditions and water shortages for extended period
Why to enhance resilience? (intent)	To conserve water resources essential for a community's everyday functions and long-term sustainability
When resilience will be observed? (timing)	Resilience over long-term to increasingly severe drought conditions due to climate change
Where resilience will be studied? (context)	Small cities and towns from contiguous United States that are prone to droughts
How resilience is perceived? (perspective)	Community's ability to endure extended water shortages without lasting effects on its everyday operations and growth
How resilience is manifested? (manifestation)	Consideration of water conservation in community's long-term development plans

2.3 Conclusion

The chapter illustrates how theories related to resilience, risk determinants, and policy diffusion may be used to understand planning response of drought-prone small cities and towns. These theories, along with existing literature on content analysis and plan evaluation, were used to design the research framework for this study. Additionally, gaps in existing literature related to application of content analysis methodology in plan evaluations, planning for resilience in small cities and towns context, and consideration of drought risk in development plans informed the research questions described in the next chapter.

Chapter 3. RESEARCH METHODS

This chapter provides a description of research framework that includes three phases. Phase 1 includes a literature review to develop a theoretical and empirical basis for this research, while phases 2 and 3 address research questions. The chapter also provides details related to tasks undertaken in Phase 2 and 3. It describes the sample development and data collection process, coding methodology for identification of water conservation references, qualitative analysis of water conservation consideration in comprehensive plans, and inferential analysis to explain water conservation consideration in these plans based on hypotheses regarding relationships between the level of consideration and multiple local and regional setting characteristics.

3.1 RESEARCH DESIGN

This research is divided in three phases (Figure 3.1). The first phase included a literature review to develop a theoretical framework to support analysis of planning response in drought-prone small cities and towns. It was also used to determine recommended strategies for water conservation, appraise content analysis methodology and its application in plan evaluation, and articulate the research context. The literature review helped identify the knowledge gaps that informed the research objectives for the second and third phase. The second phase was related to the first two objectives (Section 1.3) of this research that included using alternate coding methods (ie. ML-based and Boolean-based coding) to identify references related to water conservation in local comprehensive plans and analyzing the nature of water conservation consideration using these references based on the context in which they have been discussed in the plans. The third phase was related to the third objective of this research, which included determining potential factors that can influence the level of water conservation consideration in a jurisdiction's comprehensive plan. The third phase was informed by water conservation references identified in the second phase.

The second phase involved tasks related to sample development and collection of comprehensive plans followed by protocol development for content analysis, examining performance of coding methods, identification of references, and analysis of water conservation consideration in the plans. The "discussion analysis" of water conservation references in the plan involved classification of references under different context related themes (explained in Section 3.5.3). It also included a deeper assessment of discussion related to implementation of water conservation strategies.

The third phase involved tasks that facilitate inferential analysis to determine potential factors that can influence the level of water conservation consideration in a jurisdiction's plan. These included scoring of relevant references identified from coding plans in phase two and data collection for independent variables and covariates that can inform water conservation consideration. Scoring of references was done based on the level of specificity of information in the reference in terms of details related to the nature of strategy and location for its application. Section 3.5.4 explains the scoring methodology and Section 3.5.5 lists variables included in the inferential analysis.

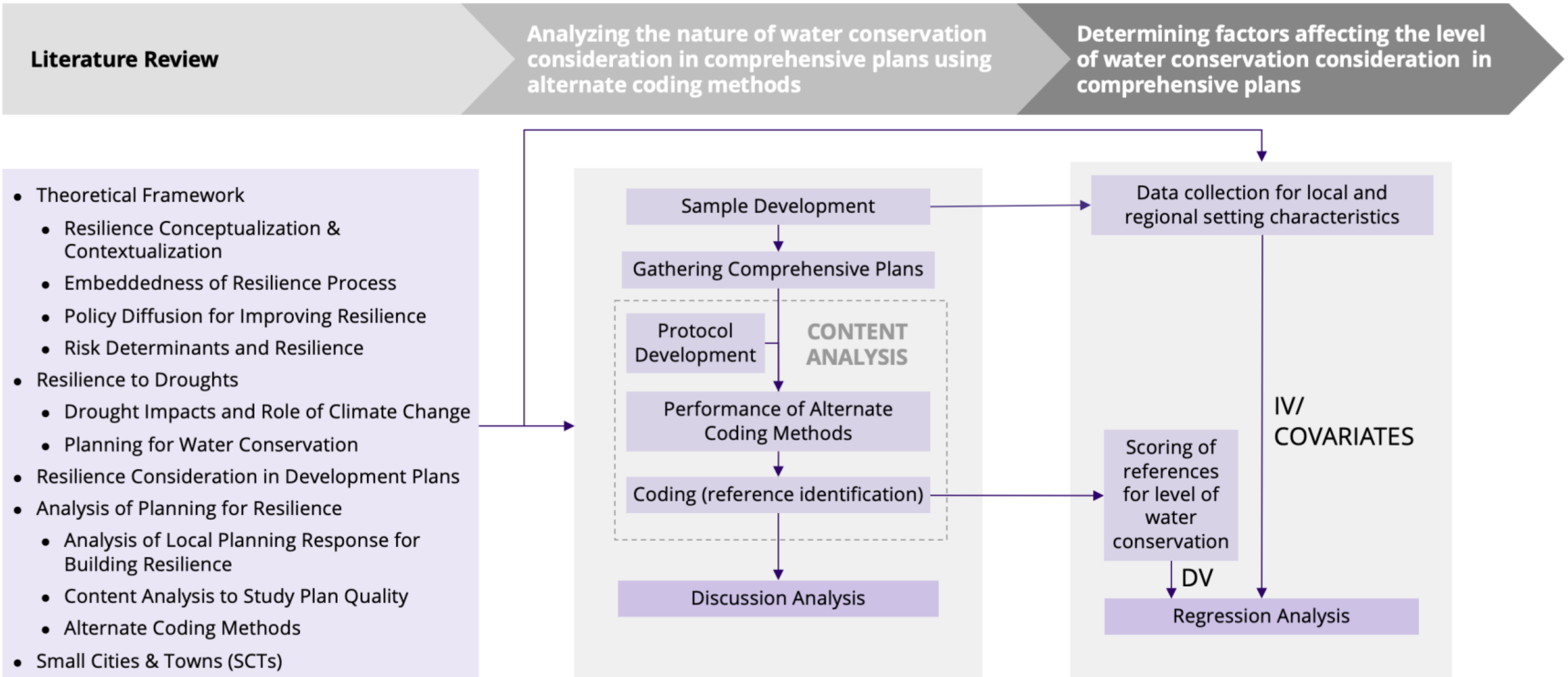


Figure 3.1. Flow-chart illustrating research design and tasks (author's diagram)

3.2 RESEARCH QUESTIONS AND HYPOTHESES

As mentioned earlier, the second phase of the research involved a qualitative analysis of water conservation consideration in the comprehensive plans. This was achieved by analyzing references identified using ML and Boolean Query-based coding methods that are potential alternatives to the traditional manual coding-based method. The tasks adopted in this phase were aimed to answer the following questions:

1. What is the nature of consideration of water conservation in drought-prone small cities and towns.
   a) In what context(s) has water conservation been discussed in comprehensive plans of these jurisdictions? How are the discussions under different types of contexts related?
   b) What types of mechanisms are used for implementing water conservation strategies? To what extent are implementation details provided? What reasons can explain the type of implementation mechanisms used and the provision of implementation details?
2. How to use plan analysis themes to study discussion of concepts under a specific topic?
3. How to judge the performance of alternate coding methods and determine the most suitable method for a plan evaluation study?

Descriptive analysis was used to determine whether consideration of water conservation follows any patterns in terms of the context in which it takes place. These contexts were based on the type of discussions usually observed in local plans. These can be related to whether a water conservation reference enhances general knowledge, applies knowledge in the local setting, identifies goals, delineates policies, or provides details related to implementation.

The third phase of the research involved inferential analysis to explain the level of consideration of water conservation by a jurisdiction in their comprehensive plans. The tasks adopted in this phase were aimed to answer the following research questions:

4. What are the local characteristics that can affect the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns?

   Below are the key hypotheses related to this question:

   a) Jurisdictions with higher hazard and exposure level, higher economic vulnerability, and/or higher capacity also have higher level of water conservation consideration in their comprehensive plans

   b) The level of consideration of water conservation in comprehensive plans is most affected by a jurisdiction's capacity when compared to the effects of its hazard and exposure, and economic vulnerability

5. What are the regional setting characteristics that can affect the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns?

   Below are the key hypotheses related to this question:

   a) Jurisdictions in coastal and inland areas have same level of consideration of water conservation when controlling for other characteristics.

   b) Jurisdictions in metropolitan areas have higher level of water conservation consideration than those in non-metropolitan areas, when controlling for other characteristics.

   c) Jurisdictions in states with drought plans that address mitigation of drought impacts have a higher level of water conservation consideration than those who are in states whose drought plans do not address mitigation. This relationship also holds when controlling for other characteristics.

d) Jurisdictions in states that have a stronger role in steering local comprehensive planning have a higher level of water conservation consideration than those that are not located in such states. This relationship also holds when controlling for other characteristics.

Potential factors that can affect the level of planning for droughts through consideration of water conservation were determined based on the theoretical framework. These factors included local characteristics related to drought hazard, exposure, vulnerability, and planning capacity. They also included regional setting characteristics related to jurisdiction's location w.r.t. the coast and metropolitan region, and their state's drought planning approach and its role in steering local comprehensive planning.

3.3 Sampling Frame

In this research, small cities and towns are defined as smaller and nonprimary (when considering metropolitan regions) incorporated areas with powers to conduct long-term planning and comprising of urban or suburban context. Following conditions were used to operationalize this definition that were applied to spatial datasets obtained from Census Bureau for the year 2021 to identify small cities and towns in contiguous US (Census Bureau, n.d.):

- Incorporated cities, towns, and boroughs with municipal planning power. This included all non-Census Designated Places (mostly cities, but includes some towns and broughs also) as well as County Sub-divisions defined by Census Bureau that are towns and boroughs from New England states, New York, and Wisconsin (Census Bureau, 2012).
- Not a Principal City in a metropolitan area as defined by the Office of Management and Budget (OMB) (Census Bureau, 2021)

- A part of Urban Areas identified by the Census Bureau that represent "densely developed" territories (Census Bureau, 2012).
- Population below 50,000, which is the minimum requirement for urban cores of metropolitan areas (Census Bureau, 2021).

To determine drought-prone small cities and towns both historical drought experience and projected impact of climate change on precipitation were considered. For the purpose of this research, drought-prone jurisdictions are defined as jurisdictions that have experienced high drought severity and those anticipated to experience a decrease in precipitation in future. Below are conditions used to operationalize this definition to identify drought-prone jurisdictions in contiguous US:

- High drought severity: The weekly county level Drought Severity and Coverage Index (DSCI) data was used in this study to determine the severity of past drought conditions in an area. This index provides a cumulative sum of weighted values of percentage area under different drought categories (1[D0] + 2[D1] + 3[D2] + 4[D3] + 5[D4] = DSCI). Weekly DSCI data was sourced from the US Drought Monitor from 2012 to 2022 (US Drought Monitor, n.d.). To determine drought severity, average weekly DSCI for summer and spring months was calculated for the 10–year period for each county, which is the minimum time period for considering drought frequency in practice (Bolinger, 2019). This county level drought severity data was later added to the small cities and towns dataset using spatial join in R statistical computing software to report the drought severity for the county with the largest overlap for each jurisdiction.
- Projected change in precipitation: The projected seasonal precipitation data was sourced for the North American region from NA-CORDEX data repository (Mearns et al., 2017).

Projections for precipitation using the model combination of Max Plank Institute (MPI) as the General Circulation Model (GCM) and The Weather Research and Forecasting (WRF) as the Regional Climate Model (RCM) for RCP 8.5 Scenario were used for this study. Summer and spring precipitation projections for the years 2071 to 2100 were extracted from the sourced multi-raster dataset and mean projected precipitation for these seasons was calculated for this 30-year period, which is also the duration used to report US Climate Normals (Arguez et al., 2012). To determine change in precipitation, the historic seasonal precipitation data was sourced from the NA-CORDEX repository. The summer and spring precipitation values were extracted for the years 1976 to 2005 (30 years before 2005, which is the latest year in the historic precipitation dataset). Mean historic precipitation for these seasons was calculated for the 30-year period. Later, projected change in precipitation was determined by calculating the difference between the 30-year mean projected precipitation and 30-year mean historic precipitation for summer and spring seasons using raster calculation in R. Change in precipitation for small cities and towns was calculated by applying Zonal Statistics on the raster for projected change in precipitation to determine mean value for each jurisdiction polygon (zone).

To determine drought-prone small cities and towns a cumulative index was created with combined information on drought severity and projected change in precipitation for each jurisdiction. To develop this index, drought severity for each jurisdiction was ranked based on quartiles, i.e. values below 25th percentile were ranked 1, between 25th-50th percentile were ranked 2, between 50th -75th percentile were ranked 3, and equal to or above 75th percentile were ranked 4. Whereas the projected change in precipitation was ranked based on a binary scheme, with jurisdictions expecting a decrease or no change in precipitation (value less than or equal to 0) ranked as 1, and those expecting an increase in precipitation to be ranked as 0. The cumulative index was calculated by adding ranked drought severity and projected change in precipitation. Based on this index, jurisdictions with values greater than or equal to 4 were considered to be prone to severe drought conditions based on the current drought severity and projected change in precipitation due to climate change. Figure 3.2 illustrates the datasets used to develop the sampling frame with all drought-prone small cities and towns in the contiguous US.

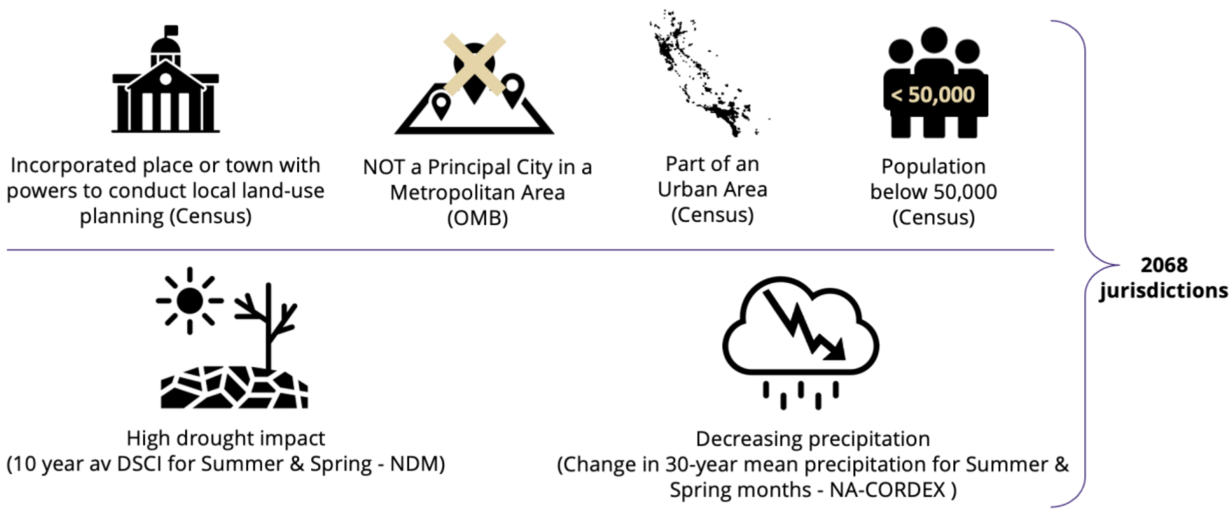


Figure 3.2. Datasets used to develop the sampling frame based on the definitions of small cities and towns and drought-prone jurisdictions in this research (author’s diagram)

The resulting sampling frame includes 2,068 jurisdictions. Appendix A illustrates the distribution of sampling frame jurisdictions by population and state. Among these jurisdictions, 60% of jurisdictions (1,222) have population below 10,000. At the same time, 39% of jurisdictions (810) are from the state of Texas, California, and Florida. To address this unequal distribution, equal number of jurisdictions were chosen for the sample from each state that contributes jurisdictions to the sampling frame.

3.4 SAMPLE DEVELOPMENT

The sampling frame identified for this research includes jurisdictions from 42 contiguous US states. As per Appendix A the number of jurisdictions from each state ranges from 2 to 363. Jurisdictions with an online and publicly available comprehensive plan from almost all states in the sampling frame were included in the sample to ensure their representation. An overall sample size of close to 100 was deemed feasible for this study, which is similar to plan analysis studies done by Fu et al. (2023) and Deslatte et al. (2023) using ML tools. This leaves about 2.4 jurisdictions per state (100/42) to be included in the sample. When deciding on a sample development approach, it was assumed that some of the states in the sampling frame may not have a drought-prone jurisdiction with an available online comprehensive plan. Hence, a maximum of 3 jurisdictions with publicly available online comprehensive plans were included in the sample from each state in the sampling frame. This approach resulted in 36 states that had 3 or more such jurisdictions in the sampling frame contributing only 3 jurisdictions to the sample, 5 states with less than 3 such jurisdictions in the sampling frame contributing all jurisdictions to the sample, and 1 state with no such jurisdictions in the sampling frame contributing no jurisdictions to the sample. Overall, this selection approach resulted in a sample with 114 jurisdictions. Figure 3.3 illustrates the location of jurisdictions in the sample across the contiguous US states. Also, Appendix B provides information related to the potential margin of error based on the sample size.

To create a sample by following the chosen approach, all jurisdictions in the sampling frame were arranged based on their FIPS code, which follows alphabetical ordering of jurisdiction names in the case of most states. The first two numbers of the jurisdiction FIPS code represent the code for the state, which also follows the alphabetical ordering of contiguous US state names. To select jurisdictions for the sample, random IDs were generated for jurisdictions in each state using the `sample()` function in R after grouping them by state. Then, jurisdictions were ordered based on these random IDs at group/state level. Jurisdictions from each state were then checked sequentially (based on the random IDs) for presence of an online and publicly available comprehensive plan by the researcher using Google Search. The first 3 jurisdictions with such a comprehensive plan were included in the sample. The validity of a comprehensive plan was also considered while developing the sample. In practice, a comprehensive plan is usually created keeping in mind a community's envisioned development over a period of next 20 years. Hence, any jurisdictions with a latest comprehensive plan older than 20 years was not included in the sample. At the same time, any jurisdiction with a joint comprehensive plan with other municipal or county jurisdiction(s) was also not included in the sample.

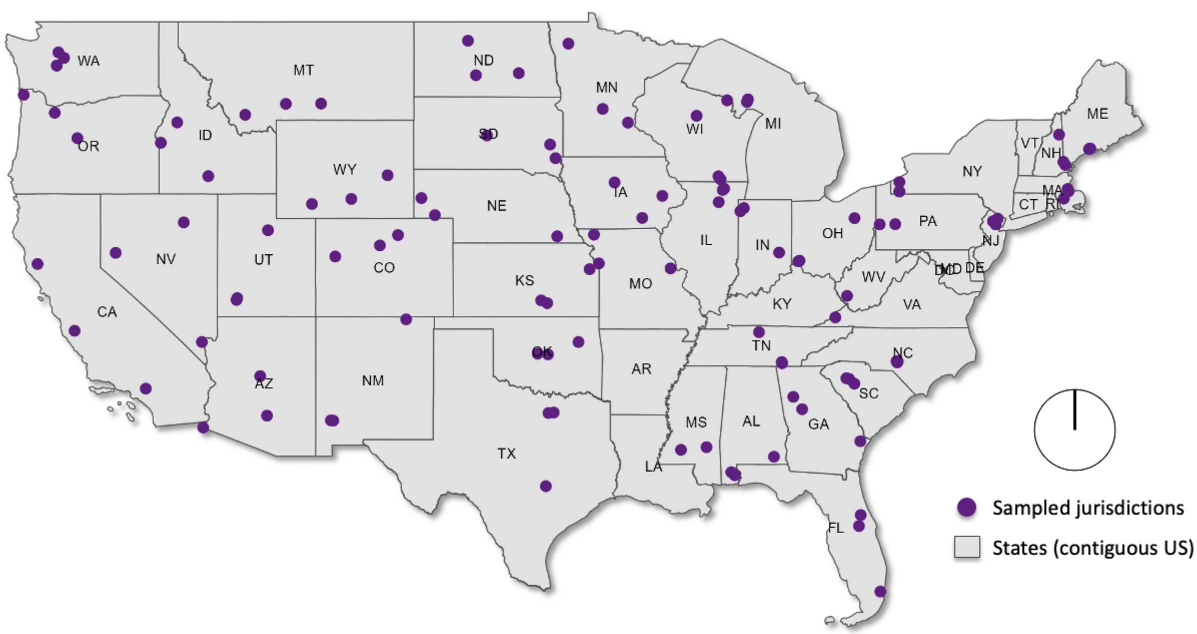


Figure 3.3. Distribution of jurisdictions included in the sample across contiguous US. Each state represented in the sampling frame has maximum 3 jurisdictions in the sample (author's diagram)

3.5 Data Collection

The comprehensive plans for jurisdictions in the sample were sourced from the municipal websites. A single plan document in PDF format was sought for every jurisdiction in the sample. For jurisdictions that had separate documents for each chapter, a combined PDF document was created in R. These plans were then used to analyze water conservation consideration in the sampled jurisdictions by using content analysis.

Along with comprehensive plans, secondary data for jurisdictions in the sample was also sourced from multiple avenues. This data was included in the analysis to explain the level of water conservation consideration in drought-prone small cities and towns in Phase 3. For local characteristics, data for drought experience was sourced from US Drought Monitor to calculate 10-year average weekly county level DSCI for summer and spring months. This data also informed the cumulative index that was used to determine drought-prone jurisdictions. Drought experience for the phase 3 tasks includes the unranked 10-year average. The DSCI value for the county with the largest overlap was used for each jurisdiction in the sample. Other local characteristics information, such as population density and employment in natural resources and food and accommodation sectors were sourced from the Census Bureau. The Social Explorer website was used to collect Census data from the American Community Survey (ACS) 5-year estimates for year 2017-2021. To report employment data for natural resource sector, percentage population 16 Years and Over employed in select natural resource dependent occupations, such as farming, fishing, and forestry was used. Similarly, to report employment in food and accommodation services sector, percentage population 16 Years and Over employed in Arts, Entertainment, Recreation, Accommodation, and Food Services sector was used for this research.

Data related to jurisdictions' capacity was obtained from municipal websites. Staff directories, planning department webpages, and in some cases comprehensive plans were used to determine total number of planning staff, which included planning and/or development director, planning managers, planners (all levels), and GIS technicians. Data for total revenue was obtained from jurisdiction's budget or annual reports from local government websites. In most cases total revenue for financial year (FY) 2023 was reported. If information was not available for 2023, the total revenue for the nearest year was used, assuming that revenue would not fluctuate in the near-term. If total revenue was not available, total expenditure or budget estimate were used instead.

Data for regional setting required spatial analysis to interpolate information at regional level to jurisdictions in the sample. To determine whether a jurisdiction is located in metropolitan, micropolitan, or non-Core Based Statistical Area (CBSA). Shapefile for CBSAs was sourced for the year 2021 from Census Bureau (Census Bureau, n.d.). A spatial intersection was conducted between the CBSA and sample dataset to report the CBSA for each jurisdiction with the largest overlap. To determine whether a jurisdiction is located in a costal or inland area, shapefile for Coastal Counties was soured from the Office for Coastal Management (2024). This data includes counties that are adjacent to the Atlantic or Pacific Ocean or have close proximity to an estuary or other coastal counties. A spatial intersection was performed between coastal counties and sampled jurisdiction polygons to determine whether jurisdictions are a part of inland or coastal areas.

Additionally, data was sourced for all 41 states represented in the sample to determine whether they focus on mitigation in their drought plans and the strength of their role in steering local comprehensive planning. State level drought plans were sourced from the state websites. Whether or not a state focusses on drought mitigation in their plans was determined based on the data from the Drought Mitigation Center (NDMC, 2023), which was also cross-checked from state drought plans using keyword mentions. Data related to the role of state in influencing local planning was obtained from the American Planning Association, 2022 Survey of State Planning Laws (APA, 2022). Particularly, the information on whether a state has statutes requiring local jurisdictions to prepare comprehensive plans was used for this analysis. Table 3.1. provides details related to data description and type for each variable.

3.6 DATA ANALYSIS

3.6.1 *Protocol Development*

A protocol for content analysis was developed based on recommended strategies for water conservation from existing literature. A code was assigned to each of the five concepts related to water conservation as described in Section 2.2.2. These codes were named Water Efficient Landscaping and Irrigation (WELI), Building Water System Efficiency (BWSE), Water Reuse (WR), Public Water Systems Efficiency (PWSE), and general Water Conservation (WC).

The protocol also identified clear rules for coding or identification of references under each code. Essentially, a description of items to be included under each code were specified in these rules. Following is the list of rules mentioned for each code in the protocol:

- References under the WELI code are related to reducing outdoor water-use. They include any mentions related to the use of native plans and other landscaping techniques to reduce water needs, use of drought-tolerant species, xeriscaping, and water efficient irrigation practices for outdoor landscape or agriculture.
- References under the BWSE code are related to reducing indoor water consumption. They include any mentions of LEED certification (or green building in general), installing low-

flow and water saving fixtures and appliances, any other practices to reduce indoor water-use, and water audits for consumers.

- References under the WR code are related to diversification of water resources through water recycling. They include any mentions of using reclaimed water and treatment of effluent for irrigation and other uses.
- References under the PWSE code are related to reducing water loss in the public water system. They include system leak detection, water audits, and any other maintenance practices or upgrades to improve system efficiency.
- References under the WC code are related to goals for water conservation and strategies that focus on reducing water use without providing specific details.

This protocol was applied to identify references related to water conservation in the plans of sampled jurisdictions. It was used to manually code some of the plans that would form the basis for applying alternate coding methods and to check relevance of references obtained from these methods.

3.6.2 *Application & Performance Evaluation of Coding Methods*

One of the questions posed in this research is how to judge the performance of alternate methods to manual coding and determine the most suitable method for a plan evaluation study. To answer this question, this study applies alternate methods to the traditional manual coding to identify references related to water conservation in the plans of sampled jurisdictions. Based on existing literature on the use of alternate coding methods discussed in Section 2.2.6, this study uses a tf-idf based Machine Learning (ML) tool and Boolean queries to identify references. Both tools are provided as in-built features in the NVivo qualitative data analysis software (QDAS), which was used in this research to apply these alternate coding methods.

To judge the performance of the alternate coding methods, it was important to evaluate their efficiency and accuracy (w.r.t. manual coding references) for identifying references related to water conservation. As the concepts under water conservation (mentioned in the previous sub-section) vary in terms of quantity (number of relevant references) and nature of vocabulary of their discussion, it was also important to identify which tool can be used in what case. Hence, a comparison of performance of these tools was also conducted to identify which tool should be applied for each water conservation codes.

Both tools required a manually coded training dataset (of plans) to determine the basis of coding for the rest of the dataset. In practice, for better performance of tf-idf based ML tool, it is recommended to allocate a minimum of 10% of the dataset for training purposes (Hai-Jew, 2014; qsrinternational.com, 2019). In this research, a training dataset with 22 plans was created, which roughly amounts to 20% of all plans in the sample (114). These 22 plans belonged to jurisdictions from states that have at least 10 jurisdictions with publicly available comprehensive plans in the sampling frame. Based on this logic, it can be said that these states have a higher proportion of plans in the sampling frame than others. In the case of each of these 22 states, the first sampled jurisdiction from the state was included in the training dataset.

A test dataset was also created to evaluate performance of alternate coding methods. In this research, a test dataset of 6 plans was used to analyze the performance. Among these, 3 plans were from jurisdictions in states that were represented in the training dataset and 3 were from jurisdictions in the states that were not. The second jurisdiction in the sample was selected from the first three states (by alphabetical order) that were represented and the first jurisdiction in the sample was selected from the first three states that were not represented in the training dataset. This structure of test dataset allowed performance evaluation of the tools for plans from the planning context (represented by states) that were included in training dataset versus those that were not.

Both training and the test dataset were manually coded as per the pre-defined protocol (Section 3.5.1). The training dataset was then used to train the “autocoding based on existing coding patterns” tool in NVivo. This tool uses term frequency - inverse document frequency (tf-idf) values to identify references, that can be calculated using Equation 1 (Aggarwal & Zhai, 2012). The tool develops a one-dimensional vector of tf-idf values for words in a code . These vectors are compared to the vectors for the sentences in the plan to identify relevant references based on a cosine similarity threshold (qsrinternational.com, 2014). A lower threshold was selected in this study than the default value to increase the number of references identified by this tool for all codes.

Equation 1:

$$tf - idf\ for\ word\ \mathrm{w}\ in\ document\ \mathrm{d}\ from\ corpus\ D = \ tf - idf(w, d, D)$$

$$= tf(w, d) * idf(w, D)$$

Where,

$$tf(w, d) = term\ frequency\ for\ w\ \ in\ d = \frac{Number\ of times\ w\ occurs\ in\ d}{Number\ of\ words\ in\ d}$$

$$idf(w, D) = inverse\ document\ frequency\ for\ w\ in\ corpus\ D$$

$$= \log\left(\frac{Total\ number\ of\ documents\ in\ D}{Number\ of\ documents\ with\ w}\right)$$

The training dataset was also used to determine important keywords in manually coded references for each water conservation code to develop Boolean search queries. To narrow down the number of references from these queries, matrix queries were used that can perform search based on a selected relationship between a combination of words in a row and column text search queries. In this case, a NEAR relationship (of 5 words before or after) was selected to search for a combination of words in a row and column queries that were separated by an OR relationship. Wildcards for multiple words were used in both the row and column queries to include multiple stems of the same word (for example, conserv* includes conservation, conserving, and conserved). Figure 3.4 shows an example of a matrix Boolean Query used in this study to identify references in the test dataset.

ACWE5 Public water system efficiency	*Row* efficien* OR leak* OR loss* OR pressure OR audit* OR improv* OR defficien* OR main OR standards OR line* OR low* *Column* water OR flow* OR detect*

Figure 3.4. Example of matrix Boolean Query used for identifying references in the test dataset (author's diagram)

References from the test dataset plans were identified for all water conservation codes using the ML and Boolean Query-based coding methods. These references were then cross-checked with the manually coded ones to determine the convergence and efficiency of both coding methods that were calculated using the Equations 2 and 3.

Equation 2:

$$Efficiency = \frac{Number\ of\ references\ identified\ using\ manual\ coding}{Number\ of\ references\ identified\ using\ ML\ or\ Boolean\ query\ based\ coding}$$

Equation 3:

$$Percentage\ of\ Convergence = \frac{\begin{array}{c}Number\ of\ references\ identified\ using\ ML\ or\ Boolean\ query\ based\ coding\\ that\ overlap\ with\ manual\ coding\ references\end{array}}{Number\ of\ manual\ coding\ references}\ X\ 100$$

3.6.3 *Classification of Relevant References*

The use of alternate coding methods results in a high number of references that are not relevant. A manual check of these references was done to identify those that are relevant to the codes based on the rules of the protocol. To analyze the nature of water conservation consideration, the relevant references were classified under different context related themes that were informed by the overarching principles from existing research on plan quality analysis. These themes refer to the 5As, including Awareness, Analysis, Aspirations, Actions, and Application. Using ideas related to plan evaluation criteria, proposed by Berke & Godschalk (2009), these themes were built upon the AAA (Awareness, Analysis, and Actions) framework that was synthesized by Luers & Moser (2006) and used by Tang et al. (2010) to analyze plan quality for climate action. The 5As correspond to the following types of references related to water conservation under the different themes:

1. Awareness: Any reference that provides generic information on a water conservation concept or existing conditions related to water usage. For example:
    a. An explanation for xeriscaping
    b. Water loss due to leakage in the system
2. Analysis: Any reference that relates a water conservation concept to water availability or reduction in water consumption in the jurisdiction. For example:
    a. Green landscaping options offer an opportunity for homeowners to reduce water consumption.
    b. Increasing water reclamation projects in the city can help reduce potable water needs.

3. Aspirations: Any reference that is part of a vision statement or goal related to water availability or conservation. For example:
    a. The town will make responsible use of its water resources
4. Actions: Any reference that describes a policy being adopted by the jurisdiction for water conservation: For example:
    a. Promote green building design concepts in the community
    b. Encourage use of recycled water for indoor and outdoor uses
5. Application: Any reference that describes a mechanism to implement water conservation. For example:
    a. Require drought-tolerant landscaping in all new construction projects in the city
    b. Assess feasibility of using reclaimed water in the city

Descriptive analysis was used to analyze the proportional frequency of references under each of the 5A themes for all water conservation codes. If a reference addressed multiple themes, it was counted under each of the relevant themes. The mean and standard deviation for the proportional frequencies were noted for all themes across the codes and used to describe the differences in the nature of discussion.

A deeper analysis of Applications theme references was also conducted. These references were further classified based on the type of implementation mechanisms they mentioned. If a reference addressed multiple implementation mechanisms, it was counted under each of the relevant mechanisms. Following are the nine types of commonly used implementation mechanisms, identified from existing literature (Section 2.2.2) and the plans, that were used to classify Applications references:

1. Assessments (includes specific studies and other related applications)

2. Requirements (includes regulations, codes, ordinances, and other related applications)
3. Programs
4. Incentives (includes rebates and subsidies)
5. Guidelines/Education (includes guidelines and educational material or activities)
6. Coordination (includes collaboration with other agencies/local residents and businesses)
7. Projects
8. Approvals/Permits
9. Other

Descriptive analysis was used to analyze the proportional frequency of references under each of the implementation mechanism for all water conservation codes. The mean and standard deviation for the proportional frequencies were noted for all mechanisms across the codes. This information was used to determine the commonly used applications for water conservation strategies. Furthermore, details related to timing, responsible agency, and funding for all Applications and Actions references were also noted. The proportional frequency of references for which these implementation details are included in the plans was calculated for both Actions and Applications under each water conservation code. This information was used to assess the depth of implementation planning for water conservation in the comprehensive plans of jurisdictions in the sample.

3.6.4 *Scoring of References*

To conduct Phase 3 analysis of this research, the qualitative information in relevant references identified in the previous section were given a numerical value for considering water conservation. Essentially, all relevant references identified under each water conservation code were scored based on the level of specificity of the information that they provided. References that provide details related to the type of strategy (what) and location of its execution (where) were classified as specific strategies and were scored as 2. Whereas, references that provided generic information related to a strategy or those that referred to strategies that were marginally related to concepts under the water conservation codes were scored as 1. This scoring scheme resulted in specific references that mostly included strategies that can be directly linked to the concepts under each water conservation code and that were recommended in the plan for adoption in the whole jurisdiction or a specific area. For example, a policy for pursuing LEED certification for public buildings in a jurisdiction under the BWSE code. On the other hand, generic references mostly included information connected to the concepts covered under water conservation codes, details related to a water conservation strategy (without recommendation for adoption), or strategies that were generic in their approach towards water conservation. For example, references related to promoting green building design under BWSE code. The scores assigned to the relevant references were later used to determine the overall level of water conservation consideration in a jurisdiction for inferential analysis.

3.6.5 *Regression Analysis*

Regression analysis was conducted in Phase 3 to explain the level of water conservation consideration by a jurisdiction in their comprehensive plans. A combined "water conservation score" representing the sum of all the scored references under each code was calculated for all jurisdictions in the sample. This score was then used to represent a jurisdiction's response to build resilience to droughts through overall consideration of water conservation in its comprehensive plan and used as the dependent variable (DV) in the regression. A number of variables related to jurisdiction's local and regional setting characteristics were included as independent variables or covariates to test multiple hypotheses that were mentioned in Section 3.2. Based on the relationship between risk determinants and resilience, as discussed in section 2.1.4, variables under local characteristics that would best represent drought hazard and exposure, economic vulnerability to water shortages, and capacity of a jurisdictions to plan for water conservation in their long-term development were selected. Table 3.1 lists variables in each of these categories.

Table 3.1. Variables under local and regional setting characteristics used in regression to explain the level of water conservation consideration in drought-prone small cities and towns

<table>
<tr><th colspan="2">Category</th><th>Variable</th><th>Description</th><th>Data type</th></tr>
<tr><td colspan="2">Resilience</td><td>Water conservation score (Dependent Variable)</td><td>Sum of all the scored references under each water conservation code in the plans of sampled jurisdictions</td><td>Numeric, Integer</td></tr>
<tr><td rowspan="6">Local Characteristics</td><td rowspan="2">Hazard & exposure score</td><td>Drought experience</td><td>10-year average of weekly county level DSCI for summer and spring months</td><td>Numeric, Continuous</td></tr>
<tr><td>Population density</td><td>Persons living per sq.mi</td><td>Numeric, Continuous</td></tr>
<tr><td rowspan="2">Economic vulnerability score</td><td>Employment in natural resource industries</td><td>Percentage population 16 Years and Over employed in natural resource dependent occupations, including Farming, Fishing, and Forestry</td><td>Numeric, Continuous</td></tr>
<tr><td>Employment in food and accommodation services</td><td>Percentage population 16 Years and Over employed in Arts, Entertainment, Recreation, Accommodation, and Food Services sector</td><td>Numeric, Continuous</td></tr>
<tr><td rowspan="2">Capacity score</td><td>Planning staff</td><td>Number of staff members in local planning departments. Includes planning or development director, planning managers, planners, and GIS Tech positions</td><td>Numeric, Integer</td></tr>
<tr><td>Total revenue</td><td>Total revenue for FY 2023 or the nearest year extracted from jurisdiction's budget or annual report. If total revenue was not available, total expenditure or budget estimate is used</td><td>Numeric, Integer</td></tr>
<tr><td colspan="2" rowspan="4">Regional Setting Characteristics</td><td>Metro/non-metro location</td><td>Whether jurisdiction is located in metropolitan areas</td><td>Categorical (Binary)</td></tr>
<tr><td>Coastal/inland location</td><td>Whether jurisdiction is located in a costal or inland area</td><td>Categorical (Binary)</td></tr>
<tr><td>State drought plan focus on mitigation</td><td>Whether the state has a drought plan that addresses mitigation of drought risks</td><td>Categorical (Binary)</td></tr>
<tr><td>State statutes requiring comprehensive plan development</td><td>Whether the state has statutes that require local jurisdictions to prepare and adopt comprehensive plans</td><td>Categorical (Binary)</td></tr>
</table>

The water conservation score (DV) has non negative integers representing the sum of individual scores (1 or 2) that were assigned to the relevant references from all plans in the sample. Given the count like nature of values for the dependent variable, a Poisson or Negative Binomial Regression could be used for this analysis. However, since the variance of the water conservation score is higher than its mean (indicating overdispersion), a Negative Binomial Regression was considered to be more appropriate for this analysis (UCLA Statistical Consulting Group, n.d.; Ver Hoef & Boveng, 2007).

A Negative Binomial Regression model is a widely accepted regression model in the field of ecology due to a high occurrence of overdispersed count data (with variance higher than the mean) representing the number of sittings, animal calls, and similar events of interest (Stoklosa et al., 2022). In this research, the level of water conservation consideration in comprehensive plans has been determined using the total score of relevant references. The score represents the level of information specificity in the reference. Based on the scoring methodology described in section 3.5.4., it can be perceived that one specific reference is worth two generic references. Hence, the overall score of water conservation consideration represents the sum of weighted counts of water conservation reference occurrences in the plans. The spread of the water conservation consideration scores for plans in the sample also suggests a negative binomial distribution. Overall, both the nature and distribution of the water conservation scores suggest that the Negative Binomial model family will be most appropriate for regression analysis in this study.

In general, a Negative Binomial regression model is used to predict occurrence of an event given by a discrete variable (Y), which in this case is the level of water conservation consideration in the local comprehensive plan (water conservation score). The model distribution is derived from the Poisson-gamma probability distribution function (PDF) (Equation 4). The traditional Negative

Binomial model assumes that the overdispersion in the Poisson model can be predicted using a Gamma distribution (Venables & Ripley, 2002, pp. 206). An unobserved variable (E) is posited to have a distribution given by gamma (θ)/θ. In this research, a generalized linear model (GLM) based Negative Binomial model has been used to explain the effects of different factors on water conservation consideration. The `glm.nb()` function from `MASS` package in R was used to run Negative Binomial regression. This model predicts a separate “Theta” (θ) or the dispersion value apart from the variable coefficients, which can be used to predict the expected variance in the water conservation scores (ibid). The predicted score (WC score) using a Negative Binomial model can be written as an additive function of the exponential form of the independent variable(s) (IV) and the covariates (CV) (Equation 5).

Equation 4:

$$Y|E \sim Poisson\ (\mu E) \qquad E \sim gamma\ (\theta)/\theta$$

Equation 5:

$$\ln\left(\widehat{WC\ score}\right) = b0 + b1 * IV1 + b2 * IV2 + b3 * CV$$

OR

$$\widehat{WC\ score} = e^{bo+b1*IV1+b2*IV2+b3*CV} = e^{b0}\, e^{b1*IV1} e^{b2*IV2} e^{b3*CV}$$

Furthermore, water conservation scores have multiple zeros. A check for zero inflation was also performed for all Negative Binomial models to see how well the models handle zeros in the observed data. The `check_zeroinflation()` function was used from `Performance` package in R to analyze whether a model is underfitting the zeros in the data. i.e. whether the number of zeros predicted using the model is less than the observed number of zeros.

3.7 CONCLUSION

The chapter describes different tasks undertaken in this research and connections between them. It explains how definitions and theoretical framework were operationalized to collect and analyze data for this study. It describes how alternate coding methods were applied in the content analysis of comprehensive plans in this research and how their performance was adjudicated. It provides an overview of the contextual themes (the 5As) that were used to analyze the discussion on water conservation consideration and implementation mechanisms that were observed in this study. Lastly, it explains the modelling approach that was used for inferential analysis to test relationships between water conservation consideration and multiple local and regional setting characteristics.

Chapter 4. RESULTS AND DISCUSSION

This chapter includes a description of results and discussion of findings from the three key tasks undertaken for this research: 1) Comparing performance of alternate coding methods and determining their suitability for coding water conservation codes in the sampled plans; 2) Analyzing water conservation consideration in sampled plans in terms of discussion context and implementation information; 3) Determining potential factors that can influence the level of water conservation consideration in sampled plans. The discussion under each section is guided by the research questions described in Section 3.2.

4.1 PERFORMANCE OF ALTERNATE CODING METHODS

Alternate coding methods were applied to determine relevant references for water conservation in the sampled plans for this research to judge the performance of these methods and determine the most suitable method for a plan evaluation study. A test dataset was constructed to check the performance of Machine Learning (ML) and Boolean Query-based coding in terms of their ability to pinpoint relevant references identified from manual coding. As mentioned in Section 3.5.2, the test dataset included 6 plans, with 3 plans from states that were represented in the training dataset and the other three plans from states that were not represented in the training dataset. References for all water conservation codes were determined using manual, ML, and Boolean Query-based coding methods for plans in the test dataset. The references from ML and Boolean-based coding were then crosschecked with those identified using manual coding to see if the alternate methods catch these relevant references. The performances of these two alternate methods were compared to determine situations where their use might be suitable for plan evaluation.

Findings from the comparison illustrate that both ML and Boolean Query-based methods identify much higher number of references than those determined to be relevant using the manual coding method. When comparing the two alternate methods, observations in Table 4.1. suggest that in the case of codes with higher manual references in the test dataset, the number of references identified using Boolean Query-based method are much higher than those identified using ML-based method. At the same time, Table 4.2 illustrates the comparison of coding methods by plans in the test dataset and does not show any correlation between number of manual references and the difference between number of references identified using ML or Boolean Query-based method. This is because the number of references across plans provides a snapshot of all references related to water conservation codes in a plan, which is why the difference between the number of references identified using the two alternate coding methods do not change trend across plans. It should also be noted that across all plans, the number of references using ML-based method are consistently lower than those identified using Boolean Query-based method.

4.1.1 *Coding Method Suitability*

While higher number of references increase that probability of capturing relevant references, it has a negative impact on efficiency of the coding method. Hence, a balance between efficiency and accuracy or "Convergence" should be kept in mind when determining the suitability of an alternate coding method for identifying references for a code. In this study, both alternate coding methods had at least 75% convergence across all codes, which was considered appropriate for this use case. Therefore, in this analysis, efficiency was mostly used to determine the suitability of the coding method for a water conservation code. The suitable method was then adopted for determining references in the remaining dataset for that code. Table 4.1. provides the convergence and efficiency values for both alternate methods for each code and the method found to be most suitable for identifying references in the remaining data. Observations show that ML-based method was more suitable to identify references for Water Efficient Landscaping and Irrigation (WELI), Water Recycling (WR), and Building Level Water System Efficiency (BWSE), while Boolean Query-based method was suitable to identify references for Public Water System Efficiency (PWSE) and General Water Conservation (WC) codes. When comparing the suitable method with number of manual references for each code, Boolean Query-based method was found to be most suitable for codes with lower number of manual coding references in the test dataset, and ML-based coding was found to be most suitable for codes with higher number of manual coding references in the test dataset. This is likely because codes with high number of manual coding references in the test dataset correspond to those with consistent reference vocabulary or high number of manual coding references in the training dataset, which form the basis for coding using alternate methods. However, this reasoning is not true in the case of WC code that has consistent reference vocabulary and comparable number manual references in the training dataset. This is probably the reason why there is also not much difference in the efficiency for ML and Boolean Query-based coding methods for this code.

4.1.2 *Convergence Analysis*

As mentioned earlier, both ML and Boolean Query-based methods have 75% or higher convergence for all water conservation codes (Table 4.1.). When comparing the performance of both approaches across different codes, convergence for Boolean Query-based method is higher or at least equal to the convergence of ML-based method. Overall, the average convergence for Boolean Query-based method is 90%, which is higher when compared to the average convergence of 83% for ML-based method. The results in Table 4.1. also suggests a positive correlation between the number of manual coding references in the test dataset and convergence for the Boolean Query-based method. On the other hand, the convergence for ML-based method fluctuates with increase in number of manual coding references and does not show a clear trend (Figure 4.1.). The diversity of topics discussed under the codes can explain low convergence from ML-based method for BWSE code, which has high number of manual coding references but also includes multiple topics. The lower convergence for WELI code is probably due to difference in patterns observed in the test dataset versus those seen in the training dataset.

A comparison of performance of alternate coding methods by plans in the test dataset was also conducted. Table 4.2. provides the findings from this comparison that suggests an overall higher convergence for Boolean Query-based method than ML-based method. The average convergence for plans in the test dataset for Boolean Query-based-method is 95%, whereas the same for ML-based method is 83%. When comparing individual plans, no trend was observed between convergence using both methods and number of manual coding references in the test dataset. However, apart from the plan from Soledad in CA, convergence was higher for Boolean Query-based method than ML-based method for all plans. In fact, apart from this plan, all plans have a 100% convergence for Boolean Query-based method. At the same time, convergence for ML-based method is equal to or above 80% for all plans apart from the plan for Southport in ME. Both Soledad and Southport plans show an abnormal behavior from the overall trend for convergence across all plans, which may be because of the nature of discussion under water conservation codes (in terms of vocabulary or strategies) that could be different from the discussion under these codes in plans from the training dataset. Furthermore, on an average, convergence for ML-based methods was found to be higher for plans whose states were represented in the training dataset (with an average of 92% for plans from AZ, CA, and CO) than those from states that were not (with an average of 73% for plans from AL, ME, and MO). This is also likely because of the difference in the nature of discussion under water conservation codes in plans from states represented in the training dataset versus those from states that were not. Jurisdictions from the same state can be expected to have similar discussions due to similar physical conditions, regional policy framework, and/or policy diffusion. As the tf-idf patterns for identifying references using ML-based method are based on the patterns found in the training dataset, difference in the nature of discussion in a plan from that in the training dataset can cause failure to identify references related to water conservation codes in that plan.

4.1.3 *Efficiency Analysis*

Apart from convergence, efficiency is also an important measure to determine the usefulness of the alternate coding methods. Overall, the efficiency of ML-based method is higher than what was observed for Boolean Query-based method. On an average, the efficiency of ML-based method is 0.09, which is higher than the average efficiency of 0.06 observed for Boolean Query-based method. Since the number of manual coding references are the same for both methods, the difference is mainly because of higher number of references (on an average) identified using Boolean Query-based method than ML-based method. When comparing methods by codes, efficiency is higher for ML-based than Boolean Query-based method for codes with higher number of manual coding references in the test dataset, whereas, the efficiency of Boolean Query-based method is higher than ML-based method for codes with lower number of manual coding references. This has been the main reason behind the selection of coding methods for this study as discussed in Section 4.1.1. Observations from Table 4.1. and Figure 4.2. suggest that there is a positive relationship between the efficiency for ML-based method and the number of manual coding references in the test dataset across different codes. On the other hand, the efficiency of Boolean Query-based method fluctuates with the increase in manual coding references across different codes and does not show a clear relationship. These observations can be explained by the direct relationship between efficiency and the number of manual references in the test dataset that is reinforced by the number of references identified using ML-based method, which is much lower than the other method for codes that have higher number of manual coding references. When comparing efficiency by plans in the test dataset, findings in Table 4.2. suggest that the efficiency of ML-based method is higher than or equal to that that of the Boolean Query-based method across all plans. The average efficiency of ML-based method across plans is 0.07, which is higher than the average of 0.04 observed for Boolean Query-based coding. This is because of higher number of references (on an average and across all plans) were identified using Boolean Query-based method than ML-based method. Efficiency for both ML-based and Boolean Query-based method increases with increase in the number of manual coding references in the plans (Figure 4.3.). This is similar to observations for efficiency using ML-based coding method when comparing across codes. In the case of Boolean-Query based method this trend may be explained by the codes for which manual references were identified in the plans. When comparing efficiency of the plans by their state's representation in the training dataset, the efficiency for ML-based method is higher for plans whose states were represented in the training dataset (with an average of 0.09) than the efficiency for those who were not (with an average of 0.05). This is because of lower number of manual coding references and higher number of references identified using ML-based method for plans from states not represented in the training dataset. The higher number of ML references could likely be due to difference in the water conservation discussion in these plans from that in the training dataset. On the other hand, efficiency for Boolean-based method does not show a clear trend based on the state's representation in the training dataset.

Table 4.1. Coding method comparison by water conservation codes

Code Name	Nature of Reference Vocabulary	Total Manual Refs in Training Dataset	Total Manual Refs in Test Dataset	ML tool references		Boolean Query references		ML-Manual Convergence[2]	Boolean-Manual Convergence[2]	Method suitable to code full dataset[3]
				Total Refs ML	ML Efficiency[1]	Total Refs Boolean	Boolean Efficiency [1]			
Water Efficient Landscaping and Irrigation (WELI)	Consistent	44	21	112	0.19	248	0.08	80.95%	100.00%	**ML**
Water Recycling (WR)	Consistent	25	9	92	0.10	138	0.07	100.00%	100.00%	**ML**
Building Level Water System Efficiency (BWSE)	Inconsistent	68	12	115	0.10	488	0.02	75.00%	91.67%	**ML**
Public Water System Efficiency (PWSE)	Inconsistent	46	6	138	0.04	51	0.12	83.33%	83.33%	**Boolean**
General Water Conservation (WC)	Consistent	42	4	198	0.02	138	0.03	75.00%	75.00%	**Boolean**
				Average	**0.09**		**0.06**	**82.86%**	**90.00%**	

1. Efficiency = Number of references identified using manual coding / Number of references identified using ML or Boolean-based coding
2. Percentage of Convergence = (Number of references identified using ML or Boolean-based coding that overlap with manual coding references / Number of manual coding references) X 100
3. If efficiency for ML is greater than efficiency for Boolean then ML-based method is chosen over Boolean-Query-based method

Table 4.2. Coding method comparison by test dataset plans

Small City or Town Plan in Test Dataset	State Representation in training dataset	Total Manual Refs	Total ML Refs	Total Boolean Refs	ML tool Efficiency[1]	Boolean Query Efficiency[1]	ML-Manual Convergence[2]	Boolean-Manual Convergence[2]
Spanish Fort, AL	No	1	42	81	0.02	0.01	100.00%	100.00%
Coolidge, AZ	Yes	19	165	167	0.12	0.11	94.74%	100.00%
Soledad, CA	Yes	11	94	223	0.12	0.05	81.82%	72.73%
Parachute, CO	Yes	1	38	163	0.03	0.01	100.00%	100.00%
Southport, ME	No	5	128	132	0.04	0.04	40.00%	100.00%
Riverside, MO	No	15	188	297	0.08	0.05	80.00%	100.00%
				Average	**0.07**	**0.04**	**82.76%**	**95.45%**

1. Efficiency = Number of references identified using manual coding / Number of references identified using ML or Boolean-based coding
2. Percentage of Convergence = (Number of references identified using ML or Boolean-based coding that overlap with manual coding references / Number of manual coding references) X 100

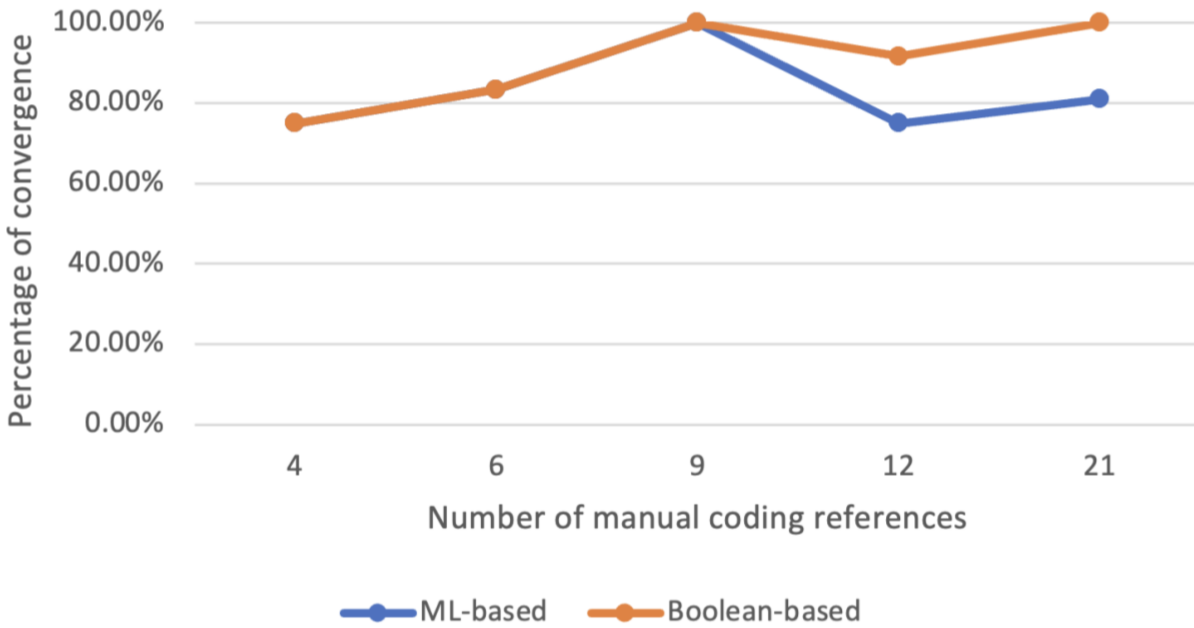


Figure 4.1. Convergence calculated for alternate coding methods versus number of manual coding references in the test dataset across different codes (author's diagram)

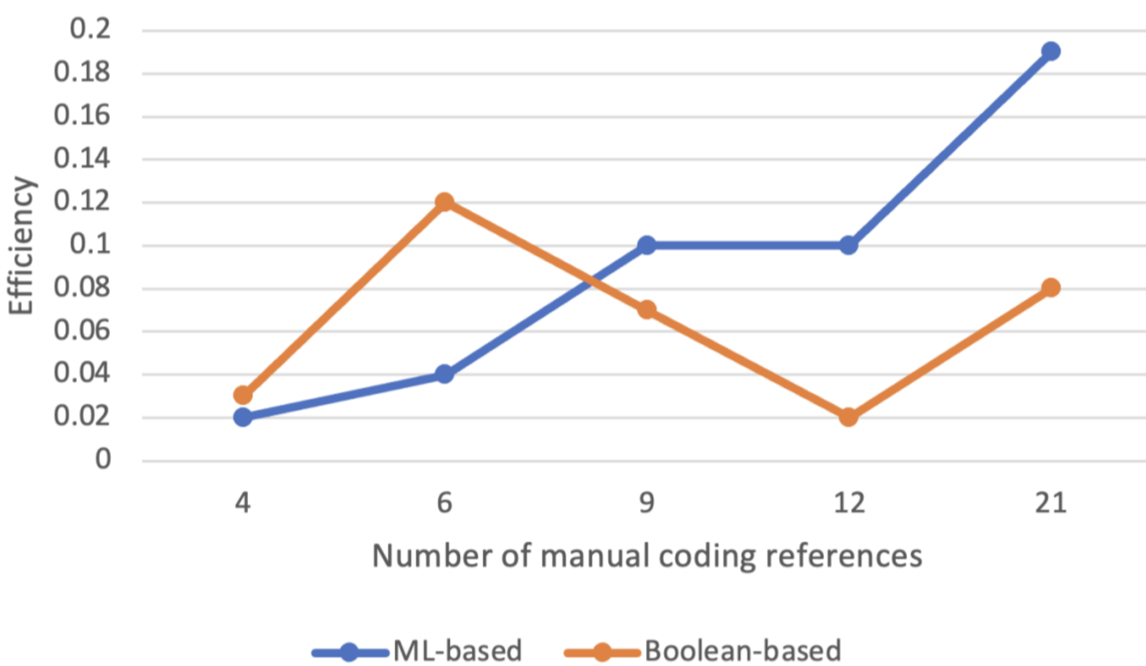


Figure 4.2. Efficiency calculated for alternate coding methods versus number of manual coding references in test dataset across different codes (author's diagram)

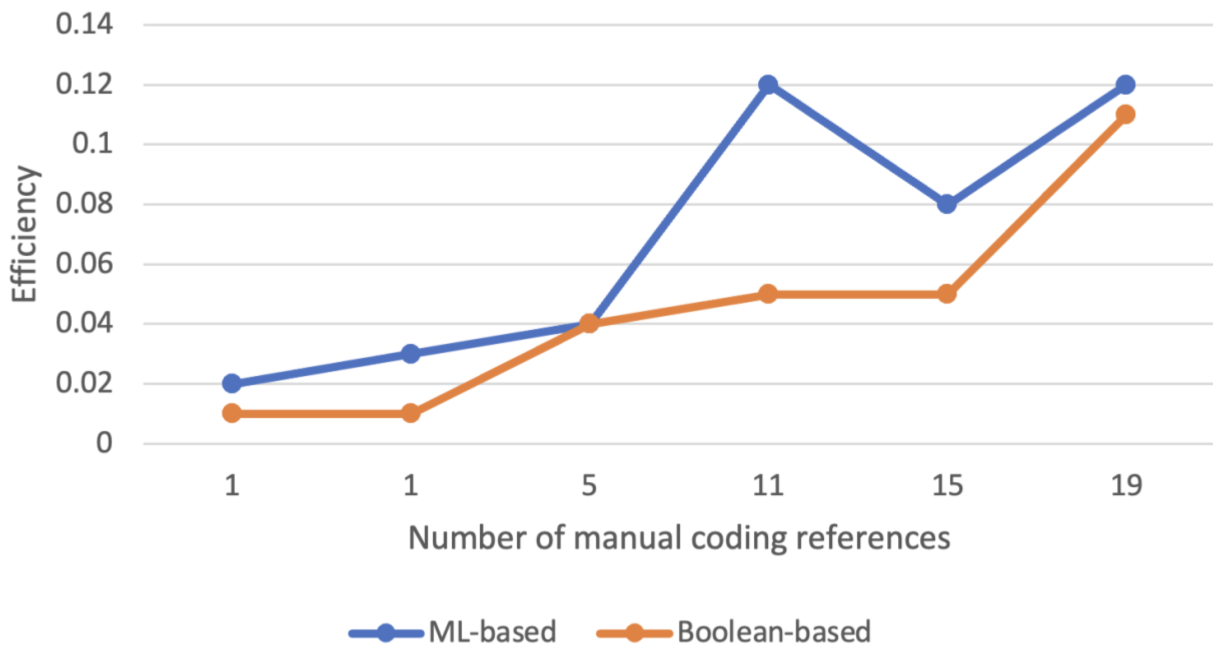


Figure 4.3. Efficiency calculated for alternate coding methods versus number of manual coding references across different plans (author's diagram)

4.2 Water Conservation in Plans

4.2.1 *Water Conservation Discussion under the "5A" Themes*

References identified in the remaining dataset using the chosen alternate coding method for each code were manually reviewed to determine their relevance to the water conservation codes. These relevant references were then classified under different context related themes or the 5As: Awareness, Analysis, Aspirations, Actions, and Applications. The classification was done to test potential use of these themes to analyze the discussion on water conservation (a specific topic) in the sampled plans. As mentioned in Section 3.5.3., these themes are connected to different types of references in the plan, i.e. whether the discussion in the reference pertains to generic information (Awareness), explains how water will be conserved through a strategy (Analysis), is related to a goal statement for water conservation in a community (Aspirations), describes a policy being adopted by a jurisdiction to save water (Actions), or delineates mechanism(s) to implement water conservation strategy (Applications). Table 4.3 and 4.4 provide the counts and the proportional frequency of references under each theme for all codes. Proportional frequency helps analyze the distribution of references across the themes irrespective of the total number of references in the dataset for a particular code. It provides an idea about the themes that dominate discussion in each code and helps identify deviations from the overall trend (in terms of the distribution of references under each theme).

With respect to total number of references, Water Efficient Landscaping and Irrigation (WELI) has the highest number of references followed by General Water Conservation (WC), Building level Water System Efficiency (BWSE), Water Recycling (WR) and Public Water System Efficiency (PWSE) (Table 4.3). The comparatively much lower number of references observed for PWSE can be explained by traditionally sparse level of discussion on system maintenance in comprehensive plans. While, the relatively much higher number of references for WELI may be attributed to potential preference of this concept and related strategies to reduce outdoor water use. In terms of distribution of references across the 5A themes, overall, both Applications and Actions have more than twice the number of references than those under Awareness and Analysis, and more than five times the number of references under Aspirations. Based on observations in Table 4.4, the proportional frequency for all codes under Actions and Applications is higher than frequencies under other themes. This difference in the frequencies is much higher for WELI, WR, BWSE, and (to some extent) PWSE codes than WC code. This is likely because the discussion under the WC code does not include details related to a specific concept to reduce water use, which results in less Actions and Applications-oriented references than other codes that focus on specific concept and related strategies to reduce water consumption.

An in-depth analysis of the distribution of references under 5A themes for each code was also conducted. Actions and Applications themes, that have the highest proportion of references across all codes, include policies and implementation mechanisms (both existing and proposed) for the jurisdiction. In the case of BWSE code, 76% of references were found to be related to Actions and Applications themes that mention encouraging installation of "low flow" and other types of water-efficient plumbing fixtures and appliances, adoption of "LEED certification" standards, and generally about reduction of water-use in buildings. The BWSE code has much higher proportion of references related to Applications theme (1 SD above average) than other codes. This high proportion of Applications references can be explained by the high complexity of implementing strategies to improve efficiency of building water systems because of low control over private use of property, high costs, consideration of equity, and the need for high level of public awareness. High complexity may be associated with higher level of discussion on implementation mechanisms for BWSE strategies when compared to other codes. At the same time, for the WR code, 73% of the references were related to Actions and Applications themes that mostly talk about encouraging "recycling graywater", implementing the use of "reclaimed water" or "treated effluent", or in general about reusing water in a community for applicable uses such as for "irrigation, industrial use and other appropriate non-potable water use applications" and "aquifer recharge". Similarly, for WELI code, 70% of references were found to be related to Actions and Applications themes. These references promote use of "native vegetation", "drought-tolerant landscaping", "xeriscaping", or similar landscaping practices and efficient irrigation methods (such as "low flow/drip irrigation systems"). In the case of PWSE, 64% of references were found to be related to Actions and Applications themes that mostly talk about providing adequate water pressure, conducting "leak detection and repair", system "water audits", and in general, about maintaining an efficient water delivery system and services (in the context of reducing water usage). Finally, in the case of WC, only 54% of the references were related to Actions and Applications themes. These references call for improving water conservation without providing specific details. They include discussions on promoting and adopting “water conservation” measures, reducing water demand, “wise” and efficient water use, and protecting resources (in the context of water conservation). The WC code has the lowest proportion of Actions (1.7 SD below average) and Applications (1.4 SD below average) references among all codes likely due to the more generic nature of discussion under this code.

For Awareness theme, findings in Table 4.4 indicate that when compared to others, PWSE has the highest proportion (1.4 SD above average) of references related to Awareness. These references provide information related to system maintenance to conserve water, water pressure management, water leakage in the system, and amount of water lost due to system leakage. In terms of the number of references, the PWSE code has the lowest count among all codes for Awareness themes. But, when looking at the proportion, w.r.t to all 5A themes, the Awareness theme forms a large portion of the overall discussion under this code. This is likely because of sparse discussion on system maintenance in comprehensive plans, which has high levels of details related to system capacity. Comprehensive plans tend to include very few goals and actions for public systems that are usually discussed in detail in Capital Improvement Plans (CIP). Findings also indicate that BWSE has the lowest proportion of references that pertain to Awareness (1 SD below average) when compared to other codes. References under this code mostly provide information on green building design (specifically the LEED standards and certification) and “water-saving” fixtures. Awareness references for WELI code majorly provide specific information for “xeric” and other types of plant species and landscaping material that conserve water and information on water saving irrigation systems. While, Awareness references for WR code mostly provide details related to water reclamation facilities (such as their capacity), and include generic mentions of “water reuse” or discuss potential uses of recycled water. At the same time, Awareness references under WC code include discussion on the importance of water conservation and how it can be beneficial, details related to current and previous water conservation efforts, and ideas related to future water conservation efforts and improvements.

For Analysis theme, the WELI code has, by far, the highest proportional frequency (1.7 SD above average) of references when compared to other codes. These references talk about the connection between landscaping and irrigation practices (such as use of “native” or “drought-resistant” plants, “green landscaping” or “xeriscape”, and “drip irrigation”) and reducing water consumption or maintenance in the community. The high proportion of Analysis references in this code is likely because of high proportions for Actions and Applications references and their high correlation (discussed later in this section) with Awareness/Analysis references. Hence, it is possible that the higher proportion of the discussion under this code related to WELI policies and mechanisms is also driving the higher level of discussion related to how strategies under this code can affect water conservation. Other codes have lower proportional frequencies when compared to the average. Under WR code, Analysis references mostly talk about the role of water recycling in general and related methods (such as “wastewater reclamation”) and mechanisms (such as the “net-blue by-law” and “educational programs”) in reducing water consumption. Under BWSE code, most of these references connect building system strategies (such as “green design” and “low-flow technologies”) and implementation mechanisms (such as “standards for installation and operation”) to lowering indoor water use or mention the role of building development and operations in reducing water consumption or improving sustainability. Under PWSE code, the

Analysis references describe the impact of public water system maintenance (such as “leak detection”) on water consumption and vice-versa (such as “lower sewer flows resulting from water conservation practices”). Lastly, under WC code, Analysis references mainly discuss the connection between water conservation goals and strategies and sustainability (such as “committed to conserving water to ensure… adequate water supply for future generations” and “efficient and sustainable management of water resources through… water conservation practices”) and the connection between generic water conservation practices and reducing water use (such as “high level of efficiency achieved…with water conservation” and “with continued water conservation practices and the current downward trend of water consumption, water security appears to be greater”).

For Aspirations theme, the WC code has much higher proportion of references (1.8 SD above the average) than other codes that have proportions lower than the overall average. This is expected because, as mentioned earlier, the WC code includes references that talk about water conservation without referring to any specific strategy, and most goals or vision statements pertaining to water conservation tend to very generic. These were therefore counted as Aspirations references under this code. These references include any commitments adopted by jurisdictions connected to water conservation (such as “our Town should set the highest standard for responsible water use” and developing a “culture of conservation” in water use). A number of these references are mentioned as goals, but were framed as actions and therefore also counted under the Actions theme (such as, “promote and increase water conservation measures among residents and businesses”). Other codes have very few Aspirations references. Under WELI, these references include goals or vision statements pertaining to reducing water consumption in irrigation or choosing landscape appropriate to local conditions for lowering water consumption (such as, lowering “use of potable water for irrigation" and achieving "Landscape Compatibility"). Under WR code, the Aspirations references are goals that specifically call for encouraging and promoting "reuse of water". Under the BWSE code, these references are part of community vision or goal statements that include "green building practices" or call for adoption of a "sustainability and resiliency framework" for guiding development of facilities. Lastly, under PWSE code, these references are goals that call for providing "safe and efficient delivery of water services" and improving "water delivery system efficiency and performance".

In multiple cases the Awareness and Analysis references under a code exist in plans that also have Actions and Applications references for that code. A correlation analysis between the sum of Awareness and Analysis references and the sum of Actions and Applications references for all plans in the sample was conducted to clarify this relationship. Findings indicated high level of association for WELI ($r = 0.60$) and WR ($r = 0.70$) codes, which suggests that the Awareness and Analysis discussions for these codes exist mostly to support policies and implementation mechanisms related to them in the sampled plans. Further analysis of proximity of these references w.r.t. each other and the level of semantic similarity between them can provide more clarity regarding existence of a relationship between Awareness/Analysis and Actions/Applications references. On the other hand, findings show only a moderate level of association between these references for BWSE ($r = 0.48$), PWSE ($r = 0.31$), and WC ($r = 0.44$) codes, leading to considerable uncertainty regarding the relationship between their Awareness/Analysis and Actions/Applications references. The observed lower associations for these codes may be attributed to multiple factors. In the case of BWSE, this may be likely a result of lower proportions of Awareness/Analysis references when compared to Actions/Applications references. In the case of PWSE, this is probably caused by scarce discussion resulting in low number of references.

Finally, in the case of WC, this is likely a result of generic discussion in Awareness/Analysis references followed by more specific policies and mechanisms that were possibly counted under other codes.

Table 4.3. Reference counts under 5A themes for each water conservation code

Code Name	Awareness	Analysis	Aspirations	Actions	Applications	Total
Water Efficient Landscaping and Irrigation (WELI)	27	38	4	74	88	231
Water Recycling (WR)	15	13	1	37	43	109
Building Level Water System Efficiency (BWSE)	16	18	2	50	62	148
Public Water System Efficiency (PWSE)	10	6	2	16	16	50
General Water Conservation (WC)	29	18	30	45	45	167
Total	97	93	39	222	254	705

Table 4.4. Proportional frequency of references under 5A themes for each code

Code Name	Awareness	Analysis	Aspirations	Actions	Applications
Water Efficient Landscaping and Irrigation (WELI)	0.117	0.165[1]	0.017	0.320	0.381
Water Recycling (WR)	0.138	0.119	0.009	0.339	0.394
Building Level Water System Efficiency (BWSE)	0.108[1]	0.122	0.014	0.338	0.419[1]
Public Water System Efficiency (PWSE)	0.200[1]	0.120	0.040	0.320	0.320
General Water Conservation (WC)	0.174	0.108	0.180[1]	0.269[1]	0.269[1]
Average	0.147	0.127	0.052	0.317	0.357
Std Dev	0.039	0.022	0.072	0.028	0.061

1. Proportion at least 1 SD away from the average

4.2.2 *Type of Applications for Water Conservation*

References related to the Applications theme account for 36% of references under water conservation codes. An in-depth analysis of Applications references was conducted to determine the nature of implementation mechanisms adopted by sampled jurisdictions for different water conservation codes. Table 4.5 provides the total number of Applications references for different implementation mechanisms across water conservation codes. If a reference mentioned multiple implementation mechanisms, it was counted under each of the relevant mechanisms. Based on the findings, references mentioning different types of requirements (such as regulations, codes, and ordinances) to implement water conservation strategies account for 31% of Applications codes followed by references that mention guidelines/education (16%), assessments (12%), projects (12%), programs (11%), coordination (8%), incentives (5%), approvals/permits (3%), and other mechanisms (2%). High percentage of references related to requirements may be attributed to higher application of local regulations to govern water-use behavior in drought-prone communities than other mechanisms. For example, local building codes and landscaping ordinances are traditionally used to manage indoor and outdoor water use in drought-prone areas. The higher percentage of references related to requirements can also be explained by higher number of WELI and BWSE Applications references that tend to include use of local regulatory mechanisms for strategy implementation.

Proportional frequencies, in Table 4.6, illustrate the distribution of mechanisms for implementing strategies under different water conservation codes. The overall distribution of implementation mechanisms based on these frequencies is more balanced for WR and WC codes (variance < 0.01 across different mechanisms) followed by BWSE and WELI (variance between 0.01 to 0.02), and PWSE (variance = 0.04). These differences in the distribution of mechanisms can be attributed to the nature of strategies discussed under these codes and their levels of applications. For example, PWSE strategies are applied at the community level and usually implemented through studies, programs, or projects. While, strategies related to WR can be implemented through both community and user level applications.

As per these finding in Table 4.6, 43% (1.2 SD above average) of the Applications references under WELI code mention some form of requirements followed mainly by those that mention guidelines/education (20%) and projects (16.7%). As mentioned earlier, outdoor water use is typically governed by some form of local regulations in drought-prone areas. Most Applications references for WELI code that are related to requirements talk about generally requiring use of drought-resistant plant species or efficient irrigation practices in a jurisdiction (without mentioning specific avenues for recording these requirements). But some references do mention adapting zoning codes and other landscape development standards with these requirements (such as "The City shall ensure that Zoning Code landscape standards and design guidelines reflect the most current water efficient landscape standards that include native, adaptive, and drought resistant vegetation"). A few of these references also talk about existing water restrictions during drought (such as "watering days, water-waste citations, and other means of conserving water should continue to be employed as needed during periods of extreme drought"). A number of jurisdictions also provide guidance to support residents and developers take decisions based on the local regulations related to landscaping and irrigation. Applications references related to guidelines/education under this code mostly mention materials or activities providing information related to water efficient planting and other landscaping measures (such as a "list of low water [use] plant materials", reducing "large outdoor residential irrigation use through education", and "demonstration garden planted with native and drought-tolerant species"). At the same time, Applications references that mention projects related to WELI mostly talk about specific existing or proposed endeavors that promote WELI strategies (such as creating "a native plant nursery"). Some projects may also coincide with guidelines/education objectives (such as, "The [an existing park] contains a small arboretum to demonstrate drought tolerant trees").

Under WR code, Applications references related to projects account for 24% of all references (1.4 SD above average), followed mainly by those related to requirements (22%) and programs (16%). Overall, mechanisms mentioned under the WR code target both the availability of the recycled water (at community level) and its use for activities that do not require potable water (at user level). References for the WR code that mention projects in the sampled plans mostly talk about existing or planed water recycling facilities and distribution (such as "Monte Vista Water District has diversified its water supply portfolio by building a non-potable recycled water distribution system"). References under this code related to requirements mention adopting regulations to mandate use of reclaimed water (or piping systems that facilitate reuse of water) for applications that do not need potable water, including irrigation and industrial activities (such as "The City shall require use of reclaimed water for irrigation and non-potable use for all new development"). References under this code related to programs either mention water recycling programs in a generic manner (such as "expand the City's waste water reuse program") or provide details related to the intent of the program (such as "continue to … develop an effluent reuse and disposal program to recharge wetlands and groundwater supplies and provide irrigation water").

Under the BWSE code, 38% of Applications references are related to requirements, which is followed mainly by those related to programs (14%), guidelines/education (13%) and incentives (12%). Similar to WELI, the BWSE code has high proportion of references that mention requirements, but it also includes other mechanisms to affect user behavior to lower indoor water consumption. Including programs and incentives that can help jurisdictions cover areas where they have low authority to affect change, such as in the case of retrofitting existing buildings with water saving techniques. The utility of these "carrot" – based mechanisms for implementing strategies under BWSE code that affect user behavior is evident from the relatively much higher proportion of references (1.7 SD above average) related to incentives under this code. Overall, under BWSE code, references related to requirements mostly mention regulations for installing water saving fixtures and other technologies in new or redevelopment projects (such as "installation of water conserving plumbing fixtures in new or renovated building construction") or requirements to adopt or facilitate green building practices (such as "update[ing] land use ordinances with new requirements to obtain LEED Certification standards"). References related to programs talk about reducing indoor water consumption (such as through "Residential Audit Program") and those related to guidelines/education mostly mention resources and educational outreach promoting strategies to reduce water consumption in buildings (such as "A free family-friendly festival to celebrate and learn more about waterwise practices") or encouraging green building practices (such as "Provide education to citizens on green housing renovation options"). References related to incentives mostly mention mechanisms to encourage adoption of water saving technologies in buildings or green building standards (such as "Rebates for replacing existing high water volume plumbing fixtures" and "Consider[ing] the use of zoning incentives to promote the development of LEED certified projects"). Some of these references are connected to programs as well (such as "Maintain incentive programs to replace inefficient water use in new development").

Under PWSE code, references related to assessments account for 59% (1.7 SD above average) of its Applications references, followed mainly by those related to programs (29%) (1.5 SD above average). High proportion of references related to assessments under PWSE code may be attributed to the community-level implementation of strategies under this code. Assessments usually take the form of jurisdiction-wide analysis and planning to affect change. For PWSE code, references related to assessment mostly mention analyzing the public water system for identifying in-efficiencies (such as conducting "system water audits", "assessment of the unaccounted[-]for water losses due to leaks, theft or other reasons", and "verify[ing] areas of high and low water pressure throughout the water system"). References related to programs mainly mention leak detection in water supply infrastructure (such as "ongoing program of leak detection and repair in the water transmission system should be continued").

Finally, under the WC code, references related to guidelines/education account for 28% of Applications references, mainly followed by coordination (23%) and requirements (17%). None of the mechanisms particularly stand out for this code likely because of generic nature of its strategies. References related to guidelines/education mostly mention providing information and public education for promoting water conservation (such as, "Educate residents, businesses and property owners on best practices in water conservation" and "online resources to learn about water conservation techniques"). References related to coordination mention collaborations with regional entities on water conservation efforts or consistency with regional plans (such as "Work[ing] with McHenry County, regional agencies, and environmental non-profit organizations …to identify innovative tools for water conservation and protection" and "The City currently employs conservation methods described in a State approved conservation plan"). References related to requirements mostly mention regulations that support water conservation in a generic sense (such as "Including water conservation measures in development regulations") or talk about the regional regulations being supported by the jurisdiction (such as "The City will continue to actively support the SFWMD and Miami-Dade County in the implementation of new regulations…that are designed to conserve water during the dry season.”)

Table 4.5. Reference counts under the Applications theme across implementation mechanisms for each water conservation code

Code Name	Assessments	Requirements	Programs	Incentives	Guidelines/ Education	Coordination	Projects	Approvals/ Permits	Others
Water Efficient Landscaping and Irrigation (WELI)	5	39	2	2	18	2	15	6	1
Water Recycling (WR)	6	11	8	1	3	6	12	1	1
Building Level Water System Efficiency (BWSE)	7	29	11	9	10	2	7	0	2
Public Water System Efficiency (PWSE)	10	1	5	0	0	0	1	0	0
Water Conservation (WC)	6	10	6	2	17	14	1	2	2
Total	34	90	32	14	48	24	36	9	6
Percentage	12%	31%	11%	5%	16%	8%	12%	3%	2%

Table 4.6. Proportional frequency of references under the Applications theme for each code across implementation mechanisms

Code Name	Assessments	Requirements	Programs	Incentives	Guidelines/ Education	Coordination	Projects	Approvals/ Permits	Others
Water Efficient Landscaping and Irrigation (WELI)	0.056	0.433[1]	0.022[1]	0.022	0.200	0.022	0.167	0.067[1]	0.011
Water Recycling (WR)	0.122	0.224	0.163	0.020	0.061	0.122	0.245[1]	0.020	0.020
Building Level Water System Efficiency (BWSE)	0.091	0.377	0.143	0.117[1]	0.130	0.026	0.091	0.000	0.026
Public Water System Efficiency (PWSE)	0.588[1]	0.059[1]	0.294[1]	0.000	0.000[1]	0.000	0.059	0.000	0.000[1]
Water Conservation (WC)	0.100	0.167	0.100	0.033	0.283	0.233	0.017	0.033	0.033
Average	0.191	0.252	0.144	0.039	0.135[1]	0.081[1]	0.116[1]	0.024	0.018[1]
Std Dev	0.223	0.153	0.100	0.045	0.112	0.097	0.091	0.028	0.013

1. Proportion at least 1 SD away from the average

4.2.3 *Implementation Details for Water Conservation*

Implementation details for both Actions and Applications references were analyzed for the sampled jurisdictions. These details include identification of responsible agency, timing or priority, and funding for policies and implementation mechanisms. In total, 7% of all Actions references and 22% of Applications references are supported by implementation details in the sampled plans Table 4.7 provides the total counts and proportional frequencies of Actions and Applications references for each code for which an implementation detail has been identified in the sampled plans. These findings indicate that, on an average, more Applications references have been supported by implementation details than Actions references. Among different types of details, timing/priority has been identified for highest number of Application and Action references. While, funding has been identified for (by far) the least number of these references. The difference in proportional frequencies by implementation detail is expected as, at this early stage, it may be less feasible to pinpoint funding for certain policies or mechanisms, but it is easier to judge their timing/priority.

Results in table 4.7 can also be used to conduct a comparison of proportion of references with different implementation details across individual codes. These findings indicate that the PWSE code has the highest proportion of Actions references for which a responsible agency has been identified, followed by WR, BWSE, WELI, and WC codes. Similarly, PWSE code has the highest proportion of Actions references for which timing/priority has been mentioned in the plan, followed by WR, BWSE, WC, and WELI. On the other hand, WR code has the highest proportion of Actions references for which funding details are mentioned in the plan, closely followed by WC and WELI codes. In fact, funding is not mentioned for any Actions references under BWSE and PWSE codes. Concurrently, findings indicate that the BWSE code has the highest proportion of

Applications references for which responsible agencies have been mentioned in the comprehensive plans, followed by WELI, WC, and WR codes, with PWSE having no such references. Similarly, the BWSE code has the highest proportion of Applications references for which timing/priority has been mentioned in the plan, followed by WELI, WC, PWSE, and WR. Whereas, WC code has the highest proportion of Applications references that are supported by funding information in the plans, followed by BWSE, WR, and WELI. The PWSE code does not have any references supported by funding details as seen in the case of Actions references.

The observed distribution of implementation details provided for policies (under Action references) and mechanisms (under Application references) for different water conservation codes can be explained by the level of control of local agencies, the nature of mechanisms used, and the amount of discussion on a topic in comprehensive plans. In the case of PWSE code, high proportion of Action references with responsible agency information can be attributed to the fact that most water distribution systems in cities and towns are owned and managed by municipal or public utility district agencies, which makes it easier to identify responsible agency for ensuring system efficiency. At the same time, reducing wastage in water system is easier due to high level of local agency control over the system and can be the first step taken by a jurisdiction to conserve water, which can explain the high proportion of Action references under this code supported by timing/priority information. On the other hand, details related to implementation of PWSE strategies are limited in comprehensive plans and are usually included in the capital improvement plans, which can explain the low funding information for policies under this code and also the overall low levels of implementation details for its mechanisms. In the case of BWSE code, high proportions of Application references supported by responsible agency and timing/priority information can be explained by the different types of mechanisms (such as building codes, rebates for reducing indoor water use, and information on water-wise practices) utilized by jurisdictions because of low control over indoor water use. Due to the varied nature of these mechanisms, proper identification of responsible agencies and determination of their timing/priority is essential for coordination and distribution of resources for their execution.

Implementation details were also analyzed with respect to different mechanisms mentioned in Applications references. Table 4.8 provides the total counts and proportional frequencies of references related to different types of mechanisms with associated implementation details. The findings indicate that the provision of implementation details can rely on the nature of the mechanism. Based on these findings, among all mechanisms, incentives have the highest proportional frequency for references that have information related to responsible agency followed by guidelines/education and requirements. This is likely because incentives usually need high degree of management. In terms of total count, requirements have the highest number of references supported by responsible agency information, but it represents a lower proportion of all references related to this mechanism. This is probably because a number of requirements do not identify the type of regulations to be amended. For references that mention timing/priority, approvals/permits have the highest proportional frequency followed by incentives and assessments. Approvals/permits references are more likely to include timing/priority information as it affects the initiation of project level strategies. Lastly, for references that are supported by funding information in the plans, coordination has the highest proportion of references, closely followed by incentives and guidelines/education. The provision of funding information for different implementation mechanisms may be explained by the ability of planners and other local staff to scope the of tasks related to a mechanism at the comprehensive planning stage. For example, coordination can be easier to scope at this stage in terms of agency personnel work hours that need to be devoted. Similarly, incentives can be scoped based on agency's previous experience and budget.

Table 4.7. Counts and proportional frequency of implementation details provided for Actions and Applications references under each water conservation code

Code Name	Theme	Responsible Agency		Timing/ Priority		Funding	
		No.	Prop	No.	Prop	No.	Prop
Water Efficient Landscaping and Irrigation (WELI)	Action	1	0.014	2	0.027	1	0.014
	Application	14	0.159	19	0.216	1	0.011
Water Recycling (WR)	Action	2	0.054	3	0.081	1	0.027
	Application	2	0.047	4	0.093	1	0.023
Building Level Water System Efficiency (BWSE)	Action	2	0.040	4	0.080	0	0.000
	Application	11	0.177	17	0.274	3	0.048
Public Water System Efficiency (PWSE)	Action	2	0.125	3	0.188	0	0.000
	Application	0	0.000	2	0.125	0	0.000
Water Conservation (WC)	Action	0	0.000	3	0.067	1	0.022
	Application	7	0.156	8	0.178	3	0.067
Average	Action	1	0.047	3	0.088	1	0.013
	Application	7	0.108	10	0.177	2	0.030

Table 4.8. Counts and proportional frequency of implementation details provided for mechanisms mentioned in Applications references under each water conservation code

Mechanisms	Responsible Agency		Timing/ Priority		Funding	
	No.	Prop.	No.	Prop.	No.	Prop.
Assessments	3	0.088	8	0.235	1	0.029
Requirements	13	0.144	18	0.200	1	0.011
Programs	1	0.031	4	0.125	0	0.000
Incentives	4	0.286	4	0.286	1	0.071
Guidelines/ Education	8	0.167	9	0.188	3	0.063
Coordination	2	0.083	3	0.125	2	0.083
Projects	3	0.083	1	0.028	0	0.000
Approvals/Permits	0	0.000	3	0.333	0	0.000

4.3 FACTORS AFFECTING WATER CONSERVATION CONSIDERATION IN PLANS

An inferential analysis using regression modelling was conducted to identify key determinants of water conservation consideration in local comprehensive plans of drought-prone small cities and towns. A descriptive analysis of variables was also performed to develop an understanding of variables being studied and the selection of regression methodology for this study as well as its limitations. Findings from these analyses are discussed in this section.

4.3.1 *Description of Variables*

a) The Water Conservation Score

The Water conservation score provides an overall picture of water conservation consideration in a comprehensive plan. After scoring references under all water conservation codes (as discussed in Section 3.5.4), an overall score was calculated by performing a summation of individual scores for references in each plan. This score was used as the dependent variable (DV) in the regression analysis performed for this study. The score includes discrete and positive numbers. The skewed distribution of water conservation scores (Figure 4.4) and descriptive statistics in Table 4.9 suggest that a high number of scores are below 10, which is close to their mean (9.14). Also, about 35 plans in the sample have a score of 0, which suggests zero inflation that should be considered while deliberating the reliability of the selected regression model. The discrete nature of this dependent variable and the potential for zero-inflation were the main criteria behind selection of the Negative Binomial Regression model for inferential analysis in this study.

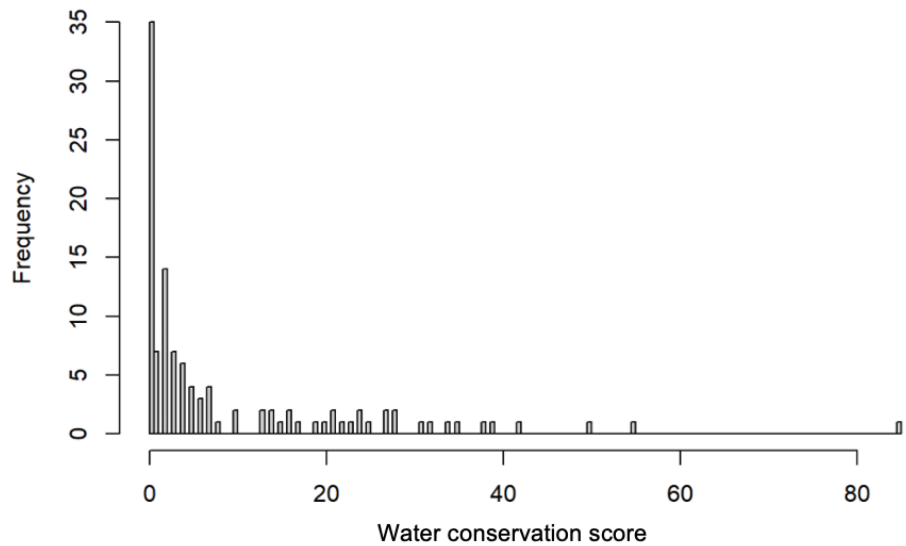


Figure 4.4. Histogram illustrating the distribution of discrete water conservation scores (author's diagram)

Table 4.9. Descriptive statistics for water conservation scores (DV) and local characteristics variables included in the inferential analysis for this study

Theme	Variable		Min	Max	Median	Mean	SD
Resilience	Water conservation score		0	85	3	9.14	14.09
Local Characteristics	Hazard & exposure score	Actual	-1.79	7.53	-0.45	0	1.58
		Std.	-1.14	4.78	-0.28	0	1
	Economic vulnerability score	Actual	-2.03	5.83	-0.28	0	1.35
		Std.	-1.5	4.31	-0.21	0	1
	Capacity score	Actual	-1.85	6.41	-0.55	0	1.74
		Std.	-1.06	3.68	-0.31	0	1

Std. = Standardized values

b) Local Characteristics

Variables related to local characteristics included combined scores representing a jurisdiction's hazard and exposure, economic vulnerability, and capacity. These scores were developed by calculating the sum of standardized values of individual variables. The hazard and exposure score combined drought experience and population density, the economic vulnerability score combined employment in natural resources and food and accommodation services occupations, and the capacity score combined planning staff members and total revenue of a jurisdiction. The distribution of these scores is illustrated in Figure 4.5 and their descriptive statistics is listed in Table 4.9. The distributions suggest high number of low values resulting in right skewness of these scores. The mean for all the scores is zero, which is likely because of their construction using standardized values of individual scores. The scores also have similar standard deviations (SDs) between 1-2.

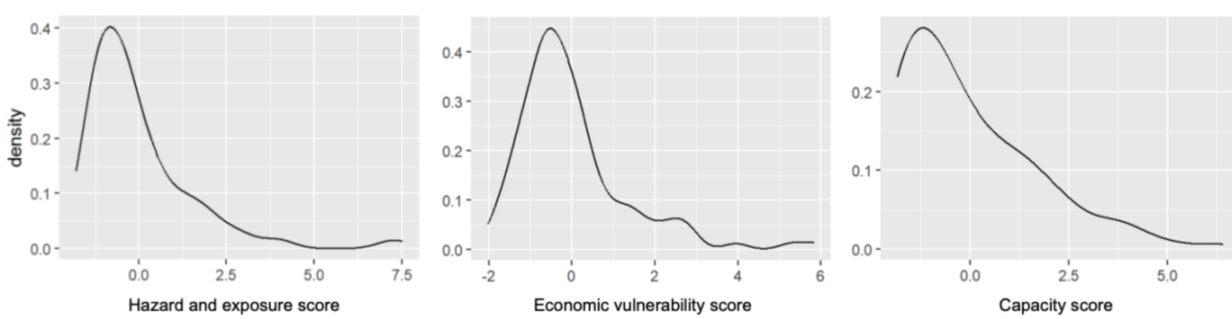


Figure 4.5. Density plots illustrating the distribution of local characteristics variables (author's diagram)

c) Regional Setting Characteristics

Multiple regional setting characteristics were also included in this analysis to study their impact on consideration of water conservation in local comprehensive plans of drought-prone small cities and towns. These variables include binary categorical data. Figure 4.6 illustrates the distribution of the regional setting variables used in this analysis. Based on the distribution, the data is almost evenly split between categories for metro/non-metro location, with 54% of jurisdictions located in metro and 46% in non-metropolitan areas. On the other hand, data for other regional setting variables is unevenly distributed between the binary categories. In the case of coastal/non-coastal location, 17.5% of jurisdictions are in coastal counties and 82.5% of jurisdictions are located in non-coastal counties. This is because of the nature of sampling strategy adopted for this research that allowed a maximum of three drought-prone jurisdictions from every state with jurisdictions in the sampling frame. 16 costal states with jurisdictions in the sampling frame have been represented in the sample. However, only 20 (out of the maximum possible 48) jurisdictions from these states were located in a coastal county.

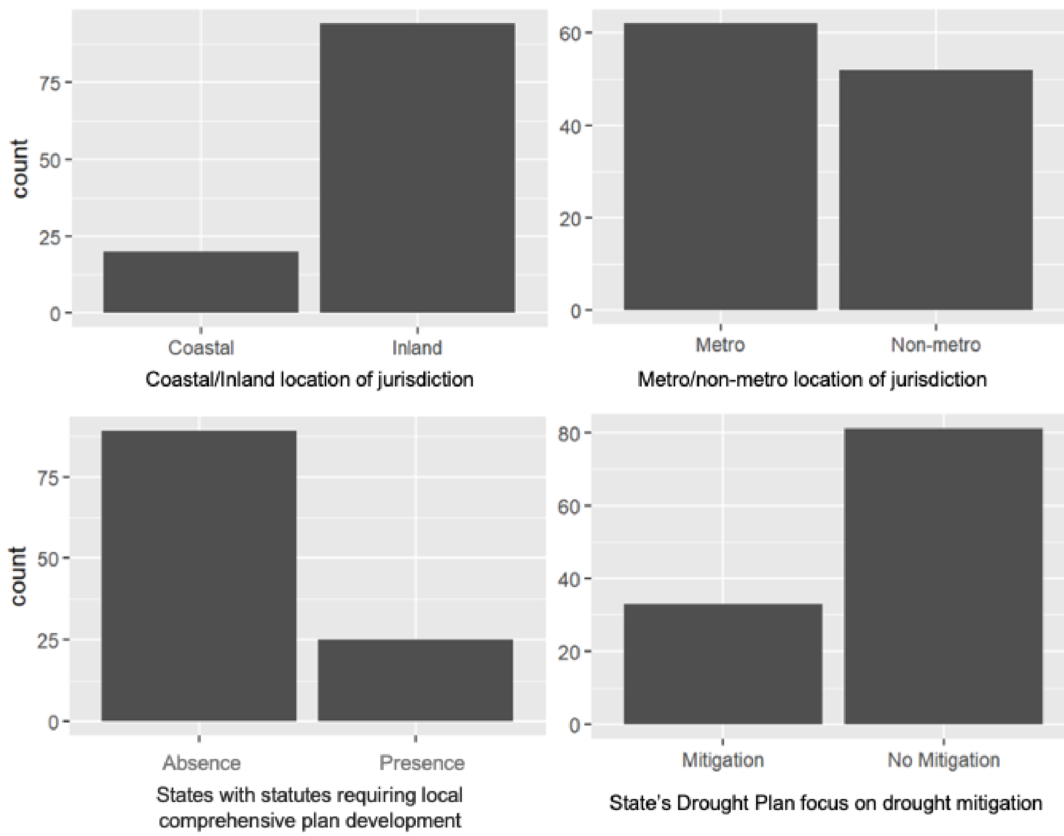


Figure 4.6. Bar charts illustrating distribution of regional setting characteristics variables (author's diagram)

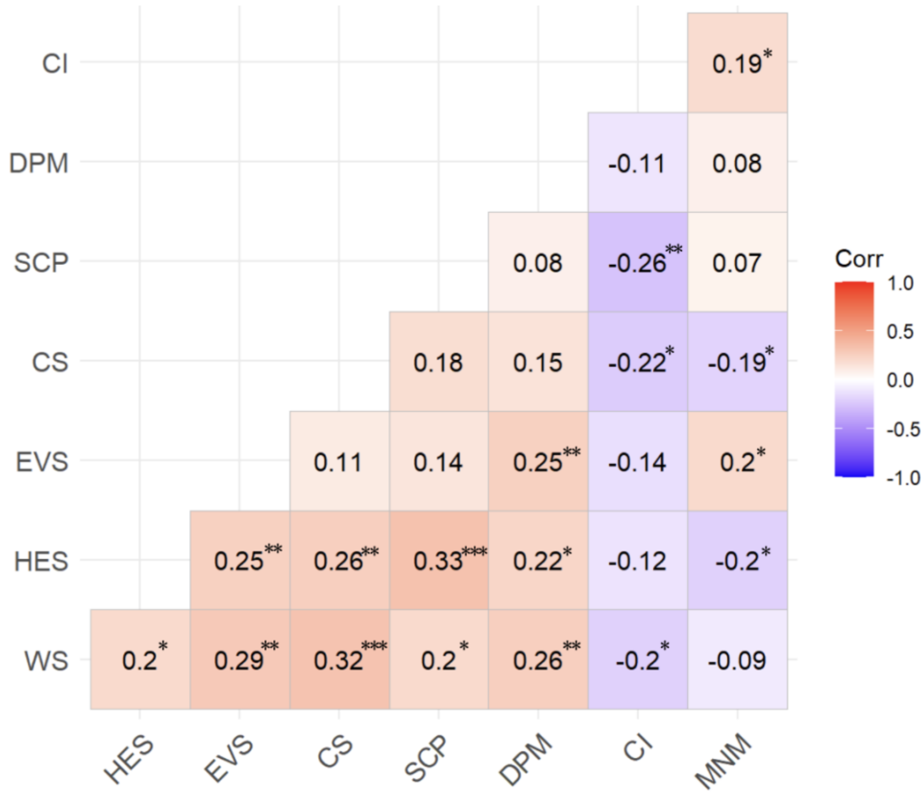
For state characteristics, 22% of jurisdictions are located in states that have statutes requiring preparation and adoption of local comprehensive plans, while 78% are located in states with no such requirements. At the same time, 29% of jurisdictions are located in states with a drought plan that focusses on drought mitigation, whereas 71% of jurisdictions are located in states with a drought plan that does not focus on mitigation. The uneven representation of categories in the dataset should be kept in mind while interpreting results from inferential analysis.

4.3.2 *Determinants of Water Conservation Consideration in Plans*

a) Correlation Analysis Results

A correlation analysis between the water conservation score (DV) and the local and regional setting characteristics was performed to determine pair-wise associations between these variables. The analysis also revealed associations between the local and regional setting characteristics that can help decipher the impact of covariates on the effect of these variables on water conservation score in regression analysis. Figure 4.7. shows the correlation matrix with correlation values (r) and their statistical significance for all possible pairings of variables included in this inferential analysis. Findings reveal that there is a positive association between water conservation score and local characteristics variables (hazard and exposure score, economic vulnerability score, and capacity score). The binary categorical variables were converted to numerical values to include them in this correlation analysis. Findings indicate that there is a positive association between water conservation score and existence of state statutes requiring a local comprehensive plan development and state's focus on drought mitigation in its Drought Plan, while there is a negative association between water conservation score and inland location of jurisdictions and water conservation score and non-metro location of jurisdictions. Overall, the matrix indicates low to moderate correlations ($|r| = 0.2$ to 0.3) between water conservation score and all local and regional setting characteristics that are also statistically significant (p value < 0.05) (apart from metro/non-metro location). These correlations provide the initial empirical evidence for the potential effect of these characteristics on consideration of water conservation in local comprehensive plans of drought-prone small cities and towns, which will be further clarified using regression analysis.

Regarding correlation among variables related to different characteristics, hazard and exposure scores have statistically significant low to moderate correlation with all other variables apart from coastal/inland location. These associations are likely the byproduct of correlation of drought experience with other local characteristics variables as well as with state's focus on drought mitigation and with presence of state statutes related to local comprehensive planning (Appendix C, ii). Another reinforcing factor could be the correlation of population density with metropolitan location and state's statutes (Appendix C, ii). The economic vulnerability score has statistically significant low to moderate correlation with state's focus on drought mitigation in its Drought Plan and with non-metro jurisdictions. This may be because economies of multiple non-metro jurisdictions depend on natural resources and tourism. At the same time, higher economic vulnerability in local jurisdictions can be associated with higher concern for drought mitigation at the state level reflected in their Drought Plans. The capacity score seems to have a statistically significant low-moderate negative correlation with inland and non-metro jurisdictions, which is expected as these jurisdictions tend to have lower tax base that is usually needed to support higher capacity. Additionally, the negative correlation between presence of state statutes requiring a local comprehensive plan development and inland jurisdictions is expected as most states with such statutes are located in coastal areas. Similarly, the positive correlation between non-metro and inland jurisdictions is expected as most metropolitan areas are located in coastal regions. These associations among and between local and regional setting characteristics have implications for their relationship with water conservation consideration in local comprehensive plans when observed by controlling for the effect of other variables using regression analysis.



* p<0.05; **p<0.01; ***p<0.001

WS = Water Conservation Score; HES = Hazard and Exposure Score; EVS = Economic Vulnerability Score; CS = Capacity Score; SCP = State statutes requiring comprehensive plan (Presence = 1); DPM = State Drought Plan focus on mitigation (Mitigation = 1); CI = Coastal/Inland location (Inland = 1); MNM = Metro/Non-Metro location (Non-metro = 1)

Figure 4.7. Correlation matrix illustrating pair-wise associations between all variables included in inferential analysis (author's diagram)

b) Regression Analysis Results

Regression analysis using Negative Binomial model family was conducted to clarify the relationship between local and regional setting characteristics and water conservation consideration in local comprehensive plans and to pinpoint potential factors. Models for regression analysis were designed to test different hypotheses, mentioned in Section 3.2, related to the impact of these characteristics on water conservation consideration. The regression model isolates the effects of independent variables on water conservation score, which clarifies the individual potential of these variables for informing water conservation consideration. Overall, three regression models have been considered in this analysis: 1) Local Characteristics Model; 2) Regional Setting Characteristics Model; 3) All Characteristics Model. In the case of all three models, regression was performed using both complete dataset (n=114) and dataset without influential data points (n=107). Influential data points were identified by performing regression diagnostics (Appendix D) for all three models. These data points (Appendix E) include jurisdictions that had high residuals and/or high leverage. All jurisdictions in this group have high water conservation scores (>75th quantile value). Table 4.10 provides results from all regression models using the complete dataset and Table 4.11 provides results from regression models after removing influential data points from the dataset. Following is a description of findings from the three models:

1) Local Characteristics Model: This model illustrates the relationship between local characteristics and water conservation consideration in comprehensive plans of drought-prone small cities and towns. It includes the water conservation score as the dependent variable and the standardized values of hazard and exposure score, economic vulnerability score, and capacity score as the independent variables. The standardized values were used in the model to compare the effects of the local characteristics on water conservation score. Based on the regression analysis using the complete dataset (n = 114) (Table 4.10), the capacity score has the highest (Coeff = 0.40) and statistically significant effect (p-value< 0.01) on water conservation score when compared to other variables. The effects of other variables when using the whole dataset were not found to be statistically significant. But findings suggest that after removing influential data points from the dataset (Table 4.11), the effect of economic vulnerability score is slightly higher (Coeff =

0.41) than that of capacity score (Coeff = 0.39). Effect of both these variables are statistically significant (p-value < 0.01). Based on these findings, we can say that when considering only the impact of local characteristics, both capacity and economic vulnerability have positive, equivalent, and statistically significant effects on the water conservation consideration in local comprehensive plans of drought-prone small cities and towns. Whereas, hazard and exposure does not have statistically significant effect on water conservation consideration, when controlling for other local characteristics. This is likely because of high correlation between hazard and exposure score and other local characteristics variables (Figure 4.7 and Appendix C, i). Controlling for the effect of these other variables reduces the influence of hazard and exposure on water conservation score, which suggests that both capacity and economic vulnerability scores may be acting as a mediator in this relationship.

2) Regional Setting Characteristics Model: This model illustrates the relationship between regional setting characteristics and water conservation consideration in local comprehensive plans of drought-prone small cities and towns. It includes water conservation score as the dependent variable and metro/non-metro and coastal/inland location as well as state's Drought Plan focus on mitigation and presence of statutes requiring local comprehensive plan development as independent variables. Results for model using the complete dataset (Table 4.10) indicates that the state's drought plan focus on mitigation has a positive (Coeff = 0.88) and the only statistically significant (p-value < 0.01) effect on water conservation score when controlling of all other regional setting characteristics variables. This effect is even higher (Coeff = 1.21) and more statistically significant (p-value < 0.001) when considering results from the model using the dataset

without influential data points (Table 4.11). The regression analysis results suggest that when controlling for other regional setting characteristics the effect of the presence of state statutes requiring comprehensive plan is not statistically significant. However, it should be noted that the p-value is close to alpha of 0.05 when considering results from the model using a complete dataset and the model using dataset without influential data points. This is likely because of the correlation between presence of state statutes requiring comprehensive plan development and coastal/inland location. At the same time, the correlation between this variable and water conservation score in the dataset without influential data points is not statistically significant (Appendix C, i), which suggests that the correlation between presence of state statutes requiring comprehensive plan and water conservation consideration in the full dataset is likely due the presence of influential values. Also, metro/non-metro and costal/inland location do not have statistically significant effects on water conservation when controlling for other regional setting characteristics, which is likely due to their correlation with each other and, in the case of coastal/inland location, correlation with the presence of state statutes requiring comprehensive plan development. Overall, based on the results from Regional Setting Characteristics model, only the state's Drought Plan focus on mitigation has a notable influence on water conservation consideration in comprehensive plans of drought-prone small cities and towns.

3) All-Characteristics Models: This model illustrates the relationship between local and regional setting characteristics and water conservation consideration. Specifically, it helps in analyzing the effect of regional setting characteristics when controlling for local characteristics and vice versa. It includes water conservation score as the dependent

variable and hazard and exposure score, economic vulnerability score, capacity score, metro/non-metro location, coastal/inland location, state's drought plan focus on mitigation, and presence of statutes requiring local comprehensive plan development as independent variables. Based on the results from the model using the complete dataset (Table 4.10), the effects of capacity score (Coeff = 0.37) and presence of statutes requiring comprehensive plan development (Coeff = 0.82) are statistically significant (p-value < 0.05). The results indicate reduction in the effect of capacity score from the effect seen in Local Characteristics model, which is mainly because of controlling for coastal/inland and metro/non-metro locations that are correlated with capacity score (r = 0.20 approx.). On the other hand, the effect of the presence of statutes requiring comprehensive plan development is higher than what was observed in the Regional Setting Characteristics model. This is likely because of the of the presence of influential data points. The results in Table 4.10 indicate that the effect of state drought plan focus on mitigation has lowered from what was observed in the Regional Characteristics Model and is not statistically significant. This is likely because of the inclusion of local characteristics variables that are correlated with the state drought plan focus on mitigation and/or due to the presence of influential values in the dataset. Regression analysis was performed after removing influential data points, to further clarify the effect of variables in this model. Findings from this analysis (Table 4.11) indicate that the effects of economic vulnerability score (Coeff = 0.38), capacity score (Coeff = 0.30), and state drought plan focus on mitigation (Coeff = 0.68) are statistically significant (p-value <0.05). These results clarify that the increase in the effect of presence of statutes requiring comprehensive plan development in this model versus that in the Regional Setting Characteristics model when using the complete dataset was due to the presence of influential data points. In fact, after removing influential data points, the correlation between this variable and water conservation score becomes statistically insignificant (Appendix C, i). The results in Table 4.11 indicate that when using the dataset without influential data points the effect of economic vulnerability score is slightly higher than the effect of capacity score when controlling for regional setting characteristics. This is because of the correlation between capacity score and the state drought plan focus on mitigation when considering the dataset without influential data points (Appendix C, i). The results also clarify that the decrease in the effect of state drought plan focus on mitigation from what was observed in the Regional Characteristics Model, when using the dataset without influential data points, is due to correlation of this variable with local characteristics (Appendix C, i). Overall, results from All Characteristics Model show that the effects of economic vulnerability score, capacity score, and state drought plan focus on mitigation are statistically significant when controlling for other characteristics, as well as after removing influential data points from the dataset. Based on these results, there is significant evidence to conclude that economic vulnerability, capacity, and state drought plan focus on mitigation are potential factors that can influence water conservation consideration in local comprehensive plans of drought-prone small cities and towns.

The main focus of this research is the statistical significance of the variables included in the models and not prediction capability of the models. Still, a comparison of prediction capability of models discussed in this section was performed. Tables 4.10 and 4.11 provide relevant statistics (such as Pseudo R^2, Adjusted Pseudo R^2, AIC, and BIC values) for each model to compare their ability to explain water conservation scores (DV). A specialized Kullback-Leiber divergence based

R^2 (using the ` r2_kullback` function from `performance` package in R) was applied to determine goodness -of-fit of Negative Binomial models used in this study (Cameron & Windmeijer, 1997). These values depict the proportionate reduction in deviance due to the variables included in the models, where deviance is defined as “twice the difference between the maximum log-likelihood achievable and the log-likelihood of the fitted model” (Cameron & Trivedi, 2013). All three models have low to moderate strength in terms their ability to fit data (Pseudo R^2 = 0.09 – 0.23 Pseudo R^2 Adjusted = 0.05 – 0.17). When comparing the AIC values, findings indicate that the Local Characteristics Model is most capable and the Regional Setting Characteristics model is least capable among all models in terms of explaining the water conservation scores. On the other hand, when comparing the BIC values, findings indicate that the Local Characteristics Model is most capable and the All Characteristics Model is least capable in explaining the water conservation scores. The difference in the results when comparing models using AIC and BIC values is because the BIC penalizes for additional number of variables. The findings also suggest that local characteristics contribute more towards the predictability of the regression model than regional setting characteristics. This is likely because of the correlation between regional setting characteristics and local characteristics. It is possible that local characteristics have a more direct influence over water conservation consideration and act as mediators or confounders in the relationship between regional setting characteristics and water conservation score. Both potential mediating and confounding roles should be investigated in future research using Causal Directed Acyclic Graphs (DAGs). Furthermore, in terms of the ability of the models to predict the zeros in water conservation score, the Regional Setting Characteristics model seems to have the highest capability (Ratio of predicted zeros = 0.95 and 0.94) when using both the complete dataset and the dataset without influential data points. The zero-prediction capability of other models is also pretty close to that of the Regional Setting Characteristics model.

Table 4.10. Regression analysis results using the full dataset from all models

Using full dataset **DV = water conservation score** **n = 114**	**Local Characteristics Model**		**Regional Setting Characteristics Model**		**All Characteristics Model**	
	Coeff	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Hazard & exposure score	0.17	0.15			0.03	0.17
Economic vulnerability score	0.29	0.15			0.30	0.16
Capacity score	0.40**	0.15			0.37*	0.15
State drought plan focus on mitigation (Mitigation)			0.88**	0.33	0.57	0.33
Statutes requiring comprehensive plan (Presence)			0.71	0.37	0.82*	0.38
Coastal/inland location (Inland)			-0.14	0.42	0.22	0.41
Metro/non-metro location (Non-metro)			-0.16	0.31	-0.14	0.32
Pseudo R^2	0.12		0.09		0.16	
Pseudo R^2 Adj	0.09		0.05		0.10	
AIC	686.45		692.21		688.31	
BIC	700.13		708.63		712.94	
Ratio of predicted zeros	0.94		0.95		0.93	

* p<0.05; **p<0.01; ***p<0.001

Table 4.11. Regression analysis results using dataset without influential data points from all models

Using dataset without influential data points **DV = water conservation score** **n = 107**	**Local Characteristics Model**		**Regional Setting Characteristics Model**		**All Characteristics Model**	
	Coeff	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Hazard & exposure score	0.25	0.15			0.13	0.16
Economic vulnerability score	0.41**	0.15			0.38*	0.15
Capacity score	0.39**	0.15			0.30*	0.15
State drought plan focus on mitigation (Mitigation)			1.21***	0.33	0.68*	0.32
Statutes requiring comprehensive plan (Presence)			0.65	0.37	0.61	0.37
Coastal/inland location (Inland)			-0.06	0.41	0.05	0.39
Metro/non-metro location (Non-metro)			0.01	0.31	-0.01	0.32
Pseudo R^2	0.18		0.14		0.23	
Pseudo R^2 Adj	0.16		0.10		0.17	
AIC	594.93		602.84		596.54	
BIC	608.30		618.88		620.59	
Ratio of predicted zeros	0.92		0.94		0.89	

* p<0.05; **p<0.01; ***p<0.001

4.4 CONCLUSION

This chapter includes a discussion of results from data analysis performed for this study. For comparison of alternate coding methods, it illustrates the use of efficiency and convergence measures for evaluating suitability of these methods to identify references under concepts related to a specific topic. It illustrates how the nature of vocabulary and number of references under each code may be used to explain the suitability of ML-based coding over Boolean Query-based coding and vice versa. For analysis of discussion on water conservation consideration, it illustrates the utility of 5A themes, inspired by plan quality analysis, to study the context of discussion in plans on concepts related to a specific topic. It discusses the types of references under each theme by codes and reveals a potential disconnect between the discussion under different themes for specific codes. Results in this chapter also identify prominent implementation mechanisms and implementation details mentioned under each water conservation code. Results illustrate how the scale of strategy application can explain the adopted mechanisms, and how the nature of mechanisms and their specificity may explain the provision of implementation details. Lastly, this chapter includes results from the inferential analysis that pinpoints economic vulnerability and capacity as local characteristics and state's drought plan focus on mitigation as the regional setting characteristic that can influence the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns. The results also highlight internal associations between characteristics that can affect their individual influence on the level of consideration.

Chapter 5. FINDINGS, LIMITIATIONS, AND IMPLICATIONS

This chapter summarizes the key findings from this research and connects them to the research questions posed for this study. It includes a discussion on key assumptions from the research methodology and their implications for the validity and reliability of results from analysis undertaken in this study. It describes the broader impacts of the findings from this study on plan evaluation methodology and on planning for resilience in drought-prone small cities and towns. Discussion in this chapter also pinpoints potential areas for future research to further clarify relationships explored in this study and to build on the methodological advancements from this research.

5.1 Key Findings

This section includes a summary of key findings from this research. The findings have been discussed under the three key areas addressed by this research. First, regarding comparison of alternate coding methods for plan evaluation, results illustrate that the performance of alternate coding methods (to traditional manual coding-based method) may be analyzed using their convergence and efficiency. While convergence helps to determine accuracy of an alternate coding method, efficiency is indicative of the of time the method may require (in terms of number of references) to identify relevant references. Results indicate that the suitability of methods tested in this research (i.e. ML-based and the Boolean Query-based methods) depends on the nature of discussion, in terms of strategies considered and vocabulary used, or the number of manual references under a code. When comparing the methods used in this research, it was found that high number of manual references in the training dataset or consistent nature of vocabulary of references in a code result in higher efficiency for ML-based coding method than Boolean Query-based method. The ML-based coding method was found to be more sensitive to the difference between strategies considered and vocabulary used in the test dataset from what was found in the training dataset for the codes being studied. This is also why state representation in the training dataset was found to be an important factor for better convergence and efficiency when using ML-based method. At the same time, Boolean Query-based method was found to have high number of references, and higher convergence than ML-based method, which makes this method more suitable for studies that require high accuracy but do not prioritize efficiency. Boolean Query-based method is also less sensitive to the difference in the nature of discussion between training and test dataset than the ML-based method, and it does not result in considerably high number of references for codes with a few relevant references in the test dataset. Based on these findings, Boolean Query-based method can be suitable for identifying references for codes that are expected to have scarce discussion and those that can have different discussion from the training dataset in the plans to be coded. Furthermore, though not tested in this study, it is possible to include keywords related to the code that were not found in the training dataset in the search query to improve this method's capability for identifying relevant references for codes with scarce discussion.

Second, the analysis of the discussion on water conservation in the sampled comprehensive plans illustrate that the 5A themes (Awareness, Analysis, Aspirations, Actions, and Applications) inspired from the plan quality analysis can be used to successfully deconstruct the discussion related to concepts under a specific topic. Results from the analysis reveal that majority of discussion under each water conservation code in the sampled plans is related to Actions and Application themes. The proportion of references under these themes is comparatively much higher when compared to the proportion for Awareness, Analysis, and Aspirations themes for all codes. The relationship between the discussions under different themes differs by codes. Findings from correlation analysis suggest that the discussion under Awareness/Analysis themes for WELI and WR codes are likely to support policies (under Actions) and/or implementation mechanisms (under Applications) for to these codes in the sampled plans. For other codes the relationship between Awareness/Analysis and Action/Application discussion is unclear and requires further analysis. In terms of types of mechanisms used for implementing water conservation strategies, the analysis reveals that overall, a high percentage of Application references mention some sort of requirements to implement water conservation strategies. The results suggest that the type of mechanisms adopted under each water conservation code differ and depend on the scale at which strategies under a code need to be applied (such as at community versus user level) and the extent of control that local governments have to affect water consumption. Results also suggest that provision of implementation details in comprehensive plans for policies and mechanisms is likely driven by the type of mechanism and their level of specificity. This is because the type of a mechanism drives the need for implementation related information. Whereas, both the type and specificity of a mechanism may affect the ability of the planning team to provide implementation details at the comprehensive planning stage.

Third, results from inferential analysis provide statistical evidence to conclude that economic vulnerability and capacity are the local characteristics and the state's drought plan focus on mitigation is the regional setting characteristic that can influence the level of water conservation consideration in comprehensive plans for drought-prone small cities and towns. The results indicate that both economic vulnerability and capacity scores have equivalent and statistically significant effect on the water conservation scores, which is much higher than the effect of hazard and exposure scores. The analysis reveals a low-moderate statistically significant correlation between drought experience (part of the hazard and exposure score) and other local characteristics, i.e. economic vulnerability and capacity scores, which reduces the overall influence of hazard and exposure scores on water conservation scores when controlling for the effect of these other variables in the regression model. This finding also suggests that the other local characteristics may be acting as mediators in the relationship between hazard and exposure and the level of water conservation consideration. Regarding the influence of regional setting characteristics, the results show that state's drought plan focus on mitigation has a statistically significant effect on water conservation consideration. The results also suggest that influence of the presence of state statutes that require comprehensive plans on the level of water conservation consideration is unclear and likely driven by influential data points. In fact, the association of this variable with water conservation scores was found to be statistically insignificant when using datasets without influential data points in regression analysis. Similarly, the effect of metro/non-metro and coastal/inland location on the level of water conservation consideration was also found to be statistically insignificant. The correlation analysis showed that metro/non-metro location did not have any significant association with water conservation scores, and the effect of coastal/inland location on water conservation scores was found to be insignificant when controlling for the effect of other characteristics in the regression models. Specifically, its correlation with capacity and presence of state statutes requiring a comprehensive plan seem to play a role in diminishing its relationship with water conservation scores. Overall, the results from this analysis indicate that local characteristics contribute more towards explaining the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns than regional setting characteristics. This could be due to the potential confounding and/or mediating role played by local characteristics in the relationship between regional setting characteristics and the level of water conservation consideration.

5.2 LIMITATIONS

The results from analyses in this research are based on multiple assumptions that should be accounted for their implications on reliability and validity of findings. This section describes these assumptions and implications and presents them in the chronological order of the tasks undertaken for this research. First, to identify drought-prone small cities and towns, forecasts for precipitation were based on a single combination of a global and regional models. This combination was assumed to have an accurate forecast of future precipitation, which can have implications for reliability of results from this study in terms of identification of drought-prone jurisdictions. Furthermore, comprehensive plans were used to determine water conservation consideration in local planning. This is based on the assumption that these plans can influence horizontal integration of strategies in multiple planning sectors for improving resilience to droughts. For example, Capital Improvement Plan and service area water plans, which also provide insights related to water conservation, should ideally follow the policy and implementation framework laid out by the comprehensive plan. However, in practice, they can deviate from the comprehensive plan, which has potential implications for generalizability of results from this study. Also, during sample development, up to 3 jurisdictions were selected from all states that were represented in the population of drought-prone small cities and towns to have equivalent representation across all states. Jurisdictions with an online and publicly available comprehensive plan that were individually developed within the last 20 years were included. But, this approach might lead to a smaller number of jurisdictions being selected from a few states that do not have minimum three jurisdictions with such a plan. This affects representation and has implications for generalizability of results from the analyses in this research.

During data collection, information on jurisdiction's planning staff was mostly obtained from municipal websites as this information was not available from comprehensive plans in multiple cases. This data was assumed to reflect the planning staff in the jurisdiction at the time of developing its comprehensive plan. Similarly, the data collected for revenue provides a more recent snapshot of fiscal capacity of jurisdictions, which was assumed to be similar to the fiscal capacity at the time of comprehensive plan development. These methodologies and associated assumptions for collecting capacity data have reliability implications for results from analysis of factors affecting the level of water conservation consideration. Future analysis may include a survey of local agencies to collect capacity data, for circumventing reliability implications to some extent.

To identify references in the sampled plans, a protocol was created that included five key concepts or codes related to strategies promoting water conservation. These commonly occurring concepts along with strategies under them were assumed to comprehensively capture any discussion on water conservation in a plan. However, it is possible that a plan could have references related to strategies that are not connected to these concepts, which will have implications for reliability of results from the analysis of factors affecting the level of water conservation consideration, and validity of results from the analysis of discussion on water conservation consideration in plans

To compare and execute alternate coding methods, manual coding of the training and test dataset was conducted based on the previously discussed protocol. The use of alternate coding methods in this research is based on the assumption that this manual coding of the datasets is done accurately. However, it is possible that the manual coding of training and test dataset may overlook relevant references in the plan. Both ML and Boolean Query-based coding methods are meant to reflect the patterns identified in training dataset. Hence, patterns in references that were not captured during manual coding will not be included to identify relevant references in the rest of the dataset and will have an impact on the reliability of results from this research. Future research may include multiple coders to manually code the smaller training and test dataset more consistently for circumventing this issue. After applying the alternate coding methods on the remaining dataset, a manual assessment was performed to check for relevance of references. Accuracy of these checks have reliability implications for results from analysis of discussion on water conservation in plans and factors determining the level of water conservation consideration. Future research should include a clear protocol of determining relevance (as used in this study) to address this issue. Researchers can also experiment with the use of more powerful ML-based tools such as Large Language Models to automate coding that may result in higher efficiency and lower number of references that are not relevant to circumvent the issue of inaccuracy due to manual checks to some extent.

To analyze the discussion related to water conservation consideration in the sampled plans, relevant references identified using the alternate coding methods were classified under the 5A themes and Application references were classified under 9 implementation mechanisms. This classification was done based on clear pre-defined rules. Accuracy of these classifications have reliability implications for results from analysis of discussion on water conservation in the sampled plans. Future research should include a clear protocol for classification (as done in this study) or may experiment with potential Large Language Models (LLMs) for automating classification of references.

Relevant references were also scored to determine the level of water conservation consideration. Scoring of references was done based on their content, i.e. the specificity of the strategy used (what) and the location of its execution (where). Accuracy of this scoring has implication for reliability of results from the analysis of factors determining the level of water conservation consideration in comprehensive plans of drought-prone small cities and towns. Also, disciplinary perspectives can differ on whether scoring should be done based on content and/or context of references. In this research, the scoring approach is agnostic to the classification of references under the 5A themes that pertain to the context of the information they provide. This is because plan quality literature does not differentiate between the importance of policies from that of fact base that justifies those policies (Norton, 2008; Berke & Godschalk, 2009). Future research may employ a scoring methodology based on content and context of references to test its implications on findings related to the level of water conservation consideration in the plans.

Later, the cumulated score of relevant references for each plan was used as the dependent variable in regression models to determine potential factors. Multiple local and regional setting characteristics were included in the regression models as independent variables. The uneven distribution of these variables can have implications for the reliability of results. For example, regional setting characteristics that include multiple categorical variables have a skewed distribution (apart from metro/non-metro location), that can affect the regression results. Furthermore, the regression analysis itself uses multiple assumptions that should checked for their implications on the reliability of results. Based on the regression diagnostics, the negative binomial regression models used in this study do not indicate an issue with zero-inflation (Table 4.10 and 4.11). However, other tests indicate issues related to residual distribution and presence of influential data points. The regression diagnostics plots (Appendix D) show that the residual distributions wavers from the desired trend for higher quantiles but follows the trend for lower quantile values. The plots also indicate presence of multiple influential data points that can skew the model results. The interpretation of regression models in this research addresses the presence of influential data points to some extent.

5.3 PLANNING AND METHODOLOGICAL IMPLICATIONS

Findings from this research have broader implications related to planning for resilience in drought-prone small cities and towns and in terms of methodology for future plan evaluation studies. This section includes a description of these implications.

5.3.1 *Plan Evaluation Methodology*

Researchers conducting plan evaluation studies can apply the approach used in this research to judge performance of alternate coding methods (such as ML and Boolean Query-based coding) to determine their suitability for identifying relevant references in their analysis. They can apply their alternate coding method(s) on test datasets and use convergence and efficiency measures to compare methods or to determine whether a method meets the minimum performance requirements for their study. More specifically, researchers can also use the findings from this study when choosing between ML and Boolean Query-based coding methods for identifying references in their studies. For each code in their study, they can decide which of the two methods to use based on the number of relevant references, the nature of reference vocabulary, and the representation of plans in the training dataset. They can also determine suitability of these methods based on the level of accuracy required for their analysis and the amount of relevant discussion they expect to find in their dataset.

Furthermore, the approach of using 5A themes to study water conservation consideration discussion in this study can be replicated in future plan evaluations to analyze discussions on concepts under any other topic. Basically, researchers can use the Awareness, Analysis, Aspirations, Actions, and Applications themes to deconstruct the discussion on their topic of interest. They can classify references under these themes to analyze the context in which the information relevant to the concepts related to their topics has been discussed in the plans. This deconstruction will allow them to analyze the dominating themes, and the relationship between them to determine the nature of discussion.

5.3.2 *Planning for Resilience in Drought-prone Small Cities and Towns*

Findings from this study have multiple implications for the quality of discussion, access to information, policies at higher levels of governance, and implementation planning related to consideration of resilience in comprehensive plans of drought-prone small cities and towns.

a) Quality of resilience discussion in the plans

Findings reveal that water conservation discussion related to Actions and Application themes are proportionally much higher compared to discussion under the Awareness and Analysis themes. Also, the relationship between the discussion under these themes seems to be unclear for BWSE, PWSE, and WC codes. These findings have implications for the quality of discussion on resilience in comprehensive plans of drought-prone small cities and towns. Evidence suggests that the policies and implementation mechanisms related to some water conservation concepts are not accompanied by supporting information to explain their need and potential impact for the jurisdiction. This information is part of issue identification and fact base that are integral characteristics of a good quality comprehensive plan (Berke & Godschalk, 2009; Norton, 2008).

Including this information supports a rational discourse related to taking action for water conservation in these plans, and provides a level of transparency regarding decision making to adopt these actions.

To improve the quality of discussion in comprehensive plans, data and policy factsheets related to resilience planning should be made more accessible to local jurisdictions. Professional organizations (such as the American Planning Association) provide some policy guidance related to planning for resilience to drought, but this information may not be on the radar of planners in small cities and towns. State agencies can highlight such resources to bring them to the attention of municipal staff in these jurisdictions. At the same time, state or regional agencies can provide useful hydrological data and regional case studies to help jurisdictions discern the potential impacts of resilience building actions in their context. For example, Washington State Department of Ecology provides a report of water availability in the state using multiple data resources (WA Department of Ecology, 2024). Supplementing these resources with training on how jurisdictions can apply this information to support resilience building actions may further promote its use, especially in smaller cities and towns that lack technical expertise.

b) Planning for implementation of resilience strategies in the plans

Findings suggest that implementation mechanisms vary based on the nature of strategies, particularly on the scale of implementation and the level of agency control. Strategies that are applied at the user-level and tend to have low agency control (such as those under BWSE code) usually include diverse mechanisms (such as incentives and guidelines/education) to influence user actions. Diversification of implementation mechanisms can be associated with high level of management that requires more staff time. Small cities and towns tend to have low staff capacity and may not be inclined to adopt multiple mechanisms to implement user-centric strategies.

Agencies at higher level of governance can assist these jurisdictions by providing funding for hiring staff/consultants and offer guidelines/education material that can be used to inform community members.

Furthermore, results from this research reveal that only 7% of Actions and 22% Application references related to water conservation are supported by implementation details. These details comprise of information related to timing/priority, responsible agency, and funding. Among these details, funding information is most scarce. Findings suggest that the inclusion of implementation details is related to the type of implementation mechanism and their level of specificity. It is noted that some mechanisms can be more difficult to scope than others for certain types of implementation details at the comprehensive planning stage. However, the level of specificity of mechanisms can greatly facilitate the provision of implementation details. Hence, local jurisdictions should strive for improved implementation planning of resilience strategies in their long-term plans by being more specific about their adopted mechanisms. To facilitate implementation planning, policy guidance on resilience strategies (by federal, states, or non-governmental agencies) should comprise of implementation resources. These resources can include examples of resilience strategy applications by local jurisdictions, potential funding sources, and useful tools that can inform implementation (such as data repositories and assessment reports).

c) Factors influencing resilience consideration in long-term development planning

Findings from the analysis of factors influencing the level of water conservation consideration in a jurisdiction reveal local and regional characteristics that can significantly affect water conservation scores in drought-prone small cities and towns. These findings have important implications for local resilience policy diffusion, design of policies and program frameworks at higher levels of governance, and communication related to planning for climate change and drought risk.

Firstly, findings from this research suggest that the capacity of drought-prone small cities and towns can likely influence the level of water conservation consideration in their comprehensive plans. This potential impact of capacity has important implications for planning in small cities and towns, as these jurisdictions tend to have low planning capacity, defined by their smaller planning staff and lower revenue due to smaller tax base. The role of capacity on planning for resilience should be kept in mind while designing policies, regulations, and programs at higher levels of governance to promote resilience development at the local level. External support can be greatly helpful, especially for smaller jurisdictions, at an initial stage for building capacity to plan for specific resilience issues. Additionally, multiple states have adopted policies or mandates related to planning at the local level that can be both funded or unfunded. Findings from this study clearly illustrate the role of local capacity in promoting planning for water conservation in small cities and towns. These findings can be used to argue for funded mandates, specifically to support smaller jurisdictions to help fulfil their planning obligations as per the mandate.

Secondly, findings suggest that economic vulnerability can also influence consideration of water conservation in comprehensive plans of drought-prone small cities and towns. These results have implications for how benefits of resilience strategies are communicated to local jurisdictions. Based on results from this research, communicating benefits of water conservation in drought-prone small cities and towns from the lens of economic development and sustainability may be more effective in improving the level of water conservation consideration in their long-term planning. Smaller jurisdictions tend to have a high percentage of employment in natural resources dependent and food and accommodation services industries (particularly if they rely heavily on tourism). As discussed earlier, these industries are deeply affected by water availability. Hence, communicating the impacts of long-term planning for water conservation from the angle of economic impacts might be more effective in these jurisdictions. At the same time, due to their high dependence on natural resources and tourism, smaller cities and towns are more vulnerable to unavoidable impacts of climate change on water availability. Hence, focused efforts are needed to diversify employment in these jurisdictions along with long-term planning for water conservation to build resilience.

Lastly, findings from this research suggest that state's drought management approach can influence water conservation consideration in comprehensive plans for drought-prone small cities and towns. The results reveal that jurisdictions from states focusing on drought mitigation are associated with those that have high water conservation scores. These results provide important empirical evidence that states' strategy for tackling a resilience issue (such as water availability) at the regional level can influence planning for that issue at the local level, illustrating the embeddedness of the resilience process. In the case of smaller cities, it is more likely that actions at the state level precede actions at the local level, because of their lack of capacity and lower tendency to be proactive about planning for environmental issues. Findings from this research related to the potential impact of the state's drought management approach on local planning response for improving water conservation have significant implications for the role of state in fostering resilience development in smaller cities and towns. States that support their resilience development policies with funding and technical guidance can further facilitate reciprocity at the local level, especially in smaller jurisdictions.

5.4 FUTURE RESEARCH

This research provides nuanced answers to key questions related to the use of alternate coding methods in plan evaluation studies, the nature of water conservation discussion in comprehensive plans of small cities and towns of US, and factors the determine the level of water conservation consideration in these plans. Future studies can provide information to further clarify findings from this research in four important ways. Firstly, a proximity analysis of Action/Application and Awareness/Analysis references w.r.t. each other can clarify the potential relationship between these references as discussed in findings of this research. This analysis can be supplemented with a semantic study to determine the level of similarity in the meaning of references under these themes for further clarification of relationship between them. Secondly, a causal analysis should be performed using correlation and regression results from this study to determine connections (paths) between the different local and regional setting characteristics. These connections will further clarify the influence of these characteristics on water conservation consideration in comprehensive plans of drought-prone small cities and towns. The empirical evidence from inferential analysis undertaken in this research already points towards potential confounding and mediating roles of certain characteristics. A causal analysis, such as one that utilizes structural equation modelling (SEM), can elucidate these roles and identify the connections between different characteristics. Thirdly, additional characteristics should be considered to explain the water conservation policy adoption. For example, further analysis of policy diffusion should be conducted to understand how nearby jurisdictions may be affecting adoption of water conservation policy by a small city or town. This research was able to analyze the coercion mechanism or vertical diffusion to a certain extent by focusing on the role of policies at the state level on planning for water conservation in smaller jurisdictions. It also includes a few aspects, such as location w.r.t metropolitan region and coastal areas, to study the role of neighboring jurisdictions and setting causing horizontal diffusion. To further explore the role of horizontal diffusion, other aspects such as regional partnerships for water management can be studied to determine their influence on water conservation policy adoption. Also, to further clarify the role of state's ability to steer local planning, the influence of state statute(s) requiring comprehensive plan development should be studied in some detail, especially its ability to promote initial consideration of water conservation in comprehensive plans of smaller jurisdictions. Finally, researchers should continue to advance the use of alternate coding approaches in plan evaluation studies. Future studies can experiment with the use of Large Language Models (LLMs) for automating coding of plans based on a pre-defined protocol. These methods can have improved performance in terms of convergence and efficiency. Such a model can help avoid the need for manual checks for relevance of references, and using "semi-supervised" (a combination of supervised and unsupervised) models can help reduce the amount of manual coding needed to train the model (Bergmann, 2023). Also, application of these models for classification of references as per the 5A themes to analyze the discussion of concepts under a topic in plans should be tested to improve reliability of results.

5.5 CONCLUSION

Findings discussed in this chapter provide nuanced answers to the research questions. They address key issues plaguing plan evaluation studies and analysis of resilience in small cities and towns. Overall, this research has three main contributions. The first important contribution is a methodology for performance evaluation and application of alternate approaches to manual-based coding in plan evaluation. The use of convergence and efficiency measures to determine the suitability of alternate methods for coding large datasets allows researchers to take informed decisions regarding their application. These methods facilitate the use of larger samples and improve generalizability of research findings. The performance comparison of ML and Boolean-Query based methods in this study using these measures revealed patterns in the selection of methods w.r.t the number and nature of vocabulary of references in a code. These patterns may be used to inform future applications of these methods. It is important to note that these alternate methods are not devoid of manual coding. Manually identified references are used to provide coding patterns to train the tools associated with these methods. Successful application of these methods relies of the accuracy of manual coding of the training dataset and manual checks to confirm relevance of references. Future research can explore alternate coding methods that can reduce the need for manual effort.

The second main contribution of this study is in terms of describing the nature of water conservation consideration in development plans of small cities and towns. This research demonstrates the use of context-based themes (inspired by plan quality literature) to study the discussion on specific water conservation concepts or codes. The study reveals much higher level of discussion related to Actions and Applications than other themes for all water conservation codes and a potential disconnect between Actions/Applications and Awareness/Analysis discussions for specific codes. This disconnect has implications for plan quality in terms of providing a rational discourse with proper justification for adopting a policy or implementation mechanism. Future research can clarify the connection between discussion under these different themes using semantic and proximity analysis. Furthermore, an in-dept analysis of implementation information reveals a higher use of requirements than other mechanisms. Results from the study indicate that the scale of application and the level of control over execution of strategies and the nature of mechanisms and their specificity can drive provision of implementation details. These findings have implications for technical assistance that can be helpful for smaller jurisdictions to improve their implementation planning.

The third main contribution of this research is in terms of explaining water conservation consideration in comprehensive plans of drought-prone small cities and towns. Results from the inferential analysis in this study pinpoint potential factors affecting the level of water conservation consideration in these jurisdictions. Findings reveal planning capacity and economic vulnerability as local characteristics and the state's drought plan focus on mitigation as the regional characteristic that can influence the level of water conservation consideration. These factors have implications for resilience policy adoption in small jurisdictions, specifically in terms of the potential role of state planning and policies and ways in which states can foster resilience development in these jurisdictions. They also show the benefits of approaching resilience development by considering economic impacts of droughts for a small jurisdiction. Other characteristics included in the inferential analysis had mutual associations that affected their individual influence on water conservation consideration. Future studies can clarify these connections (especially, between the local and regional characteristics) using causal analysis. They can also investigate the influence of regional characteristics, related to horizontal policy diffusion, that were not included in this study on water conservation consideration in local plans for long-term development.

BIBLIOGRAPHY

Aggarwal, C. C., & Zhai, C. (Eds.). (2012). *Mining Text Data*. Springer US. https://doi.org/10.1007/978-1-4614-3223-4

AMEC. (2010). *Municipal Drought Management Plan Guidance Document*. Colorado Water Conservation Board. https://dnrweblink.state.co.us/cwcbsearch/ElectronicFile.aspx?docid=211769&dbid=0

An, B. Y., Butz, A. M., & Mitchell, J. L. (2022). A contingent diffusion model of local climate change policy adoption: Evidence from Southern California cities. *Cities*, *120*, 103418. https://doi.org/10.1016/j.cities.2021.103418

APA. (2019). *Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts* (p. 41). https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf

APA. (2022). *2022 Survey of State Planning Law*. https://www.planning.org/research/2022-survey-of-state-planning-laws/

Arguez, A., Durre, I., Applequist, S., Vose, R. S., Squires, M. F., Yin, X., Heim, R. R., & Owen, T. W. (2012). NOAA's 1981–2010 U.S. Climate Normals: An Overview. *Bulletin of the American Meteorological Society*, *93*(11), 1687–1697. https://doi.org/10.1175/BAMS-D-11-00197.1

Asinas, E., Raymond, C., & Mehta, A. (2022). *Integrating Climate Resilience into Washington State Water System Planning*. https://doi.org/10.6069/PS0E-M345

Atkinson, R. (2019). The Small Towns conundrum: What do we do about them? *Regional Statistics*, *9*(2), 3–19. https://doi.org/10.15196/RS090201

Baer, W. C. (1997). General Plan Evaluation Criteria: An Approach to Making Better Plans. *Journal of the American Planning Association*, *63*(3), 329–344. https://doi.org/10.1080/01944369708975926

Bell, D., & Jayne, M. (2009). Small Cities? Towards a Research Agenda. *International Journal of Urban and Regional Research*, *33*(3), 683–699. https://doi.org/10.1111/j.1468-2427.2009.00886.x

Bergmann, D. (2023). *What is semi-supervised learning?* IBM. https://www.ibm.com/topics/semi-supervised-learning#:~:text=Semi%2Dsupervised%20learning%20is%20a,for%20classification%20and%20regression%20tasks.

Berke, P., & Godschalk, D. (2009). Searching for the Good Plan: A Meta-Analysis of Plan Quality Studies. *Journal of Planning Literature*, *23*(3), 227–240. https://doi.org/10.1177/0885412208327014

Berke, P., Newman, G., Lee, J., Combs, T., Kolosna, C., & Salvesen, D. (2015). Evaluation of Networks of Plans and Vulnerability to Hazards and Climate Change: A Resilience Scorecard. *Journal of the American Planning Association*, *81*(4), 287–302. https://doi.org/10.1080/01944363.2015.1093954

Berke, P., Smith, G., & Lyles, W. (2012). Planning for Resiliency: Evaluation of State Hazard Mitigation Plans under the Disaster Mitigation Act. *Natural Hazards Review*, *13*(2), 139–149. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000063

Berkes, F., & Ross, H. (2016). Panarchy and community resilience: Sustainability science and policy implications. *Environmental Science & Policy*, *61*, 185–193. https://doi.org/10.1016/j.envsci.2016.04.004

Berry, F. S., & Berry, W. D. (1990). State Lottery Adoptions as Policy Innovations: An Event History Analysis. *American Political Science Review*, *84*(2), 395–415. https://doi.org/10.2307/1963526

Berry, W. D., & Baybeck, B. (2005). Using Geographic Information Systems to Study Interstate Competition. *American Political Science Review*, *99*(4), 505–519. https://doi.org/10.1017/S0003055405051841

Blaney, J., Filer, K., & Lyon, J. (2014). Assessing High Impact Practices Using NVivo: An Automated Approach to Analyzing Student Reflections for Program Improvement. *Research & Practice in Assessment*, *9*, 97–100.

Bolinger, B. (2019). How Drought Prone Is Your State? A Look at the Top States and Counties in Drought Over the Last Two Decades. *Drought.Gov*. https://www.drought.gov/news/how-drought-prone-your-state-look-top-states-and-counties-drought-over-last-two-decades

Brinkley, C., & Stahmer, C. (2021). What Is in a Plan? Using Natural Language Processing to Read 461 California City General Plans. *Journal of Planning Education and Research*, *44*(2), 0739456X2199589. https://doi.org/10.1177/0739456X21995890

Brody, S. D. (2003). Are We Learning to Make Better Plans?: A Longitudinal Analysis of Plan Quality Associated with Natural Hazards. *Journal of Planning Education and Research*, *23*(2), 191–201. https://doi.org/10.1177/0739456X03258635

Brown, J., Hirsch, J. A., Tabb, L. P., Judd, S. E., Bennett, A., Rundle, A., & Lovasi, G. S. (2024). A Segmented Regression Analysis of Household Income and Recurrent Falls Among Adults in a National Cohort Study. *American Journal of Epidemiology*, *193*(3), 516–526. https://doi.org/10.1093/aje/kwad211

Butler, W., Holmes, T., & Lange, Z. (2021). Mandated Planning for Climate Change: Responding to the Peril of Flood Act for Sea Level Rise Adaptation in Florida. *Journal of the American Planning Association*, *87*(3), 370–382. https://doi.org/10.1080/01944363.2020.1865188

Cai, H., Lam, N. S. N., Qiang, Y., Zou, L., Correll, R. M., & Mihunov, V. (2018). A synthesis of disaster resilience measurement methods and indices. *International Journal of Disaster Risk Reduction*, *31*, 844–855. https://doi.org/10.1016/j.ijdrr.2018.07.015

California SB 379, California Legislation 2015-2016 Regular Session (2015). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB379

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W. L., Connors, S., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., … Péan, C. (2023). *IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.* (First). Intergovernmental Panel on Climate Change (IPCC). https://doi.org/10.59327/IPCC/AR6-9789291691647

Cameron, A. C., & Trivedi, P. K. (2013). *Regression Analysis of Count Data* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781139013567

Cameron, A., & Windmeijer, F. A. G. (1997). An R-squared measure of goodness of fit for some common nonlinear regression models. *Journal of Econometrics*, *77*(2), 329–342. https://doi.org/10.1016/S0304-4076(96)01818-0

Cardona, O.-D., Van Aalst, M. K., Birkmann, J., Fordham, M., McGregor, G., Perez, R., Pulwarty, R. S., Schipper, E. L. F., Sinh, B. T., Décamps, H., Keim, M., Davis, I., Ebi, K. L., Lavell, A., Mechler, R., Murray, V., Pelling, M., Pohl, J., Smith, A.-O., & Thomalla, F. (2012). Determinants of Risk: Exposure and Vulnerability. In C. B. Field, V. Barros, T. F. Stocker, & Q. Dahe (Eds.), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (1st ed., pp. 65–108). Cambridge University Press. https://doi.org/10.1017/CBO9781139177245.005

CDC. (2024). *Health Impacts of Droughts*. https://www.cdc.gov/drought-health/health-implications/index.html

Census Bureau. (2012). *TIGERweb Geographic Entities*. https://tigerweb.geo.census.gov/tigerwebmain/TIGERweb_geography_details.html#INCPLACE

Census Bureau. (2021). *Metropolitan and Micropolitan*. About. https://www.census.gov/programs-surveys/metro-micro/about.html

Census Bureau. (n.d.). *TIGER/Line® Shapefiles*. https://www.census.gov/cgi-bin/geo/shapefiles/index.php

Cimellaro, G. P. (2016). Resilience Indicators. In *Urban Resilience for Emergency Response and Recovery* (Vol. 41). Springer International Publishing. https://doi.org/10.1007/978-3-319-30656-8

Cox, R. S., & Hamlen, M. (2015). Community Disaster Resilience and the Rural Resilience Index. *American Behavioral Scientist*, *59*(2), 220–237. https://doi.org/10.1177/0002764214550297

Crain, R. L. (1966). Fluoridation: The Diffusion of an Innovation among Cities. *Social Forces*, *44*(4), 467. https://doi.org/10.2307/2575080

Cretney, R. (2014). Resilience for Whom? Emerging Critical Geographies of Socio-ecological Resilience. *Geography Compass*, *8*(9), 627–640. https://doi.org/10.1111/gec3.12154

Cross, J. (2001). Megacities and small towns: Different perspectives on hazard vulnerability. *Global Environmental Change Part B: Environmental Hazards*, *3*(2), 63–80. https://doi.org/10.1016/S1464-2867(01)00020-1

Cupps, K. (2000). *Water Reclamation and Reuse—The Demonstration Projects* (00-10–06). Department of Ecology, State of Washington. https://apps.ecology.wa.gov/publications/documents/0010062.pdf

Cutter, S. L. (2016a). Resilience to What? Resilience for Whom? *The Geographical Journal*, *182*(2), 110–113. https://doi.org/10.1111/geoj.12174

Cutter, S. L. (2016b). The landscape of disaster resilience indicators in the USA. *Natural Hazards*, *80*(2), 741–758. https://doi.org/10.1007/s11069-015-1993-2

Cutter, S. L., Ash, K. D., & Emrich, C. T. (2016). Urban–Rural Differences in Disaster Resilience. *Annals of the American Association of Geographers*, *106*(6), 1236–1252. https://doi.org/10.1080/24694452.2016.1194740

Da Cunha, C., & Lioubimtseva, E. (2021). Metadata for climate change adaptation plans of small and mid-size French and American cities. *Data in Brief*, *36*, 106981. https://doi.org/10.1016/j.dib.2021.106981

Daley, D. M., & Garand, J. C. (2005). Horizontal Diffusion, Vertical Diffusion, and Internal Pressure in State Environmental Policymaking, 1989-1998. *American Politics Research*, *33*(5), 615–644. https://doi.org/10.1177/1532673X04273416

Daniel, J. (2012). *Sampling Essentials: Practical Guidelines for Making Sampling Choices*. SAGE Publications, Inc. https://doi.org/10.4135/9781452272047

Deslatte, A., Chung, J., & Stokan, E. (2023). Structural drivers of sustainability and resilience strategies in small(ish) cities: A text analysis of comprehensive planning in Indiana. *Journal of Environmental Planning and Management*, 1–22. https://doi.org/10.1080/09640568.2023.2240951

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (Fourth edition). Wiley.

Dobbin, K. B., & Lubell, M. (2021). Collaborative Governance and Environmental Justice: Disadvantaged Community Representation in California Sustainable Groundwater Management. *Policy Studies Journal*, *49*(2), 562–590. https://doi.org/10.1111/psj.12375

Dolšak, N., & Sampson, K. (2012). The Diffusion of Market-Based Instruments: The Case of Air Pollution. *Administration & Society*, *44*(3), 310–342. https://doi.org/10.1177/0095399711400047

Driver, B., Miller, B., & Wojcik, D. (2003). *Smart water: A comparative study of urban water use across the Southwest.* Western Resources Advocates. https://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/cachuma/comments_rdeir/pacific_institute/4otherreports/wra_ch3smartwater2003.pdf

Drought.gov. (2021). *Drought Basics*. https://www.drought.gov/what-is-drought/drought-basics

Drought.gov. (n.d.). *Explaining Drought Category Maps*. https://www.drought.gov/explaining-drought-category-maps

EPA. (2013). *Water Efficiency for Public Water Systems*. U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100MEV6.PDF?Dockey=P100MEV6.PDF

Eppig, M., Jang, M., Oestreich, V., & Zhang, E. (2022). *Water Wise: Strategies for Drought-Resilient Development*. Urban Land Institute. https://knowledge.uli.org/-/media/files/research-reports/2022/uli-water-wise-final-report.pdf?rev=25e50177f1a24d8f85ef9c2061f83d34&hash=1A1618EE76839F04ED858922A4445B0B

Feinberg, D. S., & Ryan, C. M. (2020). Evaluating the Quality and Implementation of Hazard Mitigation Plans in Coastal Washington State. *Natural Hazards Review*, *21*(2), 04020013. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000372

FEMA. (2021a). *National Risk Index: Drought*. https://hazards.fema.gov/nri/drought

FEMA. (2021b). *Planning for Drought Resilience* (p. 3) [Factsheet]. https://www.fema.gov/sites/default/files/documents/fema_drought-planning-fact-sheet_092021.pdf

FEMA. (2024). *Regulations and Guidance*. https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/regulations-guidance

Florida SB 1094, The Florida Senate 2015 Session (2015). https://www.flsenate.gov/Session/Bill/2015/1094/BillText/er/PDF

Frazier, T. G., Walker, M. H., Kumari, A., & Thompson, C. M. (2013). Opportunities and constraints to hazard mitigation planning. *Applied Geography*, *40*, 52–60. https://doi.org/10.1016/j.apgeog.2013.01.008

Fu, X. (2013). *Planning for drought-resilient communities: Evaluating the fastest growing counties' local comprehensive plans* [University of Nebraska - Lincoln]. https://digitalcommons.unl.edu/arch_crp_theses/23/

Fu, X., Li, C., & Zhai, W. (2023). Using Natural Language Processing to Read Plans: A Study of 78 Resilience Plans From the 100 Resilient Cities Network. *Journal of the American Planning Association*, *89*(1), 107–119. https://doi.org/10.1080/01944363.2022.2038659

Fu, X., & Tang, Z. (2013). Planning for drought-resilient communities: An evaluation of local comprehensive plans in the fastest growing counties in the US. *Cities*, *32*, 60–69. https://doi.org/10.1016/j.cities.2013.03.001

Fu, X., Tang, Z., Wu, J., & McMillan, K. (2013). Drought planning research in the United States: An overview and outlook. *International Journal of Disaster Risk Science*, *4*(2), 51–58. https://doi.org/10.1007/s13753-013-0006-x

Fuller, T. (2021). Small Towns Grow Desperate for Water in California. *New York Times*. https://www.nytimes.com/2021/08/14/us/drought-california-water-shortage.html

Godschalk, D. R., Brody, S., & Burby, R. (2003). Public Participation in Natural Hazard Mitigation Policy Formation: Challenges for Comprehensive Planning. *Journal of Environmental Planning and Management*, *46*(5), 733–754. https://doi.org/10.1080/0964056032000138463

Godschalk, D. R, Kaiser, E. J., & Berke, P. R. (1998). Integrating hazard mitigation and local land-use planning. In *Cooperating with nature: Confronting natural hazards with land-use planning for sustainable communities* (pp. 85–118).

Gonick, S. A., & Errett, N. A. (2018). Integrating Climate Change into Hazard Mitigation Planning: A Survey of State Hazard Mitigation Officers. *Sustainability*, *10*(11), 4150. https://doi.org/10.3390/su10114150

Graham, E. R., Shipan, C. R., & Volden, C. (2013). The Diffusion of Policy Diffusion Research in Political Science. *British Journal of Political Science*, *43*(3), 673–701. https://doi.org/10.1017/S0007123412000415

Greene, S. K., Levin-Rector, A., McGibbon, E., Baumgartner, J., Devinney, K., Ternier, A., Sell, J., Kahn, R., & Kishore, N. (2022). Reduced COVID-19 hospitalizations among New York City residents following age-based SARS-CoV-2 vaccine eligibility: Evidence from a regression discontinuity design. *Vaccine: X*, *10*, 100134. https://doi.org/10.1016/j.jvacx.2021.100134

Grossmann, K., & Mallach, A. (2021). The small city in the urban system: Complex pathways of growth and decline. *Geografiska Annaler: Series B, Human Geography*, *103*(3), 169–175. https://doi.org/10.1080/04353684.2021.1953280

Grover, H. (2010). *Local Response to Global Climate Change: The Role of Local Development Plans in Climate Change Management* [Texas A&M University]. https://hdl.handle.net/1969.1/ETD-TAMU-2010-08-8461

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: Understanding transformations in human and natural systems*. Island Press.

Haase, T. W., Wang, W.-J., & Ross, A. D. (2021). The six capacities of community resilience: Evidence from three small Texas communities impacted by Hurricane Harvey. *Natural Hazards*, *109*(1), 1097–1118. https://doi.org/10.1007/s11069-021-04870-y

Hai-Jew, S. (2014). *"Autocoding" through Machine Learning from Existing (Human) Coding Patterns*. Using NVivo: An Unofficial and Unauthorized Primer. https://scalar.usc.edu/works/using-nvivo-an-unofficial-and-unauthorized-primer/autocoding-through-machine-learning

Hamin, E. M., Gurran, N., & Emlinger, A. M. (2014). Barriers to Municipal Climate Adaptation: Examples From Coastal Massachusetts' Smaller Cities and Towns. *Journal of the American Planning Association*, *80*(2), 110–122. https://doi.org/10.1080/01944363.2014.949590

Hilaire, R. St., Arnold, M. A., Wilkerson, D. C., Devitt, D. A., Hurd, B. H., Lesikar, B. J., Lohr, V. I., Martin, C. A., McDonald, G. V., Morris, R. L., Pittenger, D. R., Shaw, D. A., & Zoldoske, D. F. (2008). Efficient Water Use in Residential Urban Landscapes. *HortScience*, *43*(7), 2081–2092. https://doi.org/10.21273/HORTSCI.43.7.2081

Hill, T., & Polsky, C. (2007). Suburbanization and drought: A mixed methods vulnerability assessment in rainy Massachusetts. *Environmental Hazards*, *7*(4), 291–301. https://doi.org/10.1016/j.envhaz.2007.08.003

Holmes, T. J., & Butler, W. H. (2021). Implementing a mandate to plan for sea level rise: Top-down, bottom-up, and middle-out actions in the Tampa Bay region. *Journal of Environmental Planning and Management*, *64*(12), 2214–2232. https://doi.org/10.1080/09640568.2020.1865885

Homsy, G. C. (2018). Unlikely pioneers: Creative climate change policymaking in smaller U.S. cities. *Journal of Environmental Studies and Sciences*, *8*(2), 121–131. https://doi.org/10.1007/s13412-018-0483-8

Horney, J., Nguyen, M., Salvesen, D., Dwyer, C., Cooper, J., & Berke, P. (2017). Assessing the Quality of Rural Hazard Mitigation Plans in the Southeastern United States. *Journal of Planning Education and Research*, *37*(1), 56–65. https://doi.org/10.1177/0739456X16628605

Kang, J.E. (2009). *Mitigating Flood Loss through Local Comprehensive Planning in Florida* [Texas A&M University]. https://hdl.handle.net/1969.1/ETD-TAMU-2009-08-7161

Kang, K. E., Bowman, A. O., Hannibal, B., Woodruff, S., & Portney (Deceased), K. (2023). Ecological, Engineering and Community Resilience Policy Adoption in Large US Cities. *Urban Affairs Review*, *59*(6), 1973–2004. https://doi.org/10.1177/10780874221150793

Keith, L., Gabbe, C. J., & Schmidt, E. (2023). Urban heat governance: Examining the role of urban planning. *Journal of Environmental Policy & Planning*, *25*(5), 642–662. https://doi.org/10.1080/1523908X.2023.2244446

Kelly, E. D. (2012). *Community Planning An Introduction to the Comprehensive Plan, Second Edition* (2nd ed). Island Press.

Khatibi, F. S., Dedekorkut-Howes, A., Howes, M., & Torabi, E. (2021). Can public awareness, knowledge and engagement improve climate change adaptation policies? *Discover Sustainability*, *2*(1), 18. https://doi.org/10.1007/s43621-021-00024-z

Krause, R. M. (2012). An Assessment of the Impact that Participation in Local Climate Networks Has on Cities' Implementation of Climate, Energy, and Transportation Policies. *Review of Policy Research*, *29*(5), 585–604. https://doi.org/10.1111/j.1541-1338.2012.00582.x

Leetmaa, K., Kriszan, A., Nuga, M., & Burdack, J. (2015). Strategies to Cope with Shrinkage in the Lower End of the Urban Hierarchy in Estonia and Central Germany. *European Planning Studies*, *23*(1), 147–165. https://doi.org/10.1080/09654313.2013.820100

Lehmann, M., Major, D. C., Fitton, J., Doust, K., & O'Donoghue, S. (2021). Introduction to "The Unusual Suspects in Climate Change Adaptation – Small Coastal Cities and Towns" Special Issue. *Ocean & Coastal Management*, *212*, 105786. https://doi.org/10.1016/j.ocecoaman.2021.105786

Levesque, V. R., Wake, C., & Peterson, J. M. (2021). Facilitating use of climate information for adaptation actions in small coastal communities. *Elementa: Science of the Anthropocene*, *9*(1), 00048. https://doi.org/10.1525/elementa.2020.20.00048

Li, Q., Hannibal, B., Mostafavi, A., Berke, P., Woodruff, S., & Vedlitz, A. (2020). Examining of the actor collaboration networks around hazard mitigation: A hurricane harvey study. *Natural Hazards*, *103*(3), 3541–3562. https://doi.org/10.1007/s11069-020-04142-1

Logan, T. M., Aven, T., Guikema, S. D., & Flage, R. (2022). Risk science offers an integrated approach to resilience. *Nature Sustainability*, *5*(9), 741–748. https://doi.org/10.1038/s41893-022-00893-w

Luers, A., & Moser, S. (2006). *Preparing for the Impacts of Climate Change in California: Opportunities and Constraints for Adaptation* (CEC-500-2005-198-SF). https://research.fit.edu/media/site-specific/researchfitedu/coast-climate-adaptationlibrary/united-states/west-coast-amp-hawaix27i/california---statewide/CCCC.--2006.--Opportunities--Constraints-for-CC-Adaptation-in-California.pdf

Lyles, W., Berke, P., & Overstreet, K. H. (2018). Where to begin municipal climate adaptation planning? Evaluating two local choices. *Journal of Environmental Planning and Management*, *61*(11), 1994–2014. https://doi.org/10.1080/09640568.2017.1379958

Lyles, W., Berke, P., & Smith, G. (2014). A comparison of local hazard mitigation plan quality in six states, USA. *Landscape and Urban Planning*, *122*, 89–99. https://doi.org/10.1016/j.landurbplan.2013.11.010

Matisoff, D. C. (2008). The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Regional Diffusion or Internal Determinants? *Review of Policy Research*, *25*(6), 527–546. https://doi.org/10.1111/j.1541-1338.2008.00360.x

Mattson, G., & Solano, P. (1986). New Federalism and Small Towns: Do Planning-Management Skills Matter for Access Funding And Benefits? *Journal of Architectural and Planning Research*, *3*(2). https://www.jstor.org/stable/43028796

Maupin, M.A. (2018). *Summary of estimated water use in the United States in 2015* (Fact Sheet) [Fact Sheet]. U.S. Geological Survey. https://pubs.usgs.gov/publication/fs20183035

Mearns, L., McGinnis, S., Korytina, D., Arritt, R., Biner, S., Bukovsky, M., Chang, H.-I., Christensen, O., Herzmann, D., Jiao, Y., Kharin, S., Lazare, M., Nikulin, G., Qian, M., Scinocca, J., Winger, K., Castro, C., Frigon, A., & Gutowski, W. (2017). *The NA-CORDEX dataset* [netCDF]. UCAR/NCAR. https://doi.org/10.5065/D6SJ1JCH

Meerow, S., & Newell, J. P. (2019). Urban resilience for whom, what, when, where, and why? *Urban Geography*, *40*(3), 309–329. https://doi.org/10.1080/02723638.2016.1206395

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011

Meijer, M., & Syssner, J. (2017). Getting ahead in depopulating areas—How linking social capital is used for informal planning practices in Sweden and The Netherlands. *Journal of Rural Studies*, *55*, 59–70. https://doi.org/10.1016/j.jrurstud.2017.07.014

Merzdorf, J. (2019). *A Drier Future Sets the Stage for More Wildfires*. https://science.nasa.gov/earth/natural-disasters/wildfires/a-drier-future-sets-the-stage-for-more-wildfires/

Mileti, D. (1999). *Disasters by Design: A Reassessment of Natural Hazards in the United States* (p. 5782). Joseph Henry Press. https://doi.org/10.17226/5782

Miller, A. (2019). *Planning for Hazards: Land Use Drought and Cascading Hazards*. Planning for Hazards: Land Use Solutions for Drought and Cascading Impacts. https://planning-org-uploaded-media.s3.amazonaws.com/document/Planning-for-Hazards-Land-Use-Solutions-Drought-webinar.pdf

Mogelgaard, K., Dinshaw, A., Ginoya, N., Gutiérrez, M., Preethan, P., & Waslander, J. (2018). *From Planning to Action: Mainstreaming Climate Change Adaptation Into Development*. World Resources Institute. https://www.wri.org/research/planning-action-mainstreaming-climate-change-adaptation-development

Mosso, D., Flaner, R., Tonning, B., & Hair, L. (2019). *Integrating Water Quality and Natural Hazard Mitigation Planning*. https://www.epa.gov/green-infrastructure/integrating-water-quality-and-natural-hazard-mitigation-planning

MRSC. (2024). *Comprehensive Planning* [Resource]. https://mrsc.org/explore-topics/planning/gma/comprehensive-planning

Naumann, G., Cammalleri, C., Mentaschi, L., & Feyen, L. (2021). Increased economic drought impacts in Europe with anthropogenic warming. *Nature Climate Change*, *11*(6), 485–491. https://doi.org/10.1038/s41558-021-01044-3

NDMC. (2023). *Drought Plans*. https://drought.unl.edu/Planning/DroughtPlans.aspx

NDMC. (n.d.). *How does drought affect our lives?* https://drought.unl.edu/Education/DroughtforKids/DroughtEffects.aspx

NIDIS/NOAA. (2021). *Drought Impacts on Recreation and Tourism*. https://www.drought.gov/sectors/recreation-and-tourism#map

Nohrstedt, D., & Nyberg, L. (2015). Do floods drive hazard mitigation policy? Evidence from swedish municipalities. *Geografiska Annaler: Series A, Physical Geography*, *97*(1), 109–122. https://doi.org/10.1111/geoa.12081

Noonan, D. S., Richardson, L. E., & Sadiq, A.-A. (2018). *Policy Diffusion in Community-scale Flood Risk Management*. 81–92. https://doi.org/10.2495/RISK180071

Norton, R. K. (2008). Using content analysis to evaluate local master plans and zoning codes. *Land Use Policy*, *25*(3), 432–454. https://doi.org/10.1016/j.landusepol.2007.10.006

Office for Coastal Management. (2024). *Coastal Counties*. https://www.fisheries.noaa.gov/inport/item/66112

O'Grady, M., Moore, C., Smith, J., Hosterman, H., Teter, C., St. Juliana, A., Duckworth, M., & Callow, D. (2023). *HUD Community Resilience Toolkit*. Abt Associates with U.S. Department of Housing and Urban Development. https://files.hudexchange.info/resources/documents/HUD-Community-Resilient-Toolkit.pdf

Özerol, G., & Bressers, H. (2023). Enhancing the resilience of midsize cities to climate extremes: A tool for practitioners to assess their governance context. *Total Environment Research Themes*, *8*, 100080. https://doi.org/10.1016/j.totert.2023.100080

Parker, B. A. (2023). *Drought Assessment in a Changing Climate: Priority Actions and Research Needs*. https://doi.org/10.25923/5ZM3-6X83

Poyar, K. A., & Beller-Simms, N. (2010). Early Responses to Climate Change: An Analysis of Seven U.S. State and Local Climate Adaptation Planning Initiatives. *Weather, Climate, and Society*, *2*(3), 237–248. https://doi.org/10.1175/2010WCAS1047.1

Pudaruth, S., Moheeputh, S., Permessur, N., & Chamroo, A. (2018). Sentiment Analysis from Facebook Comments using Automatic Coding in NVivo 11. *ADCAIJ: Advances in Distributed Computing and Artificial Intelligence Journal*, *7*(1), 41–48. https://doi.org/10.14201/ADCAIJ2018714148

qsrinternational.com. (2014). *How does pattern-based coding work?* https://help-nv11.qsrinternational.com/desktop/deep_concepts/how_does_pattern-based_coding_work.htm

qsrinternational.com. (2019). *Automatic coding using existing coding patterns*. https://help-nv.qsrinternational.com/20/win/Content/coding/automatic-coding-existing-patterns.htm#:~:text=Automatic%20coding%20based%20on%20existing,large%20volumes%20of%20textual%20content

Rashidi, K., & Patt, A. (2018). Subsistence over symbolism: The role of transnational municipal networks on cities' climate policy innovation and adoption. *Mitigation and Adaptation Strategies for Global Change*, *23*(4), 507–523. https://doi.org/10.1007/s11027-017-9747-y

Reisinger, A., Howden, M., & Vera, C. (2020). *Guidance for IPCC authors*. https://www.ipcc.ch/site/assets/uploads/2021/02/Risk-guidance-FINAL_15Feb2021.pdf

Resilience Alliance. (2010). *Panarchy*. https://www.resalliance.org/panarchy

Richards, L. (2006). *Protecting Water Resources with Higher-Density Development* (EPA 231-R-06-001). United States Environmental Protection Agency. https://www.epa.gov/sites/default/files/2014-03/documents/protect_water_higher_density1.pdf

Robards, M. D., & Greenberg, J. A. (2007). Global constraints on rural fishing communities: Whose resilience is it anyway? *Fish and Fisheries*, *8*(1), 14–30. https://doi.org/10.1111/j.1467-2979.2007.00231.x

Rouse, D. C., & Piro, R. (2022). *The comprehensive plan: Sustainable, resilient, and equitable communities for the 21st century*. Routledge.

Rugland, E. (2020). *Incorporating Water into Comprehensive Planning*. Babbitt Center for Land and Water Policy, Lincoln Institute of Land Policy. https://www.lincolninst.edu/app/uploads/legacy-files/pubfiles/incorporating_water_into_comprehensive_planning_a_manual_for_land_use_planners_in_the_colorado_river_basin.pdf

Rumbach, A. (2016). Decentralization and small cities: Towards more effective urban disaster governance? *Habitat International*, *52*, 35–42. https://doi.org/10.1016/j.habitatint.2015.08.026

Runhaar, H., Wilk, B., Persson, Å., Uittenbroek, C., & Wamsler, C. (2018). Mainstreaming climate adaptation: Taking stock about "what works" from empirical research worldwide. *Regional Environmental Change*, *18*(4), 1201–1210. https://doi.org/10.1007/s10113-017-1259-5

Salon, D., Murphy, S., & Sciara, G.-C. (2014). Local climate action: Motives, enabling factors and barriers. *Carbon Management*, *5*(1), 67–79. https://doi.org/10.4155/cmt.13.81

Schoenefeld, J. J., Schulze, K., & Bruch, N. (2022). The diffusion of climate change adaptation policy. *WIREs Climate Change*, *13*(3), e775. https://doi.org/10.1002/wcc.775

Schwab, J. C. (2013). *Planning and Drought* (Planning Advisory Service Report 574). American Planning Association and the National Drought Mitigation Center. https://drought.unl.edu/archive/Documents/NDMC/Planning/PAS%20574.pdf

Schwarz, A., Marr, S., Schwinn, K., Townsley. E., O'Callaghan, A., Andrew, J., Quasebarth, T., Lopez-Calva, E., Kulis, P., Pelletier, G., Cox, T., Rodrigo, D., Brown, B., Hinchcliff, J., & Tijero, J. (2011). *Climate Change Handbook for Regional Water Planning*. US Environmental Protection Agency Region 9 and California Department of Water Resources. https://www.epa.gov/sites/default/files/2021-03/documents/climate_change_handbook_regional_water_planning.pdf

Seattle.gov. (2020). *Seattle 2035: Comprehensive Plan Managing Growth to Become an Equitable and Sustainable City 2015–2035* [Plan]. https://www.seattle.gov/documents/departments/opcd/ongoinginitiatives/seattlescomprehensiveplan/counciladopted2020.pdf

Shandas, V., & Parandvash, G. H. (2010). Integrating Urban Form and Demographics in Water-Demand Management: An Empirical Case Study of Portland, Oregon. *Environment and Planning B: Planning and Design*, *37*(1), 112–128. https://doi.org/10.1068/b35036

Shi, L., Chu, E., & Debats, J. (2015). Explaining Progress in Climate Adaptation Planning Across 156 U.S. Municipalities. *Journal of the American Planning Association*, *81*(3), 191–202. https://doi.org/10.1080/01944363.2015.1074526

Shimizu, M., & L. Clark, A. (2019). *Nexus of Resilience and Public Policy in a Modern Risk Society*. Springer Singapore. https://doi.org/10.1007/978-981-10-7362-5

Shipan, C. R., & Volden, C. (2008). The Mechanisms of Policy Diffusion. *American Journal of Political Science*, *52*(4), 840–857. https://doi.org/10.1111/j.1540-5907.2008.00346.x

Smit, B., & Pilifosova, O. (2003). From Adaptation to Adaptive Capacity and Vulnerability Reduction. In J. B. Smith, R. J. T. Klein, & S. Huq, *Climate Change, Adaptive Capacity* *and Development* (pp. 9–28). Published by Imperial College Press and distributed by World Scientific Publishing Co. https://doi.org/10.1142/9781860945816_0002

Smith, A. B. (2020). *U.S. Billion-dollar Weather and Climate Disasters, 1980—Present (NCEI Accession 0209268)* [Dataset]. NOAA National Centers for Environmental Information. https://doi.org/10.25921/STKW-7W73

Stoklosa, J., Blakey, R. V., & Hui, F. K. C. (2022). An Overview of Modern Applications of Negative Binomial Modelling in Ecology and Biodiversity. *Diversity*, *14*(5), 320. https://doi.org/10.3390/d14050320

Stubbs, M. (2016). *Irrigation in U.S. Agriculture: On-Farm Technologies and Best Management Practices* (R44158). Congressional Research Service. https://sgp.fas.org/crs/misc/R44158.pdf

Stults, M. (2017). Integrating climate change into hazard mitigation planning: Opportunities and examples in practice. *Climate Risk Management*, *17*, 21–34. https://doi.org/10.1016/j.crm.2017.06.004

Tang, Z., Brody, S. D., Quinn, C., Chang, L., & Wei, T. (2010). Moving from agenda to action: Evaluating local climate change action plans. *Journal of Environmental Planning and Management*, *53*(1), 41–62. https://doi.org/10.1080/09640560903399772

Tang, Z., Hussey, C. M., & Wei, T. (2009). Assessing local land use planning's awareness, analysis, and actions for climate change. *International Journal of Climate Change Strategies and Management*, *1*(4), 368–381. https://doi.org/10.1108/17568690911002898

Tang, Z., Wei, T., Quinn, C., & Zhao, N. (2012). Surveying local planning directors ' actions for climate change. *International Journal of Climate Change Strategies and Management*, *4*(1), 81–103. https://doi.org/10.1108/17568691211200236

Thomas, D. S. K., Wilhelmi, O. V., Finnessey, T. N., & Deheza, V. (2013). A comprehensive framework for tourism and recreation drought vulnerability reduction. *Environmental Research Letters*, *8*(4), 044004. https://doi.org/10.1088/1748-9326/8/4/044004

UCLA Statistical Consulting Group. (n.d.). *Negative Binomial Regression | Stata Data Analysis Examples*. https://stats.oarc.ucla.edu/stata/dae/negative-binomial-regression/

UNDRR. (2017). *Disaster Risk Reduction Terminology*. https://www.undrr.org/drr-glossary/terminology

UNDRR. (n.d.). *Disaster risk*. https://www.undrr.org/terminology/disaster-risk

US Drought Monitor. (n.d.). *Drought Severity and Coverage Index*. https://droughtmonitor.unl.edu/DmData/DataDownload/DSCI.aspx

USDA. (2020). *Saltwater Intrusion: A Growing Threat to Coastal Agriculture*. https://www.climatehubs.usda.gov/hubs/northeast/topic/saltwater-intrusion-growing-threat-coastal-agriculture

Van Breda, A. D. (2001). *Resilience theory: A literature review*. South African Military Psychological Institute. http://vanbreda.org/adrian/resilience/resilience_theory_review.pdf

Venables, W. N., & Ripley, B. D. (2002). *Modern Applied Statistics with S*. Springer New York. https://doi.org/10.1007/978-0-387-21706-2

Ver Hoef, J. M., & Boveng, P. L. (2007). Quasi-poisson vs. Negative Binomial Regression: How should we model overdispersed count data? *Ecology*, *88*(11), 2766–2772. https://doi.org/10.1890/07-0043.1

WA Department of Ecology. (2024). *Water Availability: Statewide conditions*. https://ecology.wa.gov/water-shorelines/water-supply/water-availability/statewide-conditions

Wade, G., Midcap, J., Coder, K., Landry, G., Tyson, A., & Weatherly, N. (2010). *Xeriscape: A guide to developing a water-wise landscape* (Bulletin 1073). University of Georgia. https://hdl.handle.net/10724/12344

Walker, J. L. (1969). The Diffusion of Innovations among the American States. *American Political Science Review*, *63*(3), 880–899. https://doi.org/10.2307/1954434

Washington HB 1181, Washington State Legislature 2023-24 Session (2023). https://app.leg.wa.gov/billsummary?BillNumber=1181&Chamber=House&Year=2023

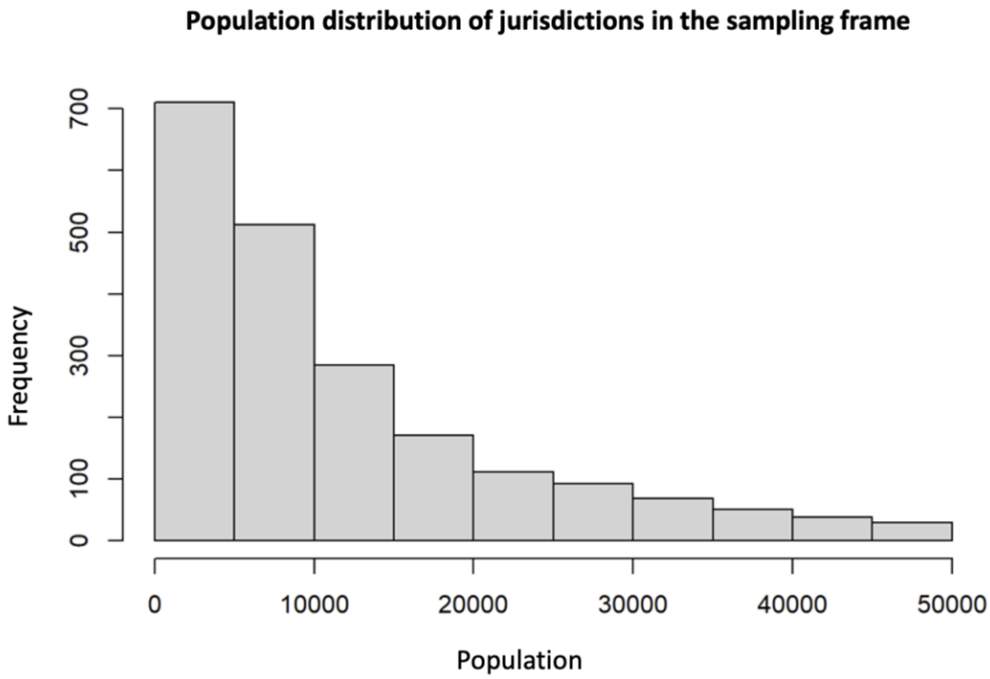
Wilhite, D. A., Sivakumar, M. V. K., & Pulwarty, R. (2014). Managing drought risk in a changing climate: The role of national drought policy. *Weather and Climate Extremes*, *3*, 4–13. https://doi.org/10.1016/j.wace.2014.01.002

Woodruff, S. C., & Stults, M. (2016). Numerous strategies but limited implementation guidance in US local adaptation plans. *Nature Climate Change*, *6*(8), 796–802. https://doi.org/10.1038/nclimate3012

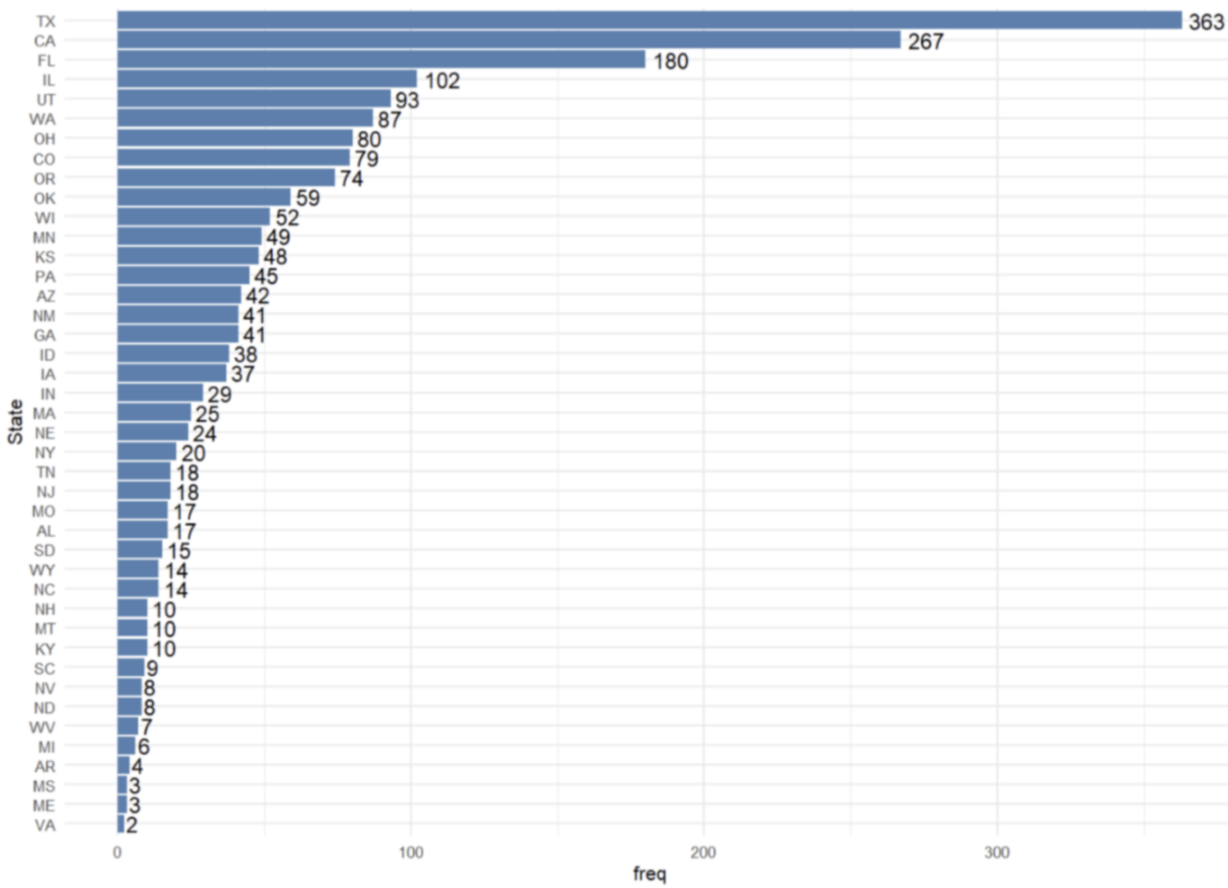
Wright, S. (2022). Automating insights Analysing the National Student Survey data using NVivo. In E. Zaĭtseva, B. Tucker, & E. Santhanam (Eds.), *Analysing student feedback in higher education: Using text-mining to interpret the student voice*. Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003138785-3/automating-insights-steve-wright

APPENDIX A

i) Distribution of all drought-prone small cities and towns in contiguous US by population (author's diagram)



ii) Distribution of all drought-prone small cities and towns in contiguous US by state (author's diagram)



APPENDIX B

i) Margin of Error for sample size of 114 jurisdictions

Based on the sample size formula for simple random samples using finite population correction (Dillman et al., 2014, pp. 79), a sample size of 114 will result in about 9% MOE (Margin of Error) for 95% confidence interval and 50% population proportion. It should be noted that the sample used in this research is a stratified sample with equal number of jurisdictions from almost all states included in the sampling frame. Stratified samples tend to have lower margin of errors as compared to simple random samples with similar sample size (Daniel, 2012, pp.140).

Equation 6:

$$n = \frac{(N * p * q)}{\left\{(N-1) * \left(\frac{MOE}{z}\right)^2 + (p * q)\right\}}$$

Where: n = Sample size; N = population size (2,068);

p = population proportion (0.5); q= (1-p);

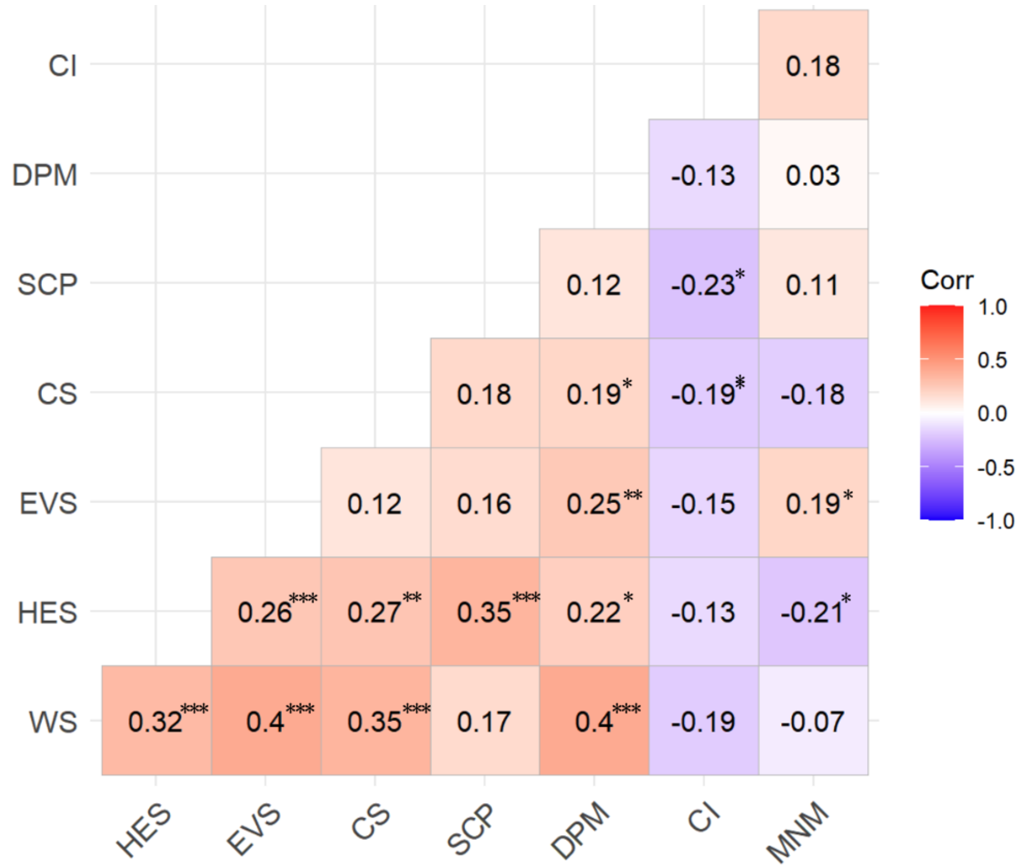
MOE = margin of error; z = z-score for 95% confidence (1.96)

$$n = \frac{(2068 * 0.5 * 0.5)}{\left\{(2068-1) * \left(\frac{0.09}{1.96}\right)^2 + (0.05 * 0.05)\right\}}$$

$$n = 112$$

APPENDIX C

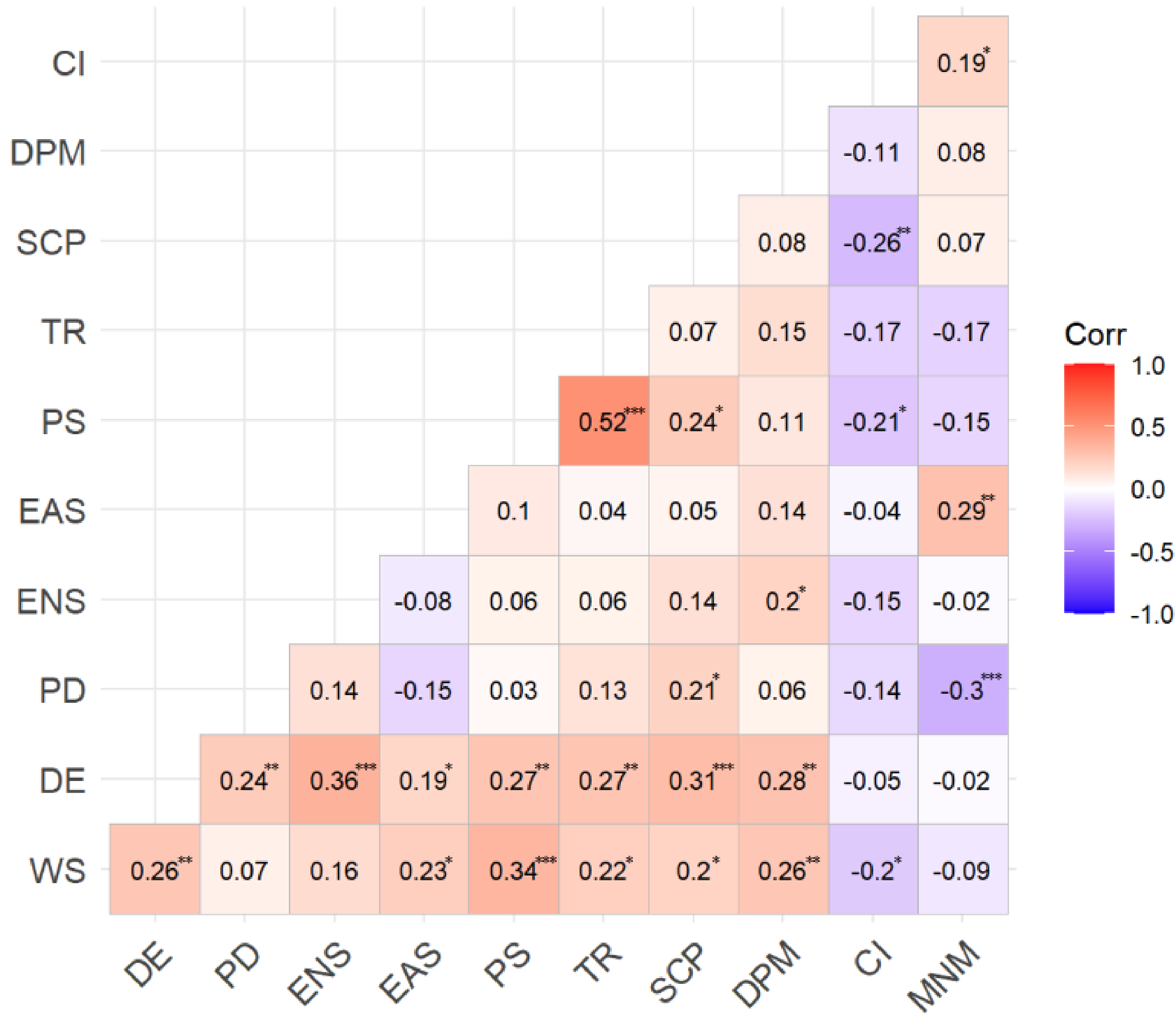
i) Correlation matrix of all variables included in regression analysis after removing influential data points from the dataset (author's diagram)



* p<0.05; **p<0.01; ***p<0.001

WS = Water Conservation Score; HES = Hazard and Exposure Score; EVS = Economic Vulnerability Score; CS = Capacity Score; SCP = State statutes requiring comprehensive plan (Presence = 1); DPM = State Drought Plan focus on mitigation (Mitigation = 1); CI = Coastal/Inland location (Inland = 1); MNM = Metro/Non-Metro location (Non-metro = 1)

ii) Correlation matrix of all individual variables included in regression modelling (author's diagram)

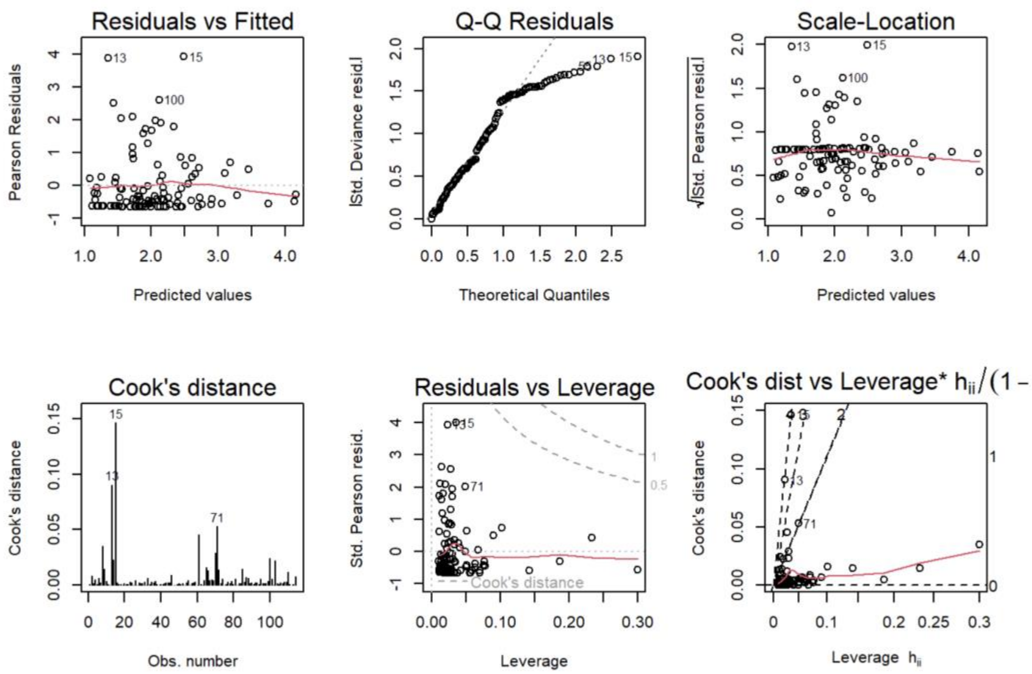


* p<0.05; **p<0.01; ***p<0.001

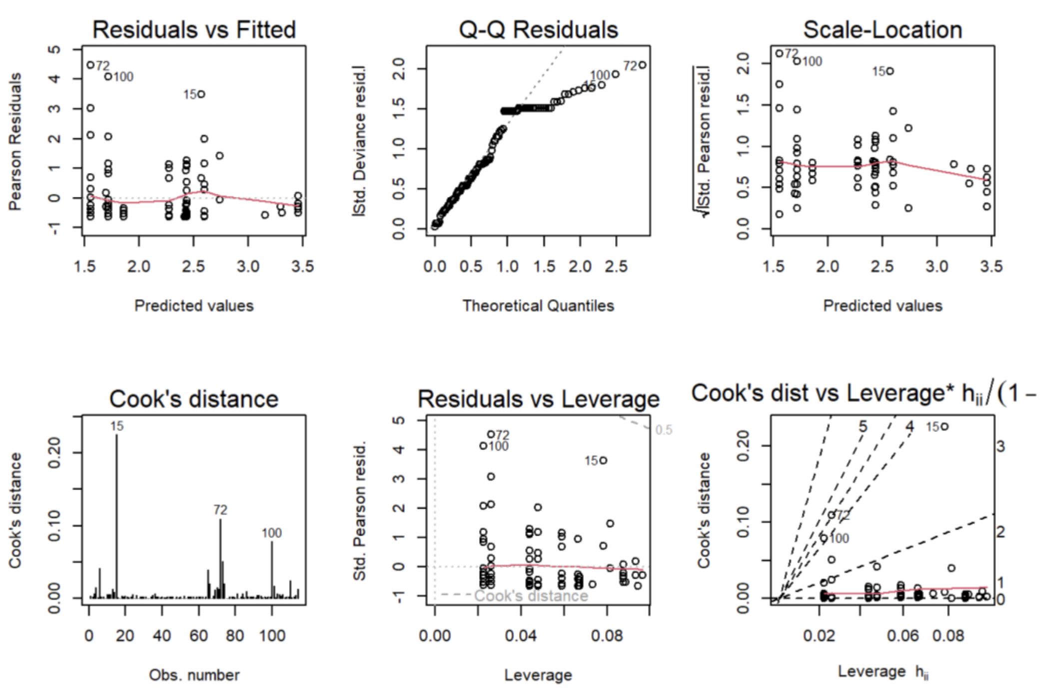
WS = Water Conservation Score; DE = Drought Experience; PD = Population Density; ENS = Employment in Natural Resource Industries; EAS = Employment in food and accommodation services; PS = Planning Staff; TR = Total Revenue; SCP = State statutes requiring comprehensive plan (Presence = 1); DPM = State Drought Plan focus on mitigation (Mitigation = 1); CI = Coastal/Inland location (Inland = 1); MNM = Metro/Non-Metro location (Non-metro = 1)

APPENDIX D

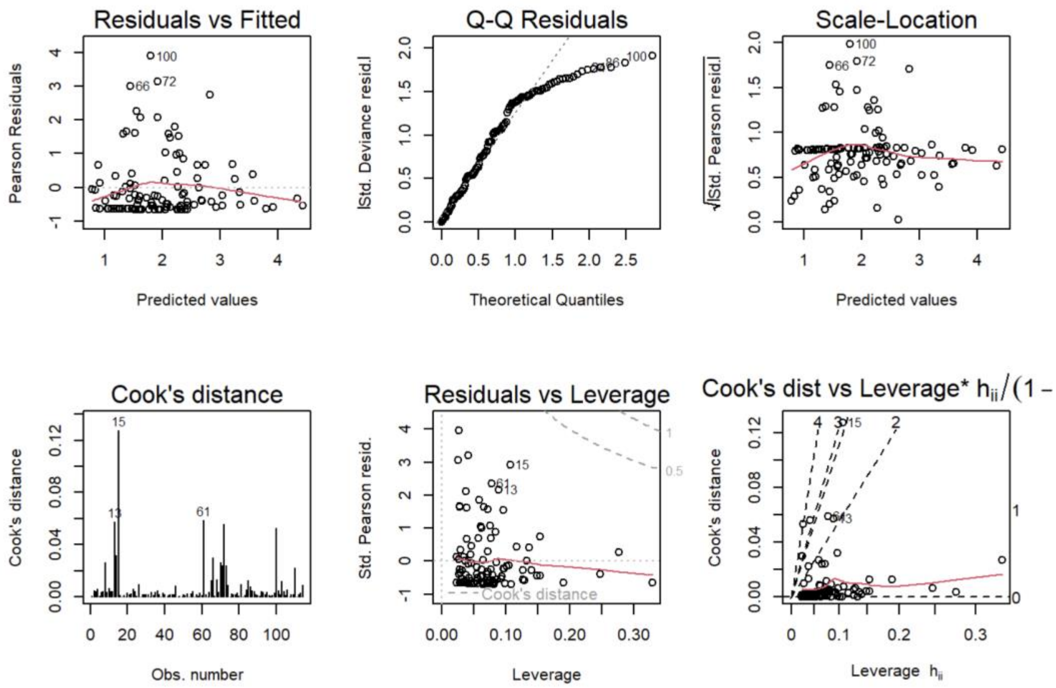
i) Regression diagnostics plots for Local Characteristics Model (author's diagram)



ii) Regression diagnostics plots for Regional Setting Characteristics Model (author's diagram)



iii) Regression diagnostics plots for All Characteristics Model (author's diagram)



APPENDIX E

Influential data points identified using regression diagnostics and removed from the dataset

ID	Name	State	Water conservation score	Hazard & exposure score	Economic vulnerability score	Capacity score	State Statues for Comp Plan	Drought Plan focus	Coastal/ Inland location	Metro/ Non-metro location
13	Edgewood city	FL	28	-0.23	-1.15	-1.77	Yes	No Mitigation	Inland	Metro
15	Orange City	FL	85	-0.91	-0.16	2.50	Yes	No Mitigation	Coastal	Metro
61	Gering city	NE	21	0.15	-1.70	-1.11	No	Mitigation	Inland	Non-metro
66	Riverdale borough	NJ	24	-0.18	-0.40	-0.93	No	No Mitigation	Inland	Metro
71	Santa Clara village	NM	32	-0.36	2.30	-1.84	No	Mitigation	Inland	Non-metro
72	Fernley city	NV	39	-0.49	0.11	1.39	No	No Mitigation	Inland	Non-metro
100	Bastrop city	TX	42	-0.11	-0.62	0.96	No	No Mitigation	Inland	Metro

VITA

Pranjali Rai is a doctoral candidate at the University of Washington (UW) in the Urban Design & Planning Interdisciplinary Ph.D. program. Her research focuses on climate adaptation and mitigation, community resilience, and hazard mitigation. She is particularly interested in the local planning response to address these issues in smaller cities and towns. She is a mixed-methods researcher with a concentration in social statistics and has taken multiple qualitative data analysis courses as part of her Ph.D. at UW. Over the years, she has used the mixed-methods analysis approach to study the role of state policies on the local planning response in smaller cities in Washington for addressing climate change impacts and reducing greenhouse gas (GHG) emissions.

As a research assistant at the Institute of Hazard Mitigation Planning and Research, Pranjali made significant contributions to a National Science Foundation-funded study on community resilience in rural counties of Upper Peninsula region in Michigan. She worked with the Washington State Department of Commerce to conduct a survey on small and mid-sized cities regarding their potential planning response to GHG emissions reduction requirements of the state's Climate Planning Law (House Bill 1181). She also analyzed the difference in built environment exposure based on FEMA's floodplain maps and flood risk data from private vendors. She has presented her analyses at reputed conferences in urban planning. She has also published her research findings in project reports for government agencies and has papers under review in journals.

Pranjali is an AICP certified planner. She is a senior planner in the Climate and Ecosystem Section at the Washington State Department of Commerce. She helps develop technical guidance for local jurisdictions in Washington to plan for resilience to climate change impacts and reduce

GHG emissions as part of their comprehensive planning efforts. She holds a dual master's degree in community planning and architecture from the University of Maryland. She has previously consulted as an urban planner and designer on multiple sub-area planning efforts and waterfront developments for municipal agencies and developers in the New England region. She is also a registered architect in India. As an architect, she has contributed to designing multiple large-scale commercial projects and public spaces in India.