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Institutional Adaptation and Drought Management in the Carolinas

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INSTITUTIONAL ADAPTATION AND DROUGHT MANAGEMENT IN THE CAROLINAS

by

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Abstract

Drought is one of the costliest hazards faced by the United States, having caused billions of dollars in damage and affected all regions of the country over the past two decades. There have been many efforts to strengthen society's technical and managerial capacity to respond to drought, mitigate risks, and adopt proactive planning and management strategies. Advances entail the adoption of drought plans, improvements to data collection and monitoring systems, and development of networks to disseminate information and foster communications. Despite recent progress, response remains reactive and crisis-oriented. Management is often uncoordinated across the multiple sectors and fragmented jurisdictions affected by and responsible for making drought decisions.

While drought adaptation efforts frequently focus on the technical and managerial aspects of drought planning and response, there are frequent acknowledgements of the need for additional research to improve understanding of how the broader system of institutional frameworks, social networks, and stakeholder values and beliefs affect society's capacity to cope with and manage drought. Furthermore, most drought research to date has focused on the western states, overlooking other regions of the country that are also vulnerable to drought and that operate within unique configurations of water rights and related institutional arrangements. As different regions, sectors, and communities perceive and experience drought in diverse ways, expanding understanding of the diverse processes and mechanisms through which different groups manage drought risks can help to inform ongoing efforts to adapt and build resilience to drought.

This study investigates the institutional factors that interact to enable and constrain the implementation and coordination of drought planning and management activities. The case study focuses on drought responses and adaptations in North Carolina and South Carolina, two states in the water-rich southeastern region of the United States, during a period in which two record-breaking droughts occurred (1998-2002, 2007-2008). Data collection took place in 2007-2008, through interviews with decision makers (n=87) working at local-, state-, and basin levels of management, observation of drought and water management meetings (n=69), and review of stakeholder documents. The analysis examines three overarching questions: 1) what types of changes in the institutional framework are necessary to support different drought adaptation strategies, 2) how do institutional interactions affect the implementation and coordination of efforts across the state and local levels, and 3) what types of institutional changes are necessary to facilitate cross-scalar management and coordination?

Findings demonstrate that significant shifts in drought management have occurred across the Carolinas. These shifts include the increasing formalization of drought response and the development of new organizational arrangements and processes that facilitate cross-scalar interactions and cooperation. However, the study reveals that these changes were implemented only when combinations of specific institutional changes also occurred. These changes were necessary to support the adoption and operationalization of new strategies to respond to and manage drought. Findings also reveal many of the institutional barriers that constrain the implementation of stand-alone drought plans and

suggest that drought response and planning is more effective when integrated into other water planning and management processes.

Overall, the study highlights the need for more careful attention to the complexities of the institutional environment of drought and water resources management and how that environment influences what adaptations are considered legitimate and feasible by different groups and decision making levels. The technical and more formal dimensions of planning require the support of informal institutions such as social practices and behavioral norms to develop the potential for adaptations and resilience-building efforts to extend beyond a crisis period. A more concerted focus on institutional issues and interactions is recommended as efforts to align national, state, and local capacities to prepare for and manage drought continue.

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LIST OF ABBREVIATIONS

ACF .... Apalachicola-Chattahoochee-Flint

APGI .... Alcoa Power Generating Inc.

ASR .... Aquifer Storage and Recovery

cfs .... cubic feet per second

COG .... Council of Governments

CP&L .... Carolina Power & Light

CRA .... Comprehensive Relicensing Agreement

CW .... Catawba-Wateree

CW DMAG .... Catawba-Wateree Drought Management Advisory Group

CW LIP .... Catawba-Wateree Low Inflow Protocol

CW WMG .... Catawba-Wateree Water Management Group

DMA .... Drought Management Area

FERC .... Federal Energy Regulatory Commission

IBT .... Interbasin Transfer

LWSP .... Local Water Supply Plan

mgd .... million gallons per day

NC .... North Carolina

NC DENR .... North Carolina Department of Environment and Natural Resources

NC DMAC .... North Carolina Drought Management Advisory Council

NC DWQ .... North Carolina Division of Water Quality

NC DWR .... North Carolina Division of Water Resources

NDMC...National Drought Mitigation Center

NGO...non-governmental organization

NIDIS...National Integrated Drought Information System

SC...South Carolina

SC DHEC......................South Carolina Department of Health and Environmental Control

SC DNR...South Carolina Department of Natural Resources

SC DRC...South Carolina Drought Response Committee

SES..social-ecological systems

USACE...United States Army Corps of Engineers

USFWS...United States Fish and Wildlife Service

USGS...United States Geological Survey

WRDA...Water Resources Development Act

WSRP...Water Shortage Response Plan

YPD...Yadkin-Pee Dee

YPD DCP...Yadkin-Pee Dee Drought Contingency Plan

YPD DMAG...............................Yadkin-Pee Dee Drought Management Advisory Group

YPD DMT...Yadkin-Pee Dee Drought Management Team

YPD LIP...Yadkin-Pee Dee Low Inflow Protocol

CHAPTER 1

INTRODUCTION

Recent droughts in the United States have contributed to considerable stress on water resources and substantial economic, social, and environmental impacts (National Drought Mitigation Center [NDMC], 2015a; Smith et al., 2015). The total estimated costs of drought from 1998 to 2012 equaled $83.5 billion; the total estimated costs in 2012 alone equaled $30 billion (Smith et al., 2015). The severity and extent of impacts has prompted calls for more concerted efforts to improve and expand the country's drought preparedness and resilience. The drought planning community, like many others, has embraced the concept of "resilience". In general, the term "resilience" refers to the ability to recover from, adjust to, or adapt to stresses and disturbances and is increasingly used to address a range of societal issues and challenges, including natural hazards, climate change, community planning, and personal well-being (Adger et al., 2011; Brown, 2014).

In terms of drought, "resilience" has been used to describe conditions where communities have adequate water supplies to meet demand, the adverse impacts of drought are avoided, and society is "better able to handle the stresses caused by drought" (Schwab, 2013, p. 75; National Integrated Drought Information System [NIDIS], 2012). Strategies to build drought resilience center on building proactive, risk management policies that shift attention from crisis response to an approach focused on mitigation and preparedness (Hayes et al., 2004; Wilhite et al., 2000).

Moving towards a risk management approach involves a variety of technical and institutional changes to secure water supplies, adopt water conservation and drought plans, improve tools and processes to monitor and communicate drought conditions, and develop education and awareness programs (Dennis, 2013; Engle, 2013; NIDIS, 2012; Schwab, 2013). Significant efforts in this regard have been led by the National Integrated Drought Information System (NIDIS) program and the National Drought Mitigation Center (NDMC). Efforts have focused on improving drought monitoring and prediction, for example through the weekly U.S. Drought Monitor and the development and assessment of drought indices, and providing technical assistance and resources to support drought planning (Botterill and Hayes, 2012; Hayes et al., 2011; NIDIS, 2012). Another important component of proactive management is incorporating drought risk analysis and planning into broader-scale management processes, for example multi-hazards planning, water management, community sustainability planning, and hydropower energy plans. Many communities, planning organizations, and researchers are considering how this goal can be accomplished most effectively (Fu and Tang, 2013; Hayes et al., 2004; Schmidt and Garland, 2012; Schwab, 2013).

While the majority of research on drought focuses on the need for new monitoring tools, planning methods, and policies, there is little published on the institutional challenges influencing drought adaptation within a fragmented, multi-level resource management environment. As in other realms of resource management and planning, drought planning and policy decisions are conducted by myriad organizations and jurisdictions (Folger et al., 2012). Most water rights and allocation decisions are made at the state level, and local communities and regional organizations generally have had responsibility for providing drinking water for municipal and business use. The lack of a national drought policy reinforces the fragmented, uncoordinated, and reactive nature of drought response (Wilhite et al., 2014). Nonetheless, although federal-level agencies (such as the United States Army Corps of Engineers, U.S. Fish and Wildlife Service, and Federal Energy Regulatory Commission) have no direct mandate for drought planning, federal legislation does give these agencies a role in drought management by requiring oversight of activities that affect water quality, environmental health, and public health. Examples of key legislation in this regard include Sections 401 and 404 of the Clean Water Act, the River and Harbors Act of 1899, and the Endangered Species Act.

Practitioners and researchers alike recommend that improved cooperation and collaboration within and between levels of government, as well as with water users, local stakeholders, industry and business, and scientists, are necessary to build capacity to respond to drought events and mitigate drought impacts (Dennis, 2013; Engle, 2012; Grigg, 2014; NIDIS, 2012; Schwab, 2013; Wilhite, 2011). Yet, while it is recognized that greater coordination across groups is needed, there have been very few assessments of how such coordination and collaboration might be facilitated in the practice of drought response and planning. As such, further research is needed to improve understanding of how the broader system of institutional frameworks, social networks, and stakeholder values and beliefs affect society's capacity to cope with and manage drought.

The term "institution" refers to the systems of rules that shape individual and collective decisions and actions. In addition to the formal aspects of institutions (e.g., policies, regulatory frameworks, legislation, organizational arrangements), institutions also entail social practices and relationships, the underlying values and norms that shape behaviors, and the routinized activities that emerge and are reproduced as actors follow rules (March and Olsen, 1989; O'Riordan and Jordan, 1999; Scott, 2008; Young, 2002). Institutions operate at different jurisdictional levels (e.g. national, state, local) as well as at different decision making levels. For example, while general management paradigms such as those related to efficiency or sustainability shape decisions at higher policy levels, operational decisions are often guided by codes, scientific standards, and professional or community practices (Bakker, 1999). As institutions also mediate how societies govern climate risks and manage responses to environmental and social change, understanding how institutions can contribute to more proactive management strategies is a particularly salient topic for the drought planning community (Wilhite, 2005, 2010).

This dissertation specifically investigates the institutional factors that interact to enable and constrain drought planning and management adaptations. Three questions serve as overarching themes for the dissertation:

1. How have water managers and organizations adapted to drought?
2. How have adaptations and institutional change contributed to increased capacity to cope with and manage drought?
3. Which institutional designs facilitate proactive (rather than reactive) drought response and management?

While this dissertation has a practical impetus, it also addresses research needs identified in the climate adaptation literature and builds on previous work investigating the role of institutional mechanisms and processes in addressing complex environmental and social challenges (Dovers and Hezri, 2010; Young, 2010). Emergent climate adaptation research suggests that the challenges and stresses associated with climate change will necessitate transformational change to existing social structures in order to enhance society's capacity to cope with those challenges (Adger et al., 2012; Kates et al., 2012). Although climate adaptation planning is occurring in various sectors and levels of government, implementation is limited and most measures appear to represent incremental adjustments rather than the transformational shifts that will be required (Bierbaum et al., 2013). Incremental adjustments are typically represented by changes that occur within existing rules, policies, and organizational procedures. Transformational change occurs when actors assess the underlying assumptions, goals, and conditions that contribute to risks and vulnerabilities and accordingly make more comprehensive reforms to a resource governance regime or management system (Nelson, 2011; O'Brien, 2012; Walker and Salt, 2012). While both types of change are important, it is expected that institutional change will be necessary to facilitate more fundamental shifts in our existing approaches to managing climate risks and vulnerabilities (Adger et al., 2012). Work is needed to clarify understanding of what institutional changes will be most beneficial and effective and what are the best ways to achieve that change (Dovers and Hezri, 2010; Kates et al., 2012).

Institutions are both an important component of adaptive capacity and can act as barriers to climate adaptation efforts. Having other components of adaptive capacity (e.g., material assets, technology infrastructure, or economic resources) does not necessarily translate into action if institutional capacity does not exist (Eakin et al., 2014; Gupta et al., 2010; McNeeley, 2014; Moser and Ekstrom 2010). Institutional capacity includes the diverse legal frameworks, values, and norms that shape a range of factors that affect how, and which, adaptations occur. These factors include perceptions of risks, knowledge and access to information, preferred behaviors, and authority for and representation in decision making (Adger et al., 2009). While the literature demonstrates the importance of institutions and the critical role they play in shaping specific adaptations, adaptive capacity, and resilience, more work is needed to understand how institutions can support change and transitions in existing management regimes (Kates et al., 2012; O'Brien, 2012, 2013).

This dissertation addresses practical concerns related to drought planning and management as well as emerging needs related to improving society's capacity to adapt to and prepare for future climate risks. To do so, the dissertation draws on a case study of drought management adaptations in North Carolina and South Carolina, two states in the Southeastern United States. The following sections provide overviews of the case study, research methods, and structure of the dissertation.

1.1 Case Study Description

The author used the case study approach to examine the evolution of drought management and to investigate the role of institutions in shaping drought-related decisions and adaptations in the Carolinas. This case is particularly significant because, while the majority of research focuses on drought in the western United States, this research sheds lights on the impacts and policy implications of drought in a water-rich region of the country that has historically operated under the assumption that abundant water supplies exists for multiple uses and users. In the southeast United States, however, many areas are now experiencing a variety of water resources stresses, due to population growth and development, increasing demands, changing water quality conditions and requirements, and climate variability and change. These stresses, in combination with more frequently occurring water shortages, suggest that the existing system of water rights and water use practices is not sufficient to ensure that all water needs will be met in the future (Dellapenna, 2011). The case study exposes the barriers that the institutional context places on the region's ability to manage severe drought events. It also indicates potential opportunities for other states and locales to pursue when considering how to enhance institutional capacity to prepare for and mitigate the impacts associated with droughts and other water stresses.

A case study was appropriate for this research as the objective was to understand how water managers have adapted to drought and why particular drought management strategies were selected and ultimately implemented (Yin, 2009). Case studies are often used in climate adaptation research to examine the mechanisms through which climate risks are managed and the factors that influence vulnerabilities and adaptive capacities. In-depth studies can be used to reveal insights from previous adaptation processes and uncover connections and interactions across scales (Ford et al., 2010; Glantz, 1989). Case studies are also appropriate when the researcher seeks to understand a complex phenomenon with many components and units of analysis. The drought management landscape is complex, shaped by hydroclimatological and social processes and populated by many stakeholders operating on different management levels and with diverse responsibilities and interests. The author selected the case study method in order to uncover and investigate the complex network of actors, infrastructures, technologies, rules, and decision-making settings that play a role in the mitigation and management of drought risks at different levels.

In this study, the author collected and integrated multiple and diverse perspectives to examine drought adaptation and management processes (Urwin and Jordan, 2008). As climate variability and adaptation capacities are context-dependent, a “bottom-up” approach to studying the experiences of decision makers in responding to drought can contribute to a deeper understanding of the factors that influence efforts at the local level (Ford et al., 2010; McNeeley, 2014; Moser and Ekstrom, 2010; Smit and Wandel, 2006). On the other hand, local decisions occur within a broader policy context that researchers should also consider when assessing the extent to which new measures are implemented on-the-ground (Urwin and Jordan, 2007). A case study approach can accommodate multiple sources of data and analytical techniques needed to investigate complex processes such as climate adaptation (Yin, 2009).

This study focuses on the 1998-2008 period when North Carolina and South Carolina experienced two record-breaking droughts (1998-2002, 2007-2008). Despite previous experiences with extreme drought (e.g., in the 1980s and 1950s), other stresses such as population growth, increasing water demand, and development pressures combined with drought to adversely impact water resources and expose the limits of the prevailing strategies in place to manage drought risks.

Beginning in 1998, the Carolinas region experienced several years of below-average precipitation, resulting in a cumulative deficit that was among the most ever recorded. The shortfall resulted in record low streamflows, ground water levels, and reservoir levels (Weaver, 2005; South Carolina Department of Natural Resources [SC DNR], 2003). Much of the response to the drought and its impacts was reactive, driven by impending water shortage crises. At the drought’s peak in summer 2002, at least 60 community water systems across the two states were vulnerable to running out of water if the drought continued through the fall (North Carolina Department of Environment and Natural Resources [NC DENR], 2004; Weaver, 2005; SC DNR, 2003).

This extreme events triggered efforts at multiple scales to reduce vulnerabilities and improve capacity to manage water resources more effectively during droughts. Measures included securing water supplies, adopting drought response plans, and improving tools to monitor and communicate drought conditions. As the author prepared for the data collection phase of this project in 2007, another "drought of record" struck the Carolinas. Above-average temperatures in summer 2007 exacerbated the drought's quick onset. In 2007 North Carolina experienced its driest year on record, and South Carolina experienced its fifth driest year (North Carolina Drought Management Advisory Council [NC DMAC], 2008). Below-average rainfall persisted throughout 2008, limiting the capacity of streams, reservoirs, and groundwater wells to recover, and conditions did not abate until 2009. Subsequent assessments by the South Carolina Department of Natural Resources also indicated that some groundwater wells in the state had not recovered from the 1998-2002 drought, compounding groundwater impacts in 2007-2008 (Harder et al., 2012ab).

During this second event, many of the adaptations initiated after 2002, such as drought response plans, protocols, and monitoring and management committees, were implemented, revealing many ways in which capacity to respond to drought had improved. However some dimensions proved challenging and were frequently contested. Despite efforts to build a more proactive drought response system within and across both states, in practice water managers and other stakeholders faced many constraints in the implementation and coordination of drought plans and other measures taken to adapt to drought. While the author's original intent was to investigate the drought adaptations made during and after the 1998-2002 drought, the Carolinas' drought of 2007-2008 provided a unique opportunity for the author to closely engage with water managers and other decision makers as they contended with severe drought conditions. Through this engagement (e.g., interviews and drought meetings), the author's understanding of, and questions regarding, the case evolved. Using the case study approach thus allowed the author the flexibility to reconsider original assumptions about drought adaptations and incorporate new information about the evolving drought into the research process.

1.2 Methods

This section outlines the methods used by the author to investigate the longer-term evolution of drought management and the processes through which drought adaptations have occurred. Accordingly, the author designed the data collection and analysis methods to enable a close and in-depth examination of 1) the linkages between drought adaptations and institutional change and 2) the institutional factors that constrained or enabled drought adaptations and other measures intended to improve drought response and preparedness.

1.2.1 Data collection

The author used a variety of sources to obtain information about drought stakeholders, the institutional context, specific drought adaptations, and the decision making processes through which drought adaptations and responses occurred. Data collection occurred from May 2007 to November 2008.

First, the author conducted eighty-seven semi-structured interviews with actors knowledgeable of, or responsible, for drought response and water supply management at local, regional, state, and basin levels. Because drought decisions occur across many decision-making and organizational levels, the author wanted to ensure that study participants represented their particular stakeholder group as well as provided a diversity of perspectives and experiences. At the same time, because the author sought to understand decision making at relatively high managerial levels and examine very specific events and processes, the group of people who actually had in-depth information about these processes was somewhat limited (Tansey, 2007). The interviewees included in this study reflect these objectives.

Thirty-eight of the interviewees represented federal agencies, state agencies, non-profit organizations, community groups, regional planning organizations, engineering consulting firms, and industry. These interviews centered on obtaining information about the drought decision-making context at different management levels, the organization's role in drought response, and insights about drought adaptations or management changes made during the study period. Appendix A includes the questions used to guide these interviews.

Forty-nine semi-structured interviews were conducted with public water system managers and other local officials to understand how drought risks are perceived and addressed in the context of local water provision and operations. Interviews with local-level participants included more focused questions regarding the management of local water systems, drought impacts experienced at the community level, and the specific adaptations made by water systems in response to droughts and other stressors (see Appendix B).

Table 1.1 provides summary information about the interviewees who participated in this study. While the author conducted some in-person interviews (twenty-eight of the total), most were conducted by phone. Interviews lasted between thirty and sixty minutes, were recorded with the interviewee's permission, and then transcribed. Appendix C includes the information provided to study participants prior to interviews. For the interviews, the author used a purposeful sampling approach to identify individuals and organizations who 1) had direct involvement in drought response (e.g. through state- or basin-level drought response and management groups) and/or 2) had participated in the Federal Energy Regulatory Commission (FERC) relicensing processes in the Catawba-Wateree and Yadkin-Pee Dee basins. From that initial group I contacted a range of stakeholders who represented multiple water interests and both states (North Carolina, South Carolina.

Of particular interest were individuals and organizations involved with the relicensing of private hydropower projects in the Catawba-Wateree and Yadkin-Pee Dee basins. Many drought adaptations emerged through the Federal Energy Regulatory Commission (FERC) relicensing processes in the two basins. These processes began in 2003 and included the licensees; local, state, and federal agencies; and other stakeholders. Since licenses are typically granted for 30- to 50-year terms, these processes provided a significant opportunity to incorporate and codify lessons from the 1998-2002 drought into the next generation of licenses and operating plans of the hydro projects.

The author included other water managers and decision makers from outside the Catawba-Wateree and Yadkin-Pee Dee basins in the study as well. For example, the United States Army Corps of Engineers (USACE) manages hydropower projects in several basins in the Carolinas. The author interviewed the Wilmington and Savannah district water managers and other agency representatives engaged in drought response activities in those basins (i.e., the Savannah, Cape Fear, Roanoke, Neuse, and Yadkin basins). Figure 1.1 shows the study area and the river basins highlighted in the dissertation. In addition, the author contacted and interviewed water system managers and other local representatives recommended by other study participants due to a distinct drought experience or management expertise. These interviewees often provided alternate perspectives regarding drought and water management issues.

Second, the author attended and observed fifty-nine meetings and conference calls where drought response and management was the primary objective. The onset of drought in spring 2007 triggered basin- and state-level drought response meetings and calls and which continued regularly throughout the study period. Observation of drought management meetings provided an invaluable opportunity to observe group decision-making processes and dynamics as water managers and other stakeholders discussed and debated how to respond and adapt to the drought. The author attended an additional ten water management meetings and conferences during this time period where participants discussed drought management issues. Attending meetings helped the author to identify key actors and potential interviewees. Table 1.2 shows the drought and water management meetings attended by the author. The author typed and reviewed notes immediately following each meeting to ensure accuracy. Meeting observations and notes focused on documenting adaptation and response measures taken by meeting participants, the types of decisions being made through group processes, the constraining and enabling factors affecting drought response decisions and actions, and the dynamics among individuals and groups.

Third, documents were used to obtain background information about water- and drought management in the Carolinas and to triangulate data gathered from other sources. Documents include state and local drought response plans, state water supply plans and assessments, monitoring reports, and drought meeting minutes. Basin-level documents include FERC relicensing studies and agreements, drought contingency plans, and drought management meeting minutes. Practitioner documents provided insights into water supply planning and drought management "best practices."

The author's extended engagement with drought management activities (May 2007 to November 2008) benefited the data collection, and subsequent analysis, in several ways. First, the author was able to develop the trust of study participants, a factor that facilitated the process of requesting, scheduling, and conducting interviews with individuals whom the author met through meetings and conference calls. This trust also facilitated 1) the ability and opportunity for the author to participate in more informal conversations with water managers and stakeholders and 2) the use of the snowball sampling method to obtain recommendations from trusted sources for additional interviewees knowledgeable about or involved with drought response and management issues. Second, by attending drought management meetings and calls from 2007 to 2008, the author was able to observe the wide range of decisions that managers of community water systems, industries, and hydropower projects make throughout the course of a year.

Furthermore, these decisions occur on a variety of time scales, i.e., hourly, daily, weekly, monthly, seasonally, and annually. The long-term of observation of drought and water management processes enabled a deeper understanding of the decision context in which managers operate. Third, the data collection period generally coincided with the onset of drought conditions in spring of 2007 and the beginning of the recovery in fall of 2008. As a result, the author was able to observe the various decisions and issues that emerged during the different drought stages. Towards the end of the study period, the author found that the data collected through interviews and meeting observations had reached saturation. Here, the term saturation refers to the point at which additional interviews or meetings did not provide new or unique information about the processes through which water managers and other stakeholders adapted and responded to drought (Small, 2009).

1.2.2 Data analysis

During the data collection process, the author began to organize and transform the raw data (i.e., interview transcripts and meeting notes) into a format conducive to analysis. The author used QSR NVivo, a qualitative software program, as a tool to organize the collected data as well as to code and analyze the data. Several, iterative steps were involved in the process of organizing, exploring, and analyzing the data.

First, the author typed and reviewed the interview transcripts and meeting observation notes saved as Microsoft Word documents. These documents were imported into NVivo in conjunction with information related to stakeholder and organization characteristics. Throughout the study the author used organizations' attribute data to compare information provided by different types of actors operating at diverse levels of management.

Second, the author used NVivo to organize and code text related to several topics of interest related to drought management. Here, coding refers to the process of classifying text to descriptive or analytical concepts in order for a researcher to analyze large amounts of qualitative data (Bazeley, 2007; Saldaña, 2009). The author first developed a set of *a priori* codes, based on conceptual and analytical frameworks in the adaptation and institution literature, to use in this process. As the researcher worked with the data, “in vivo” codes, or codes derived from participants’ responses, also emerged and were added to the coding protocol. Appendix D provides the “master list” and descriptions of the codes and categories used in data analysis.

As an initial step, the author coded text related to: the impacts experienced during 1998-2002 and 2007-2008 droughts, the specific adaptations or responses to drought, the types of data and information used to manage drought, organizations’ primary interest(s) and participation in FERC relicensing and other basin-level activities, other stressors and issues affecting the water resources management, and the institutional context in which the relevant actors make drought (and related) decisions.

In terms of drought adaptations, the author traced several types of changes and patterns in the data. Specific adaptations made at local-, state-, and basin decision-making levels included discrete and tangible actions such as the adoption of new technologies, management techniques, and response plans. Because adaptation can also be considered a progression of decisions and actions, the author also coded broader shifts in practices and norms of behavior. This phase involved identifying 1) key events that occurred during the study period and contributed to changes in the decision-making environment (e.g., new rules) and 2) shifts in drought management practices and attitudes. Indicators of the more intangible changes were demonstrated or discussed by interviewees as changes in stakeholder knowledge, attitudes, perceptions, and behaviors regarding water resources and the nature of drought management. The author designed several interview questions to elicit responses about changes in behaviors and attitudes that were helpful in this regard (e.g., "what did you or your organization learn" and "compare the similarities and differences between 1998-2002 and 2007-2008").

The author then used the range of collected sources to identify both the formal (e.g., laws, rights, rules, and regulations) and informal (e.g., shared customs, norms, and understandings) institutions that shape the drought management decision context. Uncovering the institutional details provided more than just a snapshot of the decision making context. It also enabled the researcher to further query how and why different water managers and stakeholders adopted particular approaches to drought adaptation and to explore the linkages across different water stakeholders acting at various management levels (Ostrom 1990; Strauss and Corbin, 1998).

Finally, the author used NVivo to examine questions that emerged through the author's engagement with stakeholders during data collection and the initial steps of the coding process. As noted above, the data collection process allowed for a real-time perspective of the drought decision makers' experiences. Originally, and as advocated by the drought planning and management literature, the author expected that the most prevalent and substantial adaptations for water managers after 1998-2002 would entail the adoption of 1) new drought-related data, scientific information, and monitoring tools and 2) new formal institutions such as drought response plans and protocols. However, as the author attended and observed drought management meetings, it was evident that 1) a diversity of approaches to drought response and management existed, 2) there are many levels of engagement with basin- and state-level drought management activities, and 3) the implementation of some drought response and mitigation measures (e.g., response plans) faced many constraints, particularly on the local level.

To enable a more thorough analysis of the full range of practices and perceptions that shape drought management in the Carolinas, subsequent coding examined themes and patterns in the data, focusing on 1) the management strategies used to address drought and 2) the linkages between institutions and these strategies. Using the coded text, the author developed a typology of four drought management strategies, each supported by a particular set of institutions (Elman, 2009). To link management strategies and institutions, the author determined the mutually reinforcing institutional components or "pillars" underpinning organizational actions related to drought response and planning (Scott, 2008). The normative component consists of the dominant values and expectations that affect which behaviors are considered appropriate, legitimate, or desirable through which to pursue a social system's goals and objectives. The cultural-cognitive component represents ideas and understandings about "best practices" and explains which knowledge frameworks are used to formulate problems and solutions. Technologies, planning processes, organizational structures, policies, legal structures, and daily routines may exemplify "best practice thinking." The regulative component serves an administrative function by supplying the formal rules and processes (e.g. regulations, monitoring protocols, and enforcement mechanisms) which guide decisions and actions.

The author then used this typology to further examine the analytical questions that emerged during data collection and coding. These questions include:

1. What types of changes in the institutional framework are necessary to support different drought adaptation strategies?
2. How do institutional interactions affect the implementation and coordination of drought management efforts across the state and local levels?
3. What types of institutional changes are necessary to facilitate cross-scalar drought management and coordination?

Chapters 2, 3, and 4 of the dissertation each use a different aspect of the case study to investigate these questions and related topics regarding the institutional dimensions of drought adaptation. The individual chapters are introduced in the next section.

1.3 Structure of the Dissertation

This section provides summaries of the remaining chapters of the dissertation. Chapters 2, 3, and 4 present the research findings and explore the issues and questions that emerged during the 2007-2008 drought. Throughout the chapters, the author integrates information obtained through interviews, drought management meetings and conference calls, and document analysis. Where specific information or a quote is attributable to an individual interviewee, the citation indicates the interviewee's state and/or organizational affiliation to protect the confidentiality of that individual. In addition, these chapters have been written as stand-alone manuscripts and will be prepared for submission for peer-reviewed publication. Chapter 5 provides an overview of the major findings and discusses the policy implications of this research project.

1.3.1 Chapter 2: "Drought Resilience and the Institutional Components of Water and Drought Management Adaptations"

This chapter examines the role of institutions in the selection of drought adaptation options and efforts to build resilience. It explores the question: "What types of changes in the institutional framework are necessary to support different adaptation strategies?"

It is often expected that the measures to secure supplies, establish water conservation programs, and develop tools to monitor and communicate drought conditions will improve drought resilience and society's capacity to cope with drought. However, there has been little consideration whether these existing approaches to building drought resilience sufficiently address the full range of current, and future, drought risks. For example, relatively few studies have addressed how broader changes to drought management might be facilitated in practice or assessed the capacities necessary to implement new management approaches (Dovers and Hezri, 2010; Engle, 2012, 2013). To help fill this gap, this chapter uses concepts from resilience literature to examine the process of adapting to drought and improve understanding of the broader system of institutional arrangements, networks, and stakeholder values and beliefs that contribute to drought resilience (Adger et al., 2011; Downes et al., 2013; Nelson, 2011; Welsh, 2014). More specifically, the chapter investigates the following questions:

1. What strategies were adopted by water managers and stakeholders in the Carolinas to improve capacity to cope with drought?
2. What types of changes in the institutional framework enable different types of adaptation strategies used by water managers and other decision makers?
3. How do the implemented strategies and management changes contribute to resilience?

1.3.2 Chapter 3: "Drought Planning in the Carolinas: Institutional Interactions and Constraints"

This chapter explores the challenges associated with the implementation of drought response plans and related measures. It investigates the question: "How do institutional interactions affect the implementation and coordination of drought management efforts across the state and local levels?"

The development and implementation of drought plans and programs are an important component of a proactive, risk management approach to this natural hazard. While plans have been adopted by most states and many communities across the country, the extent to which plans have been implemented or coordinate with one another is uncertain. The fragmentation of water resources and drought management responsibilities poses one challenge for the effective coordination of planning across scales and levels. This chapter considers the institutional context dimensions of the drought response process. It examines why the implementation and coordination of drought plans (and related measures) proved difficult, given the substantial efforts to improve the broader capacity to manage drought. It specifically examines the (dis)connections between state and local entities through the following questions:

1. How does the institutional context affect the implementation of local drought response plans?
2. How does the institutional context affect the coordination of state and local drought planning and management measures?

1.3.3 Chapter 4: "Developing Collaborative Drought Institutions: Lessons and Insights from FERC Relicensing and Basin-Level Drought Management"

This chapter assesses how the interplay between formal rules and the more informal components of institutions contributed to basin-specific outcomes in the Catawba-Wateree and Yadkin-Pee Dee Basins. It examines the question: "What types of institutional change are necessary to facilitate cross-scalar drought management and coordination?"

Droughts typically span wide geographic areas and impacts often extend across political and jurisdictional boundaries, limiting the ability of any one organization, community, or sector to effectively respond to, manage, and mitigate risks associated with large-scale events. Greater coordination across the numerous groups with drought responsibilities and interests is needed to support a more proactive approach to drought response. One suggestion is that drought management efforts should focus on river basins, given the many water management decisions made at that scale. However, there have been few assessments of how river basin coordination might be facilitated. In the Catawba-Wateree and Yadkin-Pee Dee basins, key adaptations entailed the development of basin-level drought response protocols and organizational structures to monitor and communicate drought conditions to stakeholders, efforts that contributed to the expansion of the drought decision making arena. However, while the structures and processes for drought response appear similar on the surface, in practice the activities in the two basins exhibited different levels of engagement and integration. To understand why and how these differences evolved, this study investigates not only the changes to formal institutions but also how processes of stakeholder engagement and learning contributed to new networks, relationships, and understanding of drought issues in the two basins. This chapter addresses three particular questions:

1. How have formal and informal drought institutions changed in the two study basins?
2. How have institutional changes through the FERC relicensing process contributed to more coordinated and collaborative drought management?
3. How has the interplay between formal rules at different levels of decision making and the more informal components of institutions contributed to basin-specific outcomes in the study basins?

1.3.4 Chapter 5: "Conclusion"

Chapter 5 provides an overview of the major findings of this research project, focusing on how an improved understanding of institutions and the interplay across levels can be used to shape and inform drought adaptations. Several final observations and reflections are reviewed to highlight relevant insights and contributions to climate adaptation research. The chapter concludes with recommendations for future research.

1.4 Tables

Table 1.1 Organizations represented by interviewees

Organization Type	**Total**	**State**		
		NC	SC	NC/SC
Community water system	49	24	25	
Industry (including licensees)	6	3	2	1
Local government	3	3		
Regional government (COGs)	3	2	1	
State agency	11	6	5	
Federal agency	4	1	3	
Engineering consulting firm	2	1		1
Lake association	2		1	1
Non-profit organization	7	2	2	3
Totals	87	42	39	6

Table 1.2 Drought and water resources management meetings attended

Meetings	**In-Person Meetings**	**Conference Calls**	**Totals**
Catawba-Wateree Drought Management Advisory Group	12	11	23
Catawba-Wateree Water Management Group	4		4
Catawba-Wateree Low Inflow Protocol Evaluation	2		2
Yadkin-Pee Dee Drought Management Team	1	19	20
Army Corps of Engineers, Wilmington District, Water Management Stakeholders	1	7	8
North Carolina Drought Management Advisory Committee	2		2
South Carolina Drought Response Committee	4		4
Water resource conferences	6		6
Totals	32	37	69

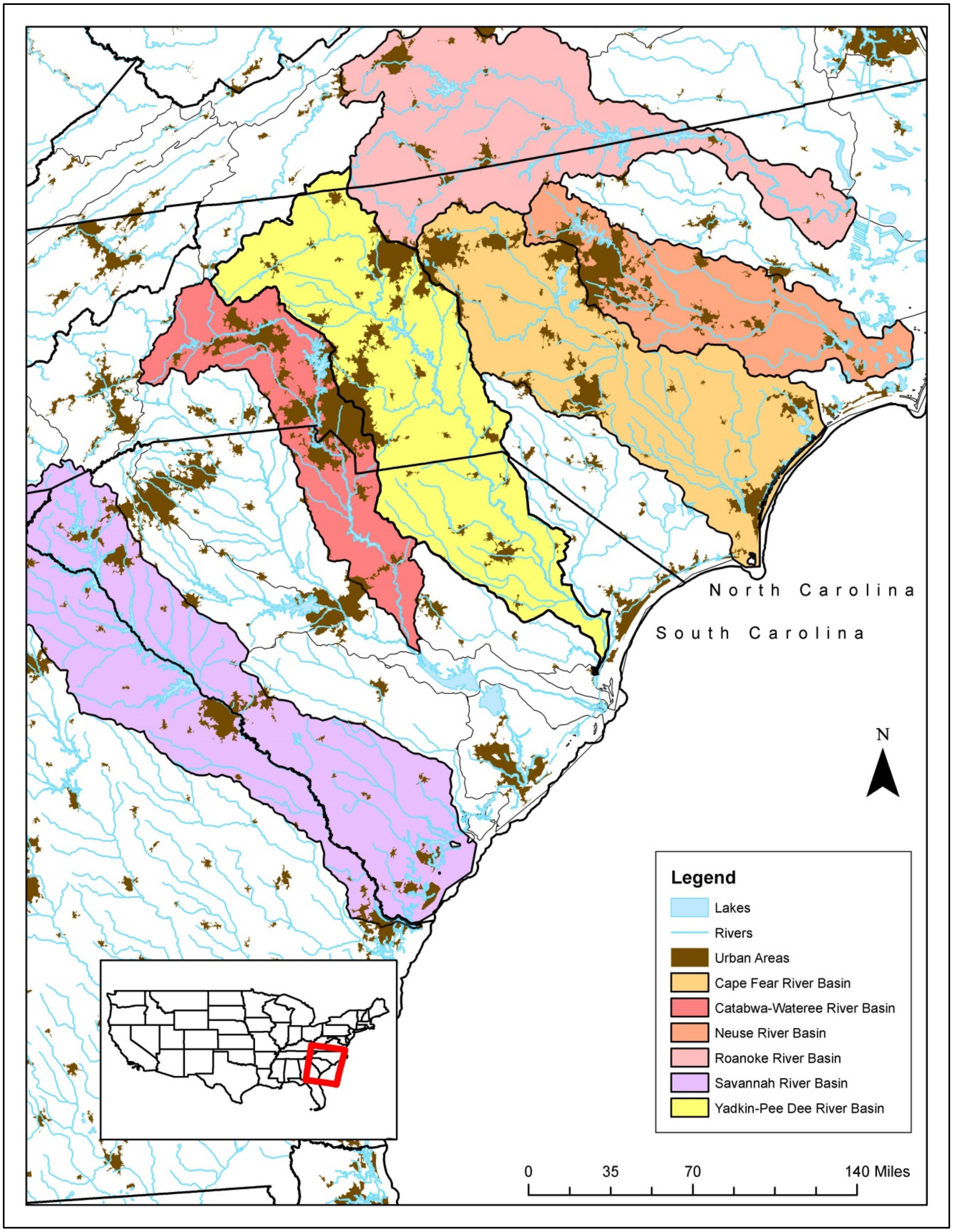

Figure 1.1 Study area

CHAPTER 2

DROUGHT RESILIENCE AND THE INSTITUTIONAL COMPONENTS OF WATER AND DROUGHT MANAGEMENT ADAPTATIONS

2.1 Abstract

New strategies to mitigate drought risks and impacts and improve preparedness and response capacities are needed at national, regional, and local scales. This chapter examines what types of institutional changes are necessary to support several different drought management strategies. It draws from a case study of drought adaptation processes in North Carolina and South Carolina during 1998-2008, a period in which two extreme droughts occurred. The author used information collected through eighty-seven interviews, observation of over sixty drought and water management meetings, and relevant stakeholder documents to develop the case study. Measures to build drought resilience often include securing water supplies, developing water conservation programs, and improving tools to monitor and communicate drought conditions. While these actions can be successful in mitigating drought impacts, they focus on technical and managerial solutions to address short-term and localized risks, rather than examine the underlying conditions that contribute to vulnerability and adaptive capacity. By using concepts from resilience literature, the author shows how the broader system of institutional arrangements, networks, and stakeholder values and beliefs influences the types of adaptations that are undertaken. The study demonstrates that particular sets of institutional structures and processes are required to support different management

strategies. More purposeful attention to the institutional context, and the need for institutional change, is necessary if society is to fully build resilience and capacity to cope with current and future droughts.

2.2 Introduction

Recent droughts in the United States have contributed to considerable stress on water resources and substantial economic, social, and environmental impacts (NDMC, 2015a; Smith et al., 2015). The severity and extent of impacts has led to calls for more concerted efforts to increase the country's drought resilience (NIDIS, 2012). This focus on "resilience" is not unique to the drought planning community. "Resilience" is being increasingly used to address a range of societal issues and challenges, including natural hazards, climate change, national security, community planning, and personal well-being (Brown, 2014). In terms of drought, resilience has meant that communities have adequate water supplies to meet demand, the adverse impacts of drought are avoided, and society is "better able to handle the stresses caused by drought" (NIDIS, 2012; Schwab, 2013, p. 75). Strategies to build drought resilience center on securing water supplies, adopting water conservation and drought plans, improving tools to monitor and communicate drought conditions, and developing education and awareness programs (Dennis, 2013; Engle, 2013; NIDIS, 2012; Schwab, 2013). Such strategies align with the predominant, and popular, usage of "resilience" to refer to the capacity of a system to avoid or "bounce back" from a specific disturbance or stress (Davoudi, 2012; Nelson, 2011; Weichselgartner and Kelman, 2014). However, one critique of this approach to resilience is that it tends to focus narrowly on technical and managerial solutions to mitigate specific risks (e.g., drought) rather than on confronting the underlying conditions that produce risks and vulnerabilities in the first place (Nelson et al., 2007; O'Brien, 2012; Weichselgartner and Kelman, 2014).

While the measures listed above have improved capacity to cope with drought, there has been little consideration whether the existing approaches to building drought resilience sufficiently address the full range of current, and future, drought risks. For example, relatively few studies have addressed how broader changes to drought management might be facilitated in practice or assessed the capacities necessary to implement new management approaches (Dovers and Hezri, 2010; Engle 2012, 2013). To help fill this gap, the author uses concepts from resilience literature to examine a process of adapting to drought and improve understanding of the broader system of institutional arrangements, networks, and stakeholder values and beliefs that contribute to drought resilience (Adger et al., 2011; Downes et al., 2013; Nelson, 2011; Welsh, 2014).

The dissertation uses a case study of drought management adaptations in North Carolina and South Carolina, two states in the Southeastern United States. Two record-breaking droughts (1998-2002, 2007-2008) combined with population growth, increasing water demand, and development pressures to stress water quantity and quality across the two states. These events and conditions also triggered efforts at multiple scales to reduce vulnerabilities and improve capacity to manage water resources more effectively during droughts. The Carolinas' drought experiences therefore provide a unique opportunity to closely examine the longer-term evolution of drought management and the processes through which changes have occurred. This chapter investigates the following questions:

1. What strategies were adopted by water managers and stakeholders in the Carolinas to improve capacity to cope with drought?

2. What types of changes in the institutional framework enable different types of adaptation strategies used by water managers and other decision makers?
3. How do the implemented strategies and management changes contribute to resilience?

Using the recent drought events and responses made during the 1998-2008 period as a starting point, this study draws from stakeholder perspectives to provide insights into the multiple dimensions of drought resilience and how different approaches to building resilience are implemented in practice (Murtinho and Hayes, 2012; Smit and Wandel, 2006). Such an analysis can improve understanding about where, why, and how particular changes occur and help identify what additional capacities, interventions, and/or system-wide changes might be necessary to foster a drought-resilient society (Adger et al., 2011; Young, 2010).

The chapter continues with a review of the literature used to inform the research approach and details about the data collection and analysis processes. The results section highlights the various actions used to address drought risks and impacts, focusing on the institutional components of drought adaptation strategies. This is followed by a discussion of how these strategies contribute to the Carolinas' drought resilience and implications for ongoing and future efforts to improve society's capacity to manage drought and other challenges.

2.3 Drought and Drought Management in the Southeast United States

Drought is a deficiency in precipitation or a departure from expected or normal rainfall conditions and a naturally part of climate variability that affects all regions of the United States. Individual droughts vary according to intensity, duration, and spatial extent and the types of impacts they produce. These differences contributes to challenges in characterizing droughts, determining when they begin and end, and monitoring and measuring their effects on society and the environment (Grigg, 2014; Wilhite et al., 2014). As drought impacts result from the interplay of the event (i.e., precipitation deficiency) with the social characteristics of an area, drought risks and perceptions also vary across regions and locales (Wilhite et al., 2007). Attention frequently focuses on the arid- and semi-arid areas of the western United States, where annual mean precipitation is low and demands are high (Pulwarty and Maia, 2015). However, humid regions such as the Southeast also experience and are vulnerable to drought (Ortegren and Maxwell, 2014; Seager et al., 2009). Recent multi-year droughts in the Southeast have contributed to depleted water supplies, substantial economic impacts, and conflicts over water use in the region (see Dow, 2010; Manuel, 2008; Weaver, 2005; Wong and Bosman, 2014).

The severity of recent drought events has highlighted the need for a better climatological understanding of drought in the Southeast, particularly in order to address potential water management challenges (Ortegren et al., 2014; Pederson et al., 2012). A wide range of factors influence drought processes and control the region's hydroclimate. These factors include local topography, land cover, and surface heating; large-scale ocean-atmosphere interactions such as the El Niño Southern Oscillation (ENSO), Atlantic Multidecadal Oscillation (AMO), Pacific Decadal Oscillation (PDO), and Bermuda High; and the spatial patterns, frequency, and occurrence of tropical cyclones. These processes contribute to considerable spatial (e.g., sub-regions across the Southeast) and temporal (seasonal, annual, decadal, and multi-decadal) variability (Labosier and Quiring, 2013; Ortegren and Maxwell, 2014; Seager et al., 2009).

Research investigating historical climate patterns and trends suggests that the region's water resources will continue to face a variety of stresses and uncertainties. Studies demonstrate that the most recent droughts are not anomalous to previous droughts, in terms of severity or duration (Pederson et al., 2012; Seager et al., 2009). Predicting drought occurrences and trends is difficult, due to the irregularity of persistent, multi-year droughts and multiple factors that produce drought conditions. In addition, climate change is expected to further stress water resources through increasing precipitation variability. For example, year-to-year variability and annual means might remain constant, but variability may shift within years (Labosier and Quiring, 2013). As a result, the changing temporal distribution of precipitation events may affect monthly and seasonal amounts and patterns (Patterson et al., 2012). Although there is high uncertainty regarding future precipitation patterns and variability, increasing temperatures are likely to contribute to higher water demands and evaporation and to an increased likelihood of both short- and long-term droughts (Georgakakos et al., 2014; Ingram et al., 2013; Seager et al., 2009).

As recent droughts highlighted the need to learn more about the Southeast's climate system, they also call attention to the necessity of appropriate water planning and management (Dow et al., 2007; Maxwell and Soulé, 2009; Nagy et al., 2011; Pederson et al., 2012). The Southeast as a whole is "water-rich" and generally has been successful in adapting to drought conditions and buffering society from impacts. Climate interacts with many other factors to affect water availability in the region. Population growth, changing land use and land cover, and increasing development suggest continuing demands on water resources (Ingram et al., 2013; Manuel, 2008; Nagy et al., 2011; Terando et al., 2014). The watershed and sub-watershed scales are expected to be most vulnerable to periods of water stress due to the myriad factors that intersect to affect water availability and use at that level (Averyt et al., 2011; Sun et al., 2008).

These interacting climate and social factors suggest that a "business as usual" approach to managing water resources will not be adequate to adapt to future droughts, particularly in a region like the Southeast where population and development changes are occurring rapidly (Milly et al., 2008; Pahl-Wostl, 2002; Patterson et al., 2012, 2013). However, despite the existing, and growing, threats to the Southeast's water resources, few peer-reviewed studies have examined how the existing systems of drought planning and management support, or inhibit, the region's capacity to manage drought. The exception is the state of Georgia where drought and water management advancements and conflicts have been documented in academic literature and the popular media. For example, Engle (2012, 2013) studied capacity to manage and prepare for drought at the local and state levels. Factors contributing to local capacity center on infrastructure investments and leadership and networks within and across community water systems. Meanwhile, Georgia has been proactive in developing state-level drought and water management plans, thereby providing structure and guidance for conservation and regional collaboration. Important documents include the Georgia Drought Management Plan (2003), which applied "best practices" in establishing drought triggers and levels for response; the Georgia Comprehensive State-wide Water Management Plan (2008), which provides guidance for long-term and regional water resources planning; and Georgia's Water Conservation Implementation Plan (Georgia Department of Natural Resources, 2010; Georgia Water Council, 2008; Steinemann and Cavalcanti, 2006). Even with these assets, the state has continued to experience drought impacts and drought-related conflicts across water users and jurisdictions, including a lengthy struggle over water in the Apalachicola-Chattahoochee-Flint (ACF) basin with Alabama and Florida (Kohl, 2013; Walton, 2012; Wong and Bosman, 2014). These persistent challenges suggest that 1) reliance on specific elements such as formal plans and infrastructure projects, while important components of capacity, has not built widespread drought resilience, and 2) more attention to the broader determinants of capacity and institutional context is warranted (Dovers and Hezri, 2010; Eakin et al., 2014; Engle and Lemos, 2010).

Institutions are the systems of rules that shape individual and collective decisions and actions. The institutional context consists of the formal rules (including laws, policies, and regulations) and informal (including norms of behavior, values, cultural practices, and social relationships) rules that govern how decisions are made, which actions are considered appropriate and legitimate, and how individuals and organizations interact with one another. In the United States the broader water management context is complex and includes many different types of institutions, operating at multiple jurisdictional (e.g., national, state, and local) levels. This context affects the types of activities conducted in water resources and drought planning, and the degree of flexibility communities and government agencies have when responding to drought (Folger et al., 2012). Institutions governing water resources determine who has rights to water and how water is valued. These include legal and regulatory frameworks such as systems of water rights (riparian, prior appropriation, and hybrid approaches), federal and state laws for environmental protection and water quality, court decisions, and interstate compacts. Institutions also shape water demand and can contribute to water shortages through government policies that encourage development and water use (Hill and Polsky, 2005, 2007). On the other hand, governments can also incentivize water conservation and promote customer behaviors that potentially reduce long-term vulnerabilities to drought (Kenney, 2014; Saurí, 2013).

In terms of drought, the institutional context has contributed to an emphasis on technical and managerial approaches to manage drought. For example, systems of water allocation and management across the United States have been guided by the concept of stationarity, which assumes that a fixed range of precipitation exists (Milly et al., 2008). The water management sector has tended to rely on infrastructure and command-and-control tools to manage the variability within that set range (Pahl-Wostl, 2009; Pahl-Wostl et al., 2007ab). Water utility managers view drought as a temporary water supply-demand balance and the goals of drought management as maintaining system efficiency and returning to normal operations as quickly as possible. While this strategy has generally been effective in buffering society from the adverse effects of drought, recent extreme events in conjunction with growing demands have strained water resources and caused significant social, economic, and environmental impacts. The drought planning community advocates that society take a more proactive approach to drought risk management. Activities center on the development and improvement of drought response plans, data collection and monitoring infrastructure, and communication systems, and pre- and post-drought assessments of vulnerabilities, risks and impacts (Wilhite, 2011). Drought planning literature often discusses institutions in terms of their formal dimensions: 1) the authorizing laws, regulations, or policies that govern drought response and 2) the agencies and organizational arrangements with a specified role in drought management, such as providing data and information or implementing drought response plans (Fontaine et al., 2014; Fu and Tang, 2013; Fu, Svoboda, et al., 2013; Wilhite, 2011).

In practice, the use of the term “institution” is framed narrowly and less attention is paid to the range of social factors that affect water availability and society’s vulnerability or capacity to cope with drought. However, drought research is beginning to highlight how the nature of policy processes, governance structures, and social networks and relationships are components of the institutional context that shapes capacity to cope with and manage drought, i.e., drought resilience (Botterill and Hayes, 2012; Carlisle, 2014; Chappells and Medd, 2012; Endter-Wada et al., 2009; Grigg, 2014; Kallis, 2008). This study builds on this research by examining how the institutional components of drought management interact to enable different types of adaptation strategies used by water managers and thereby shape drought response and efforts to build “drought resilience.” In addition, it is expected that institutional change will be necessary to support climate adaptation, including shifts in water management practices (Adger et al., 2012; Ferguson et al., 2013; Moser and Ekstrom, 2010). Knowing how to adapt to changing conditions is particularly salient for the water management sector, as the extent to which many regions of the country will be able to adapt to future hydroclimatological and social stresses is uncertain. Given the complexity of emerging social and environmental challenges, there is a need to improve understanding of the institutional mechanisms that might facilitate society’s capacity to learn, adapt, and address changing conditions and stressors (Dovers and Hezri, 2010).

2.4 Using a Resilience Perspective to Assess Drought Management Adaptations and Institutional Change

2.4.1 Resilience

The term resilience generally refers to the ability to recover or adjust to some adverse event or condition and is often used to describe the capacity of a system to return to an original state (i.e., "engineering resilience"). Although, the concept is applied differently by a variety of disciplines, the overall view of resilience as a static state contributes to policies that focus on resisting change and conserving existing systems (Brown, 2014; Folke, 2006; Walker and Salt, 2012). For example, in environmental management resilience has meant maintaining optimal resource conditions and system efficiencies (Folke, 2006). In disaster risk reduction, resilience has meant minimizing risks and responding and supporting a return "back to normal" as quickly as possible (Brown, 2014; Weichselgartner and Kelman, 2014). In the water management sector, resilience has been understood as how quickly a water system can recover from a system failure (Hashimoto et al., 1982). The main objective of water system management is to avoid system failure. As such, water system managers have typically relied on infrastructure and technical tools and ensure the reliability and redundancy of water supplies (Gleick, 2000; Pahl-Wostl et al., 2007b; Rayner et al., 2005; Wang and Blackmore, 2009).

An alternate framing has emerged through work in ecology, where resilience means accepting change and managing for flexibility and variability rather than constancy (Folke et al., 2010; Nelson et al., 2007; Walker and Salt, 2012). The resilience concept has been used to understand ecosystem processes and study how social-ecological systems (SES) respond to disturbances, recognizing that social and ecological systems are interdependent and must be viewed and managed as linked systems in order to ensure the sustainable and equitable use of resources (Adger et al., 2011; Cote and Nightingale, 2012; Folke et al., 2010; Walker and Salt, 2012). Resilience is thus considered the ability of a system to withstand stresses and maintain its core functions and structure while also continuing to change and adapt (Cote and Nightingale, 2012; Folke, 2006; Nelson et al., 2007). Furthermore, transformational change may be required if a system no longer has adequate capacity to manage the threats and challenges it faces (Folke 2006, citing Holling, 1996; Folke et al., 2010; Nelson et al., 2007; Walker and Salt, 2012). In short, resilience is "not about not changing" but recognizes that both ecological and social systems must adapt in order to persist (Walker and Salt, 2012, p. 3).

"Resilience thinking" has made key contributions to our understanding of SES dynamics, by acknowledging and highlighting the existence of multiple and heterogeneous states at different spatial and temporal scales, the linkages and interactions within and across systems and scales, and the role of adaptive capacity as attribute necessary to help systems mobilize resources, learn from disturbances, and manage change (Cote and Nightingale, 2012; Folke, 2006; Nelson et al., 2007; Walker and Salt, 2012). A social-ecological framing of resilience also calls attention to the many factors that affect a system's capacity to manage and adapt to change, including institutional arrangements and governance structures, social networks and relationships, and the diverse values held by the actors involved in the governance and management of social-ecological systems (Adger et al., 2011; Folke et al., 2010; Leach, 2008; Nelson, 2011; Walker and Salt, 2012).

Despite these contributions, applying resilience concepts in research and in the management of SES can be problematic. This challenge stems partly from the fundamental disconnect between "engineering resilience," which focuses on managing for predictability, stability, and efficiency to solve immediate problems, and "social-ecological resilience," which manages for change, adaptability, and flexibility and takes a longer view of the social conditions and processes that contribute to risks. For example, the calls for resilience being made in many decision-making arenas are indicative of the "engineering resilience" perspective and seldom question the definitions, goals, outcomes, or processes of resilience (Nelson, 2011). This illustrates the general lack of clarity between the normative and descriptive notions of resilience. While originally used and understood as a descriptive concept to study ecosystem processes, much of the discourse about resilience assumes it to be a "desired state" without interrogating the values and/or interests those outcomes are supporting (Brand and Jax, 2007; Brown, 2014, p. 109; Cote and Nightingale, 2012; Leach, 2008; Weichselgartner and Kelman, 2014). Challenges also remain in linking ecological and social theories and integrating analyses of social dynamics with efforts to assess and manage resilience (Cote and Nightingale, 2012). These issues are particularly important as many authors and advocates argue that purposeful, transformational social change will be necessary to address future challenges such as climate change (Brown, 2014; Folke et al., 2010; O'Brien, 2012).

Given the inherent contradictions between the different understandings and applications of "resilience" and the complex challenges that face social-ecological systems, there is a need to identify how we might bridge the conservative notion (and application) of resilience to one that embraces change. The next section discusses how assessments of adaptation processes and the role of institutions can be used to improve understanding of the mechanisms and processes through which resilience is built and developed (Ferguson et al., 2013; Garschagen, 2013; Nelson, 2011).

2.4.2 Assessing resilience: adaptations, transformation, and institutions

This section discusses how resilience concepts can be used to study adaptation actions and processes of change, ranging from small, incremental adjustments to transformational shifts. In this usage, resilience is not a normative concept but a framework to improve understanding of what capacity is necessary to build an adaptable society (Nelson, 2011).

A resilience framework differentiates two types of change, adaptation and transformation. Adaptation in a resilience context refers to the process of maintaining the structure of the existing system by making changes and adjustments (Nelson, 2011; Walker and Salt, 2012). In practice, adaptation focuses on reducing specific risks or building general resilience. Actions to enhance specific resilience include assessing thresholds, the point at which a system moves into a new state, and/or changing system functions to avoid a threshold (Eakin et al., 2014; Walker and Salt, 2012).

General resilience refers to the capacity of a system to respond to problems and implement a variety of potential options and entails the set of resources, conditions, and processes (also, adaptive capacity) that allows actors to manage the system (Smit and Wandel, 2006; Walker and Salt, 2012). Adaptability refers to the ability of actors to make use of those resources, understand what components of a system might need to be changed, or where change could increase resilience (Walker and Salt, 2012). Efforts to enhance or build general resilience may be indicated in a variety of ways, including: shifts in the way key actors define problems; diversification of the strategies and tools used to solve problems; changes in legal frameworks (e.g., formal rules, laws, and policies); building of social networks, new relationships, or cooperation within the system; expanding resources and options for adaptation; and exhibiting flexibility and openness to learning and new opportunities (Carlisle, 2014; Nelson et al., 2007; Nelson, 2011; Walker and Salt, 2012; Young, 2010).

Transformation occurs when the existing system can no longer manage stresses or reaches a threshold. Transformation includes fundamental changes to the structure of the system and may be indicated by tangible as well as subjective measures. Examples include adoption of technological innovations or comprehensive reforms to institutional systems. Transformational change may also signified by the questioning of the status quo, including the existing and well-established goals and values, beliefs and assumptions, and political relationships and power dynamics that might be the core causes of vulnerability (Nelson, 2011; O'Brien, 2012, 2013; Weichselgartner and Kelman, 2014). Walker and Salt (2012) refer to transformability as the capacity to form a fundamentally new system. While this capacity is strongly influenced by as system's general resilience, other attributes, such as awareness of the possibilities of change and having feasible options to employ, are also needed (Moser and Ekstrom, 2010; Walker and Salt, 2012).

Institutions are an important aspect of a system's resilience, or in other words its overall capacity to manage and adapt to disturbances. Resilience research highlights how institutions link social and ecological systems through their role in shaping the relationship between people and their environments, e.g., by determining property rights, how resources are used and by whom, and integration of different knowledge systems into resource management regimes (Adger, 2000, Folke, 2006; Walker and Salt, 2012). Institutions serve as a source of resilience by influencing the ability to mobilize and use resources, how problems are framed, and the extent to which governance structures are responsive, flexible, and support knowledge-sharing and learning (Adger et al., 2011; Eakin et al., 2014; Gupta et al., 2010; Nelson, 2011).

The resilience literature demonstrates the importance of institutions and the critical role they play in shaping specific adaptations, adaptability, and general resilience, but more work is needed to understand how institutions can support transformational change and the integration of "resilience thinking and practice" into existing management regimes (O'Brien, 2012). Furthermore, it is expected that institutional change will also be necessary to cope with emerging social and environmental challenges, thus requiring improved understanding of the mechanisms and processes through which institutions themselves change and adapt (Dovers and Hezri, 2010; Young, 2010). Breaking down particular strategies into their institutional components is one way to identify and assess the potential opportunities (and constraints) for incorporating resilience into existing institutions and resource management structures (Ferguson et al., 2013; Garschagen, 2013).

Scott (2008) provides a conceptual framework for analyzing institutions by distinguishing their normative, cultural-cognitive, and regulative dimensions. The normative component consists of the dominant values and expectations that determine which behaviors are considered appropriate, fair, legitimate, or desirable through which to pursue a social system's goals and objectives. The cultural-cognitive component represents ideas and understandings about “best practices” and explains which knowledge frameworks are used to formulate problems and solutions. The cognitive component may be exemplified by the “tools” or sets of measures used to implement the various drought management strategies – i.e., policies, organizational structures and planning processes, routines, technologies, and material objects. The regulative component serves an administrative function by supplying the formal rules and processes (e.g., regulations, monitoring protocols, and enforcement mechanisms) which guide decisions and actions.

Using drought as an example, drought planning in the water utility sector is dominated by engineering and technological tools to secure water supplies and reduce any potential effects of drought on their customers. The institutional framework consequently consists of the codes and standards used by water engineers to secure supply, water allocation rules, and water pricing regimes, i.e., the regulative and cultural-cognitive factors that affect the supply and demand of water (Kallis, 2008). These practices support the normative goal of avoiding drought risks and impacts and ensuring that customers have access to reliable and high-quality water. One challenge for the practice of resilience will be to incorporate new ways of thinking into current systems of managing SES (Garschagen, 2013; Nelson et al., 2007) and negotiating the multiple meanings of resilience that are embedded in particular drought management strategies (Chappells and Medd, 2012). The predominant approaches to drought response and planning, as described above, characterize specific resilience. That is, they target a specific risk (drought), relying on technical and managerial solutions to resolve expected problems and immediate threats on a local scale. In contrast, general resilience attends to broader scales and system-wide conditions that allow a system to cope with and manage surprise and unexpected disturbances (Adger et al., 2011). This case study of drought in the Carolinas is therefore designed to investigate how resilience, in its varying manifestations, is built in practice and how the institutional framework enables particular adaptation strategies.

2.5 Methods

The drought management landscape is complex, shaped by hydroclimatological and social processes and populated by many stakeholders operating on different management levels and with diverse responsibilities and interests. The study uses a "bottom-up" approach to document and assess how different stakeholders understand the institutional context, how that context has shaped adaptation decisions and actions, and how they are building resilience in practice (Carlisle, 2014; Cote and Nightingale, 2012; McNeeley, 2014; Smit and Wandel, 2006).

2.5.1 Context

The water management context of the Southeast serves as a backdrop for the case study which focuses specifically on the Carolinas for several reasons. First, two droughts of record, one surpassing the next in severity (1998-2002, 2007-2008), increasing water demands, and other economic stressors converged to severely stress the states' water resources and reveal drought vulnerabilities. Collectively, these conditions triggered many different efforts to improve the management of water resources before and during drought. Second, these efforts have occurred not only at the local and state levels, but also in river basins shared by the two states, allowing for an examination of the solutions and capacities developed at and across multiple scales of water management. Finally, while two extreme droughts within a short time span was neither expected nor welcome, water and drought managers were able to apply lessons learned and utilize new tools developed in response to the 1998-2002 drought in 2007-2008. Adaptive measures included plans for local drought response and protocols to guide the monitoring and communication of drought conditions at state and basin levels. Other measures, particularly at the local level, focused on augmenting water system supplies. As a result, the author used the 2007-2008 drought as an opportunity to observe drought response "in practice" and to ask water managers to reflect upon the different events and how the capacity to cope with and manage drought had changed. This interrogation revealed ways in which drought adaptations addressed both specific and general resilience.

2.5.2 Data collection

This project used a set of sources and collection methods to gather information about different actors' perspectives, the context in which they act, and the processes through which drought adaptations were enacted. The author collected data from May 2007 to November 2008, while water managers were actively addressing the second of the pair of droughts considered in this study.

First, interviews were conducted with eighty-seven decision makers and actors knowledgeable about, or responsible for, drought response and water supply management. Interviewees represented multiple levels (local, basin, state, federal) and diverse agencies and organizations. Thirty-eight interviewees represented federal agencies, state agencies, non-profit organizations, community groups, regional planning organizations, engineering consulting firms, and industrial water users. Forty-nine interviews were conducted with public water system managers and other local officials.

Of particular interest were individuals and organizations involved with the relicensing of private hydropower projects in the Catawba-Wateree and Yadkin-Pee Dee basins. "Relicensing" refers to the multi-year process through which a dam owner applies for a new operating license with the Federal Energy Regulatory Commission (FERC). Due to the length of license terms (30 to 50 years) relicensing offered a rare opportunity to modify license conditions and dam operations and establish the future course of drought management. Dam owners in both the Catawba-Wateree and Yadkin-Pee Dee basins initiated the relicensing process soon after the 1998-2002 drought, allowing stakeholders to use lessons from that event to address water- and drought management issues. The author also interviewed water managers and decision makers from outside the Catawba-Wateree and Yadkin-Pee Dee basins in the study in order to obtain alternate perspectives on drought and water management issues. Additional interviewees included decision makers in basins managed by the United States Army Corps of Engineers (USACE) and individuals knowledgeable about or involved with drought response and management issues and who were recommended by other study participants.

Second, the author attended and observed fifty-nine meetings and conference calls where drought response and management was the primary objective. The onset of drought in spring 2007 triggered basin- and state-level drought response meetings and calls and which continued regularly throughout the study period. Observation of drought management meetings provided an invaluable opportunity to observe group decision-making processes as water managers and other stakeholders discussed and debated how to respond and adapt to the drought. The author attended an additional ten water management meetings and conferences during this time period and where participants discussed drought management issues.

Third, documents were used to obtain background information about water- and drought management in the Carolinas and to triangulate data gathered from other sources. State-level documents included drought-related rules and legislation, state water supply plans, and drought monitoring reports. Basin-level documents FERC-related studies, memos, reports, and relicensing applications; drought contingency plans; and drought management group meeting (and call) minutes. Local-level documents include water shortage and drought response plans, annual water system reports, city and town council minutes, and public education materials. Practitioner publications (e.g., American Water Works Association [AWWA], 2007) provided information regarding water supply planning and drought management "best practices." These documents were used to identify existing institutional normative, cultural-cognitive, and regulative components, adaptations made in response to the first drought, and reflections and observations about drought response during the 2007-2008 event.

2.5.3 Data processing and analysis

The author imported interview transcripts and drought management meeting minutes and notes into QSR NVivo, a qualitative software program, for coding and content analysis. Coding was conducted in an iterative manner to categorize and then explore different themes within the data. The coding and analysis process was designed with three objectives: 1) identifying the specific adaptations and responses that occurred during the study period, as well as the overall strategies used to guide actions; 2) elucidating the institutional arrangements which play a role in mitigating drought risks and/or managing water supplies during a drought event; and 3) assessing how the various efforts being made in the Carolinas are contributing to drought resilience.

The initial coding involved identifying and characterizing the various stakeholders and organizations involved or interested in drought decisions and the institutional context prior to and in place during the 1998-2002 drought. The first round of coding was also used to record drought impacts and other water resource stresses, as well as the drought adaptations reported by interviewees or discussed during drought management meetings and calls. Adaptations entailed specific actions taken, as well as broader behavioral or institutional change made, by water managers and stakeholders to cope with, minimize, or adapt to drought risks. Institutional changes included the adoption of new, or modification of, existing plans, policies, tools and/or technologies, information used in decision making, participation in organizations or networks, and ideas about water resources and drought management. Adaptations were then organized into a typology of "drought management strategies" which represent the four overarching approaches to addressing drought risks and building response capacity (Bazeley, 2007; Elman, 2009).

The second stage of analysis identified the institutional components of the different drought management and capacity building strategies. Each strategy is supported by a set of three institutional components, i.e., normative, cultural-cognitive, and regulative (Scott, 2008). The author examined the linkages between the institutional components and different management strategies and then traced where and how institutional changes occurred and how those changes supported new drought management strategies or activities. The third step in the analysis involved examining how the overarching strategies, and their institutional components, contributed to diminishing or increasing forms of resilience. This analysis focused on investigating the connections between the types of institutional changes that had occurred, how they contributed to specific and/or general resilience, and the extent to which they demonstrated "social-ecological resilience" in the sense that they supported and built capacity for water managers acting at multiple management levels to adapt to new and changing conditions (Adger, 2000).

2.6 The Evolution of Drought Management in the Carolinas

This section discusses the role of institutional changes in the overall development of drought management in response to these major, back-to-back drought events. It traces the institutional context through three main periods: prior to 1998, the 1998-2002 drought, and the post-2002 responses. The text in this section integrates information obtained through interviews and drought management meetings and conference calls. Where information is attributable to an individual reference, the citation indicates the state and/or organizational affiliation.

2.6.1 "An unlimited supply of water" and the institutional context prior to 1998

The drought management strategies and tools that existed before and during the 1998-2002 drought reflect a legacy of deep-rooted ideas, practices, and a set of institutions that evolved as part of the history of surface water development and management. On the state level, the prevailing mindset that both states had plenty of water to accommodate all uses and demands contributed to a "traditional hands-off approach to water allocation" (Moreau and Hatch, 2008, p. 2). Operating within a water rights system where riparian landowners can access and make reasonable use of water, state oversight had centered on water quality parameters and water system operations, but not necessarily the amount of water withdrawn or used (SC State Agency). The two states engaged in drought planning and preparedness after a significant, but not equally severe, drought in the 1980s. North Carolina formed the Drought Management Council (1992) to facilitate interagency cooperation and information-sharing during drought events and incorporated a state drought response plan into the State Emergency Operations Plan (1994). The South Carolina Drought Response Act (1985) gave the Department of Natural Resources responsibility for drought response (i.e., develop and implement a state drought response plan), established the state-level Drought Response Committee (SC DRC) and six regional drought management areas, and required local water systems to develop response plans and ordinances (Mizzell and Lakshmi, 2003). However, South Carolina had no incentives or enforcement mechanisms to prompt water systems to develop or implement plans (SC State Agency).

On the basin-level, dam operations greatly influence water availability in the Carolinas, where hydropower projects constructed by private industries, utilities, and the Army Corps of Engineers regulate most of the major rivers (Moreau and Hatch, 2008). Private entities initiated hydropower development in the late 19^{th} century, when they began to harness surface water resources for electricity production. Hydropower fueled regional development throughout the 20^{th} century by providing power and stable water supplies for industrial, municipal, and domestic use (Maynor, 1980; Savage, 1968). The Federal Energy Regulatory Commission (FERC) permits nonfederal projects, built primarily by private industries and utilities to produce hydropower. United States Army Corps of Engineers (USACE) projects are authorized through the River and Harbors Act, the Flood Control Act, and/or Water Resources Development Act (WRDA) provisions and support multiple uses, including flood control, navigation, hydropower generation, recreation, fish and wildlife protection, water quality control, and water supply). Despite the long history of hydropower and variable climate in the Carolinas, drought plans for many of the major hydropower projects were either outdated or non-existent in 1998. Specifically, in the two case study basins (the Catawba-Wateree and Yadkin-Pee Dee), the FERC licenses in place had been issued in 1958. The licenses of that era generally favored hydropower generation over other water use, environmental, or downstream interests and included no drought contingency plans. Since that time, federal legislation such as the National Environmental Policy Act (1969), Endangered Species Act (1973), Clean Water Act (1972), Electric Consumers Protection Act (1986), and Water Resources Development Acts (1986, 1990) has expanded the responsibility for dam managers to consider the environmental quality and public health impacts of dam operations.

Local governments and utilities have had the primary responsibility for drought planning, through their role in developing public water supplies and providing reliable water services to their customers (Cockerill, 2014; Dow et al., 2007). Droughts are considered a temporary water supply-demand imbalance and consequently treated as an engineering problem. Water system infrastructure is built with the intent to minimize the impacts of climate variability, accommodate periods of peak demand, and prevent water use disruptions. In addition, water systems have considered droughts to be "money-makers." Water system governing boards have used low water rates as a component of local development strategies (Hughes, 2005). However, because low prices require high usage to produce sufficient revenues for operations and maintenance, systems rely on increased water consumption during dry periods to provide the extra revenue needed to support the water system throughout the year. While increased demand during these dry periods may have strained the capacity of treatment and distribution systems, water systems rarely implemented water restrictions or demand-side (i.e., conservation) management.

2.6.2 Crisis in the Carolinas: The 1998-2002 drought

Beginning in 1998, many areas in the Carolinas experienced several years of below-normal precipitation. Deficits over the four-year period were among the largest ever recorded, and the cumulative deficit resulted in severe hydrologic impacts, including critically low streamflows, groundwater levels, and reservoir storage (Kiuchi, 2002; SC DNR, 2004; Weaver, 2005). The most severe water supply impacts occurred when river and reservoir levels reached critical lows in summer 2002. At least 60 community water systems across the two states were vulnerable to running out of water had the drought continued (NC DENR, 2004, SC DNR, 2003, Weaver, 2005). On the Yadkin-Pee Dee River, rapidly declining water supplies necessitated emergency meetings between dam operators, NC and SC state agencies, and water users to manage the limited resource for the duration of the drought.

The Carolinas were in crisis mode in 2002. Water managers and decision-makers were ill-prepared for an unprecedented, severe and long-lasting drought. Much of the management activity was reactive, driven by impending water shortage emergencies. As one interviewee recalled, “One day we had water in the river, and the next day, it was like somebody cut the faucet off. We were really scrambling at the time, when we saw it starting to drop like that” (NC State Agency). On the local level, “everyone was doing their own thing" (NC Water System). For those water systems or communities faced with water shortage emergencies, response was described as "off the cuff" and "shoot from the hip" (NC Water Systems). With limited authority or previous experience with such a severe event, state-level response was also reactive. There was little or no knowledge of water stakeholders' needs (including basic contact information), minimal expertise with drought monitoring, and underdeveloped channels of communication.

While the crisis conditions were partly attributable to the severity of the drought, they were also a legacy of the institutional components that underpinned drought management throughout the 20th century. The prevailing assumption that the Carolinas were "so well-watered that we would never have that [drought] problem" guided the region's overarching approach to water resources management and drought planning (NC Regional Government). Consequently, local water systems made most drought planning decisions. Their decisions were primarily based on knowledge about the local water supplies and demands and historical hydrological and climatological data. While this local-level approach had proven adequate to prevent and mitigate impacts during previous droughts, the drought's spatial and temporal extent taxed the region's capacity to cope with a "drought of record." Furthermore, the lack of formal drought plans also contributed to a reactive, crisis-oriented response. Few municipalities had up-to-date response plans "because it just never, nothing ever close to what occurred in that drought, had occurred before." (NC Local Government) Although the 1980s drought had triggered the adoption of local response plans in South Carolina, by the late 1990s, the systems were "out of practice" in terms of implementing those plans (SC State Agency). NC and SC state-level drought plans provided only a skeletal structure for state and local response. The FERC-licensed hydropower projects in the Catawba-Wateree and Yadkin-Pee Dee had neither drought contingency plans nor other formal rules to guide management decisions during the drought. In short, the 1998-2002 drought exposed the limits of the prevailing strategies and practices in place to manage and prepare for drought risks. The drought also highlighted how increased demands on water supplies and lack of coordination and communication among decision makers could contribute to the vulnerability of water resources and users in the Carolinas at a regional level. The next section discusses how government agencies and other stakeholders responded and adapted to these experiences.

2.6.3 The institutional components of drought adaptations

Beginning with the 1998-2002 drought, water resource managers and policy makers initiated a wide range of adaptations to improve drought planning and response at multiple levels, extend and ensure adequate supplies for multiple water uses during drought, and mitigate potential impacts. While stakeholders did not expect another severe drought so soon after 2002, the Carolinas experienced another "drought of record" in 2007-2008. Above-average summer temperatures in 2007 exacerbated the drought's rapid and intense onset. North Carolina experienced its driest year (2007) on record and a record number of days above 90˚F. It was the state's worst drought since record-keeping began in 1895 (NC DMAC, 2009). South Carolina experienced its fifth driest year on record in 2007, and by November 2007 many streams and reservoirs were at or near record lows, even lower than in 1998-2002 (NC DMAC, 2008). Below-average rainfall persisted throughout 2008, and streamflow-, reservoir-, and groundwater levels failed to recover as they normally would through the winter and spring months. Although the region experienced exceptional drought and severe water resources impacts in 2007-2008, many study participants indicated that they were better prepared compared to 1998-2002. Water managers from both states applied lessons learned from the previous drought and utilized new tools (e.g., drought response plans and committees to monitor and communicate drought conditions). At the same time, decision makers also learned that "every drought is unique" and found that additional changes and adjustments were needed in order to further enhance the capacity to respond and lessen the adverse effects of drought (NC State Agency).

This section presents the four overarching strategies that emerged during the study period to improve drought management and reduce drought risks and impacts: securing supply, demand management, drought response planning, and basin-level management. Each strategy entails a particular combination of objectives, tools, and actors, and all of these, from new technologies to planning, depended on changes in institutional components to be successfully implemented. The findings presented here focus on the institutional configurations that emerged to support each drought management strategy: the normative (e.g., goals and values), regulative (e.g., rules and administrative processes), and cultural-cognitive (e.g., beliefs and knowledge) components. The institutional components of each strategy are summarized in the accompanying tables (Tables 2.1, 2.2, 2.3, and 2.4). Overall, it is important to note that the adoption and implementation of a particular strategy would not occur unless the supporting institutions were in place. Section 2.7 discusses how the different strategies contribute to drought resilience.

2.6.3.1 Supply management strategies

Supply-side adaptations primarily involve actions taken by local water systems and/or communities to secure and augment water supplies. Particularly on the local level, the idea that plenty of water exists to meet needs remained the overarching mindset. The primary objective of this drought management strategy, then, was to bolster capacity to avoid risks and minimize the impacts of drought on water customers. Table 2.1 shows the institutional components of the supply-oriented strategy.

2.6.3.1.1 Adaptation 1: Secure supply – the "baseline" approach

Specific adaptations included moving intakes, constructing backup storage or new reservoirs, and expanding pumping and distribution capacity. These actions were generally consistent with traditional methods used by water systems to secure supply and relied primarily on engineering and technical expertise.

2.6.3.1.2 Adaptation 2: Diversify tools to develop and secure new supplies

In order to supplement "baseline" approach or structural tools to secure supply, many interviewees also acknowledged that new technologies and techniques can help to better manage and distribute existing supply and improve water system efficiency. Measures included upgrading treatment and distribution systems, adopting new technologies or management techniques to improve system efficiencies (e.g., leak reduction programs), and developing alternate sources of water (e.g., reclaimed water, aquifer storage and recovery, new purchasing agreements or interconnects to other systems). Such measures were considered to be consistent with emerging, professional best practices but also represented some diversification of the tools used to secure and augment supplies.

Although many of the institutional components of the supply management strategy remained fundamentally unchanged at the system level, some adaptations did require new, or revised existing, rules and regulations. For example, water purchases or transfers between local systems required formal contracts, and aquifer storage and recovery and reclaimed water systems necessitated new systems of state regulation and oversight. While drought management has occurred traditionally on the local level, such examples suggest that regional and state interests may play a larger role in future water and drought planning efforts.

2.6.3.2 Customer and demand management strategies

In contrast to the supply management strategies that assume unlimited water supplies, demand management strategies recognize that supply constraints do exist (see Table 2.2). The 1998-2002 and 2007-2008 droughts, and the severe impacts to reservoir and stream levels, contributed to an increased awareness of the vulnerability of water resources. As one state agency representative articulated: "…the light bulb finally went on, that this is not an infinite resource out there" (NC State Agency). According to interviewees, this emerging awareness about the vulnerability of water resources also contributed to a growing acceptance of the value of demand-side programs in augmenting their water systems' overall strategy to balance supply and demand, particularly during dry periods or droughts. For some water systems, drought was not necessarily the primary motivation for demand-oriented adaptations. However, in those situations, many interviewees reported that recent drought experiences increased the feasibility of and local support for such efforts.

2.6.3.2.1 Adaptation 3: Rethink the "business of water"

Adaptations to address the demand-side of water planning and management included water rate and fee increases, metering system upgrades, and education and conservation programs. These measures are intended to encourage conservation, help the water system to control demand, or improve capacity to track and manage customers' water consumption. According to interviewees, these actions represent a shift in how water systems think about water provision and their customers. A key objective in the supply management strategy is to buffer water customers from the impacts of climate variability. A demand-oriented approach holds that customers should pay the true cost of water service and delivery and be aware of the impacts that unrestrained water use can have on a water system. These informal changes have been accompanied by formal changes to water rates and water rate policies. Increasing block rate structures are replacing decreasing rates, for example, and are intended to discourage high levels of consumption. These adaptations have been implemented primarily on the local level and are based on local knowledge of water system and community, as well as managerial experience and expertise regarding water use and water system finances.

2.6.3.2.2 Adaptation 4: Reduce overall demand

Only two water system representatives in the study indicated that limited water supplies necessitated more fundamental changes in how their systems approached supply and demand management (see Table 2.5). These systems had reached a threshold where it was not practical for them to continue to develop supply to meet increasing demands and had initiated policies to reduce overall demand.

These local governments implemented incentives, mandates, and education programs to alter customer and organizational behaviors and reduce water consumption. Water system representatives also noted that peer and social pressure emerged within their communities as an informal means to reduce water use. New policies relied on the use of community-based knowledge and expertise. Implementation involved developing new mechanisms to coordinate local water management efforts with the land use planning and economic development sectors.

2.6.3.3 Drought response planning strategies

Contrary to previous assumptions about the region's "unlimited supply of water," the 1998-2002 drought triggered "a new idea that the Southeast might have water shortages" (NC-SC Non-Profit Organization). Two key lessons began to emerge during this drought. First, following "best management practices" to secure and manage supply does not make water systems immune to drought risks. Reliance on historical knowledge and experience did not adequately prepare many systems for an extreme drought. Second, drought conditions and impacts need to be monitored and managed before drought reaches a critical stage. Even those systems with plans found that "a lot of our old drought plans did things [conservation] too late" (NC State Agency).

2.6.3.3.1 Adaptation 5: Improve drought response capacity

This strategy centers on the development of drought response plans and enhancing the capacity of state and local agencies to cope with and manage drought (see Table 2.3). It follows from the premise that formal plans support a proactive risk management approach to drought by articulating the responsibilities for monitoring conditions, making drought designations, communications, taking response actions, and enforcement (Wilhite, 2011; Wilhite et al., 2000). Local-level actions centered on the development of response plans, primarily in reaction to state requirements and assumptions that plans would help water systems and communities balance supply-demand during a drought event (i.e., through water use restrictions). On the state level many adaptations to improve drought preparedness entailed the increasing formalization of drought response, through the adoption of legislation, protocols, and rules to guide state-level activities and provide direction for local actions and planning.

In North Carolina, 2002 legislation strengthened role of the state's Drought Management Advisory Council and required that water systems develop Water Shortage Response Plans (WSRP). New rules set guidelines and minimum standards for response plans, water conservation, and other activities to be implemented during drought and water supply emergencies. However, no authority existed to enforce adoption of response plans and water conservation measures. The severity of impacts in 2007-2008 moved Governor Easley to become actively involved in drought response efforts and request that all water systems ask customers to conserve and report their systems' weekly water use. The governor also introduced legislation (the 2008 "Drought Bill") that gave state agencies more authority to oversee drought response and further strengthened the requirements for the development and implementation of WSRPs and conservation measures.

In South Carolina, the Drought Response Act was amended in 2000 based on recommendations from the 1998 SC Water Plan. The 2000 legislation redrew drought management areas to follow the four major river basins rather than climate divisions and required that the Department of Natural Resources (SC DNR) establish specific numerical values for each drought level. During the 2007-2008 drought, SC DNR followed and led the state's drought response program as authorized by the Drought Response Act. The South Carolina Drought Response Committee (SC DRC) was active, convening regularly for in-person meetings or conference calls to consider drought conditions and designate drought status for the state's forty-six counties. While the SC DRC encouraged water conservation and increased awareness of drought impacts through press releases and other communications tools, individual communities and water systems made final decisions regarding water restrictions based on their local drought response plans and conditions.

In addition, state agencies enhanced their technical capacity by building drought-related data and monitoring systems and using hydroclimatological data and drought indices to develop management triggers and responses. They assisted local water systems by assessing options during water shortage emergencies, providing information and other resources to support drought response planning processes, and developing online tools to facilitate reporting of and access to drought-related data. State agencies, through their participation in state-level response committees (North Carolina Drought Management Advisory Council, South Carolina Drought Response Committee) also played a key role in expanding the states' capacity to communicate drought conditions to a wide range of water users and stakeholders.

2.6.3.4 Basin-level cooperation strategies

As discussed above, drought management and planning prior to 1998-2002 was conducted primarily at the local level, by individual communities and water systems, with little if any involvement from other decision-making levels. The 2002 drought was "the beginning of the realization that everybody had to work together, that yes, we do have to rely on each other" (NC State Agency). Concerns "that this is not an infinite resource out there" highlighted the need for coordinated efforts to address water and drought issues (SC State Agency). Increased awareness about the lack of coordination across different water management levels led to systematic efforts to communicate, cooperate, and collaborate with other water users (see Table 2.4). These efforts were supported by a shift in the underlying understanding of how drought risks should be addressed, that is all water users are interdependent and should "share the pain" of drought impacts and water conservation measures.

The general approach has been to address how the role of operations in affecting water availability and creating, exacerbating, or mitigating drought vulnerabilities and impacts. Some activities have been basin-specific, dependent on the overarching regulatory framework governing hydropower projects, stakeholder makeup, the nature of competing water demands, and types of opportunities available to address drought issues. For example, in the Catawba-Wateree and Yadkin-Pee Dee basins, the FERC relicensing provided a significant opportunity for a wide range of stakeholders to shape and develop the next generation of operation plans and practices. With licenses scheduled to expire in 2008, all three licensees (Duke Energy in the Catawba-Wateree and Alcoa Power Generating Inc. (APGI) and Progress Energy in the Yadkin-Pee Dee) initiated relicensing processes in 2003. In the basins with U.S. Army Corps of Engineers projects, the droughts prompted actions to adjust operational plans and water shortage responses. Two overarching strategies emerged during these processes. Strategy 6 focuses on improving communications and modifying hydropower operations during drought. Strategy 7 is unique to the Catawba-Wateree basin, where stakeholders developed and implemented coordinated efforts to respond to drought.

2.6.3.4.1 Adaptation 6: Address impacts of hydropower operations on water availability

In basins managed by the Army Corps of Engineers (USACE), efforts have centered on updating drought response protocols and implementing procedures to share information and discuss management actions with stakeholders. Some of these efforts emerged as drought conditions worsened during the 1998-2002 event. For example, in the Wilmington (NC) Water Management District, a stakeholder group was launched in 2002 to address dam operations and drought impacts. The USACE-Wilmington Water Management District initiated regular conference calls and meetings that continued throughout the study period. In addition, NC Division of Water Resources (DWR) and local stakeholders worked with the Wilmington District to revise drought plans for dam operations. In the Savannah River basin, USACE water managers have also worked to enhance basin-level communications through conference calls and meetings to update stakeholders on conditions and consultations with state resource agencies and water users to inform decisions about dam releases and management. Water resources in the Savannah Basin were hit particularly hard by the 2007-2008 drought, and emergency measures were necessary in 2008 to conserve dwindling supplies. South Carolina agency officials negotiated with their Georgia counterparts and the Army Corps of Engineers to reduce flows beyond minimum releases as specified in the Savannah River reservoirs' Drought Contingency Plan.

In the Yadkin-Pee Dee basin, an initial Drought Contingency Plan (YPD DCP) was developed, and a Drought Management Team (YPD DMT) was established, during the emergency conditions of 2002. The YPD DMT consisted of APGI, Progress Energy, NC Department of Environment and Natural Resources (NC DENR), SC Department of Natural Resources (SC DNR), SC Department of Health and Environmental Control (SC DHEC), United States Fish and Wildlife Service (USFWS), Duke Power, and High Rock Lake Association. Minor modifications were made to the YPD DCP in 2003 and 2004. The YPD DCP guided APGI's and Progress Energy's actions during drought, requiring that APGI notify and convene the YPD DMT when conditions warrant, coordinate with Progress Energy to conserve storage and balance lake elevations while meeting needs of reservoir and downstream users, and consult with stakeholders to discuss drought conditions. The YPD DCP also required that APGI file variance requests to FERC when modifying dam operations and submit monthly updates regarding drought conditions and management actions. Both APGI and Progress Energy included a Yadkin-Pee Dee Low Inflow Protocol (YPD LIP) in their FERC license applications in 2006. In comparison to the YPD DCP, the YPD LIP provides more specific details regarding drought triggers and required response actions and establishes a Drought Management Advisory Group (YPD DMAG), expanding the membership of the original YPD DMT. New members included the North Carolina Wildlife Resources Commission, Badin Lake Association, a Lake Tillery homeowners' representative, the South Carolina Pee Dee River Coalition, and owners of water intakes that withdraw from a project reservoir. During the 2007-2008 drought APGI and Progress Energy continued to employ the YPD DCP and work through the YPD DMT to share information about drought conditions and response. They did not use the YPD LIP as approval of their FERC license applications was pending at the time.

2.6.3.4.2 Adaptation 7: Coordinate drought response and mitigation

In the Catawba-Wateree, a collective mindset evolved throughout the study period, as Duke Energy, state and federal agencies, and local stakeholders worked together to address drought impacts and vulnerabilities in the basin. In contrast to the crisis conditions experienced in the Yadkin-Pee Dee, the Catawba-Wateree basin did not suffer major impacts during the 1998-2002 drought. Duke Energy recognized in 1999-2000 that dry conditions might extend into a longer-term drought due to La Niña conditions. As the primary manager of the basin's water resources, Duke Energy started to operate conservatively in order to maintain reservoir water levels. However, they acted independently and did not communicate with local water utilities and other water users until the summer of 2002, when worsening conditions suggested that some intakes in the basin were at risk of losing access to water if the drought continued into 2003. According to interviews, many of the stakeholders in the basin did not realize the severity of the drought, and vulnerability of their water resources, until Duke Energy began to approach them in 2002. With reservoirs kept artificially high by Duke Energy's operations, most users had not been adversely affected in the short-term. They were also unaccustomed to looking beyond their individual lakes to longer-term, basin-wide risks. While higher-than-normal precipitation in 2003 alleviated immediate drought concerns, improving drought response at the basin level was one of the key objectives of Duke Energy's FERC relicensing process.

During the relicensing process, which took place between 2003 and 2006, stakeholders worked together to develop the Catawba-Wateree Low Inflow Protocol (CW LIP). The stakeholder-developed trigger points specify when certain management actions are required and establish procedures for stakeholder communications and public notification. The CW LIP established the Catawba-Wateree Drought Management Advisory Group (CW DMAG) which consists of the licensee (Duke Energy), state and federal agency representatives, and water systems and industrial users that withdraw water from the FERC project boundaries. In 2007, Duke Energy implemented the CW LIP and convened the CW DMAG to help monitor conditions and share information with the member organizations and across the basin. Most importantly, in following the CW LIP, Duke Energy and local water utilities jointly implemented water use restrictions. For some communities, this was the first time they had ever required customers to reduce their water use. While this new approach to drought management did contribute to tensions in some individual communities (e.g., water managers did not always have the immediate support of local government), overall the basin-level approach to drought management was supported by a new risk-sharing perspective (i.e., that the risks and impacts of drought should be distributed fairly and equitably across water users).

2.6.3.5 Summary

At the beginning of the study period, individual water systems conducted drought planning and response, centered on engineering and infrastructure tools to secure supply and avoid impacts on water customers. There was limited engagement with other entities, minimal involvement by state- or federal agencies in drought management, and weak formal mechanisms to guide drought response. The case study history and findings demonstrate several shifts in drought management, represented by the distinct strategies and adaptations discussed above. Furthermore, the case study findings also indicate how the implementation of new strategies occurred only when all three institutional components (normative, cultural-cognitive, and normative) were in place (Nelson et al. 2007; Tompkins and Adger, 2005).

The different strategies evolved as water managers developed new tools to prepare, respond, and cope with drought. According to interviewees, the adoption of new strategies was partly attributable to recent drought events and how drought contributed to changing perceptions of water management, new attitudes about water use, and reevaluation of the underlying assumptions and norms that underpin drought management policies at multiple scales. Shifts in water- and drought management would not be possible without institutional change, specifically the concomitant changes that occurred across the mutually reinforcing institutional components and which underlie each strategy.

For example, for those interviewees who suggested that they were reconsidering the "business of water," changes indicate more than an adjustment to existing management practices. Adoption of a demand-side strategy also required that water managers and planners re-evaluate how they interact with customers, via new pricing policies or awareness campaigns, with the goal of altering well-established behaviors and attitudes regarding the consumption and value of water.

The adoption of the drought response planning strategy required multiple forms of institutional change including the development of new plans and rules, use of new information and expertise to augment management efforts, and establishment of new organizations and organizational arrangements to monitor and communicate drought conditions. Underpinning the increasing formalization of drought response was a set of evolving, and more “informal” rules, i.e., that water use should be curtailed rather than increased or encouraged during dry periods.

Another fundamental shift entailed the expansion of the drought decision making arena. This change is represented by the state involvement in drought response and planning activities and collective efforts to address basin-level risks and impacts. The implementation of basin-level efforts, in particular, required that previously independent and disconnected water users accept and embrace new institutional structures and processes that promote stakeholder involvement, information sharing, and collaboration. As the decision-making arena has expanded to include dam operators, state and federal agencies, local water systems and actors, a combination of basin- and local-level knowledge and expertise has been integrated into drought management. While the development of drought triggers and management responses required engineering and hydrological expertise, basin-level activities and communications facilitated the inclusion of local knowledge and experiences into drought response and supported ongoing cooperation among diverse water users.

These findings suggest that the adoption of new drought management strategies will require a variety of supporting changes (i.e., to the institutional components) and “buy-in” at different management levels. The case study shows evidence of the different types of change that occurred, not only in terms of the four management strategies, but also in terms of the extent to which specific actions are implemented by different decision makers and stakeholders. This has implications for adaptation processes, and resilience, as it suggests that decision makers may not perceive a need to adapt or reconsider new strategies, if their experiences with drought are adequately addressed by their existing approach (Berkhout, 2012; Huntjens et al., 2011). The following section discusses how the different management strategies and adaptations are contributing to drought resilience within and across multiple levels of drought and water resources management.

2.7 Discussion: A Drought Resilient Carolinas

On the surface, the shifts in drought management in the Carolinas indicate the characteristics of social-ecological resilience. There is evidence of change, not only in terms of specific tools used to respond to and mitigate drought but also in terms of the way water managers and planners have broadened their conceptions of drought risks and solutions. Due to the necessity of assuring capacity to cope with extreme droughts, water managers and agencies at multiple scales have demonstrated capacity to learn and adapt, taking measures to ensure that water systems, water users, and communities can withstand drought stresses and continue to perform their core functions and responsibilities (Walker and Salt, 2012). At the same time, there has been considerable diversity in terms of the strategies and specific adaptations adopted. While the drought management landscape has expanded and shifted, suggesting that the capacity to cope with drought has increased, there has been minimal interrogation of how these newly adopted actions contribute to long-term resilience.

Local-level interviewees, in particular, articulated a variety of intents and purposes of adaptations. Some actions were intended to mitigate or prevent a localized or specific risk or impact, for example those taken by water systems to relocate water intakes in order to improve access to water supply. Other adaptations involved modifying broader-scale practices (e.g., through water conservation programs) and processes (e.g., through the building of social networks and relationships). The implication is that a range of capacities and types of resilience exist across the landscape. Table 2.5 shows the types of drought response and adaptation actions, organized by drought management strategy, as reported by local-level interviewees.

In practice, many of the efforts at the local level aimed to build specific resilience and address the specific risks associated with drought. The focus was on ensuring that the water system would not reach the point, or threshold, that would create adverse effects on their ability to provide water to customers. The majority of respondents indicated that their system or community had taken action to secure or augment their water supply (e.g., through infrastructure projects or other measures to enable their system to manage through a drought of record). About half of the respondents indicated adopting customer-oriented measures. While these measures expanded the "toolbox" used by water managers to balance supply and demand, they represent adjustments made within the overall context of managing for stability and efficiency.

Individual locales exhibited diversity in terms of the particulars of how, and why, they adopted and implemented supply and demand strategies and specific tools. New tools and strategies were not uniformly adopted. This was, in part, due to how local factors (e.g., location in a watershed, system size, community demographics, predominant water uses) and existing capacities and resources interacted with drought and other stressors. The characteristics of place and context mattered in determining system- and community-specific thresholds (Carlisle, 2014; Moser and Ekstrom, 2010). In fact, for many water systems, existing strategies and tools to secure supply were adequate, even during severe drought conditions. For those systems, adaptations fell within the most familiar repertoire of management tools, focusing on supply-oriented solutions (Berkhout, 2012). Other water utility and community representatives reported that drought provided an opportunity to respond to a combination of pressures affecting their ability to manage water supplies efficiently. Drought alone did not move water systems closer to their thresholds and coping capacity limits. Rather, it was a combination of drought overlaid across broad-scale and context-specific factors including rising (financial, environmental) costs of constructing new reservoirs and investing in new infrastructure, increasingly stringent water quality requirements, and growing populations and demands on water resources.

While many actions on the local level continued to be framed in terms of specific resilience, that is managing for supply and demand and treating drought as a short-term water shortage, other adaptation efforts have contributed to general resilience. In this case study, general resilience has been addressed through the broader-scale changes to drought response, including improvements to drought monitoring and communications that have occurred across management levels. Signs of general resilience relate to the set of resources conditions that characterize a system and that system's ability to implement a variety of potential options. Measures or changes that enhance general resilience include shifts in how actors define problems; diversification of strategies and tools used to solve problems; changes in legal frameworks; building of social networks, relationships, and cooperation; and flexibility and openness to learning and new opportunities.

On the local level this capacity has evolved over time and manifested in the implementation of specific practices and participation in state and regional processes. For example, while only sixteen (of forty-nine) water system representatives reported developing drought response plans as a specific drought adaptation measure in their interviews, almost all (forty-two) reported that their community did implement water restrictions in 2007-08. The implementation of restrictions was the result of a variety of factors, including meeting drought plan triggers, acknowledging the severity of statewide conditions, and/or state-level declarations and pressures for local water systems to show water conservation efforts. State-level efforts to build drought response capacity not only contributed to a more structured response on the state level but also fostered an environment that enabled the implementation of local action (i.e., water use restrictions).

However, although both states provided a structured, legal framework for drought response, the overall focus of state-level capacity building was on technical and managerial approaches to drought management. As a result, tensions between the increasing formalization on the state level and local desires to retain decision making flexibility on drought issues emerged during the 2007-2008 drought. These tensions demonstrate the potential institutional challenges for building drought resilience and capacity across multiple scales and are examined more closely in Chapter 3.

Almost half of the local-level study participants reported that they participated in a FERC relicensing process or other basin-scale efforts (e.g., with the USACE) after the 1998-2002 drought to address impacts and improve basin-level drought management. Through these processes, stakeholders established mechanisms for communications and cooperation; reformulated the drought problem (drought as a shared risk); and created joint solutions, organizations, and procedures to balance multiple and often competing interests. However, there is a substantial difference in the nature and extent of involvement in those processes in 2007-2008, suggesting that different aspects of resilience were addressed in the different processes and basins. For example, changes made in the YPD and USACE generally entailed modifications to hydro project operating protocols and the establishment of new communication practices to ensure that all stakeholders and the public received information pertinent to drought monitoring and condition status. Similar formal changes were made in the Catawba-Wateree, but the implementation of coordinated drought monitoring, declarations, and response actions contributed to the evolution of a decision making arena in which all drought decision makers are engaged. These changes highlight the importance of "institutionalization" in integrating new practices and approaches into drought management, namely basin-level collective action that facilitates multi-scalar response and planning. The differences between the YPD and CW basins are addressed in Chapter 4.

While steps to build specific resilience can be ascertained through an examination of individual actions focused on identifying thresholds and mitigating risks, general resilience is difficult to measure. First, general resilience is a latent property, in that it may not be activated until it is needed to address specific, or emerging, problems. Second, the building of general resilience may require longer timeframes and processes that entail the adoption of different beliefs and values, gradual shifts in behaviors, and questioning of the status quo and existing relationships, changes that might also contribute to transformational change.

In this case study, two of the new drought management strategies demonstrate some of these prerequisites and potential opportunities for transformative change. These strategies include the coordination of drought response in the Catawba-Wateree and efforts to reduce overall water demand. However, expanding these strategies across a broader area will be difficult. The Catawba-Wateree is one basin of many across the

Carolinas, and only two communities have recognized the need to reduce water demand as an integral part of their broader planning efforts. In this study, the water systems that adopted these new strategies indicated 1) awareness and knowledge that their systems were approaching thresholds at which "business as usual" operations would not be sustainable in the long-term and 2) the existence of local and/or basin-level political, social, and institutional capacity that enabled new management practices. Although many measures taken in the Carolinas could be considered proactive and have helped to build adaptive capacity across the two states, existing institutional structures continue to frame drought planning, particularly at the local level, in terms of specific, or "engineering," resilience. There are many barriers and disincentives to altering existing strategies, one of which is that without fundamental changes to norms and values, certain types of adaptations are not feasible, if considered at all (Kallis, 2008; Moser and Ekstrom, 2010). As discussed above, adoption of new strategies require that the core, and mutually reinforcing, institutional components are in place (Scott, 2008). Beyond that, decision makers need to have knowledge of system thresholds at multiple scales and be open to new and innovative options (Walker and Salt, 2012).

2.8 Conclusion

The purpose of this chapter was to identify the new strategies adopted in the Carolinas to improve capacity to cope with drought, examine how the institutional framework shapes and evolved to accommodate drought adaptation options, and investigate how drought adaptations and new strategies contribute to resilience. The case study indicates that major shifts in drought management have occurred and that institutional change was necessary to support these shifts. At the beginning of the study period there were weak, if any, formal institutional mechanisms to respond to drought in the Carolinas. Water users acted independently, and no formal structures and processes existed to promote interactions, communication, or coordination across water users and agencies. During the study period (1998-2008), measures at state, basin, and local scales were enacted to improve drought monitoring, communications, and response, thereby contributing to and advancing the region's capacity to cope with drought. However, the primary responsibility for drought planning remained on the local level. Local activities were diverse, shaped by the water system-specific context, capacities, and thresholds, but still centered on supply-oriented measures to mitigate drought impacts.

The case study highlights how more purposeful attention to the meaning and practice of resilience could help inform ongoing efforts to fully build capacity to cope with current and future droughts. For example, while many water systems are well-adapted to system-specific risks, and have diversified the tools used to manage supply and demand, most measures focus on localized and short-term problems. However, building capacity to address longer-term and broader water resources challenges will require that incentives and support for transformational change exist at a variety of management levels. Local water systems and communities possess varying capacities to cope with and adapt to the complex social and environmental processes that interact to produce drought risks and vulnerabilities. The examples of transformation "successes" suggest that future policy and planning efforts at state and basin levels should be more attentive to the particular sets of institutional structures and processes are required to support different drought management strategies. By only focusing on specific threats and managing for stability, water systems may be less resilient in the long-term if they are not also developing the capacity and flexibility to adapt to emerging challenges and changing conditions (Adger et al., 2011; Dovers and Hezri, 2010; Folke et al., 2010). Future efforts should look for and take advantage of opportunities to develop the institutional mechanisms that will foster the integration of resilience into the multiple scales of water operations, management, and planning (Carlisle, 2014; Moser and Ekstrom, 2010; Young, 2010).

2.9 Tables

Table 2.1 Supply management strategies

Level and overall objective of adaptations Actions taken by local water systems and/or communities to secure water supply	
Adaptation	**Secure supply - the "baseline" approach**
Key Action(s)	Upgrade existing infrastructure: expand pumping capacity, distribution systems, storage capacity; lower or move intakes
Institutional Components	Normative Drought risks and impacts to water customers should be avoided
	Cultural-Cognitive Beliefs: "Water is plentiful." "Everyone thought that the Carolinas were so well-watered that we would never have that [drought] problem." Knowledge: technical, engineering, local knowledge about the water supply system, historical hydrological and climatological conditions
	Regulative Capital plans, reservoir safe yield analyses, operating protocols
Adaptation	**Diversify tools to develop and secure new supplies**
Key Action(s)	Develop new supplies: aquifer storage and recovery (ASR), reclaimed water, interbasin transfers (IBTs) Purchase from other systems; sell or merge systems Improve water system efficiency (treatment processes; leak reduction)
Institutional Components	Normative Water system operations should strive to be as efficient as possible in managing supplies
	Cultural-Cognitive Beliefs: Plenty of water exists to meet needs, but new tools can help to better manage, access, and distribute supplies Knowledge: Continued emphasis on technical and engineering expertise, knowledge of the local water system and the available legal, administrative, and managerial tools
	Regulative Interbasin transfer permits, purchase contracts and other agreements among local systems New practices may require development of new, or revision of existing, state-level rules and oversight (e.g., for aquifer storage and recovery, reclaimed water systems, interbasin transfers)

Table 2.2 Customer and demand management strategies

Level and overall objective of adaptations Actions taken by local water systems and/or communities to increase options for balancing supply and demand	
Adaptation	**Rethink the "business of water"**
Key Action(s)	Programs that target water customers, improve customer efficiency and conservation; upgrades to water metering systems, water rate structure changes (increases, surcharges, fees), public education and awareness campaigns
Institutional Components	<u>Normative</u> Customers should contribute to the cost of water service and delivery
	<u>Cultural-Cognitive</u> Beliefs: Demand-side programs can augment systems' overall water management Knowledge: Combination of technical and managerial tools, knowledge of the water system and customer base
	<u>Regulative</u> Water pricing policies and protocols
Adaptation	**Reduce overall demand**
Key Action(s)	Adoption of long-term policies, plans, and education programs to reduce demand and water use; integration of water planning with other sectors (land use, economic development)
Institutional Components	<u>Normative</u> Fundamental changes to how society develops and consumes water are needed to cope with limited supplies; all sectors of a community need to contribute to water conservation
	<u>Cultural-Cognitive</u> Beliefs: Water resources are not infinite, capacity to build new supplies is limited Knowledge: Combination of technical and managerial tools and knowledge of the water system and customer base, in coordination with land use planning and development interests
	<u>Regulative</u> Local government incentives and mandates (e.g., water use and efficiency ordinances) to reduce consumption, change customer water use behaviors and attitudes

Table 2.3 Drought response planning strategies

Level and overall objective of adaptations Actions taken by state and local agencies to develop a more structured approach to drought response	
Adaptation	**Improve drought response capacity**
Key Action(s)	Local level: response plans and ordinances, public awareness and communications State level: response plans; drought monitoring, data collection; organizational structures and processes to assess, communicate, and disseminate drought information (NC Drought Advisory Council, SC Drought Response Committee) ; providing technical assistance and guidance to local level
Institutional Components	<u>Normative</u> A structured approach to drought monitoring and response can help communities and water-dependent sectors balance supply and demand during drought
	<u>Cultural-Cognitive</u> Beliefs: The Southeast can have water shortages; the region is not immune to drought risks and impacts Knowledge: hydrological and climatological expertise used to develop drought triggers and monitoring tools; knowledge and expertise related to water resources and management used to inform state and local response actions;
	<u>Regulative</u> Local drought- and water shortage response plans and ordinances; protocols for decision-making, water use restrictions, and enforcement State laws, plans, and requirements: NC Session Law 2008-143; Drought Assessment and Response Plan, NC Emergency Operations Plan (2005); SC Drought Response Act and Regulations (1985, 2000)

Table 2.4 Basin-level cooperation strategies

Level and overall objective of adaptations Actions taken by multiple actors, across management levels, to work together to address drought risks and impacts	
Adaptation	**Address impacts of hydropower operations on water availability**
Key Action(s)	Modifications of existing and adoption of new protocols for hydropower operations during drought; development of regional and basin-level organizations and stakeholder groups; communication networks
Institutional Components	Normative Drought risks and impacts should be distributed fairly across water users
	Cultural-Cognitive Beliefs: Dam operations should balance maintenance of water supplies while ensuring adequate downstream flows during drought Knowledge: Engineering, technical, hydrological expertise; basin-scale data and information; knowledge of all water users' needs and interests
	Regulative Drought plans and protocols for dam operations
Adaptation	**Coordinate drought response and mitigation (Catawba-Wateree basin)**
Key Action(s)	Adoption of new response plans and protocols across the basin (e.g., CW Low Inflow Protocol, 2007); basin-level drought management group (CW DMAG) makes basin-wide drought designations and disseminates information; coordinated implementation of drought response plans of CW DMAG members
Institutional Components	Normative Drought risks and impacts should be addressed collectively, rather than on an individual or local basis
	Cultural-Cognitive Beliefs: Water users are interdependent, risks should be shared Knowledge: Engineering, technical, hydrological expertise; view of water resources as shared reinforced through group decision making processes and engagement with regional resource management issues
	Regulative CW Low Inflow Protocol (LIP), local drought and water shortage response plans that permit adherence to the CW LIP and CW DMAG decisions

Table 2.5 Drought responses and adaptations, as reported by local-level interviewees

Drought management strategies (n=49, representatives of water systems and/or local governments)	# of reports
Supply Management	
Secure supply - the “baseline” approach	36
Diversify tools to develop and secure new supplies	37
Customer and Demand Management	
Rethink the “business of water”	24
Reduce overall water demand	2
Improve Drought Response Capacity	
Updated or developed drought response plan	16
Implemented conservation during the 2007-08 drought	42
Basin-level cooperation	
Addressed impacts of hydropower operations on water availability • Participated in FERC relicensing after the 1998-2002 drought, work with dam licensees and other stakeholders to address impacts of hydro operations on water supply	23
Participated in basin-level activities during the 2007-2008 drought	
• Conference calls, information-sharing (in YPD and U.S. Army Corps of Engineers basins)	5
• Coordination of communications and water restrictions in the Catawba-Wateree basin (of 17 total interviewees in the CW)	13

CHAPTER 3

DROUGHT PLANNING IN THE CAROLINAS: INSTITUTIONAL INTERACTIONS AND CONSTRAINTS

3.1 Abstract

The development of drought plans and programs at multiple levels of water management and decision making are an important component of a proactive, risk management approach to this natural hazard. While plans have been adopted by most states and many communities across the country, the extent to which plans have been implemented or coordinate with one another is unclear. This chapter draws from a case study of drought response and management in North Carolina and South Carolina to investigate how institutional interactions affect the implementation and coordination of drought planning efforts across state and local levels. Data collection for this study occurred in 2007-2008, a period of exceptional drought and a time when state and local agencies across the two states adopted, revised, and/or implemented drought response plans and protocols. Sources of information included eight-seven interviews with water managers and other stakeholders involved with drought response, observation of fifty-nine drought management meetings, and review of state and local drought response plans and other drought program documents. Findings indicated that a range of barriers to the local-level implementation of drought response plans exists. These barriers include conflicts between the goals of water supply provision and water restrictions, disconnects between the types of information used by state and local agencies to determine drought,

and different perceptions about the appropriate and legitimate levels at which drought decisions should be made. In addition, broader-scale institutions that govern water allocation and influence water use practices also served to limit the extent to which communities and water systems could enact proactive measures to manage drought risks and impacts. This study demonstrates how drought policy and planning efforts need to account for the set of complex institutional mechanisms and processes that both enable, and constrain, the implementation and coordination of drought response at multiple levels of water management.

3.2 Introduction

Drought is a natural hazard to which many sectors of society have adapted. However, since the late 1990s, many regions of the United States have experienced events that "have been rather dramatic in terms of duration, intensity, and spatial extent" (Wilhite, 2011, p. 8), revealing the significant impacts that drought can have on society and the environment. The total estimated costs of drought from 1998 to 2012 equaled $83.5 billion; the total estimated costs in 2012 alone equaled $30 billion (Smith et al., 2015). These impacts also evoke the difficulties this hazard presents to society's ability to prepare and respond effectively. First, drought can be difficult to monitor and measure as its effects are gradual and cumulative, often span broad geographic areas, and exhibit different regional manifestations (Redmond, 2002; Wilhite, 2005). Second, different regions, sectors, and organizations will possess varying resources, capacities, and abilities to adapt effectively.

In order to improve society's capacity to respond to drought events, drought planning proponents have long argued for proactive, risk management policies (Hayes et al., 2004; Wilhite et al., 2000). Key components of a risk management approach include the development and implementation of early warning and monitoring systems, preparedness and response plans, and mitigation programs intended to prevent impacts from occurring (Fu, Tang et al., 2013; Wilhite, 2011). It is also advocated that drought policies, programs, and plans be coordinated at multiple levels (NIDIS, 2012; Schwab, 2013; Wilhite, 2011). Drought response and planning is complicated by the fact that multiple federal, state, and local agencies with water management responsibilities make drought-related decisions in an environment characterized by conflicting laws, objectives, and obligations (Folger et al., 2012). The fragmented context of water planning constrains interagency actions and consequently limits the options available for addressing drought's effects on water resources. The lack of coordination between the state and local agencies is of particular concern, as much of the direct responsibility for regulating water supplies and use (and conducting drought planning and management) is located at these levels. However, research in this area is limited and there are only a few studies that have investigated the intersections between state and local efforts to conduct drought planning and management activities.

In general, previous work has found tensions between state and local efforts, suggesting that more attention needs to be devoted to the development of processes and mechanisms that would facilitate coordination (Engle, 2013; Pirie et al., 2004). In addition, state-level processes should be sensitive in recognizing that tools and methods developed and used at a higher level may not be applicable in different contexts and sectors (Durley and De Loë, 2005; Fontaine et al., 2014; Jacobs et al., 2005). Improved understanding of the interplay between drought planning and management at multiple levels is necessary to help build both state and local capacities to prepare for drought (Engle, 2013; Urwin and Jordan, 2008; Young, 2002).

To address this gap, this chapter uses a case study of drought planning and response in North Carolina and South Carolina to investigate how the institutional context has affected the implementation and coordination of drought response measures. Understood as the rules, practices, beliefs, and values that govern individual and collective behavior, institutions play a key role in drought planning by shaping decisions regarding resource allocation and preferred risk management goals and strategies. The institutional context also influences who participates in management and policy processes, the extent to which actors have flexibility to adopt new practices, and the extent to which policies and activities at different levels are compatible and/or complementary (Adger et al., 2009; Bakker, 1999; Eakin et al., 2014; Gupta et al., 2010; O'Riordan and Jordan, 1999; Urwin and Jordan, 2008). Furthermore, whether a specific option is considered feasible and legitimate, and ultimately put into action, may depend on whether the "appropriate institutional framework" is in place (Moser and Ekstrom, 2010; Nelson et al. 2007, p. 402).

The study focuses on the 1998-2008 period when the Carolinas experienced two extreme droughts (1998-2002, 2007-2008). During this time many state and local efforts to improve drought preparedness and response were initiated, including the development of drought response plans. In 2007-2008, drought response plans and other measures developed during and after the 1998-2002 drought were enacted, revealing many ways in which capacity to respond to drought had improved. In many communities, however, the actual employment of plans on the local level was challenging and frequently contested.

Implementation was difficult despite the considerable public and media attention paid to the severity of 2007-2008 drought conditions and widespread calls for water conservation.

To uncover the barriers faced by local decision makers in implementing response plans, this chapter examines the institutional dimensions of the drought planning and adaptation process. It investigates why the implementation and coordination of drought plans (and related measures) was so challenging, given the substantial efforts to improve the overall capacity to manage drought. The aim is to examine the following questions:

1. How does the institutional context affect the implementation of local drought response plans?
2. How does the institutional context affect the coordination of state and local drought planning and management measures?

Through this case study, the author provides an in-depth examination of how the institutional context, and institutional interactions, affects drought planning and management decisions, and thereby constrains (or enables) overall capacity to manage drought and the integration of state and local activities. The next section provides an overview of drought planning literature. This is followed by a review of institutional research, its application to drought management, and the research methods. The findings section is divided into three parts. Section 3.6.1 provides an overview of the Carolinas' drought experiences and adaptations taken to improve drought response and management. Section 3.6.2 focuses on the tensions between state and local drought response that challenge the implementation of plans at the local level. Section 3.6.3 discusses the broader disconnects across levels that constrain drought response and planning. The chapter then discusses the implications for drought and water management, highlighting the barriers to, and potential opportunities to improve, cross-level coordination of drought response.

3.3 Drought Planning and Management: Theory and Practice

All climate regions are susceptible to drought, although impacts may vary according to social, economic, and environmental contexts (Wilhite, 2011). In order to address the extensive and severe nature of drought impacts experienced across the world, drought management and planning research has used analysis from planning, risk analysis, and hazard management scholarship to develop, and help apply, best practices for drought response and mitigation. While the hazard mitigation and planning literature provides many useful insights about the characteristics of effective and high-quality plans (see for example, Berke and French, 1994; Burby, 2003), this review draws from research that has focused specifically on drought plans and planning processes. The overall objective is to move from a reactive, short-term, crisis-oriented approach, that focuses on alleviating impacts during drought and providing financial assistance after drought (and what often occurs in practice), to a proactive risk management approach that centers on longer-term mitigation and preparedness efforts (Wilhite, 2011; Wilhite et al., 2000).

There are several components to a risk management approach. First, drought response plans are necessary to establish management objectives, provide a structure for drought monitoring and response actions, and ensure timely and appropriate actions when drought occurs (Fu, Tang et al., 2013; Hayes et al., 2004; Wilhite et al., 2000). Ideally, plans should be developed by governments at all levels (local, state, national, and tribal) through a process that involves the public and pertinent stakeholders in assessing the risks, vulnerabilities, and adverse impacts associated with drought (Wilhite et al., 2000). Response plans themselves should articulate roles and responsibilities for water agencies and water users; detail what data and information is used to make drought declarations; establish clearly defined actions (e.g., water use reductions or conservation) that correspond to drought levels; delineate how information will be communicated among and to water managers, water users and stakeholders, and the public; and include procedures for updating the plan (Durley and de Loë, 2005; Durley et al., 2003; Engle, 2012; Fontaine et al., 2014; Ivey et al., 2004; Jacobs et al., 2005; Shepherd, 1998).

Second, a risk management approach also includes longer-term mitigation plans and programs with the intent to reduce drought risks, vulnerabilities, and potential impacts and build capacity to manage drought before an event occurs (Shepherd, 1998; Wilhite, 2011). Activities include developing drought observation and monitoring networks, enhancing communication and coordination mechanisms, and conducting post-drought assessments of impacts and the effectiveness of mitigation and response actions (Fontaine et al., 2014; Wilhite et al., 2000). In addition, incorporating drought risk analysis and planning into broader-scale management processes, e.g., multi-hazards planning, water management, and community sustainability planning, is a recommended component of a comprehensive strategy to reduce drought risks (Hayes et al., 2004).

While the components of a risk management approach have been put forth in the literature, in practice considerable diversity exists within and across management levels, in terms of the resources allocated to drought programs and the extent to which different types of activities are supported (Fontaine et al., 2014; Fu, Tang et al., 2013; NDMC, 2015b; Wilhite, 2011). Plans and programs generally reflect three approaches to drought management: 1) provision of post-drought relief following an emergency, 2) short-term, operational response plans that detail drought indicators, triggers, and response actions during a drought, and 3) longer-term mitigation programs intended to reduce drought vulnerabilities (Fontaine et al., 2014; Fu, Svoboda et al., 2013; NDMC, 2015b). Although recent studies indicate the growing adoption of drought plans, findings also suggest that many programs still emphasize relief and response, i.e., they react to drought events by implementing action only when drought emerges, and allocate more resources to response rather than to pre-drought mitigation or post-drought assessments (Fontaine et al., 2014; Fu, Tang, et al., 2013; Wilhite, 2011).

It is difficult to know with certainty the extent to which response plans have been implemented. While most states have drought plans or programs, few have conducted post-drought assessments or provide progress reports about when or how plans are evaluated or revised (Fontaine et al., 2014; Fu, Svoboda et al., 2013; Wilhite, 2011). In a survey of drought programs in the western United States, Steinemann (2014, p. 844) found that "most plans were not regularly used, tested, or revised." Rather, drought response officials used plans as guidance documents, to document the resources and responsibilities of different agencies and general instructions to follow when drought conditions emerge (Fontaine et al., 2014). Drought planning is conducted inconsistently on the local level, where mandates, as well as financial or political incentives, to plan generally do not exist. While some local governments create stand-alone drought plans, others incorporate drought into hazard mitigation plans (which are mainly prepared for emergency response) or into water resource or comprehensive land use plans (Fu, Tang et al., 2013).

Variations in drought response and planning are partly attributable to the different risks, i.e., exposure to the drought hazard and vulnerability of society to drought events, faced by different regions (Hayes et al., 2004, citing Wilhite, 1997; Wilhite et al., 2007). However, the institutional context also plays a significant role in the diverse approaches across regional, state, and local levels. The drought planning arena is characterized by the lack of a national drought policy and fragmented responsibilities for addressing drought risks (Folger et al., 2012; Fu, Tang et al., 2013). Federal agencies have important responsibilities for collecting and disseminating information, drought monitoring, providing emergency assistance to impacted sectors, funding and facilitating coordination efforts (e.g., NDMC, NIDIS), and managing water projects (e.g., Bureau of Reclamation, Army Corps of Engineers). However, state and local governments have a clearer role in drought planning due to their authority to regulate and manage water allocations and water use (Schwab, 2013; Folger et al., 2012; Fu, Tang, et al., 2013; Grigg, 2014).

Both the academic and policy communities continue to call for plans and programs that are coordinated across levels of government, and with the private sector, in order to ensure that vulnerabilities and impacts are addressed in an effective and comprehensive manner (NIDIS, 2012; Shepherd, 1998; Wilhite, 2011). As discussed above, this can be difficult to accomplish in practice. To a large extent the landscape remains a "patchwork of drought programs" with limited consistency or coordination within and across levels of government (Folger et al., 2012, p. 2; Fu, Svoboda, et al., 2013; Steinemann, 2014). While national- (e.g., NIDIS, National Drought Resilience Partnership) and regional- (e.g., Western Governors' Association, NIDIS Regional Drought Early Warning System programs) level initiatives to improve coordination across agencies and jurisdictions receive resources and attention, the severity of recent droughts and associated impacts suggest that the mechanisms and processes to coordinate with local-level response and mitigation efforts need improvement.

The above discussion illustrates some of the ongoing concerns about the current state of drought planning activities, namely that despite the adoption of plans and development of new programs, response continues to be reactive and uncoordinated. Some observers contend that improved institutional capacity is needed to support more effective and proactive drought planning and preparedness (Wilhite, 2005, 2011). However, very few studies have explicitly examined how institutions, or improved institutional capacity, might support drought response and planning activities. Those studies that have tended to emphasize the formal dimensions of institutions, e.g., the rules, agency responsibilities, and organizational arrangements associated with drought planning (Fontaine et al., 2014; Fu and Tang, 2013; Fu, Svoboda, et al., 2013; Wilhite, 2011). In contrast, many efforts to examine climate change adaptation processes use a broader conception of institutions and institutional capacity (e.g., O'Riordan and Jordan, 1999; Young, 2002). For example, Moser and Ekstrom (2010, p. 22029) argue that the capacity of actors and organizations to implement new strategies and tools is influenced by the institutional context, "in part through its impact on the actor's perception, freedom, and capacity to do so, in part through its impact on available resources, authorization, permits, political climate, or social norms...." Gupta et al. (2010) also suggest that institutions promote adaptive capacity by enabling learning, providing flexibility, involving a variety of perspectives in decision making, and supporting fair and equitable governance processes. The next section outlines how a fuller characterization of the institutional environment can be used to better understand drought planning constraints and opportunities.

3.4 An Institutional Approach to Drought Planning and Management

Drawing from institutional theory, and research investigating the role of institutions in climate change adaptation processes, this section discusses how institutions affect the implementation of drought planning and management and support and/or constrain the coordination of drought planning efforts across state and local levels.

3.4.1 Overview

Institutions consist of the systems of rules, organizational arrangements, shared customs and values that shape individual and collective decisions and actions. Institutions may be formal (e.g., sanctioned and enforced laws, rights, constitutions, court decisions, administrative regulations, organizational arrangements) or informal (e.g., shared beliefs, routine practices, prevalent discourses, values and norms) (Young, 2002). Together, these components provide an "institutional logic," that is a coherent set of expectations for social behaviors and interactions (Thornton and Ocasio, 2008). Institutional logics also signify what actions are considered "legitimate," i.e., appropriate, acceptable, desirable, and consistent with existing rules, norms, and beliefs (Deephouse and Suchman, 2008).

While the traditional focus of much institutional research has been to understand how institutions structure decisions and actions, institutions are not static but undergo change as individuals and organizations ("actors") respond to new emerging conditions, problems, or crises (Seo and Creed, 2002). Institutional researchers are interested in how actors affect and change institutions, exposing a fundamental tension between structure and agency, i.e., how do actors modify the very structures that shape their decisions and behaviors (Lawrence and Suddaby, 2006; O'Riordan and Jordan, 1999; Seo and Creed, 2002).

One research area has focused on the manner and processes through which actors negotiate institutional complexity (Greenwood et al., 2011). Actors often face multiple institutional logics that pose contradictory demands regarding the goals or course of action to be followed (Greenwood et al,. 2011; Pache and Santos, 2010). One hypothesis is that it is through the process of navigating different logics that institutional change occurs. Actors respond to complexity using strategies that range from resistance and defiance to compromise, cooperation, and compliance. Which strategy is employed depends on a variety of factors, including and the extent to which different logics are compatible (or conflicting), are flexible (or prescriptive), or perform key organizational functions (Besharov and Smith, 2014; Greenwood et al., 2011; Oliver, 1991).

As actors face multiple and interacting logics, the extent to which the existing, and dominant, institution is meeting actors' needs or interests may also affect the type and extent of change. For example, the adoption of new rules, day-to-day practices, and organizational arrangements may be easier to negotiate than changes to overarching norms and values (Lawrence and Suddaby, 2006; Seo and Creed, 2002). Furthermore, actors will consider the perceived and real costs involved in creating novel, or modifying existing, institutions. These can be very tangible costs, i.e., efforts to mobilize and use resources, or social costs, i.e., a loss of legitimacy and support from constituents (Greenwood et al., 2011; Oliver, 1991).

3.4.2 Drought and institutions

Institutions shape society's capacity to cope with drought, and other climate risks, in many important ways. First, institutions affect many aspects of adaptive capacity, that is, the ability of a system to adapt or implement adaptations. Adaptive capacity includes factors such as the availability of and access to resources, information and technological infrastructure, governance structures, and social networks. Adaptive capacity is context-specific and varies across different locations, jurisdictions, and management levels (i.e., by country, community, social groups, and individuals). Local capacity is also dynamic, shaped by local factors as well as by conditions and processes occurring at higher scales (Eakin et al., 2014; Brooks et al., 2005; Smit and Wandel, 2006). Consequently, issues of scale (temporal, spatial, and organizational), linkages across scales, and the broader context are important to consider when analyzing adaptation processes and adaptive capacity (Brooks et al., 2005; Nelson et al., 2007; Vincent, 2007). Some research has highlighted where vertical linkages can help facilitate cooperation, coordination, and the capacity to address drought. For example, state-level guidance, financial or technical resources, and/or mandates have been shown to support local-level drought planning and capacity-building efforts (Pirie et al., 2004, Shepherd, 1998). However, in systems where institutions are diverse and not well-integrated, institutional interactions can create disconnects among levels and across different management regimes and can pose constraints to climate adaptation (Urwin and Jordan, 2008). Actions implemented or successful at one scale may impose externalities or adverse effects at other temporal or spatial scales (Eriksen et al., 2011). Empirical studies suggest that such disconnects across higher and lower scales can also hinder local-level capacity to adapt (Naess et al., 2005; Ivey et al., 2006) and affect the ability of existing institutions to support participatory or collaborative problem-solving.

Second, by providing the logics that guide decisions, institutions require or incentivize particular types of actions (Adger et al., 2005; Tompkins et al., 2010). Institutions support (or constrain) drought planning processes by influencing the overall perceptions of the drought hazard, decision makers' willingness to use innovative tools or novel approaches to address risks, and how drought fits into other organizational priorities (Ivey et al., 2004; Pirie et al., 2004; Rayner et al., 2005). Institutions govern who participates in decision-making processes and the types of information, expertise, and knowledge (e.g., local, scientific) used in those activities (Gupta et al., 2010). Institutions also support (or constrain) flexibility and adaptability, that is, the ability of a given system to experiment or make modifications as or when conditions change (Gupta et al., 2010).

There is no one overarching "institutional logic" that guides all drought decision making and activities. Rather, drought-related research exists in a variety of academic fields and practitioner literatures, related to and including climatology, hazards, hydrology, water resources, and political ecology. As a result, different discipline- and sector-specific understandings and framings of drought have co-evolved with particular institutional arrangements, or logics, that guide how drought planning and management is approached. These different logics are characterized by: different, and sometimes conflicting, underlying values; varying perceptions of drought risks and vulnerabilities; and diverse ideas about which management strategies and tools are appropriate and legitimate (Adger et al., 2009; Kallis, 2008; Medd and Chappells, 2007; Sonnett et al., 2006). Different framings also have implications for who is considered responsible (or not) for action, how potential responses are identified and assessed, what information or expertise is be used, and at what scale or level adaptive actions occur (Adger et al., 2011; Cockfield, 2013; Dewulf, 2013).

Several "drought logics" are evident in academic, practitioner, and policy literature. These logics are summarized in Table 3.1. Each logic is characterized by a predominant framing, set of goals and preferred means to achieve those goals, and which management levels, agencies, and types of expertise are responsible for planning and management.

The first logic focuses on drought as a natural hazard and climatic risk (Cockfield, 2013). Drought refers to a deficiency in precipitation or a departure from expected or normal rainfall conditions. Droughts are temporary, recurring phenomena and a natural part of climate variability. Planning and management goals center on reducing impacts and enhancing preparedness, and many of the related activities are technically-oriented, such as improving the collection of hydroclimatological data and developing monitoring systems. Other efforts involve communicating information about drought conditions and anticipated impacts to decision makers, affected sectors, and the public, and providing guidance and support for drought planning at the state and local levels (Hayes et al., 2004, 2011; NIDIS, 2012; Wilhite et al., 2000).

Institutions that support drought preparedness and planning do so through: the allocation of financial, technical, or information resources; setting of clear and consistent roles, responsibilities, and processes for drought monitoring and communications; inclusion of diverse stakeholders and the public in decision making; and providing forums and opportunities for coordination (Engle, 2013; Ivey et al., 2004). The legitimacy of drought plans and programs has been linked to the extent to which different groups (e.g., scientists, decision makers, water users and stakeholders, and other community members) have opportunities to interact, exchange information, and work together to develop plans, monitor and communicate drought conditions, and assess impacts (Durley et al., 2003; Ivey et al., 2004; Jacobs et al., 2005; Shepherd, 1998).

The second logic considers drought to be a temporary water supply-demand imbalance. "Drought" implies a short-term mismatch between supply and demand or "insufficient water to meet needs" (Redmond, 2002, p. 1144). Relevant decision makers, and those with a role in drought management, include the water industry and providers of drinking water and wastewater treatment services. On the local level, communities and water systems use a variety of strategies to address drought, only one of which is developing drought or water shortage contingency plans. Drought planning is embedded primarily in existing water system practices, in the form of the codes and standards used by water engineers to secure and augment supply (AWWA, 2007, 2011; Kallis, 2008).

Tools to augment supply and bolster capacity to manage drought include diversifying water sources, interconnecting water systems, water reuse and recycling, and adopting more efficient water treatment and distribution methods. Water systems and communities have also implemented demand-side strategies. Relevant tools include customer conservation programs, increasing block rate structures, water surcharges and excess use charges, and increased rates during drought or high usage seasons. Customer-oriented tools are intended to encourage lower water use while maintaining adequate revenue to support the water system (AWWA, 2007; 2011; Dennis, 2013; Schwab, 2013).

As a result, demand-side tools can be considered proactive in that such measures are conducted prior to drought, may limit the need for communities to implement mandatory water rationing, and can often be accomplished at lesser expense to a water system than reactive measures that are taken during a water shortage crisis (Deoreo, 2006; Kenney, 2014).

In the third logic, drought is viewed as a manifestation of deep-rooted water scarcity or water availability problems, and drought impacts and vulnerabilities are a function of broader social, political, and economic processes and practices (Kallis, 2008; Swyngedouw, 2004). Water shortages, as well as longer-term water scarcity, are attributed to increasing water demands and consumption, government policies and incentives that encourage development and water use, and other water system stresses, such as aging infrastructure (Hill and Polsky, 2005, 2007; Saurí, 2013). A wide range of sectors and interests are involved in and affect water resources. Relevant actors include elected officials and policy makers, as well as the broader water resources management, development, and planning communities. Overall, water availability problems are expected to require wide-ranging institutional changes that would support more sustainable water management practices and the inclusion of multiple interests in planning processes. Water scarcity issues can be addressed through a variety of tools. Legal and regulatory frameworks include systems of water rights (riparian, prior appropriation, and hybrid), allocation systems, federal and state laws for environmental protection and water quality, court decisions, and interstate compacts. Other legal and policy options to manage the quantity, quality, and use of water resources include water pricing regimes, watershed protection measures, and integrated water resources management.

Residential water demand and conservation policies also play a role in water availability. Water conservation can be an important component of a long-range plan to help mitigate drought impacts and reduce vulnerabilities (Deoreo, 2006). However, as short-term restrictions have been shown to effectively reduce consumption during droughts (Kenney et al., 2004), and other disincentives to controlling customer demand exist, many water systems are reluctant to adopt permanent water conservation policies (Kenney, 2014). Overall, these frameworks affect not only the availability of water resources in a particular location, but also the feasible options for given users or jurisdictions to manage water, during a drought event (Folger et al., 2012; Gastélum and Cullom, 2013; Jacobs et al., 2005; McNeeley, 2014; Miller et al., 1997).

There is much diversity in how water resources are regulated from state-to-state and how local communities develop and manage their water resources. When looking across multiple levels, there are countless possible configurations of goals, management tools, and stakeholders influencing how water resources are managed, the amounts and timing of available water resources for myriad uses, and which approaches to addressing drought vulnerabilities and impacts are implemented. The following section provides an overview of several state-level approaches to and experiences with drought planning and management.

3.4.3 Examples of best practices and challenges in state-level drought planning and management

Few single studies provide a holistic view of the process(es) through which coordinated drought plans and programs are developed and implemented between the state and local levels. Rather, understanding of these processes must be gleaned from sets of studies that in aggregate provide insights about the complexities of the drought planning and management landscape. This section discusses the drought response and management experiences of several states that have been examined in academic and policy literature, to highlight "best practices" as well as the constraints and barriers that exist to implementing coordinated drought planning and management across state and local levels.

Colorado and Arizona provide models for other states to emulate (Fu, Tang, et al., 2013), as both states have comprehensive drought programs that include statewide response plans and activities to mitigate impacts and improve overall preparedness. Their programs have evolved over many years with careful attention to the assessment of vulnerabilities and risks, building of capacity by providing technical assistance and resources to local communities, and supporting partnerships and processes to facilitate the incorporation of new information and management tools over time (see Arizona Department of Water Resources [AZ DWR], 2014; Colorado Water Conservation Board, 2013; Jacobs et al., 2005; Wilder et al., 2012). Despite proactive drought policies, the underlying institutional context (i.e., Colorado River Compact, prior appropriation system of water rights, and otherwise fragmented nature of authority and responsibilities) plays a significant role in the extent to which new tools, e.g., interstate water markets (Wildman and Forde, 2012), water banking (Megdal et al., 2014), or reservoir operation modifications (Kenney et al., 2010), are used to reduce drought risks and vulnerabilities. Meanwhile, local governments and water systems have a long history of developing capacity, and a variety of tools, to prepare for and manage drought. Collectively, these factors affect which local drought planning and management activities are undertaken and the extent to which they coordinate with the state programs.

Arizona requires local water systems to submit water system plans, which include water supply, drought preparedness, and water conservation plans, yet the Department of Water Resources lacks authority to require the implementation of local water conservation measures. Conflicts between water resources management and development interests, and varying perspectives on the protection of common pool resources v. property rights, have constrained drought coordination efforts (Wilder et al., 2012). Resource constraints have limited involvement by the Local Drought Impact Groups (LDIGs) in state-level response and mitigation activities, with only two of the original ten groups currently and actively engaged in drought impact monitoring and reporting (AZ DWR, 2014; Meadow et al., 2013). In Colorado, the overall state process provides technical support and other resources to encourage, but does not require, the development or implementation of local drought response or mitigation plans. On the other hand, many local entities do incorporate drought into water conservation and/or mitigation plans, and the state has developed a process to track the drought-related activities included in other plans. This information contributes to ongoing state assessments of vulnerabilities and efforts to coordinate state, regional, and local adaptive capacities (Colorado Water Conservation Board, 2013). However, other studies indicate considerable variability in terms of the content and scope of local plans (Klein and Kenney, 2006), gaps in understanding the range and extent of drought vulnerabilities and impacts (Travis et al., 2011), and local and regional preferences for the types of drought responses that are enacted (McNeeley, 2014).

Recent, severe drought events in Texas and California have exposed issues related to coordination of state and local drought response in those two states. In Texas, sixteen regional water planning groups assess and make recommendations regarding water availability and needs, taking water use projections and drought-of-record conditions into consideration. This information is used to develop the State Water Plan. For the most part, regional plans have emphasized the water supply development as the primary strategy to address drought risks (Kelly et al., 2014). While required by the Texas Water Code, local drought contingency and water conservation plans are diverse, varying in terms of their quality, enforceability, and potential ability to realize water savings (BBC Research & Consulting, 2009). The overall concern is that the existing approach to drought preparedness has led to inconsistent responses and has not adequately addressed drought vulnerability, across state, regional, and local levels. As a result, the State of Texas Emergency Management Plan was updated with a new Drought Annex (State of Texas, 2014), and rules revisions were made to enhance the inclusion of drought response activities in regional water plans (Texas Water Development Board, 2013).

California has been progressive and proactive in some areas, for example in terms of thinking about climate change impacts to water resources and encouraging water use efficiency and conservation by urban water systems (BBC Research & Consulting, 2009; California Department of Water Resources, 2008, 2013). However, the state did not adopt its first Drought Contingency Plan until 2010. It serves as a guide for state agency drought response and interagency coordination but leaves primary responsibility for drought response and management to local governments and water suppliers (California Department of Water Resources, 2010). Water utilities are voicing concerns that the extreme drought that began in 2012 has “exposed key vulnerabilities in California’s water management system.” (Association of California Water Agencies [ACWA], 2014, p. 1) Water planning is conducted by a variety of agencies; however plans are not linked with one another and there can be disconnects with development policies that encourage water use and plans that encourage conservation (ACWA, 2014; Schwab, 2013). Real-time concerns about the state’s “tepid response to drought” (Gleick, 2014) and a lack of a comprehensive strategy to reduce impacts (ACWA, 2014) suggest that future efforts to improve state-local coordination may be necessary.

While the above examples focus on the western region of the United States, the Southeast also experiences considerable climate variability and faces increasing pressures and demands on its water resources (Ingram et al., 2013; Seager et al., 2009; Sun et al., 2008). Although “water-rich” in general, the region is susceptible to drought and has suffered significant impacts over the past two decades (Dow, 2010; Manuel, 2008). However, few peer-reviewed studies have examined drought planning and management in the Southeast. The exception is the state of Georgia where drought and water management advancements and conflicts have been documented in academic literature as well as in the popular media. Georgia’s initial approach to drought response required local water utilities to develop drought contingency plans (Shepherd, 1998), but the severe drought of 1998-2002 prompted the state to develop a statewide plan. The process was informed by “best practices” for developing and testing appropriate drought indicators, triggers, and drought levels (Steinemann and Cavalcanti, 2006). The plan itself also established the drought declaration process, pre-drought strategies, and response actions (Georgia Drought Management Plan, 2003). The Georgia

Comprehensive State-wide Water Management Plan was adopted in 2008. It provides guidance for long-term water resources planning and delineates the responsibilities of regional water planning councils in developing regional water plans (Georgia Water Council, 2008). While the plan does not explicitly address either short-term response or longer-term drought mitigation and planning, drought considerations are included in Georgia's Water Conservation Implementation Plan (Georgia Department of Natural Resources, 2010).

Despite having formal state, regional, and local drought and water management plans, drought response in Georgia has not been clear-cut or uncontroversial. During the 2007-2008 drought, then Governor Perdue declared a drought emergency, requiring municipalities "to follow broad-stroke conservation measures that did not necessarily take into consideration local conditions and needs" (Engle, 2012, p. 1142). Local water utilities implemented drought plans and water restrictions, but political conflicts ensued when water-dependent businesses (namely the green industry) pressured the state to alleviate the financial impacts of water restrictions on their industry. Ultimately, the Georgia legislature passed House Bill 1281 in 2008, prohibiting local government water use restrictions to be more stringent than those required by the state (Kohl, 2013; see also Walton, 2012). In 2011, when Governor Deal replaced the state's long-standing state climatologist, media observers suggested it was for political reasons (see Crawford, 2011; Engle, 2013). In addition, Georgia has been mired in a conflict over water in the Apalachicola-Chattahoochee-Flint (ACF) basin with Alabama and Florida for over two decades, with drought, multiple water needs, and lack of a comprehensive water-sharing agreement as the backdrop (Wong and Bosman, 2014).

The examples provided above illustrate some of the challenges to coordinating, and balancing, state and local interests in drought planning and management. On the one hand, local-level approaches are desirable as they are more likely to address specific stakeholder and community needs directly, as they are more sensitive to, and knowledgeable, of the climate variability, water supply and demand, and economic and social conditions at that level (Fu, Svoboda et al., 2013; Fu, Tang, et al., 2013; Schwab, 2013). Many states appear reluctant to impose demands for water restrictions on local utilities, preferring that to be a local decision (Steinemann, 2014). Local water systems also prefer flexibility and autonomy in their drought decision making (Engle, 2012; Jacobs et al., 2005; Pirie et al., 2004).

On the other hand, community-level planning may focus narrowly on localized needs and water management issues and not consider regional or state interests regarding water availability and vulnerability (Kelly et al., 2014). Such an approach can lead to inconsistent drought response across locales. In many places, local governments lack the tools, resources, and/or willingness to adopt and implement drought planning and management measures. In this case, state-level (or "top-down") involvement can provide the support, structures, and/or enforcement mechanisms to increase local planning and help to ensure that broader regional and state-level interests and impacts are addressed (Pirie et al., 2004; Shepherd, 1998). In addition, adequate resources and long-term commitment to collaboration are necessary for state-level initiatives to be successful at multiple management levels (Engle, 2012; Jacobs et al., 2005).

3.5 Methods

The author used the case study approach to examine the on-the-ground experiences of local-level decision makers in responding to drought (Yin, 2009). Case studies are often used in climate adaptation research to examine the mechanisms through which climate risks are managed and the factors that influence vulnerabilities and adaptive capacities. In-depth studies can be used to reveal insights from previous adaptation processes and uncover connections and interactions across scales (Ford et al., 2010; Glantz, 1989). As climate variability and adaptation capacities are context-dependent, a “bottom-up” approach to studying drought response can contribute to a deeper understanding of the implementation process and the factors that constrained or facilitated local efforts (Ford et al., 2010; McNeeley, 2014; Moser and Ekstrom, 2010; Smit and Wandel, 2006). Understanding the local perspective is important as it cannot be expected that guidelines and prescriptions from higher levels or sources will work at lower levels (Moser and Ekstrom, 2010; Urwin and Jordan, 2008).

This study focuses on the Carolinas for several reasons. The two states have experienced several droughts since the mid-1980s, giving water managers and other decisions makers an opportunity to adjust and improve drought planning and management systems (Mizzell and Lakshmi, 2003). Furthermore, the Southeast as a whole may expect increasing vulnerability to drought due to other water resources stressors, such as population growth and in-migration, development, and increasing water demands (Nagy et al., 2011; Terando et al., 2014; Wilhite, 2011). The Georgia example notwithstanding, the drought response experiences of other southeastern states have not been investigated. This case study from North Carolina and South Carolina delves deeper into the dynamics of state and local interactions to provide insights that can be used to identify potential opportunities to improve or modify existing practices.

The author used a variety of information sources and collection methods to gather information about the processes and mechanisms through which drought adaptation actions occurred during the study period (1998-2008). Data collection occurred from May 2007 to November 2008, a period of extreme drought conditions in the Carolinas. Efforts focused on obtaining information about the specific drought adaptations developed and implemented during and in response to the two drought events, different actors' perspectives on drought and water supply management issues, and the broader context in which drought planning and decisions are made. Data sources included interviews, and notes from drought management meeting observations, and documents.

The author conducted eighty-seven interviews with actors knowledgeable of, or responsible, for drought response and water supply management. Thirty-eight of the interviewees represented federal agencies, state agencies, non-profit organizations, community groups, regional planning organizations, engineering consulting firms, and industry. Forty-nine interviews were conducted with public water system managers and other local officials.

The onset of drought in spring 2007 triggered basin- and state-level drought response meetings and conference calls which continued regularly throughout the data collection period. The author attended and observed fifty-nine meetings and conference calls where drought response and management was the primary objective and an additional ten water management meetings and conferences where participants discussed drought issues. Observation of drought management meetings provided an invaluable opportunity to observe the adaptation process as stakeholders discussed and debated the successes, and unanticipated consequences, of previous adaptations (i.e., after the 1998-2002 drought).

Documents provided background information about water- and drought management in the Carolinas and triangulate data gathered from other sources. State-level documents included drought-related rules and legislation, state water supply plans, and drought monitoring reports. Local-level documents included water shortage and drought response plans, annual water system reports, city and town council minutes, and public education materials. Practitioner publications (e.g., AWWA 2007) provided insights into water supply planning and drought management "best practices."

The author imported interview transcripts and minutes and notes from observed drought management meetings into QSR NVivo, a qualitative software program, for coding and content analysis. The author then used NVivo in an iterative manner to categorize and then explore different themes within the data. The initial coding process involved identifying and characterizing stakeholders and decision makers, the existing (pre-drought) water resources and drought management institutions, and the connections and linkages across stakeholders and institutions (Bakker, 1999). Information provided by interviewees about drought impacts, other stressors, and adaptations were then coded and examined to understand triggers and motivations for specific adaptation decisions and actions at the state and local levels (Smit et al., 2000).

During the data collection process, it was evident that the implementation of drought response plans (and water restrictions, in particular) was challenging and contested, particularly at the local level. Preliminary analysis of the data from interviews and meeting observations also indicated that state and local approaches to drought response differed in intent and scope and in what might be considered drought planning "best practices." In order to better understand the source(s) of this disconnect and the barriers to the implementation and coordination of drought plans and other water management measures, the author examined the different state and local approaches to drought response and planning during the next phase of analysis.

The author compared three institutional aspects of drought response – what rules are used to guide decisions, what information or expertise is used, and who has authority to make drought declarations and response decisions – and how interactions across state and local levels affected drought plan implementation (Cash and Moser, 2000; Cash et al., 2006). To assess how the institutional context affected coordination of efforts, the investigation focused on identifying the water management (and other) institutions that influenced drought response. It was expected that the willingness and ability of local decision makers and officials to adopt new approaches to drought planning and response would depend on the interactions across the mix of existing formal policies, laws, rules; sectoral practices; and the beliefs and values related to water resources (Moser and Ekstrom, 2010; Thornton and Ocasio, 2008).

3.6 Findings

This section provides an overview of the drought experiences and adaptations in the Carolinas and details regarding the role of the institutional context in constraining drought response efforts across state and local levels.

3.6.1 Anatomy of drought and drought adaptations in the Carolinas

Although the Carolinas normally receive ample annual precipitation (over 40 inches per year), the region is not immune to drought risks. The two states experience interannual variability, as well as seasonal variations, in precipitation. Drought adaptations and decision making processes have evolved within a riparian water rights system, where riparian landowners can access and make reasonable use of water, state oversight has centered on water quality parameters and water system operations, not necessarily the amount of water resources users withdraw or use (SC State Agency). As in other southeastern states, state-level water supply management has been typified by a "hands-off approach to water allocation" (Moreau and Hatch, 2008, p. 2). Local-level actors (i.e., water systems and municipalities) were responsible for drought planning, with limited engagement by other actors. The underlying assumption was that the Carolinas had plenty of water and that droughts represented temporary supply-demand imbalances. Structural solutions have, in general, successfully minimized drought risks, prevented service disruptions, and lessened the impacts of climate variability on water customers.

Beginning in 1998, many areas in the Carolinas experienced several years of below-normal precipitation before river and reservoir levels reached critical lows in summer 2002. Precipitation deficits over the four-year period were among the largest ever recorded. This cumulative shortfall resulted in record lows for stream flows, ground water levels, and reservoir storage (Weaver, 2005; SC DNR, 2003). In 2007-2008, the Carolinas experienced another "drought of record." This drought's rapid and intense onset in summer 2007 was exacerbated by above-average temperatures. North Carolina experienced the driest year on record and a record number of days above 90˚F. South Carolina experienced its 5th driest year on record in 2007 (NC DMAC, 2008). Below-average rainfall persisted throughout 2008, and streamflow-, reservoir-, and groundwater levels failed to recover as they normally would through the winter and spring months.

Despite previous experiences with drought, many water systems and communities were not prepared for the severe and long-lasting drought that occurred from 1998-2002. The Carolinas were in crisis-mode as the 1998-2002 event exposed the limits of the prevailing strategies to manage drought risks. Much of the activity was reactive, driven by impending water shortage emergencies. According to reports published after 2002, at least 60 community water systems across the two states were vulnerable to running out of water had the drought continued (NC DENR, 2004; Weaver, 2005; SC DNR, 2003). At the state level, both North Carolina and South Carolina had initiated drought preparedness and planning after a severe drought in the 1980s, but the plans in place during 1998-2002 provided only minimal guidance for state agency involvement in drought response. With limited authority and no precedents to guide the monitoring and communication of water supply conditions and impacts, state-level response was also reactive. There was little or no knowledge of water stakeholders' needs (including basic contact information), minimal expertise with drought monitoring, and underdeveloped channels of communication.

Many efforts to improve drought preparedness and response occurred during this time. Table 3.2 summarizes the types of adaptations adopted at the state and local levels during the study period.

State-level efforts involved updating drought response plans, improving monitoring and communication systems, and supporting inter-agency coordination. State agency engagement in drought planning and response accelerated in 2002 when water supplies reached critically low levels and water shortage crises necessitated emergency action and coordination among the different agencies involved in water management (NC State Agency; Wachob et al., 2009). While the specifics of implementation differ between North Carolina and South Carolina, state-level adaptations demonstrate common themes and activities. Both states have used state-level legislation to provide more structure to state- and local response by requiring local planning, authorizing state agency responsibilities, and strengthening organizational capacity to monitor and communicate drought conditions.

In North Carolina, 2002 legislation strengthened the role of the state's Drought Management Advisory Council and required that water systems develop Water Shortage Response Plans (WSRP). The severity of impacts in 2007-2008 moved Governor Easley to become actively involved in drought response efforts and request that all water systems ask customers to conserve and report weekly water use. The governor also introduced legislation (the 2008 "Drought Bill") that gave state agencies more authority to oversee drought response and further strengthened the requirements for the development and implementation of WSRPs and conservation measures.

In South Carolina the Drought Response Act of 1986, which already required local plans, was amended in 2000 based on recommendations from the 1998 SC Water Plan. The 2000 legislation redrew drought management areas to follow the four major river basins rather than climate divisions and required that the Department of Natural

Resources (SC DNR, the agency responsible for drought response) establish specific numerical values for each drought level. SC DNR followed and led the state's drought response program as authorized by the Drought Response Act in 2007-2008. The South Carolina Drought Response Committee (SC DRC) convened regularly for in-person meetings or conference calls to monitor drought conditions and determine drought status. While the SC DRC encouraged water conservation due to the severity of the drought, individual communities and water systems made final decisions regarding water restrictions based on their local drought response plans and conditions.

With increasing authority (and opportunity, i.e., the 2007-2008 drought) to coordinate drought management, state agencies improved capacity to respond to drought through drought monitoring and communication adaptations. Efforts to improve drought-related data and information included research activities to refine understanding of the physical characteristics of drought (e.g., the factors that contribute to the onset and/or receding of drought) and developing new tools to quantify, monitor, and assess drought conditions. State agencies also provided technical assistance to affected water systems and communities as they coped with drought events and supported longer-term planning efforts. In North Carolina, a structured strategy to help water systems cope with drought emerged in 2007-2008. The Division of Water Resources (NC DWR) developed a "drought response toolbox" that identifies specific actions to reduce community water use during a water shortage emergency. NC DWR also expanded work with the most at-risk water systems and communities, helping communities with less than 100 days of water supply remaining to identify sources of and secure emergency supplies, find funding and complete grant applications, expedite permitting process, facilitate interlocal agreements, and perform leak detection audits. In South Carolina the Department of Health and Environmental Control (SC DHEC) and SC DNR aided water systems and communities experiencing or at risk of a water supply emergency (or dischargers approaching discharge limits due to low stream flows). Throughout and after the 1998-2002 drought, the SC State Climate Office assisted water systems as they developed new, or updated existing, plans and ordinances and helped systems to determine appropriate triggers and response actions during the planning process.

Local-level drought adaptations involved many different activities. Communities and water systems diversified water supply sources, improved water system efficiency, and developed drought response plans. While the primary focus of adaptations was related to securing supply, the demand-side of water management is increasingly being addressed. This represented a transition from the management practices prior to the 1998-2002, when few, if any, tools were used to manage customer water demand and use.

Interviewees reported several types of structural and non-structural measures focused on securing and supplies and intended to minimize drought risks and impacts on water customers. In extreme water shortage situations, emergency measures to access water supplies were necessary. Actions included constructing emergency interconnections, dredging around intakes, and using temporary pumps to access water at deeper river or reservoir levels. Longer-term water system adaptations were intended to reduce the likelihood that the system will face a water shortage in the first place, ensure the system can meet demand, and build capacity for future anticipated needs. Managers reported upgrading existing or building new infrastructure, modifying or relocating intakes, building backup storage, or developing new sources (e.g., recycled water for irrigation, aquifer storage and recovery). Water system managers also discussed implementing non-structural measures to improve system operation, such as reviewing and updating reservoir safe-yield calculations and promoting more sustainable water system and water use practices. For example, many water systems adopted new technologies, treatment processes, and leak detection programs to reduce water system inefficiencies.

A second set of adaptations entailed addressing the demand- (or customer-) side of water planning and management and included water rate and fee increases, metering system upgrades, and education and conservation programs. Such measures were intended to encourage conservation, reduce demand, and augment water systems' overall management strategy to balance supply and demand, particularly during dry periods or droughts.

Third, local communities and water systems developed and updated drought response plans, often in response to state requirements. This process involved developing drought indicators and triggers, determining appropriate actions at different drought levels, and establishing communications and enforcement procedures and protocols. Many water system representatives also reported initiating education programs to communicate drought policies and response actions to water customers and to encourage compliance with voluntary or mandatory conservation, particularly during the 2007-2008 drought.

3.6.2 Drought response in practice: state and local disconnects

Overall changes to drought management during the 1998-2008 period were significant. On the local level, water systems diversified the tools and methods used to manage supply and demand and engaged, to some extent, in drought response planning. An increasing formalization of drought response occurred at the state level, as state agencies used their authority to lead planning, monitoring, and communication efforts. Many interviewees (particularly those with state or broader/regional perspectives) indicated that response in 2007-2008 was not nearly as crisis-oriented as in 1998-2002, partly due to the strengthening and implementation of state and local response plans. However, data analysis also revealed mixed experiences within and across management levels as plans were implemented in 2007-2008. Despite increasing attention to the severity of drought conditions, and efforts on the state-level to support proactive drought planning and response, many communities either had not updated their plans or were reluctant to impose water use restrictions on their customers. This section explores why local level actors resisted implementing water conservation measures, water restrictions, and other practices that would be considered drought “best practices.” It compares the institutions that govern drought response at state and local levels to uncover differences that constrain or enable actions. The focus is on what rules are used to guide decisions, what information or expertise is used, and who has authority to make drought declarations and response decisions.

3.6.2.1 Rules governing drought planning and response

The rules that govern drought response decisions and govern drought management strategies differ across state and local levels. As was described in the previous section, state-level adaptations introduced formal drought response policies and rules that required the development of local response plans. Table 3.3 shows the formal components of the states’ drought response plans. Supporting the development of local plans that detail response measures, including restricting water use when triggers are met, was a key component of the states' overall adaptation strategy. While the objective of these adaptations was to improve the capacity of state and local actors to respond to drought and to ensure that water resources would be protected for essential uses, this approach to drought preparedness and response that emphasizes restrictions on water use does not "fit" with how water systems and local-level decision makers perceive, prepare for, or manage drought.

Community-level implementation of water restrictions exposed the incongruities of the two drought preparedness and response strategies. Implementing drought response plans means restricting water use. Many interviewees discussed the reluctance to issue water use restrictions not only because they are counter to conventional thinking and practices but also because of the very real financial implications. Water systems are designed to provide water, not restrict water use, during dry periods. Because "our cities' water systems are set up to sell water," (NC Local Government) drought is viewed as a "money-maker" for water systems. Water system governing boards have traditionally maintained low water rates and rate structures, as the ability to develop and provide clean, plentiful – and, inexpensive – water for domestic and industrial use has been a critical component of local economic development strategies (Hughes, 2005). Annual revenues decline if systems do not sell water during times when demand is expected to be high. Interviewees suggest that in this setting, water managers make a utilitarian determination of costs and benefits for their water system when they support selling, rather than conserving, water. Particularly during the 1998-2002 drought, asking customers to conserve water in order to reduce demand was considered only an emergency measure to cope with extreme water supply shortages. For many communities that did implement drought response plans (i.e., water restrictions), this was a “big deal.” Some interviewees reported that their water systems subjected households and businesses to mandatory water use restrictions for the first time ever.

3.6.2.2 Information used in drought response

State-level adaptations expanded the extent to which different actors, from multiple levels, engaged in drought planning and response, and more specifically the extent to which state-level actors were actively involved in monitoring and communicating drought conditions. Associated with this expanded engagement was the use of different types of information, knowledge and expertise to designate and declare drought levels and appropriate response actions and an emerging shift in the assumptions about the most appropriate scale or level of management for drought response and planning.

Table 3.3 summarizes drought committee membership, the process of making drought designations, and the information used. In both states, state-level committees followed the state drought response plans, using a variety of hydro-climatological indicators, and broad-scale information and data about water resources to monitor and characterize drought conditions. In North Carolina a technical committee meets weekly throughout the year to issue drought designations, including no drought. This group consists of state and regional experts in water resources, meteorology and climate, and sectors such as agriculture and forestry. The group considers streamflows, groundwater levels, reservoir storage, rainfall conditions, and other factors in determining drought status. This information is used to determine county-level drought status, develop the NC drought monitor map, and communicate conditions to the public on the NC Drought Management Advisory Council (NC DMAC) website (www.ncdrought.org). Some local water plans use these drought designations as triggers for their drought response actions. Other water systems use locally developed triggers, such as reservoir levels, which are approved by the NC DWR.

In South Carolina, the Office of the State Climatologist (located within the Department of Natural Resources [SC DNR]) routinely monitors drought data and communicates information about drought conditions and impacts to the Drought Response Committee (SC DRC). The SC DRC convenes when conditions warrant and includes representatives from state agencies, as well as from local government, public water supply systems, power generation facilities, Soil and Water Conservation Districts, and agriculture, industrial, and domestic users. The SC DRC is divided into four Drought Management Areas (DMA) based on river basin boundaries. DMA committee members make county drought designations, informed by drought data provided by SC DNR and their regional-local expertise. The SC DRC is responsible for working with SC DNR to coordinate and implement response within the defined DMAs. In addition, the State Climatologist's office is responsible for preparing a model drought response ordinance and plan for local water systems and reviewing local plans and ordinances for consistency with the State Drought Response Plan. As in North Carolina, local plans vary in that they incorporate both state drought designations and local indicators in their plans.

In contrast to the state-level drought monitoring processes that guide drought actions, local-level interviewees reported that while they have state-approved plans, they continued to rely primarily on local, system-specific data to make drought decisions.

Water system managers who participated in the study indicated using a variety of tools and information to monitor local water supply conditions; this was also demonstrated in a review of local plans and ordinances. Some rely solely on system-specific information, for example visual inspections of water levels as compared to intake locations, treatment capacity compared to demand, and demand data (hourly, daily, seasonal). Others reported also considering rainfall data, groundwater conditions, saltwater intrusion (in coastal systems), forecasts, and drought indicators. In terms of the information used to take drought response actions (e.g., use a supplemental water supply source, request conservation from customers), managers indicated that such decisions are based on management expertise and their experiences related to the water system and local supply and demand rather than relatively general drought triggers. While managers consider both local- and broader scale conditions and factors, the extent to which hydro-climatological data is integrated into local drought decisions and management remains limited. Interviews suggested that decision makers seek to balance scientific data with business-related factors (i.e., how will customers respond to restrictions, will implementing conservation lead to other impacts such as revenue losses). Final decisions at the local level are somewhat subjective in that managers consider a wide range of factors, and try to assess how those factors interact.

3.6.2.3 Authority for drought response decisions

The increasing formalization and engagement of state-level actors through formal plans created a more standardized and regulated approach to drought response and planning that does not necessarily take into account local or regional knowledge or information systems or existing practices (Scott, 1998). The extent to which different stakeholders perceive such new institutions as equitable and legitimate will affect the extent to which adaptations are viewed as successful and are related to the consequences of adaptations (are they fair, do they create negative consequences?) and who is allowed to participate in decision making (Adger et al., 2005). In the Carolinas, changes to the processes of monitoring, designating and communicating drought status generated concerns about the legitimacy of these new state-level institutions and processes and questions about who has the requisite expertise and knowledge for drought response and planning and who ultimately should have authority to make drought status declarations.

In North Carolina, tensions between state and local authority became clear during the 2007-2008 drought. First, although NC DWR is the lead agency for the NC DMAC and oversees local water shortage planning and efforts, the agency had only limited authority to enforce the implementation of water conservation measures on the community level. State agencies have traditionally provided oversight on water quality and treatment issues, not water supply. Interview data suggested that local decision makers consequently did not perceive the agency to be a source of expertise on drought management issues. Second, with many water systems reluctant to implement water restrictions, the NC governor placed considerable top-down pressure on communities to require water conservation as the drought continued. State-level officials, and to some extent the general public, perceived that local officials and water managers were not doing enough to respond to the exceptional drought. On the other hand, local-level interviewees suggested that state officials in Raleigh (the NC state capitol) lacked understanding of local water management issues and that calls for water conservation were politically-inspired. Furthermore, because the NC DMAC used regional data to make county-level drought designations, these designations were perceived as less credible than assessments based on local factors and conditions and made by local managers. A representative of one town reported asking for conservation only "when [the] governor came in and started twisting people's arms. It only became a drought when it was a drought in Raleigh." (NC Water System) Third, when the 2008 NC drought bill proposed minimum, uniform standards for drought response and planning by water systems, local-level interests strongly opposed the legislation. Some interviewees perceived that requirements for "one-size-fits-all conservation measures" punished local systems that were already managing their resources effectively and sustainably and would hinder local flexibility. They questioned the legitimacy of state mandates for conservation, considering them too heavy-handed, stringent, and unaware of local issues:

> People saw something they didn't like, and they think it [drought response] wasn't managed well, and they're going to make sure it doesn't happen again. And there's a lot of disagreement, and debate, about how the best way to do that is and how to make it simple, and of course the legislators think it's very simple. And so they can write a law that sounds very simple and motherhood and apple pie, and in reality, when you start applying it to local situations, sometimes it makes sense, and sometimes it doesn't." (NC Water System)

In South Carolina, questions regarding the legitimacy of state-level institutions related to 1) how drought declarations are made and 2) the lack of a comprehensive, statewide response to drought. First, the statewide Drought Response Committee (SC DRC), tasked with assessing drought conditions and designating drought status, is intended to include broad representation from diverse interests and geographic scales. However, the process to add or approve new members is arduous, so that all interests and sectors may not always be well-represented. Interviewees also suggested that the scale at which drought conditions are assessed (by river basin boundaries) and drought declarations are made (by county boundaries) does not adequately account for local water system conditions. The size of the Drought Management Areas (DMAs) likely contributes to this mismatch. Established to enable drought mitigation within defined geographical areas while preventing an overly broad response to drought (SC Drought Response Act, 2000), the DMAs as currently constituted are still too large in size and scope to address all the complexities associated with drought.

A second, more general concern involved what has not happened on the state level, or what some interviewees expressed as the lack of a comprehensive, statewide response to drought. During the early evolution of South Carolina's drought program, Mizzell and Lakshmi (2003) noted difficulties associated with incorporating scientific and technological information with management and policy goals and political challenges where different groups sought to protect their own "turf" and interests in times of water shortages. During the 2007-2008 drought, the SC DRC did not advocate specific drought response practices, preferring to defer decisions about drought response and water restrictions to local actors. In contrast to the NC experience where the governor actively engaged with the public and required all systems in drought-stricken counties to conserve water, the SC DRC only encouraged water systems and communities to take "strong measures to promote conservation." Conservation was never required, and without a SC DRC recommendation, neither SC DNR nor elected officials have the authority to mandate conservation. Given the severe to extreme conditions across the state, and other disincentives that exist to hinder conservation efforts by local water systems, some interviewees noted concerns about the lack of leadership and efforts on the state-, policy-making level to educate the public about the state's water resources, drought impacts, and proactive actions that could be taken in response to drought.

3.6.3 Coordination within and across management levels: the role of the broader institutional context

Water system managers and others who make drought decisions on the local level negotiate many different layers and types of institutions, many of which are not specific to drought response or management. While the previous section discussed the tensions and disconnects between state and local approaches to drought response planning, this section explores how the institutional frameworks guiding other sectors and interests (e.g., economic development, local planning, and emergency management) and broader water management policies interact with other drought adaptation efforts. Drought plans are only one option available to water systems and communities to manage and mitigate drought risks. In this study, water managers and other local-level interviewees reported a wide range of measures taken by their systems and communities to reduce impacts and improve their ability to cope with and respond to future droughts. Adaptations included diversifying water supply sources, improving water system efficiencies, and taking actions to manage customers' water demand and use.

This section highlights how institutional capacity, i.e., the presence of appropriate institutions to support new and proactive drought management tools, is necessary for the feasibility of adaptations. Drought adaptations in the Carolinas are situated within an evolving institutional context. New formal institutions are reflected in drought response plans, processes, and organizational arrangements (particularly on the state level). At the same time evidence of evolving social norms is growing, through increasing interest in water conservation and societal awareness of water supply vulnerabilities. Putting these changes into practice, however, requires an enabling local and broader institutional context (Dupuis and Biesbroek, 2013). The tensions between various policies and practices were made more obvious as extreme drought conditions persisted, and as pressure for systemic water use reductions and conservation grew, during 2007-08. This section explores how interactions within and across the local and broader institutional contexts affected the implementation, as well as coordination, of new strategies and tools intended to reduce drought risks and impacts.

3.6.3.1 Local dynamics and willingness to adapt

Community leaders and elected officials can provide leadership through their willingness to devote resources to drought adaptation measures as well as support alternative strategies to "traditional" supply and demand management, such as incentivizing water efficiency, encouraging conservation, and enforcing local drought response plans and ordinances. Some interviewees did report that local leadership was a key factor in providing support for demand management adaptations and that the drought did provide a window of opportunity to garner support for such measures. However, the perceived and real financial, social and political costs, and attachment to deep-rooted water use practices and expectations, held back political and public support in many other communities.

The financial cost of drought adaptations was a major concern. Adaptations that involved increasing efficiencies or encouraging conservation by water customers often necessitated additional measures, such as raising rates and fees, changing water rate structures, and pursuing grants and loans when available from state and federal sources. Actions to augment existing or develop backup water supplies also required investments in new infrastructure improvements. Many interviewees suggested that local officials and boards were reluctant, if not totally adverse, to adopting new projects or programs because they opposed increasing rates and fees or committing to large-scale capital investments.

As noted earlier, drought events have been considered money makers for local water systems. In this environment, any water use restrictions or conservation measures (as are included in most drought response plans) can have significant financial costs for a water system. This new strategy created additional challenges and financial impacts for systems that had inadequate rates and/or fees to cover costs as water use decreased. As a result, some systems ultimately increased water rates or fees to offset losses. Interviews also revealed that decisions surrounding the implementation of drought plans led to highly politicized debates where plans were perceived as unfairly targeting certain practices and, when implemented, did result in adverse consequences for small businesses associated with landscaping, car washing, or recreation.

Water restrictions or policies to encourage conservation can send an undesirable message to potential customers in a highly competitive economic development context – it appears that the water system or community is vulnerable to water shortages. Furthermore, many local rules and regulations contradict water conservation, e.g., building codes that require lawn installation before banks can close on new construction and homeowners' association rules that require lawn irrigation systems. Interviewees suggested that attempts to change such rules would likely entail a contentious political process amongst local officials and stakeholders.

Support (or lack thereof) for financial investment in drought adaptation and other water supply-demand management measures illustrates the barriers posed by the broader political-economic environment in which water managers and local officials act. Local governments typically fund and construct infrastructure projects with little or no coordination with neighboring utilities. Since neighboring communities may be in competition with one another for development, there is continued pressure to maintain low rates and fees to attract new water customers. However, maintaining low water prices also necessitates high customer consumption to produce sufficient revenues for water system operations.

Interviews and discussions at drought management meetings revealed the disconnects between deep-rooted water use practices and new approaches to manage and monitor customer demand. This struggle to modify long-established water practices affected the extent to which adaptations were considered feasible and supported at the local level. In many places, new approaches did not fit with existing institutions, particularly in terms of the expectations and standard behaviors related to water use.

3.6.3.2 Flexibility and adaptability of interacting institutions

As discussed above, well-established institutions guide the practice of water supply and demand management. One component of institutional capacity entails flexibility and adaptability, that is does a given system have the capacity for change, improvisation, and experimentation as or when conditions change (Gupta et al., 2010). This case study revealed how several other existing institutional frameworks (i.e., rules, regulations, permitting systems regarding other aspects of water management and use) limited the flexibility of water systems and communities looking for alternative ways to manage supply and respond proactively to drought conditions.

For example, in emergency water shortage situations, systems must comply with the permitting systems that regulate dredging activities, deployment of temporary pumps, and constructing emergency interconnections with other water systems. As drought conditions can contribute to altered water quality characteristics that must be treated, water systems must follow environmental and water quality regulations set by higher-level state and federal authorities (e.g., National Pollutant Discharge Elimination System [NPDES] permits, drinking water standards). Efforts to limit water use (as through drought response plans) often collided with other local codes and ordinances that promote, endorse, or mandate water use. For example, use of water for hydrant flushing, fire-fighting training, and washing emergency vehicles is required for public safety purposes and difficult to limit, except in the most extreme water shortage emergency situations.

Interacting institutions also affected longer-term approaches to securing water supplies, such as water reuse, the development of reclaimed water systems, and aquifer storage and recovery (ASR). Such strategies are frequently offered as solutions to mitigate drought risks (see National Research Council, 2010; Safrit, 2009, 2010). However, as stakeholders in North Carolina during the 2007-2008 drought learned, although such options may be technically feasible and desirable during a severe drought, the state's reuse rules at the time did not allow extensive reuse of water. Water reuse as an adaptation strategy has not been viable without institutional support and change. While there has been interest in and some movement toward expanding the regulatory framework for water reuse permitting and oversight, this process was still in the development stages in 2007-2008 and progress towards full implementation has been slow.

Interconnections with other systems, including interbasin transfers, are also often-recommended strategies to augment water supplies. An interbasin transfer (IBT) refers to "the withdrawal, diversion, or pumping of surface water from one river basin and subsequent use or discharge of all or any of the water into another basin." (Wachob et al., 2009, p. 9-45) Planning and infrastructure development is conducted by individual water systems, while state-level systems approve and regulate transfers. According to interviewees, water systems in the Carolinas have frequently used IBTs to address water needs and/or scarcity. In some places interbasin transfers may be the most efficient way secure supplies; in other areas, developing the infrastructure for an IBT may be prohibitively expensive, e.g., due to local topography. Just as drought contributed to increased awareness of the limited nature of water supplies, interviewees also reported that scrutiny of IBTs has increased, particularly where there are potential implications for interstate waters. These concerns came to a head in the Concord-Kannapolis (NC) IBT application, which revealed the highly contentious nature of intra- and interstate water allocation issues. Stakeholders in both states opposed the permit, citing concerns that the permitting process did not adequately protect upstream and downstream water users and interest in the donor basin, particularly during drought. As a result of these concerns, North Carolina's Regulation of Surface Water Transfers Act (1993) was modified in 2007, extending notification boundaries to include neighboring HUCs and states. The new regulations also provide more opportunities for public involvement in the permitting process. However, the most significant action was taken by the State of South Carolina soon after the permit was approved in January 2007. In June 2007, South Carolina filed a lawsuit against North Carolina in the U.S. Supreme Court to seek equitable apportionment of the Catawba-Wateree Basin's water resources.

3.6.3.3 You can't manage what you don't measure: water allocation in the Carolinas

> Crisis can create political consent or act as a catalyst for change even while crisis management itself if usually ineffective in the long term. The impetus of the recent drought has not only focused attention on disturbing water resource trends at different scales of use, but also illuminated the shortcomings of the existing water management frameworks, which were effectively designed but for a different era. (Pulwarty et al., 2005, p. 280)

Although the quote above was made in reference to events in the Colorado River basin, it is easily applicable to the Carolinas. The examples discussed to this point assume that the presence of institutions, existing or new, affect how and which drought adaptations are considered and implemented. In the Carolinas, the tradition of local-level control over water resources and lack of policy-level institutions to oversee water allocation and use contributed to an institutional gap. As discussed above, in the absence of formal rules or regulations, de facto rules have governed water allocation and water use across the two states. This gap not only limits the states' overall capacity to manage water supplies effectively and sustainably but also contributed to the reactive and crisis-oriented response to drought in 2002. Without a broader institutional framework in place, i.e., no comprehensive system to oversee water allocation and use on the state level, the states lacked basic organizational capacity to perform the data collection, monitoring, and information dissemination functions that are so critical during drought. The lack of data, information, and knowledge about the water resource made it difficult to monitor and manage water availability and risks to supply, during normal as well as drought periods.

The 1998-2002 drought demonstrated the extent to which the economies and environments of the Carolinas were vulnerable to a combination of climate variability, growing demands, and lack of a comprehensive system to oversee water supplies and use (The Governor's Water Law Review Committee of South Carolina, 2004). Consequently many water stakeholders began to question the underlying assumptions and norms that underpin water and drought management policies and practices. The drought experiences in 1999-2002 and 2007-08 triggered a series of state actions to modify existing systems of water supply allocation and management.

North Carolina initiated steps in 2008 to address broader water management issues as well as drought response. Session Law 2008-143 (HB 2499) linked water system funding and grants to the adoption of water efficiency measures, rate structures that support system operations as well as water conservation, and public education programs. The new law also recognized water reuse as a potential resource for the first time (and directed the State's Environmental Management Commission to promote and adopt rules pertaining to water reuse) and required the registration of water withdrawals and transfers greater than 100,000 gallons/day. In 2008, the NC legislature also authorized a Water Allocation Study to assess the current system and make recommendations to improve surface water resources planning and management. The study recommended that the State develop a water allocation system that would permit large water withdrawals, implement river basin planning, and support other measures to improve the resilience of the State's resources. Such measures include upgrading infrastructure, creating more storage, promoting water efficiency, and developing new sources of supply (e.g., reclaimed water, ASR, desalination) (Whisnant et al., 2008). To support this process, the NC General Assembly passed legislation in 2010 that directed NC DENR to develop hydrologic basin models for each river basin. These models are being used to identify ecological flows for the different river basins and regions that are likely to experience water supply shortages.

In South Carolina, several state-level efforts have emerged in order to address lessons learned from the 1998-2002 drought. The SC Water Plan (Badr et al., 2004) updated state-level water management goals (e.g., reducing vulnerability to drought) and guidelines for state agencies as they carry out activities and programs. Also in 2004, the Governor's Water Law Review Committee recommended changes to the formal, legal structures that govern water allocation and use, as "…this State can no longer merely assume that water will always be a plentiful, inexhaustible resource." (The Governor's Water Law Review Committee, 2004, p. 5) The report highlighted the need for a water withdrawal permitting system that would give the State a better understanding of water use and availability and thereby improve the State's ability to 1) manage in-state water resources and 2) work with neighboring states to address interstate water allocation issues (Wachob et al., 2009). Steps to enhance statewide water management include the development of the SC Water Assessment (Wachob et al., 2009), which updated baseline information about the State's water supplies (including quantity, quality, availability, and use), and the passage of the Surface Water Withdrawal Permitting, Use, and Reporting Act (S. 452). This Act represents a long-term effort to translate the lessons of 1998-2002 into a reform with broad implications for water management. Originally introduced in 2007-2008, the bill was revised and re-introduced in 2009, finally passing in June 2010 and implemented in 2011. The Act creates a formal, legal structure for the State to permit surface water withdrawals; collect data about water use; establish seasonably variable minimum instream flows to protect fish and wildlife as well as downstream users; and, require permittees to have drought contingency plans. (Existing users are grandfathered into the program, thereby maintaining the status quo of major water withdrawals. However, users must register their use with the State and report the quantity of withdrawn water on annual basis.) The overall intent of the Act is to strengthen state-level study and oversight of how water resources are developed and the impacts of water use on the wide range of water interests. The Act also reflects the growing trend toward a regulated riparianism system of water rights in the eastern United States (Dellapenna, 2011). At the time of this writing, the SC DHEC and SC DNR are working jointly to conduct a Surface Water Availability Assessment (SC DNR, n.d.; SC DNR, 2015). Information regarding water availability and demands gathered during the assessment process will be used to update the State's Water Plan.

As discussed above, efforts to fill the institutional gaps made some progress during the study period, but it has been a slow process and the extent to which improved institutional capacity on the state level benefits local capacity remains unclear. Despite the efforts to improve state-level monitoring and management of water resources, the fragmentation of water management agencies, and the institutional frameworks that guide their decisions and actions, persists. Coordination at the state-level does not necessarily translate to uniform messages and programmatic goals on the local level, where many water and drought risks and vulnerabilities are managed. Certain sectors and water users, e.g., agriculture and owners of private wells, continue to not be regulated by the state. Policy inconsistencies such as this can create a conundrum for communities interested in implementing strategies and tools to manage local and regional water resources in a more integrative, comprehensive manner.

3.7 Discussion: Navigating Institutional Complexity

This case study reveals the experiences of state and local drought decision makers as they faced a record-breaking drought in 2007-2008 and were tasked with responding to and managing drought conditions in a proactive manner. While adaptations made during the study period provided a more formal structure and process for drought response at the state level, the actual implementation of response actions (i.e., water use restrictions) was disjointed and not well-coordinated across the local and state-local landscapes. The institutional complexity was a major contributor to the contestation and lack of coordination that was evident in 2007-2008, by creating a decision-making environment where water resource agencies and local governments faced multiple logics regarding drought response. Local actors and organizations negotiated these competing logics in different ways, as they worked to balance the demands and institutional pressures placed on them.

First, one of the key drought response objectives (i.e., reduce water use in order to expand water supplies) inherent in state and local plans conflicted with the legacy water system approaches to drought management (i.e., accommodate user demands and limit service disruptions during dry periods). The overall goals of drought response plans thus contradicted the tendency of the water management sector to be conservative, relying on proven tools and localized, personal experience and expertise to manage risks (Rayner et al., 2005). These fundamentally different approaches to drought management were not easily reconciled on the local level.

Local-level interviewees also suggested that the overall flexibility of water systems to implement a full suite of proactive drought response measures was limited by these conflicting objectives. Managers must respond to multiple pressures, while their options for coping with and mitigating drought are constrained by the interplay with other water management institutions and community preferences regarding water provision and use. Interviewees discussed the challenges of working in an environment where intersecting demands produced a fairly narrow decision space within which to consider and investigate new options. These demands include 1) maintaining traditionally low water rates and making enough revenue to run the water system and pay rising costs, 2) providing a safe, reliable, and high-quality product, 3) promoting and implementing water conservation, and 4) meeting state requirements to develop and implement drought response plans. Many of these pressures and demands likely came from stakeholders who may or may not share similar goals, approaches, and perspectives (Greenwood et al., 2011).

Second, although state adaptations did lead to a more certain approach to drought monitoring and response, the case study also demonstrated the potential limitations of top-down measures made through legislation and state-level policy initiatives and the different logics used in making drought decisions. For example, operational drought response decisions occur on the local level and use a fundamentally different approach than what is provided by state-level committees. This is clear when comparing the types of information used at the different level, e.g., water system-specific and supply-demand data information used by local water managers v. drought indicators, climate and hydrological data, and broad-scale information about water resource conditions used by state committees.

Overall, the case study demonstrates the practical challenges involved in introducing a new institutional logic into existing systems of managing and preparing for drought. Garschagen (2011) argues that new strategies and tools need to consider how they fit with established institutional and organizational contexts. In this case “drought response planning” is the new institutional logic being introduced to local water system management. This logic is accompanied by new formal mechanisms for response, new organizational arrangements, different framings of drought problems, and different ideas about the appropriate tools and solutions to address those problems. Many local-level interviewees in this study questioned the legitimacy of these new (and state-level) institutions and how drought decisions were being made, exposing the tensions between certainty (e.g., rules in response plans) and having the flexibility and autonomy to use local information and expertise to respond to local conditions. These tensions also suggest that while some measures and activities may be most efficiently conducted at higher (state) levels (e.g., monitoring, data collection, coordination), there needs to be capacity, commitment, and public support at local levels to implement plans and integrate different management approaches (Berke and French, 1004; Burby, 2003; Urwin and Jordan, 2008).

Institutional complexity and the interaction of multiple logics (e.g., non-drought policies, plans, and practices from other sectors, including environment, public safety, economic development) also affected how short-term drought response was conducted. However, the major concern here relates to how competing and multiple institutional frameworks inhibit coordination among local agencies (i.e., water utilities, planning officials, and development interests) and hinders efforts to address conservation and demand management issues in a comprehensive manner. During times of drought, this maze of institutions and diverse interests can constrain the effectiveness and implementability of proactive drought approaches (Urwin and Jordan, 2008). This complexity also highlights the potential challenges in integrating drought response and mitigation planning with water conservation programs and making clear the goals of each, e.g., short-term restrictions or long-term changes and improvements in water use and efficiency (Colorado Water Conservation Board, 2015: Steinemann, 2014).

Proactive drought management includes a variety of tools and measures, including early warning and monitoring systems, preparedness and response plans, mitigation programs, and multi-level coordination of policies, programs, and plans (Wilhite, 2011). The findings from this study suggest that institutional complexity needs to be addressed in drought planning in order to facilitate the implementation of proactive strategies and coordination of existing practices that vary considerably across spatial scales, temporal scales, political jurisdictions, and different management levels. Effective planning and implementation processes will need to be supported by a web of interconnected institutional arrangements. There will be limited success if the institutional and policy contexts in which different actors at different scales make adaptation decisions are not accounted for (Urwin and Jordan, 2008). Specifically, ongoing and future efforts will need to consider how to balance the desire for local autonomy in decision making with broader state-wide needs for enhanced coordination across management levels.

As most communities use a diversified approach to managing drought risks and impacts, drought response plans (as a specific tool to manage resources during drought) will need to be consistent with other drought planning tools and water management practices. In addition, efforts to incorporate drought-sensitive practices in other large-scale planning processes (e.g., land management, local planning, hazards management, water resources) will be required. For example, water infrastructure and systems of delivering water for consumption are linked to household practices such as lawn watering, car washing, and water-dependent recreation. Such practices are difficult to change as they represent and reinforce social conventions, customs, expectations (Medd and Chappells, 2007). In addition, efforts by both states to transition to regulated riparianism will have implications for future drought planning and management practices. The need for such a system grew evident during the 1998-2002 and 2007-2008 droughts when the capacity of the existing system of water management to meet multiple and diverse water demands was strained. The extent to which new management regimes regulate and/or alter existing water withdrawals will play a key role in whether and how future water shortages are prevented (Dellapenna, 2011).

This study reiterates and reinforces findings from previous studies that demonstrate the importance of improving the process(es) of drought planning, rather than focusing on the development and adoption of plans (Burby, 2003; Shepherd, 1998; Schwab, 2013). While drought response plans are an important component of a proactive strategy to drought risk management, increased state and local engagement in long-term drought and related water planning processes are likely to help build greater institutional capacity and the ability to implement a broader suite of drought adaptations. Efforts to advance drought preparedness will require improving understanding of how and why diverse drought and water decisions are made (Anderies et al., 2004) and managing the tensions and conflicts that emerge as multiple logics intersect (Storbjörk and Hedrén, 2011). Improving the available resources and developing stronger mechanisms for community and public participation at state and local levels is one way to build support for new management practices and approaches (Innes and Booher, 2004). This can be a slow, and a political process, as different groups and networks of actors negotiate and strive to achieve their objectives and goals (March and Olsen, 1989; Nelson et al., 2007; Pahl-Wostl, 2009). However, without such efforts, opportunities to implement proactive strategies will be limited, and fragmented approaches to drought and water management will persist.

3.8 Conclusion

This case study provides an in-depth examination of drought response and planning adaptations in North Carolina and South Carolina. A record-breaking drought and water shortage emergencies in 2002 exposed the shortcomings of the existing system of drought management and the need for a more proactive approach to preparing for and mitigating drought risks. In response, both states made great strides to improve their capacity to cope with drought and manage water resources during drought conditions. State-level efforts focused on developing state processes for drought response, improving drought monitoring and communication of drought conditions, and providing technical assistance to local water systems and communities. Local efforts included developing and updating drought and water plans, upgrading infrastructure, and adopting water efficiency measures. However, as the study findings indicate, when tested by another major drought

2007-2008, adaptations that appeared appropriate "on paper" and followed "best practices" for drought response were not feasible in practice and some were politically contentious, particularly on the local level.

While focused on the Carolinas, this case study reveals core institutional issues that constrain the implementation of proactive drought risk management strategies and the coordination of policies and plans across management and decision making levels. Drought planning literature typically focuses on the more formal aspects of institutions, such as the protocols, responsibilities, and organizational arrangements associated with drought response. This study highlights the need for more careful attention to the wide range of institutional arrangements that shape drought decision making processes, participation in those processes, and how different actors and organizations perceive and address drought risks. Close attention also needs to be paid to the different institutional configurations that exist within and across states. For example, although the systems of drought and water management have evolved in somewhat similar fashion in North Carolina and South Carolina, each state takes a different approach to balancing state and local control and authority over drought management and the processes through which the state-level drought committees make drought designations. As such, these institutions influence what options are considered legitimate by different decision makers and how response options, and trade-offs between options, are assessed. Furthermore, the appropriate institutional framework and capacities need to be in place at multiple levels to support implementation of drought response measures and avoid multi-level and cross-scale conflicts (Nelson et al., 2007).

A more comprehensive approach to drought planning would account for the institutional disconnects that currently exist and support processes to facilitate improved coordination of water and drought management activities. To be more proactive and better connect across state and local levels, drought planning "needs to be better integrated with larger scale and longer term planning issues and less focused on one-time crisis management" (Shepherd, 1998, p. 251). As this study indicates, drought planning processes should identify the contradictions, as well as possible synergies, between mitigation (e.g., long-term investments in infrastructure and water allocation systems) and response (short-term actions during drought) strategies. This study also reinforces what has been noted previously in the literature, that such processes will require that policy makers provide resources and commitment to ongoing engagement with drought issues. Specific activities should include conducting multi-level vulnerability and risk analyses, accounting for the multiple scales of drought, assessing plan effectiveness and impacts after drought events, and engaging stakeholders and the public in decision-making processes (Fontaine et al., 2014; Hayes et al., 2004; Jacobs et al., 2005).

Furthermore, many national-level institutions and frameworks that affect water use and development practices could be modified to improve regional, state, and local capacity to cope with and prepare for drought. One concern is that existing water management across the country continues to focus on infrastructure and supporting growth, practices that are not sustainable in the long-term and contribute to social and environmental costs. Gleick (1998, 2010) recommends a number of institutional improvements, including more flexible laws, broader participation in water management decisions, procedures to establish a better balance between water quantity and water use, and mechanisms to ensure protection of water quality and sustainability of water resources for multiple and future uses. As drought continues to threaten extensive areas of the United States, a concerted focus on institutional issues will be necessary to better align national, state, and local policies and capacities.

3.9 Tables

Table 3.1 The institutional logics of drought planning and management

	Natural hazard and climate risk	Water supply-demand imbalance	Water availability
Predominant framing	climate phenomenon, departure from expected or normal rainfall conditions	short-term mismatch between supply and demand	social, political, economic practices account for water scarcity and shortages
Goals	reduce impacts, enable a proactive and risk management approach to drought response	secure supply, buffer customers from water supply shortages	implement wide-ranging institutional changes to support more sustainable water management practices
Primary means to achieve goals [tools]	drought response plans, mitigation programs	infrastructure, water system efficiency, conservation programs, pricing policies	legal and regulatory frameworks (e.g., water rights, allocation systems), economic policies and incentives, participatory and stakeholder engagement processes
Level of management	local, state	local, regional	local, regional, state, national
Responsible sectors and decision makers	emergency management and response, hazard mitigation, water utilities, community planners	water industry, water and wastewater service providers	policy makers, elected officials; water resources management, planning, and development communities

Table 3.2 Summary of local and state drought adaptations

	Primary actors	Purpose of adaptations	Form of adaptations
Local	Water supply providers • Water systems • Governing authorities and boards (e.g, municipalities, counties, special purpose districts and authorities)	• Avoid drought risks by securing clean and reliable supplies • Expand coping capacity through demand-side management and drought response planning	• Infrastructure improvements and upgrades • Efficiency measures • Rate and fee increases • Metering systems • Education • Drought response plans
State	• Resource agencies (e.g., NC DWR, SC DNR) • Legislative, executive branches of government	• Ensure adequate supplies to protect essential uses (social, economic, environmental) • Improve state- and local-level preparedness and response	• Legislation and regulation that require drought planning • Organizational structures to monitor and communicate conditions • Improvements to technical capacity (e.g., drought-related data, monitoring tools, planning assistance for water systems)

Table 3.3 Summary of state-level drought response

	North Carolina	**South Carolina**
Governing Legislation	Session Law 2008-143, House Bill 2499 (General Statute 143)	Drought Response Act (1985, amended 2000)
Responsible Organizations	Division of Water Resources, Department of Environment and Natural Resources	State Climate Office, Department of Natural Resources
Committees	*Drought Management Advisory Council (DMAC)* State agencies • Cooperative Extension Service • State Climate Office • Utilities Commission • Wildlife Resources Commission • Departments of Agriculture, Commerce, Crime Control & Public Safety Federal agencies • National Weather Service • US Geological Survey • US Army Corps of Engineers • US Department of Agriculture • Federal Emergency Management Agency	*Drought Response Committee (DRC)* State agencies • Emergency Management • Forestry Commission • Departments of Health and Environmental Control, Agriculture, Natural Resources Drought Management Area committees include representatives from: • local government • private and public water suppliers • power generation facilities • agricultural, industrial, and domestic water users • Soil and Water Conservation Districts
Drought Designations	A technical committee (sub-group of the NC DMAC consisting of state and regional experts) meets weekly to discuss hydro-climatological conditions and make recommendations to the US Drought Monitor. County designations are updated weekly on the NC Drought Monitor and map.	The Office of the State Climatologist collects and communicates information about drought conditions and impacts to the SC DRC. The SC DRC convenes when conditions warrant. Drought Management Area committees (based on river basin divisions) make county drought designations.
Information Used/Drought Indicators	• Stream flows • Ground water levels • Reservoir storage • Rainfall conditions and weather forecasts • Time of year • Effect of rainfall (or lack of rainfall) on crops and wildfire activity	Specific indicators used to determine drought status and levels include: • Palmer Drought Index • Crop Moisture Index • Keetch Byram Drought Index • US Drought Monitor • Average daily streamflow, 2-week period • Static aquifer water levels, 2-month period Additional consulted information includes forecasts, outlooks, climatic conditions, water supply and water use data

CHAPTER 4

DEVELOPING COLLABORATIVE DROUGHT INSTITUTIONS: INSIGHTS FROM FERC RELICENSING AND BASIN-LEVEL DROUGHT MANAGEMENT

4.1 Abstract

Droughts often extend across political and jurisdictional boundaries, limiting the ability of any one organization, community, or sector to effectively respond to, manage, and mitigate risks associated with large-scale events. Greater coordination across groups with drought responsibilities and interests is needed to support a more proactive approach to drought response. This chapter examines what types of institutional changes are necessary to facilitate cross-scalar drought management and coordination. The analysis draws from a case study of drought adaptations in the Catawba-Wateree and Yadkin-Pee Dee River Basins in North Carolina and South Carolina as they were undergoing Federal Energy Regulatory Commission (FERC) relicensing. Using information obtained through stakeholder interviews, observation of drought management meetings, and review of basin- and local-level documents, the author assessed the mechanisms and processes through which a collaborative and collective approach to drought management was developed and implemented in the study basins. Findings demonstrate the importance of the interplay between formal and informal institutions in facilitating the integration and coordination of drought response across scales. Shared objectives and basin-level relationships that evolved during and after FERC relicensing established social processes and networks necessary for decision makers to successfully implement the technical and

more formal aspects of drought planning, such as response protocols and organizational arrangements.

4.2 Introduction

Drought spans wide geographic areas and affects numerous sectors and economic activities of society, including agriculture, navigation, water supply, energy production, public health, and tourism. As drought affects all regions of the country, management approaches and tools to proactively prepare for and mitigate drought impacts are needed at multiple levels (Hayes et al., 2004; Wilhite et al., 2000). When regional-level droughts occur, impacts often extend across political and jurisdictional boundaries, limiting the ability of any one authority, community, or sector to effectively respond to, manage, and mitigate risks associated with large-scale events (Grigg, 2014; Schwab, 2013). However existing drought management organizations and institutions are currently fragmented, particularly when viewed over large geographic extents, such as at the river basin scale or across multi-state regions. As a result, there is a lack of coordination across the many agencies responsible for drought, contributing to a reactive response to drought events when they occur (Folger et al., 2012; Wilhite, 2011). Practitioners and researchers alike recommend that improved cooperation and collaboration within and between levels of government, as well as with water users, local stakeholders, industry and business, and scientists, are necessary to build capacity to respond to drought events and mitigate drought impacts (Dennis, 2013; Engle, 2012; Grigg, 2014; NIDIS, 2012; Schwab, 2013; Wilhite, 2011). While it is increasingly recognized that greater coordination across groups is needed, there have been very few assessments of how such coordination and collaboration might be facilitated in practice.

Research examining environmental governance and resource management questions demonstrates the important role that institutions play in facilitating collaboration and coordination amongst stakeholders, by providing participatory processes and opportunities, promoting learning, and mobilizing and integrating knowledge from different groups (Gupta et al., 2010; Kiparsky et al., 2012; Olsson et al., 2007; Wise et al., 2014). However, institutional questions have not been extensively explored in the context of drought management. Much of the drought literature discusses managerial and technical approaches to improving drought management (Endter-Wada et al., 2009), for example, through the development of monitoring networks, indices that accurately depict drought conditions, and response plans (e.g.,Hayes et al., 2011, Steinemann and Cavalcanti, 2006, Wilhite et al., 2000). The drought planning literature has focused predominantly on the more formal aspects of institutions (e.g., protocols and organizational responsibilities for drought monitoring and response; laws, policies, and plans that affect water allocation and water system management) rather than the norms, values, accepted behaviors and practices, and systems of social relationships that contribute to the institutional context.

Complex environmental and social challenges necessitate the cooperative efforts of heterogeneous interests to resolve fragmentation and scale mismatch problems. The institutional context can enable that cooperation, but more attention needs to be paid to how to build the institutions that facilitate vertical and horizontal linkages, the integration of adaptation policies and management across scales, and public and stakeholder participation in decision making (Amaru and Chhetri, 2013; Dovers and Hezri, 2010). More specifically, the drought management community needs to consider not just the technical and formal aspects of drought planning and response but also how institutions can support the social processes necessary for building collaboration (Endter-Wada et al., 2009; Folke et al., 2005; Welsh et al., 2013).

This chapter uses a case study of drought adaption in North Carolina and South Carolina to examine the processes through which society can develop and implement collaborative drought governance and management structures. The case study focuses on the Catawba-Wateree and Yadkin-Pee Dee River Basins and the period from 1998-2008, during which the region experienced two record-breaking droughts (1998-2002, 2007-2008). Many drought adaptations emerged through the Federal Energy Regulatory Commission (FERC) relicensing processes in both the Catawba-Wateree and Yadkin-Pee Dee Basins. These processes began in 2003 and included the licensees; local, state, and federal agencies; and other stakeholders. Since licenses are typically granted for 30- to 50-year terms, these processes provided a once-in-a-lifetime opportunity to incorporate lessons from the 1998-2002 drought into the next generation of licenses and operating plans of the hydro projects. In 2007-2008, the Carolinas experienced another record-breaking drought, providing an opportunity for water managers implement new tools and processes that had been developed.

Overall, these changes have contributed to increasing stakeholder engagement in drought decision making, more coordinated response to drought events, and collective approaches to problem-solving. In the two study basins, key adaptations entailed the development of basin-level drought response protocols and organizational structures to monitor and communicate drought conditions to stakeholders. However, while the structures and processes for drought response appear similar on the surface, in practice the activities in the two basins exhibited different levels of engagement and integration. The premise of the dissertation is that novel institutional arrangements will be needed to advance drought management and improve coordination. To understand why and how these differences evolved, this study investigates not only the changes to formal institutions but also how processes of stakeholder engagement and learning contributed to new networks, relationships, and understanding of drought issues in the two basins. This chapter addresses three questions:

1. How have formal and informal drought institutions changed in the two study basins?
2. How have institutional changes through the FERC relicensing process contributed to more coordinated and collaborative drought management?
3. How has the interplay between formal rules at different levels of decision making and the more informal components of institutions contributed to basin-specific outcomes in the study basins?

The study draws from a combination of data sources, including interviews, observations of drought management meetings, and drought- and water management documents, to examine the interplay of formal and informal institutions. The two extreme droughts and opportunity of FERC relicensing undoubtedly triggered a range of measures to improve capacity to respond to and prepare for drought in the region. However, it was through the process of developing and implementing new drought management tools in 2007-2008 that this capacity was mobilized. Overall, these changes have contributed to increasing stakeholder engagement in drought decision making, more coordinated response to drought events, and collective approaches to problem-solving, the cultivation of new relationships and networks, and the evolution of basin-level norms and values.

This chapter continues with an overview of drought literature that addresses issues related to regional and basin coordination, a review of insights from environmental management and governance research that are used to develop the study's analytical framework, and the methods section, with details about data collection and analyses processes. The results section includes the histories of the Catawba-Wateree and Yadkin-Pee Dee basins, focusing on the processes of drought response and implementation of drought plans and protocols; an assessment of the key basin-level drought adaptations adopted during the study period; and, a comparative analysis of the adaptations and institutional changes made in the two study basins. This is followed by a discussion of the implications and insights for current and future efforts that seek to improve coordination and collaboration in drought management.

4.3 Coordinating Drought Management: Needs and Challenges

One of the key challenges in coordinating drought response and planning is the fact that numerous and separate government agencies have diverse responsibilities, authority, and missions related to the management of water resources. Different organizations and stakeholders often possess divergent understandings and knowledge of drought and different ideas about the most appropriate ways to address drought risks and impacts. The drought landscape is characterized by fragmentation and lacks a cohesive policy to support integration and consistency within and between management levels (Chappells and Medd, 2012; Dennis, 2013; Folger et al., 2012, 2013; Grigg, 2014).

Wilhite (2011) has argued that greater institutional capacity is needed to improve drought planning coordination and collaboration across multiple levels of government and other entities affected by drought or responsible for drought management and response in some way. One suggestion is that the river basin, or watershed, scale is an appropriate one at which to focus efforts and one at which the myriad agencies and organizations responsible for drought-related decisions could converge (Dennis, 2013; National Integrated Drought Information System Program Implementation Team, 2007; Schwab, 2013; Wilhite, 2011). There are several imperatives that warrant a basin-focused drought management. Several studies note that increasing vulnerability to drought will occur at watershed and sub-watershed scales, due to the other sources of water stress that affect those scales. These stressors include land use change, development patterns, and increasing water demands due to consumptive use and energy production needs for water (Averyt et al., 2011; Sun et al., 2008). Water users in a river basin are increasingly interconnected and dependent on the activities and requirements of other systems and communities that may appear quite distant geographically, economically, or socially (Whisnant et al., 2008). Impaired hydrological conditions during drought can have important implications for water resources management decisions, particularly those based in river basins. For example, declining streamflows can affect the ability of upstream and downstream water users to access water, reservoirs to refill, and adjacent and connected basins to alleviate water shortages through interbasin transfers (Patterson et al., 2013).

While many water management policies and programs are disconnected from one another, drought planning activities could take advantage of the many water and drought-related decisions already made at the river basin level in order to address critical issues occurring at that level (Pulwarty and Maia, 2015). For example, the federal government manages many water infrastructure projects, such as reservoirs, dams, locks, and hydroelectric. Key agencies include the U.S. Army Corps of Engineers and Bureau of Reclamation (Folger et al., 2012, 2013). In addition, the Federal Energy Regulatory Commission (FERC) issues licenses and oversees operations for over 1,000 private hydropower projects (Federal Energy Regulatory Commission, 2015). During drought, these projects (and their managing agencies) are expected to balance multiple interests, including water supply (and quality) for municipal and industrial use, agriculture, electricity generation, and protected and endangered species. Planning and management often involves evaluating trade-offs, such as those between upstream and downstream users and those between maintaining adequate reservoir levels and releasing minimum downstream flows (Carter et al., 2008). On the state level, many states have developed comprehensive river basin planning programs or watershed management plans and initiatives. In the Carolinas, watershed-level programs have primarily focused on water quality monitoring and stream and watershed conservation and restoration efforts. More recent efforts are paying attention to other aspects of water resources management, including determination of ecological flows and assessments of water availability and use on the basin scale (North Carolina Division of Water Resources, 2015; South Carolina Department of Health and Environmental Control, 2015; Wachob et al., 2009).

The drought planning literature abounds with calls for coordination, however, specific examples of where and how this capacity has been developed and operationalized are limited. Several NIDIS Drought Early Warning System pilot programs are organized and conducted at the basin level, including the Upper Colorado and Apalachicola-Chattahoochee-Flint (ACF) River Basins. Pilot projects focus on developing, and improving, the components of an early warning system. Tools include targeted products and information for regional and local decision makers, in order to improve monitoring and communications, foster partnerships, facilitate more proactive decision making (NIDIS, n.d., 2012; NIDIS Program Implementation Team, 2007; U.S. Drought Portal, 2015). Improving drought monitoring and communications capacity, however, is just one component of the many steps needed to develop more coordinated approaches to drought. Efforts to address fragmentation should also include consideration of the specific institutional arrangements that can enable cooperation and coordination, such as consistent plans and response strategies or processes that encourage or require participatory decision-making (Cook, 2014; Endter-Wada et al., 2009; Schwab, 2013). Studies of the Upper Colorado and ACF Basins demonstrate the importance of the underlying institutional context but also the difficulties inherent in building more collaborative drought institutions.

In the Upper Colorado River Basin any effort to reduce drought risks and vulnerabilities are shaped by the Colorado River Compact and the system of prior appropriation for allocating water rights, in addition to the generally fragmented nature of water responsibilities in that basin (Kenney et al., 2010). For example, while reservoirs and interbasin transfers have been able to mitigate short-term droughts, modifications to the existing reservoir operating rules were adopted in 2007 to address some the impacts on water resources caused by persistent drought in the western United States (Kenney et al., 2010, 2011; Pulwarty and Maia, 2015). At present, adaptations made in the basin fall within the existing institutional structures, allowing for some adjustments that improved the implementation of the "Law of the River." However, questions are emerging regarding the extent to which the existing water management tools adequately address the complex and interacting set of factors that affect the availability of water in the region, including climate and hydrological variability, physical infrastructure, legal frameworks, growing demands, and different historical, cultural, and economic uses and values of water (Kenney et al., 2010; Pulwarty and Maia, 2015). The recent experiences with drought also demonstrated the limited flexibility of the existing framework, raising concerns about its ability to enable long-term cooperation across the multiple interests in the basin and address major issues such as climate change and the current trajectory of declining supplies and increasing demands (Kenney et al., 2011; Pulwarty and Maia, 2015).

In the ACF Basin droughts have exacerbated a long-standing conflict over water between Alabama, Florida, and Georgia. Droughts have also revealed the important role of the institutional context in contributing to drought vulnerabilities and impacts as well as the capacity and willingness to cooperate. Water and drought management issues in the region are contentious, characterized by multiple, often conflicting, interests and increasing demands and competition for water resources. Unlike the very formal, legalistic framework in the Colorado River Basin, there is no overarching plan or policy to govern the management, or distribution, of water across the ACF states. Without such a plan or agreement, there have been few incentives or mandates for collaboration and limited political interest in considering new approaches to addressing the complex issues surrounding development and water use. Meanwhile, as states in the basin remain embroiled in a lengthy court battle over water issues, many jurisdictions and organizations continue to conduct water supply planning on an individual basis, placing more pressure on the region's resources (Missimer et al., 2014; Wong and Bosman, 2014).

As the examples discussed above suggest, institutional change (e.g., new rules, laws, and organizational arrangements) will be necessary to support the adoption and coordination of proactive drought management tools and strategies (Kenney et al., 2011; Wilhite, 2011). While there are plentiful examples where drought contributes to conflict or exposes other water management challenges, there are only a few examples where drought-specific research has examined how change occurs or might be supported in practice, particularly at the watershed or river basin scale. Similar to the Colorado River and ACF cases, these individual studies also demonstrate how drought vulnerabilities and adaptive capacities are a function of many factors, including hydroclimate and environmental conditions, physical availability of water, and the legal frameworks which regulate water rights and allocations. In addition, these studies also call attention to the role of informal institutions in shaping: water use behaviors, stakeholders' knowledge and understandings about water resources and the interests of other water users, and the extent to which different stakeholders cooperate in implementing drought response and adaptation measures (Endter-Wada et al., 2009; McNeeley, 2014; Welsh et al., 2013). This project builds on previous work by investigating in more detail the institutional mechanisms, both formal and informal, that are needed to foster greater coordination of drought management efforts. The next section reviews watershed management and environmental governance literature, two areas of research that can provide key insights regarding the roles and functions of institutions in enabling cooperative and collective behavior.

4.4 Collaborative Institutions for Drought Management

Actors and organizations must continually adapt to address problems that existing structures and knowledge systems cannot adequately address (Berkhout, 2012). In terms of drought management, the premise of this study is that the challenges of coordination will require modification of formal rules which govern water and drought management as well as the adoption of new water management practices to address regional and watershed-scale vulnerabilities. Insights regarding the implementation of watershed- and river basin-based management, and from environmental governance research, are discussed in the following section and then used to develop the framework to assess institutional change and adaptations that enable drought management collaboration and coordination.

4.4.1 Watershed and river basin management and governance issues

Using the watershed and river basins as a focal point of coordination has been advocated in water policy and planning literature. The approach is intended to resolve issues and problems created or exacerbated by fragmentation by convening groups with diverse responsibilities over a shared resource. Expected benefits include improved cooperation between different water users and the development of shared policies, programs, or management approaches (Berardo and Gerlak, 2012; Pahl-Wostl et al., 2007b). However, while it assumed that watershed and basin-scale arrangements and processes will lead to integration and help manage multiple interests, the literature often does not specify or demonstrate how to achieve integration in practice (Cook, 2014).

Furthermore, critics argue that proponents of the concept envision the watershed as the preferred jurisdiction for water management, emphasizing the technical advantages of this solution but without fully considering the governance challenges this approach presents.

As with any other management unit, watershed or basin-oriented management will also intersect with disparate interests, authorities, and policies and face external stressors and pressures that come from outside its borders. Other challenges relate to how decisions about the delineation of watershed boundaries and issues to be addressed are made and the potential lack of formal mechanisms to ensure accountability, representation, and public participation (Cohen and Davidson, 2011; Cook, 2014; Davidson and de Loë, 2014). In addition, processes to develop watershed approaches also involve the relinquishment of some power or authority by actors and organizations participating in new form of decision making or management (Norman and Bakker, 2009). Consequently, watershed and basin-based efforts need to be clear about the problem to be solved, determine if the watershed or another scale is most appropriate to address the problem, and be deliberate about identifying the potential governance challenges and mechanisms to address those challenges (Cohen and Davidson, 2011; Davidson and de Loë, 2014). Efforts should also be wary of the "panacea problem," in which a predetermined solution (i.e., using the river basin or watershed as a governance unit) is assumed to apply in multiple and diverse contexts (Ostrom and Cox, 2010).

These critiques highlight the importance of distinguishing between management and governance, particularly as concerns about water resources crises are increasingly focusing on governance issues, rather than questions of management or technical capacity

(Pahl-Wostl et al., 2011). Understanding the aspects of both management and governance are important for improving society's capacity to address water-related challenges. Management refers to the measures used to implement policy goals and objectives. Water resources management includes the on-the-ground activities required to monitor, secure, control, and provide water supplies. Governance refers to the range of processes, social actors and networks, and formal and informal institutions that influence who participates in decision making, how power and authority are applied or shared, how decisions are made and carried out, the extent to which decisions are considered legitimate, and decisions makers are held accountable (Dovers and Hezri, 2010; Folke et al., 2005; Pahl-Wostl, 2009; Reed and Bruyneel, 2010, citing Bakker, 2007). As such, attention should be directed to 1) the processes through which various interests are represented and allowed or encouraged to participate in watershed management and 2) the mechanisms through which watershed-based efforts develop effective solutions to water management problems (Sabatier et al., 2005).

4.4.2 The roles and functions of collaborative institutions

It is through governance processes that an environment conducive to enhancing collective action, coordination, and collaboration across different perspectives is created (Folke et al., 2005). Furthermore, institutions play a key governance function by providing the norms, cultural expectations, and formal rules that affect what opportunities are available to expand the decision making arena.

Institutions can support processes that bring together stakeholders with different types and levels of authority, address resource issues where users are interdependent, and provide space for trade-offs to be evaluated and policies to be modified over time

(Andonova and Mitchell, 2010; Folke et al., 2005; Paavola, 2007). It is through such processes that shared learning about the system as a whole can occur and opportunities to share information and jointly produce knowledge are facilitated (Brondizio et al., 2009, from Cash et al., 2006; Folke et al., 2005). Such processes can help to reduce transaction costs associated with addressing watershed-scale problems (Lubell, 2005). By contributing to new linkages across different actors and organizations, the institutional framework can also contribute to "rescaling," the processes through which environmental governance shift and/or expands vertically and horizontally across scales. Such processes seek to include multiple levels of government, local communities, and non-state and private actors in decision making processes, but may require institutional change to enable new administrative arrangements (Andonova and Mitchell, 2010; Reed and Bruyneel, 2010; Thiel and Egerton, 2011).

The above summary implies that the appropriate institutional arrangements will create the conditions for cooperation and resolve fragmentation issues. However, the ability of new institutions to accomplish these goals will depend on the wider institutional context and the extent to which existing structures can integrate innovations or new practices. In practice, as institutional arrangements vary across the landscape, patterns of collaboration and governance processes will also differ (Bromdizio et al., 2009; Cook, 2014; Hughes and Pincetl, 2014). This calls attention to the ongoing need to better understand the conditions that contribute to the realization of collaborative efforts and the factors that limit their success (Hughes and Pincetl, 2014).

4.4.3 Identifying and assessing collaborative institutions

In addressing new challenges, such as improved drought management and preparedness, the need for institutional change, and better coordinated and collaborative institutions, is frequently cited (Dovers and Hezri, 2010). Research is increasingly paying attention to the mechanisms of institutional change by examining "on-the-ground" governance processes, changes to those processes, and the interplay of the formal and informal components of institutions (Pahl-Wostl, 2009; Reed and Bruyneel, 2010; Weber, 2009).

Collaborative institutions create the "conditions under which institutions are most likely to foster meaningful cooperation in the management of shared rivers" (Berardo and Gerlak, 2012, pp. 101-102). Institutional mechanisms that affect cooperation in multi-jurisdictional basins are those that foster agreement across interests, shape cooperative relationships in the use and allocation of resources, and contribute to transparency and legitimacy through the production and dissemination of information and opportunities for public participation and conflict resolution. (Berardo and Gerlak, 2012).

The formal components of collaborative institutions include rules as articulated in regulatory and legal frameworks (Pahl-Wostl, 2009). Formal institutions, in the form of shared rules and joint organizational membership, can serve to link different actors and organizations and reinforce the functional interdependencies across groups that may facilitate or hinder collaboration (Berardo and Gerlak, 2012; Heikkila et al., 2011; Young, 2002). Elements of shared rule elements include the setting of agreed-to project boundaries, issues, and proposed solutions, e.g., a monitoring or management plan (Cook, 2014). Formal rules can also influence cooperation by requiring members to engage in collective activities, such as implementing response actions or administering agreements, and determining actor and organizational responsibilities for group interactions (Heikkila et al., 2011).

The informal components of collaborative institutions include the shared beliefs and values that are produced and reinforced through social relations (Pahl-Wostl, 2009; Reed and Bruyneel, 2010). It is through social interactions and processes that trust, norms of reciprocity, and interpersonal relationships and networks are produced (Brondizio et al., 2009). While changes to formal rules often represent the more tangible signs of institutional adaptation (Weber, 2009), uncovering the informal dimensions of institutional change is not a clear cut task.

As learning plays a central role in guiding change, examining the types and extent of learning that occurs in group processes is one approach to understanding the more informal dimensions of institutional change.

4.4.4 Assessing learning in institutions

The ability to learn is a key dimension of adaptive capacity, and flexibility within institutions can contribute to change in those institutions. This study builds on others that use learning as a conceptual framework to analyze change (Balazs and Lubell, 2014; Heikkila and Gerlak, 2013; Pahl-Wostl, 2009). This literature assumes that learning is an integral component of adaptive capacity and a necessary part of the adaptation process in which actors experience impacts, identify problems, assess options, and develop solutions (Armitage et al., 2008; Gupta et al., 2010). Part of that learning is assessing the potential and value in different forms of collaboration and what actions are useful in fostering it. For example, Heikkila and Gerlak (2013) recommend identifying and examining the "products of learning" to understand how collective processes and groups enact policy change. "Learning products" include cognitive changes, including changes to ideas, beliefs, values related to the nature of the policy problem or the appropriate solutions to address the problem. Cognitive changes may lead to behavioral changes, such as changes to collective actions, routines, and strategies. These changes may be signified by expanded plans or programs that influence group behavior or new formalized rules or sets of institutional arrangements. Learning and shifts in institutional arrangements do not occur in a vacuum. It is also important to consider the overall characteristics of the setting, including the existing institutional structure, social dynamics, technological infrastructure, organizational environment, and external political, social, or economic processes.

Learning can be a deliberate process as actors examine previous approaches and outcomes of implemented policies and programs and implement tangible measures to adapt (Brooks and Adger, 2005; Huntjens et al., 2010; Storbjörk, 2010). Learning can also occur through a continuous process of reflection and examination, involving changes in behavior, attitude, perceptions, and relationships (Pelling et al., 2008). Different types and forms of learning correspond to the types of adaptation options that are identified, considered, and ultimately selected and implemented (Storbjörk, 2010; Berkhout, 2012). At the organizational level, social learning is understood as the process through which diverse individuals and groups collaborate to develop a shared definition of a problem and a new, collective knowledge of the system (Armitage et al., 2011; Pahl-Wostl et al., 2007a).

Pahl-Wostl (2009) suggests that social learning may also indicate institutional change and adaptation. Social learning processes facilitate the creation and use of new knowledge and expertise that is not individually-based but emerges through social interactions and the evolution of new shared rules and practices (Armitage et al., 2011; Pahl-Wostl et al., 2010). The extent to which collaboration is successful and enduring will depend on a range of adaptations, including changes to legal frameworks, expanded social networks, use of new knowledge and information used in decision making, and modifications to operational protocols.

Social learning can support these institutional changes (Pahl-Wostl 200s; Pahl-Wostl et al., 2007a), but new innovations will also need to be supported through institutionalization, so they become routine and embedded in standard practices (Burch, 2010). And, the development of collaborative institutions is a long-term process. Institutional change may emerge only gradually as individuals and organizations continue to learn from experiences, interact with other actors, and reconfigure a system's dominant norms through practice (March and Olsen, 1989; Ostrom, 1990).

In these learning frameworks, formal and informal institutional change is conceptualized as moving from single-, to double-, to triple-loop learning, each with deeper insights and implications for resource management and governance frameworks. Single-loop learning refers to an incremental improvement of strategies and actions without questioning the underlying assumptions of established routines or practices (Pahl-Wostl, 2009). Such learning results in small and incremental adjustments to rules, routines, activities, technologies, or procedures (Burton et al., 1993; Crabbé and Robin, 2006; Berkhout et al., 2006). These "business as usual" actions occur within the existing organizational or management framework to ensure that the organization is able to fulfill its mission, goals, and core functions (Ivey et al., 2004). Such changes may occur consciously or unconsciously through direct experience, gaining expertise, or problem-solving (Berkhout et al., 2004). Adaptations may draw from an array of already-known and available choices, rather than invest in a search for novel or optimal solutions, as resource users experiment with new combinations of already-familiar rules, seek to improve the efficiency of ineffective rules or routines, or reduce transaction costs (Birkland, 2005; Berkhout et al, 2006; Dovers, 2008). Incremental changes are likely to be consistent with the underlying values and norms that underpin a particular institution.

Double-loop learning occurs when an organization questions and reexamines the conditions and assumptions that created a problem in the first place. Learning and change may involve reframing goals and problems, revisiting assumptions about how to achieve goals, and correcting errors through policy modification (Pahl-Wostl, 2009). Double-loop learning may result in limited adjustments to the underlying goals, values, and norms of an organization, although the overall functioning of the system is maintained.

Triple-loop learning occurs when actors begin to reconsider the values, beliefs, and worldviews that underpin governance and management paradigms (Pahl-Wostl, 2009). Triple-loop learning may be represented by transformational change, through the re-designing of governance norms or the creation of a fundamentally new institutional system. For example, there may be a change in constitutional rules such as national water law, or a paradigm shift in water management i.e., from command and control to participatory governance. Such change occurs when the existing and predominant values, norms, and assumptions are unable to resolve significant problems (Armitage et al., 2008; Herrfardt and Pahl-Wostl, 2012).

In combination, formal and informal institutions can serve as a form of social capital for environmental governance, by providing processes to develop shared understandings and norms of behavior, opportunities to develop new relationships, and forums to engage with alternate ideas and perspectives (Brondizio et al., 2009; Folke et al., 2005; Pelling and High, 2005; Weber, 2009). Cross-scale institutional arrangements can serve a linking function, by connecting actors that operate at different political jurisdictions or social organization and enabling emerging networks to develop new relationships, patterns of interactions, and shared practices (Armitage et al., 2011; Heikkila et al., 2011). Over the long-term, new linkages and social relations can be supported through social learning.

4.5 Methods

4.5.1. Case study approach and context

This analysis relies on a case study approach as a comprehensive strategy to examine the process of adaptation and the evolution of drought management in the Carolinas. A case study approach is appropriate when the researcher seeks to understand 1) a complex phenomenon with many components/units of analysis and layers and 2) a process, where the researcher asks “how” and “why” questions and has little or no control over the events being studied (Yin, 2009). This approach is suited to studying the drought management landscape which is complex, shaped by hydroclimatological and social processes and populated by many different stakeholders operating on different management levels and with diverse responsibilities. This analysis focuses on the river basin as the unit of analysis and as a decision-making arena consisting of actors, decisions, actions, and interactions among actors. Selecting two basins for analysis enabled a comparison of similar processes and deeper insight into the institutional factors that contributed to enhanced collaboration amongst stakeholders within the basins (Pulwarty and Maia, 2015).

The author selected the Catawba-Wateree and Yadkin-Pee Dee as case study basins as they experienced significant impacts during the 1998-2002 drought and have similar institutional arrangements. First, the basins are shared by North Carolina and South Carolina, which creates some interstate allocation issues. However, the overarching state and local systems of water allocation, water provision, and drought management are generally similar. Second, the flow and availability of water resources are affected by the entities that own and operate dams and reservoirs in those basins. Dam operations are regulated through licenses granted by the Federal Energy Regulatory Commission (FERC). In 2003, shortly after the 1998-2002 drought ended, all three licensees (Duke Energy, Alcoa Power Generating Inc. [APGI], and Progress Energy) initiated relicensing, the multiple-year process through which a dam owner applies for a new operating license. Due to the length of the license terms (30- to 50 years), relicensing provides an invaluable opportunity to formally and systematically change license conditions, and in light of the region's recent drought experiences, incorporate learning from the drought event into the new license applications. In summer 2007 another "drought of record" struck the Carolinas. During this second event, many of the adaptations initiated after 2002, such as drought response plans and protocols, were implemented in the study basins. This provided the author with a unique research opportunity to observe and examine the implementation of drought adaptations and the constraints stakeholders faced during the process.

4.5.2 Data collection

The author collected data for this project from May 2007 to November 2008, a period of exceptional drought conditions in the Carolinas. The author used several methods of data collection to ensure that a range of perspectives would be captured, including those from key drought decision makers. Data and information sources for the project included interviews, observation of drought management meetings and conference calls, and stakeholder documents. These sources were used jointly to trace the key events and processes through which collaborative institutions developed and evolved (Tansey, 2007).

The author conducted thirty-eight semi-structured interviews with representatives from federal agencies, state agencies, non-governmental organizations, community groups, and industry. Twenty-three of the interviewees had participated in FERC relicensing processes in the CW and/or YPD Basins, and an additional three interviewees had experience with other processes. These interviews provided in-depth information and insights about drought decision making and the relicensing processes.

The author conducted forty-nine interviews with community water system managers and local officials engaged with water and drought management across the two states. Thirteen of seventeen interviewees in the Catawba-Wateree Basin were involved with the Duke Energy relicensing processes, and ten of sixteen in the Yadkin-Pee Dee Basin participated in either the APGI or Progress Energy processes. These interviews were important for understanding how drought risks were perceived and addressed in the context of water system operations and planning and how participation in collective efforts affected local water and drought management decision making.

The onset of dry conditions in spring 2007 triggered basin- and state-level drought response meetings and conference calls which continued regularly throughout the data collection period. Long-term observation of drought management meetings provided the author with an invaluable opportunity to observe the adaptation and implementation process as stakeholders discussed and debated the successes, and consequences, of previous adaptations (i.e., after the 1998-2002 drought). The author recorded notes and observations from sixty-nine meetings and conference calls into MS-Word documents.

The author used stakeholder documents to obtain background information about different organizations and triangulate with data from other sources and perspectives during data analysis. Documents provided supplementary information about water- and drought management and the history of water development in the Carolinas. Documents also provided information about the formal institutions and rules that guide water management and drought response and the social, demographic, environmental, physical, economic characteristics of the two study basins. Basin-level documents included FERC studies, memos, reports, relicensing applications; drought contingency plans; drought management group call and meeting minutes, miscellaneous reports and updates provided at meetings or through email. Local-level documents included water shortage and drought response plans, annual water system reports, city and town council minutes, and public education materials.

4.5.3 Coding and analysis

The author used the data collected from interviewees involved in the CW and YPD, meeting observations, and documents associated with the two basins for the case study analysis. The author used the QSR NVivo software program to organize, categorize, and code the information embedded in interview transcripts and meeting observations. Coding was an iterative and analytic process to explore ideas, themes, and relationships that emerged through the data collection process and to answer the research questions:

1. How have formal and informal drought institutions changed in the two study basins?
2. How have institutional changes made through the FERC relicensing process contributed to more coordinated and collaborative drought management?
3. How has the interplay between formal rules at different levels of decision making and the more informal components of institutions contributed to basin-specific outcomes?

The different data sources described above were used to identify adaptations, i.e., the actions taken by stakeholders to cope with, respond to, or manage drought stressors or related risks (Smit and Wandel, 2006). The focus of analysis for this chapter was on adaptations made within the context of basin-level processes, interactions, and activities.

To identify and assess the formal components of institutional change, the author relied primarily on document analysis but also used information from drought management meeting notes and interviews. Specific to this chapter, the analysis included FERC relicensing documents, the drought response plans of the licensees (APGI, Duke

Energy, and Progress Energy) and the thirty-eight local water systems located in the two study basins. The author located local water system drought response plans through an internet search. Plans for three of the systems were not available online. The most current versions of North Carolina Water Shortage Response Plans are located on the NC Division of Water Resources webpage . Many of the South Carolina plans were obtained from the SC State Climatology Office Website, while others were obtained directly from the water system or local government website.

For the first step of the analysis, the author identified the levels at which formal drought-relevant institutions function. For example, rules at the constitutional level establish resource system boundaries, appropriation and provision rules, authority to participate on the collective choice level, and monitoring, enforcement, and conflict resolution activities (Heikkila et al., 2011). Such rules include state laws and systems of water management and the FERC licenses which regulate the management and operations of hydropower projects. The collective choice level includes the rules and regularized actions that affect who participates in decision making, who conducts monitoring, and how members enforce rules and resolve conflict. The operational level entails the day-to-day administration and implementation of decisions (Heikkila et al., 2011). Formal institutions may change, or adapt, through the development and implementation of new codified rules, such as drought legislation or local drought response plans; the creation of new organizations or modification of organizational arrangements; and the development of monitoring systems (Birkmann et al., 2010; Hardy and Koontz, 2009).

Next, the author identified the linkages across the decision making levels and investigated how rules at multiple levels affected different stakeholders (i.e., licensees, water systems, industries, and other actors), their drought response decisions, and participation in basin-level activities. Linkages were indicated by a rule, strategy, or routine action that establishes a connection between distinct actors and entails tasks or decision-making related to the monitoring, managing, or provision of water resources (Hardy and Koontz, 2009; Heikkila et al., 2011).

The author specifically examined local water system drought response plans to ascertain: does the organization have a plan (yes or no); when the plan was developed or updated; what data or information is used in monitoring and responding to drought; who monitors conditions; who makes drought decisions and/or drought declarations; enforcement of response actions; s; connections or linkages to other decision making entities in the basin (i.e., other water systems, CW DMAG or YPD DMT).

Second, the author assessed the informal component of institutions by identifying the "rules-in-use" that guided stakeholder behaviors, attitudes, and practices and which were not necessarily codified in plans, protocols, or administrative codes (March and Olsen, 1989). For this analysis, the author relied primarily on interview data and recorded observations from drought management meetings. Indicators of informal institutional change and adaptation included the extent to which stakeholders exhibited engagement in new basin-level drought management organizations, established new relationships, and articulated new understandings of problems and solutions.

Signs of social learning included learning about other stakeholder perspectives and mutual interests, and developing long-term partnerships and shared objectives to facilitate resource management (Keen et al., 2005; Pahl-Wostl, 2009). The author identified social learning through interviewee statements that indicated recognition of interdependence and connectedness among stakeholders; commitment to collaborative processes; trust; and shared understandings about drought management and water resources in the respective basins (Ansell and Gash, 2008; Keen et al., 2005; Pahl-Wostl, 2002).

In the final step, the author compared the drought management adaptations and institutional changes made in CW and YPD basins, focusing on the interplay between formal-informal institutions and the processes that contributed to the development of collaborative institutions. This analysis centered on examining how the types of learning (e.g., single-, double-, and triple-loop learning and social learning) that occurred through the FERC process was mobilized and demonstrated during the implementation of drought response plans in 2007-2008. Indicators of collaborative institutions included events and activities that included multiple types of stakeholders, interests, and expertise; made connections across scales and levels; allowed for ongoing dialogue, exchange of information, and evaluation; and promoted equity and fairness in decision making (Armitage et al., 2008).

4.6 Institutional Context Prior to 1998

In the Carolinas, adaptations to climate variability, including droughts, have co-evolved within a particular institutional and historical context. As in other southeastern states, water supply planning and management has occurred within a riparian water rights system, typified by a "hands-off approach to water allocation" with few statutes or regulations to govern water use (Moreau and Hatch, 2008, p. 2). This has influenced systems of water supply provision and management as well as the strategies to mitigate or respond to drought risks. This section provides an overview of the institutional landscape that existed prior to the 1998-2002 drought, highlighting the drought decision making responsibilities and activities at state, local, and basin levels of water management.

4.6.1 State

In general, state agencies played a minimal role in water planning and drought response until the 1985-1988 drought, when both states initiated efforts to improve statewide capacity to prepare for and respond to drought.

In North Carolina, the Division of Water Resources (NC DWR) saw its planning responsibilities increase when it was recognized that a better understanding of water systems was needed to cope with drought. In 1989 the state legislature authorized the Local Water Supply Planning program which required that water supply systems submit Local Water Supply Plans (LWSPs) to the agency and update them every five years and which are then compiled into a statewide NC Water Supply Plan. The program was intended to be an education experience for the water systems, so that they review and anticipate long- and short-term supply needs. Although NC did not require local drought response plans at the time, the LWSPs did provide information about local water sources, system capacity, populations served, future water availability and needs, and contact information. NC DWR used this information to communicate with systems and learn what technical and planning assistance might have value to water systems during subsequent droughts (NC Resource Agencies). In 1992, the NC Drought Management Council was formed to facilitate interagency cooperation and information-sharing during drought events. In 1994 a state drought response plan was finalized and incorporated into the State Emergency Operations Plan.

In South Carolina, the SC Drought Response Act (1985) established the Department of Natural Resources' (SC DNR) responsibilities for drought response (i.e., develop and follow a state drought response plan), established the state-level Drought Response Committee and six regional drought management areas, and required local water systems to develop response plans and ordinances (Mizzell and Lakshmi, 2003).

The 1980s drought did trigger some state-level water planning initiatives and the adoption of local planning or response plans. However, few systems had up-to-date plans, or were "out of practice" in terms of plan implementation, by the late 1990s: "I can tell you for a fact that a lot of our water systems, they went from 1985-86 until probably about 2000, and maybe looked at their drought ordinance once, in ten years…." (SC State Agency) At the state level, only a limited structure for state agency involvement in drought response and monitoring existed.

With limited state involvement in water supply planning, surface water resources have been developed through two primary means. First, local governments developed water and sewer services and infrastructure to provide water for public consumption. Second, private industries, utilities, and the Army Corps of Engineers have constructed dams and hydropower projects in most of the major rivers in the Carolinas (Moreau and Hatch, 2008). These processes, and underlying assumptions about water resources, have also influenced how the region has addressed climate variability.

4.6.2 Local

The protection of public safety and health provided the early impetus for the development of community water supply systems, but such services expanded slowly through the 19th- and mid-20th century. Increased demands for water-sewer services accompanied industrialization and urban and suburban population growth after World War II (Howells, 1989). In October 2008, 2,136 NC community water systems served a population of 7.1 million. 623 SC Community Water Systems served a population of 3.7 million. Table 4.1 compares the state and water system populations for NC and SC. This large number of systems stems from the states' minimal formal role in supply management and the lack of enforceable mechanisms or incentives for comprehensive planning. Water systems have traditionally managed and provided water as independent entities, in order support to a community's economic development and domestic consumption. Local governments individually fund and construct infrastructure projects, often to attract new industrial and residential users, with little or no coordination with neighboring utilities. Individual municipalities are the most common water services provider, but other arrangements include county systems, partnerships among local governments, and special purpose water and sewer districts (Hughes and Lawrence, 2007).

In terms of drought planning, the underlying assumption was that the Carolinas had plenty of water and that droughts represented temporary supply-demand imbalances. As is typical across the United States, drought planning has been conducted primarily by water systems, based on local experiences and historical climate records and embedded in their long-term capital planning processes. Water storage infrastructure, distribution systems, and treatment and pumping capacity are constructed to minimize drought risks, prevent service disruptions, and lessen the impacts of climate variability on water customers. Safe-yield analyses are conducted to determine the amount of water available in a reservoir or reservoir system to last through a drought event. Systems withdrawing directly from rivers use historical low inflow information to guide intake construction. Such strategies are intended to allow for normal water use event during drought events, and restricting water use has not been a standard practice.

4.6.3 Basin

Hydropower projects have transformed the Carolinas' landscape and fueled regional development by providing electrical power and stable water supplies for industrial, municipal, and domestic use. Hydropower development began in the late 19th century when private developers began to harness surface water resources for electricity production. Dam construction and hydropower development continued through the middle of the 20th century, but eventually ended due to 1) most of the easily developable sites had already been developed and 2) growing concerns about the adverse impacts caused by dam structures and operations (Licensee Interview). Some of the last major impoundments to be constructed in the Carolinas include the Keowee Development (1971, Duke Energy, Savannah River basin), Jordan Dam (1982, USACE, Cape Fear River Basin) and Falls Dam (1983, USACE, Neuse River Basin). Today, thirty-four projects use or influence the waters of NC, including developments in Virginia and Tennessee. Forty-six hydroelectric plants use the waters in or adjacent to SC, including several projects located along the Savannah River (South Carolina's border with Georgia). Table 4.2 shows the hydropower power projects in the Catawba-Wateree and

Yadkin-Pee Dee Basins. While there are no major dams in the South Carolina section of the Yadkin-Pee Dee River, dam operations in the North Carolinas do influence streamflow conditions in South Carolina, an important issue during the 1998-2002 drought and in the relicensing process (Wachob et al., 2009).

Two sets of institutional arrangements govern the management and operations of hydroelectric projects in the Carolinas. First, United States Army Corps of Engineers (USACE) projects are authorized through the River and Harbors Act, the Flood Control Act, and/or Water Resources Development Act (WRDA) provisions. In contrast to dams which were built primarily by private entities to produce hydropower, USACE projects must support multiple uses. Project purposes include flood control, navigation, hydropower generation, recreation, fish and wildlife protection, water quality control, and water supply. The Water Control Plan provides instructions for dam and reservoir operations and is designed to achieve the Project's multiple purposes as specified by its enabling legislation (Hillyer and Hofbauer, 1998). The electricity generated by USACE projects is marketed and distributed by the Southeastern Power Administration.

Second, the Federal Power Act authorizes the Federal Energy Regulatory Commission (FERC) to issue 30- to 50-year licenses to nonfederal hydropower projects "located on navigable waterways or federal lands, or connected to the interstate electric grid" (Federal Energy Regulatory Commission [FERC], 2004, p. 1-1). Licensees include municipalities and cooperatives producing electricity for local consumption; private industries that generate power for manufacturing processes; and, publicly-owned utilities that supply power to large populations and service areas. FERC licenses establish the terms and standards for hydropower operations, reservoir levels, and release schedules.

License terms regulate dam operations and affect a variety of water users and interests, depending on the requirements to balance hydropower generation and other needs. Water resources are a critical component of energy production, and hydropower stations play an important role within these complex systems. For large, public utilities (such as Duke Energy and Progress Energy), nuclear and coal-fired power stations are often the most cost efficient means to generate much of the baseload, but they also require large volumes of water. Hydrostations are generally used to 1) regulate the flows and reservoir levels so that thermoelectric plants have access to cooling water and 2) supply power during times of peak electrical demand (as they can be turned on and off quickly) (Licensee Interviews; Progress Energy, 2006a; Savage, 1968; Wachob et al., 2009). While the utilities prefer to produce and distribute electricity through the lowest cost, most efficient means possible, they face many other constraints. Overall, dam operators are constantly balancing demands for power generation (which fluctuate on an hourly and daily basis) with their reservoir/water management responsibilities. Maintaining a "full pool" provides many benefits, including more efficient hydropower generation, opportunities for lake recreation, consistent shoreline for lake property owners, and storage to supply other uses.

Rule curves (or "guide curves") guide the day-to-day operations and seasonal management of hydropower projects. The rule curve is based on climate and hydrological patterns that occur on an annual basis and indicates the target reservoir level for any given day of the year. During the course of the year, dam operators manage reservoir levels to minimize potential flooding risks, while also maintaining adequate storage to meet future power demands and water needs. For example, the goal is to have a full reservoir at the end of each spring in order to meet the summer's increased water and energy demands and higher evapotranspiration rates. Although localized thunderstorms and tropical storms help to replenish supplies and temporarily lower demands (e.g., for irrigation), inflows and reservoir levels begin to decline in the summer and typically reach annual lows by mid- to late fall. Lake levels may be brought down in fall and early winter to accommodate springtime rainfall, high inflows, and possible flood events, a sensitive issue and point of contention between reservoir managers and lake interests.

The construction of dams and reservoirs has provided multiple benefits, namely power production, stable water supplies, and recreation and tourism opportunities, and played an integral role in the Carolinas' development in the 20th century. Large-scale projects in the 1950s and 1960s, in particular, fueled economic development and demand for both power and water (Licensee Interview). Overall, water supply agreements between reservoir managers (whether USACE or FERC-licensees) have been conducted on a case-by-case, one-on-one basis, rather than in a comprehensive manner. Little coordination has occurred between the entities developing large-scale reservoirs and the local actors using those reservoir supplies and/or building their own infrastructure projects, a situation that contributes to the overarching fragmentation that exists in drought management.

In terms of drought planning and response, drought response plans for hydropower dam operations were either outdated or non-existent in 1998. Reservoir management plans generally placed few constraints on hydro-operations, set low minimum reservoir levels and release requirements for the operators (i.e., utilities, industries, and the Army Corps of Engineers). Operating plans were based on guidelines and rule curves that favored power generation. Individual communities and local water systems were primarily responsible for their own drought planning, relying on historic information about drought and structural tools (i.e., intakes in the reservoirs or rivers) to secure supplies. However, planning was generally based on the expectation that annual and seasonal variability would fall within the historical record and that existing infrastructure (either that operated by local systems or associated with hydropower projects) would protect water users from an extreme or extended event.

4.6.4 The 1998-2002 drought

Overall, the lack of formal drought planning initiatives and guidance in place in 1998 reflects the assumptions and perceptions about water resources that had underpinned most water resources management decisions in the Carolinas. Although both states experienced several periods of significant drought through the 20th century, the prevailing mindset was that both states had plenty of water to accommodate all needs, uses, and demands. In fact, the region's general adaptation strategy of building reservoirs and water supply infrastructure had been effective in previous droughts. However, the limitations of that approach were exposed during the 1998-2002 drought. Many resource managers, agencies, and water users were ill-prepared for the cumulative effects of a long-term drought. By the time the drought reached its peak in 2002, response was reactive and crisis-driven as reservoirs, streams, and groundwater wells hit record lows, threatening community water systems and water availability for municipal, industrial, and environmental uses (see Chapters 2 and 3). The drought exposed the limitations of the existing system of drought management, particularly the reliance on structural solutions to secure supply amidst growing societal demands for water, lack of up-to-date drought response plans, and limited authority and expertise at the state and river basin levels to manage and coordinate responses across community, county, and state boundaries. So while the two droughts were indeed exceptional and record-breaking, it was not only the lack of rainfall but also lack of institutional capacity that contributed to the significant impacts on water resources.

In response, water managers and agencies at multiple levels have taken a variety of measures to improve drought response and preparedness. Chapters 2 and 3 of this dissertation provide details about the drought adaptations that occurred at the state and local levels during the study period. Local water systems and communities report taking measures to augment existing or secure new water supplies and using demand management tools to influence water use and customer behaviors. Demand-side tools include education programs, metering system upgrades, efficiency initiatives and incentives, and rate and fee increases. On the state-level drought-related legislation in both states has required the adoption of local drought response plans, delineated the authority and responsibilities for state-level drought response, and directed state agencies to take a more proactive role in drought preparedness. The North Carolina Division of Water Resources and the South Carolina State Climatology Office, located within the Department of Natural Resources, are the lead state agencies. They work to coordinate drought response across state agencies and lead efforts to monitor and communicate drought conditions, through the NC Drought Management Advisory Council and the SC Drought Response Committee. State agencies have also taken an active role in providing technical assistance to water systems and communities as they develop response plans and engage in longer-term drought and water management planning.

The remainder of this chapter focuses on the adaptations made in the Catawba-Wateree and Yadkin-Pee Dee basins, where the FERC licenses in place in 1998-2002 had no drought contingency plans. As these hydropower projects had been constructed in different era of water management, their operating plans were limited in terms of the extent to which they incorporated the full range of drought risks, and other water users' needs.

4.7 FERC Relicensing and Drought Adaptations

"Relicensing" refers to the multiple-year process through which a dam owner applies for a new operating license with the Federal Energy Regulatory Commission (FERC). The CW (Duke Energy projects) and the YPD (APGI and Progress Energy projects) licenses were issued in 1958, reflecting an era in which power production predominated. The licenses set low minimum reservoir level and release requirements and contained no requirements to consider environmental, water supply, or downstream interests. From the licensees' perspective, this earlier generation of FERC licenses provided "maximum flexibility," i.e., dam operators could operate the hydrostations in their best interest (i.e., power production), although they would manage releases to benefit other users on an ad hoc basis.

FERC (re)licensing has evolved over the past two decades as demands on water resources have multiplied and as awareness of the adverse impacts caused by dams and their operations has grown. Section 4(e) of the Federal Power Act requires that FERC consider power production (including water needs of nuclear and coal-fired plant operations) as well as the requirements of other resource users in issuing licenses. Today, FERC-licensed dam owner-operators must follow water quality requirements; take actions to mitigate impacts to fish and wildlife and to protect and enhance their habitat; and meet other uses of the reservoir and river resources (public water supply, wastewater discharges, and recreation). Licenses also contain operations protocols for periods of low inflow, high flows, maintenance, and emergencies (FERC, 2004). In addition, the relicensing process itself has also evolved. Rules changes in 2003 were made with the intent of increasing stakeholder coordination and public participation and improving the agency consultation process (Purdy, 2012).

The FERC relicensing provided a significant opportunity for a wide range of stakeholders in the Catawba-Wateree and Yadkin-Pee Dee basins to shape and develop the next generation of operation plans and practices. Table 4.3 summarizes the types of stakeholders involved in the relicensing processes, all of whom different roles, responsibilities, and interests regarding water planning and management as well as drought response. The group includes federal-level regulatory agencies, state agencies, municipal and industrial water users, local and regional governmental organizations, and non-profit organizations with water or environmental interests. Table 4.4 shows the community water systems that withdraw water from the hydropower project boundaries and those downstream water systems interested in or involved in the relicensing process.

With licenses scheduled to expire in 2008, all three licensees (Duke Energy, APGI, and Progress Energy) initiated relicensing processes in 2003. This section details the drought and relicensing experiences, and the subsequent adaptations, in the two study basins.

4.7.1 Catawba-Wateree

4.7.1.1 Catawba-Wateree history and context

Efforts to develop hydropower on the CW began in the 1890s, and Duke Power's first project was completed in 1904. By 1927, all but one of the company's thirteen projects had been constructed. Lake Norman was completed in 1963. Although dams were originally constructed to provide baseload capacity, the developers soon recognized that hydropower alone would not be able to meet the region's increasing demands for electrical power. In 1925 the area experienced a severe drought, and the company depleted reservoir supplies in order to maintain power generation. Duke learned that they should not place "too much reliance on nature's staying 'normal' over an extensive period" (Savage, 1968, p. 351). The company increased their overall power-producing capacity by developing coal-fired plants in the 1920s and 1930s. Nuclear stations (in the CW and other basins) were later added to provide the baseload generation, and the hydrostations were increasingly used to provide supplemental power during times of peak demand.

Duke Energy actively used its available water supply to encourage economic development in the Catawba-Wateree basin. Subsidizing the development of textile mills and promoting water use was part of their overall strategy to increase electricity demand (Savage, 1968). The company:

> ...encouraged people to put their intakes in our reservoir because that meant more people could be served with water, that meant more residences, that meant more [electricity] customers for Duke. So we were all for people putting in their intakes. At Duke at that time we didn't think you could ever run out of water either. ... A lot of these towns were textile-dependent; we really wanted to sell electricity. So, giving them water out of our reservoirs seemed like a natural fit, so much so that we never even charged them for the water." (Licensee Interview)

Meanwhile, communities, economic developers, and planners took advantage of the system of reservoirs to facilitate industrial and municipal development in the basin. Although water use and withdrawals were not coordinated across the basin, Duke would work with intake owners to ensure that flows were adequate for them to meet their water quality (e.g., National Pollutant Discharge Elimination System permits) and other permitting requirements. Otherwise, most water users and intake owners were not aware of the stresses and potential risks that climate variability and development could place on the region's water resources (Licensee Interview). A combination of population growth, development, and other water management stressors prompted American Rivers to declare the Catawba-Wateree "America's Most Endangered River" in 2008 (Wachob et al., 2009).

Duke Energy's Catawba Wateree Hydroelectric Project consists of eleven reservoirs and thirteen hydrostations which are operated in an integrated manner to balance energy production and demands, reservoir levels, and downstream flows effectively. The project includes nine North Carolina counties and five South Carolina counties, has a total drainage area of 4,750 square miles, and spans 225 river miles. The region is highly developed and includes the major metropolitan region of Charlotte, North Carolina. The population of the counties located in and/or bordering the project boundaries totaled over 1.7 million in 2000 (Duke Energy, 2006). Although the hydro projects were developed primarily for energy production, by the beginning of the study period, the reservoirs supported multiple uses, including municipal and industrial water supply, recreation, and fish and wildlife habitat (Duke Energy Corporation, 2003; Wachob et al., 2009).

4.7.1.2 Catawba-Wateree and the 1998-2002 drought

As discussed in Chapter 2, the Catawba-Wateree basin did not suffer major impacts during the 1998-2002 drought. Duke Energy staff recognized in 1999-2000 that dry conditions might extend into a longer-term drought due to La Niña conditions. As the primary manager of the basin's water resources, Duke Energy started to operate conservatively in order to maintain reservoir water levels. With no formal requirements to inform local water utilities and other water users of these modifications, they acted independently and did not communicate these groups until summer 2002 when worsening conditions suggested that some intakes in the basin were at risk of losing access to water if the drought continued into 2003. According to interviews, many of the stakeholders in the basin did not realize the severity of the drought, and vulnerability of their water resources, until Duke Energy began to approach them in 2002. With reservoirs kept artificially high by Duke Energy's operations, most users had not been adversely affected in the short-term.

The drought revealed several important issues that were subsequently addressed in relicensing. First, the presence of large reservoirs contributed to the public perception that "there was an unlimited supply of water." (Licensee Interview) The public was accustomed to seeing full reservoirs, an artificial indicator of water resource conditions, without realizing that Duke Energy may have been reducing hydropower generation and taking other measures to conserve water in its operations. Water users were also accustomed to focusing on their particular community, lake, or intake and did not have a basin-perspective on the resource. The region's limited recent experience with drought (the last lengthy drought to hit the region occurred in the 1950s before the experience of most water users) also contributed to a perception that did not match the reality of drought risks (Licensee, Water System Interviews). Likewise Duke Energy had not perceived the need to communicate with intake owners in the basin prior to 2002 as the company had not experienced such severe drought conditions that they were not able to manage their system without major impacts. The lack of communications capacity was obvious during that summer when the company worked to alert potentially affected water users about the severity of the drought:

> We had no idea who the contacts were at any of these municipalities. We spent a month and a half scrambling just trying to find contact information, who's the utility director, what's their phone number, do they have an email. We had none of that. (Licensee Interview)

Finally, the drought reinforced for Duke Energy the vulnerability of the basin, not only to drought, but to a variety of stressors. The Duke Energy reservoirs provided the communities in the basin with capacity to develop and grow. However, as one of Duke Energy's engineers noted in a CW DMAG meeting, "Everyday it doesn't rain in the Catawba-Wateree is a drought." The Catawba-Wateree project is located in a small basin, particularly when the compared to the size of the population that depends on its water resources to develop and grown. Compared to the needs and demands, the system does not possess much extra storage and consequently is rain-dependent. From the Duke Energy's perspective, the reservoirs, and the existing system of management, were quickly reaching their limits to accommodate increasing demands and cope with drought events. These concerns and issues would be a central focus of the soon-to-follow relicensing process and negotiations with stakeholders (Licensee Interviewee).

4.7.1.3 Catawba-Wateree relicensing and drought adaptations

While higher-than-normal precipitation in 2003 alleviated immediate drought concerns, improving drought response at the basin level was one of the key objectives of Duke Energy's FERC relicensing process. Duke Energy began its relicensing for its Catawba Wateree project in 2003. The company also initiated informal outreach to local governments and the public in 2002 and adopted plans for ensuring stakeholder involvement opportunities. Over the next three years relicensing involved over 160 individuals from 80 organizations who participated in two state relicensing teams, four regional advisory committees, and over 300 meetings and contributed to twenty-nine study reports included in the license application in 2006 (Duke Energy, 2006). In addition, the Catawba-Wateree Relicensing Coalition, a stakeholder initiated and led group, created a united voice of local and environmental interests during the process.

In conjunction with the license application, Duke Energy submitted a Comprehensive Relicensing Agreement (CRA) to FERC. This legally-binding Agreement includes the stakeholder-negotiated recommendations for the new license and the measures to be taken by Duke Energy during the next license term. New plans, initiatives, and projects were developed to enhance many aspects of the Catawba-Wateree basin and its resources, including water quality and flows for fisheries, habitat and species protection, and recreation. Other plans are intended to improve management of cultural resources, shorelines, and flooding, and enhance recreation facilities and the public information system (Duke Energy, 2006).

One important component of the relicensing process is the development of datasets and analytical models with which to simulate scenarios of inflow, flow releases, water withdrawals, reservoir levels, and other operational issues, in order to develop an operations plan for the next license (Duke Energy, 2006). In general terms, the 1998-2002 drought affected the relicensing process in terms of the hydrological data included in these models and some of the recommendations made for infrastructure or operational modifications and other efforts to improve coping capacity across the basin (Licensee Interview).

The Water Supply Study project was another important component of the CW relicensing process. The study resulted from concerns over water supply impacts caused by the 1998-2002 drought and stakeholder requests during relicensing for an evaluation of the CW Project's ability to reliably support future water supply needs for the region. The study team gathered information from local water providers and industrial users to better understand long-term, basin-wide water supply needs and vulnerabilities, an effort that had not been done previously. The study found that future net outflow (water withdrawals minus water returns, or the net water usage for the basin) would double during the study period, with much of the projected increase going to support power plants, population growth, and interbasin transfers (HDR Engineering, Inc. of the Carolinas, 2006). The study recommended that Duke Energy and water users adhere closely to the mutual gains operating conditions developed during the relicensing process and the CW LIP, to ensure a reliable safe yield for the next fifty years. The information gathered for, and findings from, this study directly contributed to two specific outcomes of the relicensing that would enhance drought response and water supply planning.

First, Duke Energy and relicensing stakeholders developed a Low Inflow Protocol (CW LIP) (Duke Energy, 2006). The LIP established the CW DMAG which consists of the licensee (Duke Energy), state and federal agency representatives, and water systems and industrial users that withdraw water from the project boundaries. There are a total of forty members in the CW DMAG (see Table 4.5). The stakeholder-developed trigger points specify when certain management actions are required and establish procedures for stakeholder communications and public notification. Drought indicators include reservoir storage, percentage of average streamflow, the U.S. Drought Monitor, and groundwater levels. The purpose is to conserve available water storage in the reservoirs during drought and is based on the idea that "…all parties with interests in water quantity will share the responsibility to establish priorities and to conserve the limited water supply." (Duke Energy, 2006, p. C-1) In conjunction with CW DMAG membership, all large water intake owners were required to review and update their drought response plans or ordinances by June 2007 to ensure that they comply and coordinate with the CW LIP. Intake owners are also required to submit average monthly water withdrawals from and returns (in millions of gallons per day [mgd]) to the CW system. These reports are submitted annually to Duke Energy who maintains the data, with the expectation that the information will be used in ongoing evaluations of the CW LIP and future water supply planning projects.

A second important initiative was the establishment of the Catawba-Wateree Water Management Group (CW WMG). Even before relicensing and the Water Supply Study, Duke Energy recognized that the continued maintenance of reservoirs would cost significant amounts of money. Although reservoirs were originally built for power production, they were increasingly used for other uses such as public water supply and recreation. The company began to consider whether other major users or beneficiaries of the reservoirs, namely water suppliers and municipalities should contribute financially to the upkeep of the dams and reservoirs in the CW system. During the course of relicensing, Duke Energy proposed that water systems should be charged fees for their water withdrawals. This proposal was met with considerable condemnation from the public water suppliers. During the process of negotiating the CRA, Duke Energy and the large water systems in the basin agreed to form the CW Water Management Group. The parties agreed that members will not be charged withdrawal fees and would work collaboratively on basin-wide issues related to improving water supply planning, water and energy conservation, drought management, and water quality (Licensee, Water System Interviews). While the CW LIP established rules for short-term response to drought, the formation of the CW WMG was intended to facilitate a shared and longer-term approach to water resources planning.

4.7.2 Yadkin-Pee Dee

There are two FERC licensees in the Yadkin-Pee Dee River, Alcoa Power Generating Inc. (APGI) and Progress Energy. Information about the two projects, their drought experiences and adaptations, are presented in tandem. The two projects historically have had somewhat different operating objectives and conducted two separate relicensing processes. However, they have operated in an integrated manner to coordinate downstream releases and together negotiated a drought contingency plan in 2002.

4.7.2.1 Yadkin-Pee Dee history and context

APGI, a subsidiary of the multinational corporation Alcoa, is responsible for the operation of the Yadkin Project. Alcoa constructed hydrostations to provide low cost, reliable power to their aluminum smelter and processing plant in Badin, NC. The project consists of four developments: Narrows (1917), Falls (1919), High Rock (1927), and Tuckertown (1962). High Rock Lake is the largest reservoir and serves as the "storage tank for the rest of the reservoirs (Licensee Interview; Alcoa Power Generating Inc. (APGI), 2006a). Aluminum production continued until 2002, at which time global changes in aluminum production and markets made it no longer economically efficient to operate. The plant worked with high-purity aluminum intended for niche markets until 2007, when all production ended. Now the hydrostations produce power to be sold on the electric grid, and a dispatch center in Alcoa, Tennessee, controls project operations (Licensee Interview). According to Alcoa's license application, selling power to wholesale markets helps the company to "offset the cost of electricity purchases required for Alcoa's other domestic smelting operations." (APGI, 2006c, p. H-2) However, because the Yadkin Project is connected to Duke Energy and Progress Energy transmission systems, APGI does help to increase the reliability of the region's energy production and lower costs for power customers (APGI, 2006c).

Carolina Power & Light (CP&L), the predecessor to Progress Energy, was officially created in 1908 with the acquisition of several municipal electric services in the Raleigh, NC, area. CP&L acquired the Blewett Falls operation on the Yadkin River in 1911, and operations began in 1912. The Norwood-Lake Tillery project commenced operations in 1928. After a slowdown during the Depression, the company expanded in the post-World War II period by extending service to rural areas, attracting industries from other areas to relocate to the South, and developing nuclear power (Riley, 1959). The Blewett Falls Dam is located 15 miles north of the North Carolina-South Carolina border, and the Tillery project is approximately 30 miles upstream from Blewett Falls. In the 2006 FERC license application, Progress Energy reported using the upstream Tillery station to provide on-peak generation as a supplement to baseload plants during times of high demand. Such a service helps to improve the overall reliability and redundancy of their energy production system. The Blewett Falls station regulates discharges from Tillery in order to minimize river level fluctuations experienced by downstream users (Progress Energy, 2006b).

The two projects are bordered by six North Carolina counties (Anson, Davidson, Davie, Montgomery, Richmond, and Rowan). In 2000 the population of the counties was 467,136. The drainage area totals 6,839 square miles and includes 65 river miles. The region includes agricultural and forest lands (including a national forest and state park), rural communities, a wildlife refuge, and some residential development in areas closer to the larger population centers of Charlotte, Winston-Salem, and Salisbury and along reservoir shorelines. The lakes themselves provide recreational opportunities, fisheries habitat, and protected natural areas (Progress Energy, 2006c).

Approximately 132 miles upstream from APGI's High Rock Development, the USACE Wilmington Water Management District operates the W. Scott Kerr Dam. The dam was constructed in 1962 and authorized to provide flood control, recreation, fish and wildlife management, and water supply for Winston-Salem. Dam operations and management affect the inflows into High Rock Reservoir. As the largest reservoir in the APGI-Progress Energy system, High Rock Reservoir provides primary storage for the system and helps to regulate flows through the APGI facilities and to the Progress Energy projects (APGI, 2006b; Progress Energy, 2006a). In the APGI project, primary water users include Duke Energy's coal-fired Buck Steam Station and several community water systems. With fewer needs for water supply from the project, a more significant problem for project management has been water quality due to a proportionately larger number of permitted point discharges and nonpoint sources releasing wastewater directly into or near the project (APGI, 2006b).

Similar water uses and interests exist in the Progress Energy project, including power generation, flood control, and recreation. The river is a source of raw water supply for, and receives treated wastewater from, industrial and municipal users (Progress Energy, 2006a). Downstream of Blewett Falls, the Pee Dee River flows freely in South Carolina, but is heavily influenced by the dam operations in North Carolina. Historically the releases were variable, fluctuating on a daily to weekly basis depending on electricity demands and hydropower generation. Although several South Carolina communities rely on the river directly for municipal water supply, many of the South Carolina water users are industrial users and need particular flows to discharge effluent into the river. In addition, water systems on the South Carolina coast, and the rapidly growing Horry and Georgetown Counties, depend on Pee Dee River. Although many of the systems are located in the Waccamaw River sub-basin and also use groundwater sources, Pee Dee River freshwater flows do have an influence on salinity levels in the downstream reaches of the Pee Dee and Waccamaw Rivers (Conrads and Roehl, 2007; Wachob et al., 2009).

4.7.2.2 Yadkin-Pee Dee and the 1998-2002 drought

As discussed in Chapter 2, the Carolinas experienced several years of below-normal precipitation beginning in 1998. During the 1998-2002 period, cumulative rainfall deficits contributed to severe streamflow, reservoir, groundwater impacts (Kiuchi, 2002; SC DNR, 2004; Weaver, 2005). The most critical conditions and impacts occurred in the

YPD Basin where, in early summer 2002, a crisis situation emerged. APGI generated hydroelectricity during the drought, severely depleting water supplies and creating adverse impacts for other water users. Streamflow in the river was diminishing, and downstream users feared that they would run out of water. High Rock Lake was drawn down 23 feet. The reservoir experienced fish kills and financial losses to recreation-oriented businesses. In the South Carolina section of the Pee Dee River, where flows historically average 8,000 cfs, flow rates dropped to 300 cfs due to the depleted storage upstream and Progress Energy's inability to generate electricity and release water. The low flows affected industries' ability to discharge effluent, and on the coast, low flows caused saltwater to move upstream, threatening water supplies (SC DNR, 2004). One coastal water system was forced one municipal water supplier to close its intake (Conrads and Roehl, 2007).

The deteriorating conditions "caused all kinds of anger, resentments" and required emergency meetings to determine a plan to manage the depleted resource (Licensee Interview). APGI received much negative publicity and had to work through "difficult" and contentious negotiations with resource agencies from NC and SC, Progress Energy, reservoir and downstream interests to develop an emergency protocol for dam operations (APGI). On August 29, 2002, the "Yadkin-Pee Dee River Basin Emergency Drought Management Protocol for Post-September 15 Operations" was finalized. The agreement, negotiated agreement by NC DENR, SC DHEC, SC DNR, APGI, and Progress Energy established a dam operations plan to begin September 15, 2002, and continue "until March 6, 2003 or until parties agree the drought emergency has passed." The protocol established temporary revisions to normal operating policies in order to minimize subsequent risks and impacts to water supplies. The parties agreed to target flows of 900 cfs (the daily average measured at the Rockingham, NC, USGS gage) in order to prevent saltwater intrusion into SC public water supply intakes and meet the needs of other downstream users. The plan also included reservoir drawdown parameters, to minimize additional impacts as lake elevations declined.

Rains arrived in Fall 2002, relieving drought conditions and averting further crisis. On December 12, 2002, Alcoa submitted a letter to FERC to state that conditions were such that normal operations could resume. FERC directed APGI to develop a Drought Contingency Plan (YPD DCP) for Summer 2003 in consultation with the other stakeholders. In February 2003 APGI submitted a YPD DCP that included monthly stakeholder calls to monitor and assess conditions. In the annual report submitted December 23, 2003, APGI noted that streamflow into their Yadkin Project was 68% higher than average (based on over 70 years of data) and only one month (March 2003) was considered "abnormally dry" in 2003. APGI proposed quarterly meetings for 2004, and monthly (or more frequent) calls if drought conditions emerged and/or if the USDM indicated D1 or higher in 10% or more of basin. On March 31, 2004, FERC recommended modifications and directed Alcoa to continue to implement the YPD DCP until such time that a more comprehensive, longer-term protocol could be developed in coordination with Progress Energy during the relicensing processes. In May 2004, Alcoa submitted a final, revised YPD DCP to FERC, based on consultation with Progress Energy, NC DENR, SC DNR, SC DHEC, US Fish and Wildlife Service, Duke Power Company (Buck Steam Station), and the High Rock Lake Association. The YPD Drought Management Team (YPD DMT) membership consisted of representatives from these organizations. This group would play a key role in responding to the drought in 2007-2008.

4.7.2.3 Yadkin-Pee Dee relicensing and drought adaptations

The 2002 drought raised many stakeholder concerns regarding the management of water resources by the two licensees, particularly during times of drought. This experience also heightened awareness of other issues that had been smoldering in the region. For example, the Salisbury water system had concerns regarding sediment encroaching on their water intake and overarching doubts that APGI was adequately ameliorating reservoir and dam impacts on other water users. The High Rock Lake community had been severely impacted by APGI hydropower generating decisions in 2002, leading local homeowners and business to consider the implications of the APGI project's transition to power-generating and question the company's commitment to the local economy and community, due to its closing of the aluminum plant. For Progress Energy, some of the most vocal concerns came from downstream South Carolina industries and state agencies due to the "weekend droughts" and huge fluctuations in releases from the Blewett Falls operations. Similar to the Catawba Wateree, until the crisis in Summer 2002, no systematic mechanisms were in place for communications, information sharing, or coordination among different water users and upstream and downstream interests. These issues were part of the underlying context as the licensees and stakeholders headed into relicensing processes in 2003 and which affected how drought-related issues were considered.

APGI and Progress Energy initiated their relicensing processes in 2003. As in the Catawba-Wateree, the process itself entailed the development of detailed technical models to examine the potential impacts of system operations on water releases and outflows, based on projected inflows to the system, power generation, water withdrawals and transfers, and other factors such as seasonal precipitation and evaporation. Other studies included assessments of dam operation impacts on environmental resources, water quality, cultural resources, recreational opportunities, and land conservation and recommended measures for the licensees to take to enhance those resources or mitigate impacts. While not as extensive as the Duke Energy stakeholder engagement process, both APGI and Progress Energy integrated stakeholder perspectives and input into their processes.

APGI organized Issue Advisory Groups to assist with scoping and conducting studies related to the project application and stakeholder interests. Groups were formed around the following topics: fish and aquatics resources, wildlife and terrestrial resources, water quality, recreation and shoreline management, operations, and county economic impacts. APGI filed its official license application in April 2006 and submitted a Relicensing Settlement Agreement, signed by twenty-four agencies and other stakeholder groups from North and South Carolina, in February 2007.

Progress Energy established Resource Working Groups, focused on water resources, cultural resources, terrestrial resources, land use and recreation, to facilitate stakeholder consultation and input into its relicensing process. Their role was to identify resource issues and needs, review data and identify study goals, review study plans, and participate in reviewing study results and developing recommended solutions where necessary. An important recommendation from the Water Resources Working Group was for the study and assessment of the impacts of Pee Dee River releases and flows on downstream salinity. A group of stakeholders, including APGI, Progress Energy, the Pee Dee River Coalition (an industry user group), and SC DNR, commissioned a study to model and assess the minimum flows needed to protect coastal water quality and supplies (Conrads and Roehl, 2007). Progress Energy filed its application to FERC in April 2006 and a stakeholder-signed settlement agreement in June 2007.

While modeling exercises and studies addressed low flow issues through the incorporation of precipitation and hydrological data from the recent 1998-2002 drought event, drought specifically made its way into the stakeholder settlement agreements in the form of the Low Inflow Protocol (YPD LIP). APGI and Progress Energy jointly developed the new protocol, with the intent that it would replace the existing YPD DCP once FERC approved their new licenses. In comparison to the YPD DCP, the YPD LIP provides details regarding drought triggers and required response actions For example, the YPD LIP uses High Rock Reservoir Elevation, the U.S. Drought Monitor, and stream gage flow averages as indicators of drought conditions and specifies normal minimum and critical reservoir water elevations, target full pond elevations, and target flows throughout the project. The YPD LIP also established a Drought Management Advisory Group (YPD DMAG), expanding the membership of the YPD DMT to include several other stakeholder organizations in the basin. New members represented the NC Wildlife Resources Commission, United States Fish and Wildlife Service, Basin Lake Association, Lake Tillery homeowners, South Carolina Pee Dee River Coalition, and owners of water intakes that withdraw from a project reservoir (≥1 mgd). The new protocol, once in effect, would also require water system and water users in the project boundaries to comply with state water reporting and drought response requirements, participate in water use reduction measures and implement customer water use restrictions when YPD LIP triggers are reached, and provide information about water withdrawals and use to the YPD DMAG as requested (APGI, 2007).

4.7.3 Summary

To summarize, Section 4.6 described the institutional context of water supply planning and development, and the approaches to drought response and management across the Carolinas prior to the 1998-2002 drought. In short, only limited formal structures were in place at that time to support drought response and mechanisms to enable communications, information-sharing, and coordination were non-existent.

Section 4.7 discussed the historical context, experiences and impacts associated with the 1998-2002 drought experiences, important stakeholder issues, and measures taken in FERC relicensing processes to improve drought response and planning capacity in the Catawba-Wateree and Yadkin-Pee Dee Basins. The FERC relicensing processes were benchmark events for water resources management in those basins. As relicensing entailed substantial efforts to collect and analyze data and information related to dam operations, new information and understandings about basin-level resources and the interconnections across the systems also emerged. Collectively, the learning that occurred through these processes informed not only changes to formal institutions, e.g., the procedures detailed in the Low Inflow Protocols, but it is also reflected in changes to informal institutions. For example, the learning is reflected in new approaches to water management. Low Inflow Protocols specified that multiple water interests should be balanced and that decisions regarding operations and management, particularly during drought, should be equitable and fair. While the development of drought response protocols and management groups represent important drought adaptations, the implementation of those plans in 2007-2008 provided tangible evidence that the extent to which new institutional arrangements enabled new practices and collaboration.

4.8 Catawba-Wateree and Yadkin-Pee Dee Comparison: Drought Response in 2007-2008

In 2007 another extreme drought struck the Carolinas. This drought was notable for its quick onset and above-average summer temperatures that exacerbated the adverse effects on streamflow-, reservoir-, and groundwater levels. The drought continued into 2008 as below-average rainfall continued into the winter and spring months. While conditions slowly improved later in 2008 and in 2009, it was North Carolina's worst drought on record, and many South Carolinas counties remained in extreme (D4) status throughout the event (NC DMAC, 2008, 2009).

Compared to 2002, the licensees were quick to respond when conditions began to deteriorate in late spring to early summer of 2007. APGI initiated the first YPD DMT conference call in June 2007, and the first CW DMAG call occurred in September. Table 4.6 shows the full schedule of drought management meetings and conference calls that occurred during the drought. In addition to convening the drought management groups, the licensees also operationalized their drought response plans by reducing hydropower generation in order to conserve reservoir storage. Drought management meetings and calls allowed for communications between the licensees, water users, and stakeholders regarding drought conditions and the response measures being implemented by the licensees.

Despite these basic similarities across the two basins in following the formal rules and procedures indicated by the drought plans, there were considerable differences in terms of the nature and extent of collaboration and coordination that occurred on the ground as different communities and stakeholders engaged with drought response processes. This section discusses how institutional changes have contributed to improved coordination and compares the experiences and types of basin-specific collaborations that have occurred in the Catawba-Wateree and Yadkin-Pee Dee basin. The discussion draws from findings regarding the formal (i.e., drought response plans, drought management groups) and informal (i.e., social networks, social learning) aspects of drought response that enabled coordination across multiple jurisdictions and interests.

4.8.1 Coordination in the Catawba-Wateree

Although their license application to FERC was under review in 2007, Duke Energy decided to formally implement the Low Inflow Protocol that was negotiated with stakeholders during the relicensing process. Signatories to the 2006 Comprehensive Relicensing Agreement, namely the water system members of the newly established CW Water Management Group, were also required to implement water conservation measures at the appropriate drought stage and update their drought response plans to coordinate with the CW LIP. As the drought progressed and the CW DMAG began to meet regularly in Fall 2007 and discuss implementing basin-wide restrictions on water customers, it became evident that water systems' existing plans were not coordinated with the CW LIP or with each other (Lackstrom, 2007).

One important activity during this initial period was for the water systems and local governments to modify existing or develop new drought response plans that did, in fact, coordinate with the CW LIP. Of the eighteen water systems and/or local governments that were CW WMG members and withdrew water from the Duke Energy project boundaries in 2007-2008 (listed in Table 4.4), twelve systems made changes to their local plans and/or ordinances in 2007-2008, specifying the use of the CW LIP and basin-wide triggers to monitor conditions and guide response. Three systems in South Carolina did not have plans that were available through internet searches. However, these systems, and one system in North Carolina without an updated plan, did participate in the CW DMAG meetings and calls and implemented water restrictions in concert with the other systems. While representatives from Mooresville and Statesville frequently attended CW DMAG meetings and included CW LIP triggers in their response plans, these municipalities did not adopt water restrictions in concert with the other CW DMAG members.

In total, sixteen of eighteen of the water systems withdrawing water from the Duke Energy Catawba-Wateree projects worked collaboratively to implement water use restrictions across the basin. This marked a significant departure from previous droughts, and from standard practices in the Carolinas, where the primary objective of water provision was to ensure that water demands were met during drought (see Chapters 2 and 3). Having the CW LIP changed the way water systems coped with drought, providing the CW DMAG members with a concrete plan to follow and to facilitate communications to elected officials and water customers. Nevertheless, extra attention was paid to the communication aspects of the CW LIP, including regular CW DMAG meetings and calls, joint press releases, and timely dissemination of information to local stakeholders and the public to ensure transparency and legitimacy (Licensee, Non-Profit Organization Interviews). Specific activities included the development of a CW DMAG webpage and logo to help promote CW DMAG and WMG activities and the adoption of materials developed by the Charlotte-Mecklenburg Utilities Department to communicate a regionally-oriented conservation message and "de-governmentalize" drought-related water use restrictions (Water System Interview).

While these tangible measures helped to enable coordination and implementation of the CW LIP, some significant challenges also emerged. In many communities, elected officials perceived the collective approach as relinquishing their decision-making power to an external organization. For example, one city council was particularly wary of CW DMAG authority and required that the city council make the official drought declaration for the community. Each time the CW DMAG updated information or drought status for the basin, the utility director would need to obtain approval from the city council to implement any management changes (Water System Interview). Another community resented the expectation that all water intake modifications were required to be submitted to FERC through Duke Energy. For that system, the requirement represented a potential restriction of access to water and a loss of local decision-making authority (Water System Interview). As water use restrictions were implemented across the basin and water-dependent industries (e.g., landscapers, car washes) were adversely affected, business pressures and lack of local political commitment from elected officials to the regional approach posed challenges to some water system managers as they worked to implement the CW LIP. Some upstream-downstream concerns emerged as upstream users, and lake interests in particular, voiced their perception that they were bearing an unfair burden in the basin. Not only were they obligated to follow water restrictions but their upstream reservoirs were also required to make releases to downstream users, leading to declining reservoir levels. Finally, several interviewees indicated some lingering resentment regarding Duke Energy's original "threats" to charge withdrawal fees to community water systems, which acted more as a "stick," rather than a "carrot," in building a regional partnership (Water System Interview).

Despite these constraints, interviewees discussed many factors that enabled coordination of drought response in 2007-2008. First, one outcome from the relicensing process was an expanded understanding of the basin, not only its potential limitations (i.e., in terms of the mismatch between storage capacity and growing demands) but also the potential opportunities to develop a more integrated and collaborative approach to water management. Participants gained technical knowledge about hydrology- and weather issues, awareness about water allocation issues, information about other water users, and a shared perspective about the region's water resources (NGO Interviews). The initial learning that occurred in the FERC relicensing processes provided the capacity (and social capital) that was necessary to advance participation in the CW LIP when the drought began.

Second, as the CW LIP was implemented, the CW DMAG members were able to learn through the actual practice and lived experience of drought monitoring and response, making operational adjustments to conserve water, and gradually modifying traditional strategies of water management. For example, on the operational level, Duke Energy evaluated ways to enhance available storage, and expedited permitting processes as the drought persisted through 2008. As part of these efforts, Duke Energy made modifications to the McGuire Nuclear Station to increase efficiency and operational capacity; worked jointly with the CW Water Management Group (CW WMG), CW Drought Management Advisory Group (CW DMAG), and USGS to establish a groundwater well monitoring network, that will be used to monitor conditions and inform CW LIP decisions; and conducted a basin-mapping project with the Centralina Council of Governments, the nine-county planning organization for the Charlotte, North Carolina, region.

The CW DMAG began to collect data about water use, withdrawals and returns in order to monitor the effectiveness of conservation measures. The CW DMAG also initiated an LIP evaluation process to assess effectiveness of triggers, implementation and management responses, communication processes. Duke Energy also extended water restrictions and conservation guidelines to water users (e.g., golf courses, property owners) who draw directly from the reservoirs and developed pilot projects ("smart irrigation system") to increase efficiency of golf-course irrigators.

The process of implementing the CW LIP also contributed to the strengthening of relationships within the CW DMAG and further building of social capital within the group. Efforts to coordinate drought response not only facilitated communications, but also provided a forum to discuss and resolve management issues and opportunities to develop a common set of information and knowledge related to the basin's vulnerabilities to drought and other stressors. The collaborative nature of drought response, and the sense of shared obligation in managing risks and impacts, also served as a political asset for the managers of water systems where elected officials, local interest groups, and/or water customers were directly opposed or complacent about water conservation.

4.8.2 Coordination in the Yadkin-Pee Dee

During the 2007-2008 drought APGI and Progress Energy continued to employ the YPD DCP and work through the DMT to share information about drought conditions and response. They did not use the YPD LIP as approval of their FERC license applications was pending at the time. Using the YPD DCP required that APGI undertake an number of measures: notify and convene the YPD DMT when conditions warranted, coordinate with Progress Energy to conserve storage and balance lake elevations while meeting needs of reservoir and downstream users, and consult with stakeholders to discuss drought conditions. The DCP also required that APGI file variance requests to FERC when modifying dam operations and submit monthly updates regarding drought conditions and management actions.

The 2003 YPD DCP itself did not set very specific triggers, levels of drought status, or response actions. For example, regarding monitoring and evaluating drought conditions, the YPD DCP states:

> …the existence of a drought will be deemed to occur if at any time the U.S. Drought Monitor elevates 10% or more of the Yadkin-Pee Dee River basin to a Drought Severity Classification of D1 or higher. (Yadkin Project Drought Contingency Plan, 2003, p. 3)

If a drought is determined, the YPD DMT members meet to consider streamflow, precipitation, groundwater, reservoir levels, and other data in order to develop a specific response, including changes to project operations that would require FERC approval. While the protocol does not predetermine actions, it does require that actions balance impacts across water users and other interests and that information about conditions and responses be communicated across the group and to the public. The plan also indicates a target release of 900 cfs to prevent downstream saltwater intrusion. Municipalities and other water users are not required to act under the YPD DCP, rather:

> Municipalities, in turn, could choose to implement demand side management such as water use restrictions as deemed appropriate. Thus, the implementation of regularly-scheduled discussions will facilitate

communication among the Parties and provide the opportunity for implementation of anticipatory measures to mitigate exposure to a drought where possible. (Yadkin Project Drought Contingency Plan, 2003, p. 3)

In contrast to the CW LIP, which delineated specific triggers, response actions, and required formal coordination (via response plans) with the water systems in the basin, the YPD DCP gave APGI primary responsibility (albeit with YPD DMT members) for convening drought management meetings and coordinating response actions. During the course of the drought, APGI submitted several variance requests to FERC, to request permission to modify operations, including the reduction of reservoir releases to 900 cfs to conserve supply. Conditions were monitored regularly by APGI and Progress Energy as they sought to manage the dynamic situation and maintain balanced reservoir levels. The requests also included documentation (i.e., conference call minutes) of the stakeholder involvement in the drought monitoring process. Although APGI and Progress Energy were proactive in communicating with each other, YPD DMT members, and other stakeholders during the drought, the extent to which actions across the basin were coordinated beyond the modification of hydrostations operations was limited.

Although the water users in the APGI and Progress Energy boundaries were included in the YPD LIP, there was no formal requirement, mandate, or incentive for local water systems, or other water users affected by the projects, to participate in the YPD DCP process. Regarding the formal components of drought response, the water systems in the YPD basin (listed in Table 4.4) appeared to follow state, either North Carolina or South Carolina, requirements and guidelines for their local response plans. Eighteen of the twenty plans indicated specific indicators for monitoring drought conditions and triggers to initiate drought response actions. Two of the South Carolinas water systems rely primarily on purchased water, and they indicated following the response actions of their supplier. The six NC water systems that withdraw from the project boundaries, and the four SC water systems that draw directly from or depend on the YPD River, used YPD reservoir levels or river flows and levels as a drought indicator. However, none of the plans indicated a connection to the YPD DCP or decisions made by the YPD DMT. As required by South Carolina, the local plans from that state included information about interconnections with other water systems, either through purchase agreements or for water system emergencies, but the YPD DCP was not included in this category.

Despite the lack of formal mechanisms for coordination, the YPD drought response and management process did evolve to include other stakeholders in the communications and consultation process. In August 2007, a Pee Dee River Coalition representative was invited to attend and participate in the YPD DMT conference calls. The Coalition represented primarily downstream, industrial water users and dischargers from South Carolina. They had participated in Progress Energy relicensing process and were mainly concerned about maintaining adequate river flow for dischargers and reducing the risks of saltwater intrusion for coastal systems. In October 2007, a group of water managers, users, and other state agencies from the upstream portion of the basin began to participate in calls as well. This group included the manager of the USACE W. Kerr Scott Project, the NC Division of Water Quality (NC DWQ), the City of Winston-Salem, and the Town of Wilkesboro. The intent was to learn about the operations of the respective projects and how the upstream (i.e., USACE) might affect the downstream (i.e., APGI, Progress Energy) projects and water users. The USACE and NC DWQ regularly attended YPD DMT calls for the duration of the process, while other upstream stakeholders attended less regularly.

In contrast to the crisis situation that occurred in the basin in 2002, the more conservative approach to water management and communications efforts helped to minimize and distribute the impacts of the 2007-2008 drought. Interviewees discussed a number of factors for this progress. As in the Catawba-Wateree, the relicensing process had allowed different stakeholders to get to know each other and contributed to an environment where they could at subsequent occasions, such as the YPD DMT calls, discuss collectively how to balance water resources and "share the pain" of the drought (Licensee, Industry Interviews). Participation in the FERC relicensing processes also increased awareness amongst stakeholders about the interconnectedness of the reservoir and river systems and the important role large hydropower projects can play in mitigating, creating, or exacerbating water resource vulnerabilities. As the drought continued into 2008, the APGI manager began to monitor drought conditions based on the YPD LIP triggers and uses LIP-based calculations and guidelines in the variance requests to FERC. Through practice and modification of standard routines, the licensees were able to continue to learn about the system and how to operate most efficiently and equitably. From the perspective of the YPD DMT members, the licensees' investment in the communications process also helped participants to share information, build trust, and prevent potential conflicts among water users. Despite the financial costs of operating conservatively, one licensee noted that the public relations benefits the company received in terms of communicating with customers, working other stakeholders, and protecting the environment was worth more than the lost revenues from reducing hydropower generation (Licensee Interview).

4.8.3 Discussion

On paper, many of the new plans and protocols developed during the FERC relicensing processes in the Catawba-Wateree and Yadkin-Pee Dee Basins appear similar. Duke Energy, APGI, and Progress Energy developed drought response plans based on the goals of conservation and balancing multiple water uses, needs, and interests. The FERC license applicants and relicensing participants established new organizational structures and processes (i.e., the Catawba-Wateree DMAG and Yadkin-Pee Dee DMT) to monitor and communicate conditions and share information. The drought decision-making arena expanded to include the dam operators, state and federal agencies, local water systems, and other actors, enabling new knowledge and expertise to be integrated into drought management.

However, as the previous sections demonstrate, the actual implementation of the new plans and protocols in 2007-2008 revealed differences in the extent to which drought response is coordinated across the different levels of decision making in the two basins. A higher level of coordination occurred in the Catawba-Wateree, where the CW DMAG members collectively implemented drought response actions and basin-wide communication messages. In the Yadkin-Pee Dee, while basin stakeholders benefitted from changes to hydropower operations and increased consultation with the licensees, due to the nature of the YPD Drought Contingency Plan, response actions focused on modifying dam operations and as a result were implemented by the licensees individually rather than by the collective group.

Several factors contribute to different trajectories of institutional change exhibited by the study basins. First, although the broader institutional context and history was similar, other basin-specific characteristics and factors interacted to affect the vulnerabilities and capacities in the basins. In the Yadkin-Pee Dee, the crisis and contentiousness of 2002 was a result of the presence of two licensees with different power generating objectives and minimal requirements to consult with or consider other water needs. In the Catawba-Wateree in 2002, the licensee understood the vulnerability of the system and possessed the flexibility to modify operations, but the basin lacked the communications and information-sharing capacity to coordinate coordinated initiatives with other water users.

Once the relicensing processes began, their evolution was differentiated further by the inputs into the process. The type of stakeholder involvement and the extent to which licensees initiated new studies and responded to stakeholder requests shaped the development of additional coordination capacity. In each basin there were also different risks and vulnerabilities, and perceptions of those risks and vulnerabilities, that would affect what issues were addressed and how. Likewise the outcomes, e.g., agreements that were negotiated and settled among stakeholders, reflect the new information, knowledge, and understandings that were generated through social interactions and joint efforts to identify basin-level issues and approaches to resolve potential problems.

For the Catawba-Wateree, because the basin was facing increasing and intense demands on the water resource, Duke Energy used the relicensing as a "platform to get buy-in for better water management throughout the basin" (NGO Interview). The company recognized that fundamental changes across the region would be necessary if the existing system was to continue to support growing populations, and supported a relicensing process that would encourage constructive dialogue among stakeholders across both states and provide opportunities for learning about the Catawba-Wateree system. Interviewees involved in the process highlighted the benefits and outcomes that emerged, for example a “real sense of camaraderie,” “the mutual understanding about all the dependent players,” and the “shared, regional approach to conservation and monitoring.” The social capital, trust, and “systems-thinking” that developed during the relicensing was available to be mobilized in 2007 when drought plans and protocols were implemented.

In contrast to the Catawba-Wateree, the Yadkin-Pee Dee basin has few water supply pressures, particularly within the North Carolina project boundaries, due to its large drainage area, smaller urban populations, and greater proportion of agricultural and forested land. Although some coordinated consultation occurred during relicensing, APGI and Progress Energy conducted separate processes that were, according to interviewees involved in both, qualitatively different from the Catawba-Wateree processes in terms of overall stakeholder engagement. One part of the explanation is that the project boundaries include very few water utilities and other users. Consequently there was little interest in addressing water management and water supply issues. Since no dams are located in South Carolina, and no South Carolina water systems are located in the project boundaries, the state was less engaged in the Alcoa process. With the Progress Energy project, the state’s primary interest was to ensure that the Blewett Falls flows and releases were adequately addressed for downstream users. Although many YPD interviewees indicated the value of the relicensing process for fostering awareness of other stakeholders and interests in the basin, the extent to which the processes has resulted in long-term stakeholder cooperation and collaboration appears to be limited. The value of relicensing was largely due to its utilitarian function. With operating plans and protocols providing adequate water supplies, there was little need or incentive to participate in basin-level activities more deeply. The difference in the need for, and the nature of, coordination between the two basins is illustrated in this quote from a NC state agency representative:

> In 2002 our problem was the Myrtle Beach, the Grand Strand area. South Carolina was coming up knocking on our door giving us grief about not releasing, drawing [down] the Yadkin. …[I]t's almost been a silent issue over in the Yadkin [in 2007]. You can even hardly drum up the interest in the Yadkin in some respects. I guess as long as the Grand Strand and Myrtle Beach don't have to tell the tourists that they can't serve them water, I guess SC is happy and I guess as long as High Rock is full, they're happy there. If either one [Grand Strand or High Rock] of those fails, then we're back to fighting over things again. (NC State Agency)

4.9 Conclusion

The purpose of this chapter was to examine how collaborative institutions for drought management can be developed and supported. The case study demonstrates that significant changes were made to drought response and management on the basin level and that these changes supported more coordinated response. For example, new protocols guide basin-oriented drought response with stakeholder-negotiated monitoring tools, triggers, and corresponding actions. The new basin-level drought management groups provide a means through which collective drought monitoring and decision-making can occur. These new tools represent innovations for drought management, however, they represent only the formal components of institutions that shape decisions and which actions are implemented.

The case study highlights the importance of refining how we think about institutions and the ways in which formal and informal institutions reinforce one another. In the Carolinas, the implementation of new formal drought laws, decision-making processes, and organizational arrangements was most effective when there was concomitant change to the informal institutions that govern collective practices and understandings. In both the Yadkin-Pee Dee and Catawba-Wateree basins, the FERC relicensing processes contributed to learning about the water management challenges facing the each basin, the building of new relationships and networks among stakeholders, and the development of shared objectives in drought. However, findings also indicate differences in the extent and types of learning and informal institutions that emerged in the study basins. The significance of these differences was revealed in the relative effectiveness of drought response and management outcomes during the 2007-2008 drought.

For example, in the Catawba-Wateree relicensing process, social learning ultimately contributed to the successful implementation of the new protocols and cooperative agreements in 2007-2008, including the implementation and coordination of drought plans and water restrictions across the basin. In the Yadkin-Pee Dee basin, the resultant learning revealed that the adjustments made to hydropower operations were adequate to limit the severity and extent of drought impacts. Furthermore, the lack of need or incentive precluded any additional efforts to develop or implement a more coordinated or integrated approach to drought response in the basin.

This case study reinforces findings from other research that shows that resource management outcomes vary as resource users adjust to different contexts and incentives.

Furthermore, actors and organizations select particular actions based on configurations of individual preferences, formal rules, and social norms of behavior. As a result, different management strategies emerge as these formal and informal institutions interact and reinforce new behaviors and patterns of resource use (Agrawal et al. 2013).

These findings also have important implications for efforts to conduct drought planning and management at the watershed or river basin management. It is evident that different watershed or river basin collaborations will have diverse purposes, functions, and incentives for participation (Margerum, 2008). As such, it will be important to identify the specific problems to be addressed and the most effective mechanisms to address those problems. The experience of the water-rich Carolinas suggest that in basins where increasing water demands are threatening water supply capacities, such as the Catawba-Wateree, adaptations involving broad-scale systemic changes will be required to address drought and water resource vulnerabilities. In other basins, such as the Yadkin-Pee Dee, what might be considered incremental adjustments to existing drought management may be considered a more appropriate and feasible option by stakeholders. In either situation, decision makers and stakeholders at multiple levels should be prepared to take advantages of opportunities (e.g., increased awareness of water resources vulnerabilities due to extreme droughts, the FERC relicensing process) that will help to facilitate a range of learning processes and support future changes and improvements to water and drought management (Young, 2010).

4.10 Tables

Table 4.1 State and water system populations, 2008

		NC	SC
# of Community Water Systems (total)		2136	623
Population Served by Community Water Systems		7,140,116	3,730,888
Percentage of Total State Population		77.4%	83.3%
Primary Water Source			
Ground Water (total)	# of Systems	1716	416
	Population Served	1,620,673	544,984
Surface Water (total)	# of Systems	420	342
	Population Served	5,519,443	3,185,904
Surface Water	# of Systems	128	50
	Population Served	4,663,656	1,979,469
Purchased Surface Water	# of Systems	292	292
	Population Served	855,787	1,206,435
State Population (2008 estimate)		9,222,414	4,479,800
State Population, percent change (April 1, 2000 to July 1, 2008)		14.6%	11.7%
Sources: Environmental Protection Agency, 2008; U.S. Census Bureau, 2009ab			

Table 4.2 FERC-licensed projects in the Catawba-Wateree and Yadkin-Pee Dee Basins

River basin and licensee	Project name	Estimated storage capacity (acre-feet)	State	Year built/ operations started
Catawba-Wateree	Wylie	229,200	SC	1904
• Duke Energy	Great Falls	1,700	SC	1907
	Rocky Creek	7,900	SC	1909
	Lookout Shoals	25,000	NC	1915
	Fishing Creek	48,800	SC	1916
	Wateree	183,860	SC	1920
	James	275,300	NC	1923
	Dearborn[1]	-	SC	1923
	Mountain Island Lake	57,300	NC	1924
	Rhodhiss	46,500	NC	1925
	Cedar Creek[2]	-	SC	1926
	Hickory	103,300	NC	1927
	Norman	1,093,600	NC	1963
Yadkin-Pee Dee				
• APGI	Narrows/Badin Lake	129,100	NC	1917
	High Rock	217,400	NC	1919
	Falls	760	NC	1927
	Tuckertown	6,700	NC	1962
• Progress Energy	Blewett Falls	30,893	NC	1912
	Tillery	84,150	NC	1928
Sources: Alcoa Power Generating Inc., 2006a; Duke Energy Corporation, 2003; Progress Energy, 2006a				

[1] Included with Great Falls project
[2] Included with Rocky Creek project

Table 4.3 Stakeholders in the FERC relicensing process

Stakeholder Groups	Water Management Role or Interests	Intersection with Drought Management	Level of Action				
			Local	Region	Basin	State	Federal
Regulatory Organizations: monitor and enforce compliance with water-related regulations							
Federal Energy Regulatory Commission (FERC)	Authority for issuing licenses and providing oversight for hydropower projects	Ensure compliance with other federal and state requirements (e.g., water quality, environmental protection)			•		•
Water and Environmental Quality Agencies	Permitting authority for discharges, drinking water quality	Monitor and communicate water quality conditions	•		•	•	
Wildlife Agencies	Protect environmental resources	Monitor impacts of drought on endangered species, habitats			•	•	•
Army Corps of Engineers	Permitting authority for projects with potential to interfere with navigation	Even in drought emergencies, water system construction projects must be permitted	•		•		•
Water Users and Interest Groups							
Local government	Planning and development: land use policies, building and construction codes	Policies, ordinances, and codes shape the extent and patterns of local water consumption	•				
Industry	Water use for industrial processes	Must adhere to permit requirements, low flows may impair ability to discharge wastewater	•				
NGOs	Environment, recreation, stakeholder participation	Water supply and/or quality impacts as they relate to group's interest	•	•	•	•	•
Lake Organizations	Recreation, property owners' interests	Impacts to lake levels, safety, aesthetics	•	•			
Residential and Business Customers	Availability of plentiful and clean water supplies	Impacts to water use when drought ordinances are enacted and enforced	•	•			
Assistance and Support Organizations							
USGS	Hydrological data, information, monitoring, research		•		•	•	•
Councils of Government	Planning, management assistance		•	•			
Consulting Firms	Engineering, technical, and water planning assistance to water systems		•		•		
Member Organizations	Water Systems: Technical information, professional support and advocacy Local Government: Legislative support and advocacy, education about governance issues		•			•	

Table 4.4 Community water systems in the Catawba-Wateree and Yadkin-Pee Dee Basins

Basin and State		
Catawba-Wateree	**Systems that withdraw from Duke Energy project boundaries**[3]	
• North Carolina	Belmont	
	Charlotte-Mecklenburg Utility Department	
	Gastonia	
	Granite Falls	
	Hickory	
	Lenoir	
	Lincoln County	
	Mooresville	
	Morganton	
	Mount Holly	
	Statesville[4]	
	Union County (Catawba River Water Treatment Plant)	
	Valdese	
• South Carolina	Camden	
	Chester	
	Lancaster County (Catawba River Water Treatment Plant)	
	Lugoff-Elgin	
	Rock Hill	
Yadkin-Pee Dee	**Systems that withdraw from project boundaries**	**Upstream systems**
• North Carolina	Albemarle (APGI)	Davidson Water (private)
	Anson County (Progress Energy)	Davie County
	Denton (APGI)	King
	Montgomery County (Progress Energy)	North Wilkesboro
	Norwood (Progress Energy)	Wilkesboro
	Salisbury (APGI)	Winston-Salem
• South Carolina	**Downstream systems, withdraw from river**	**Downstream systems, withdraw from tributaries**
	Bennettsville	Georgetown County
	Cheraw	Grand Strand Water and Sewer Authority
	Florence	Myrtle Beach
	Georgetown[5]	North Myrtle Beach

[3] Concord obtained an interbasin transfer from the Catawba-Wateree after the study period, currently follows the CW LIP

[4] obtains water through interbasin transfer

[5] obtains water through interbasin transfer

Table 4.5 Basin-level drought management meeting summary and list of members

	Catawba-Wateree	Yadkin-Pee Dee
Total # of meetings	33	34
Total # of different meeting participants	45	22
Total # of CW DMAG or YPD DMT members	40	10
Total # of CW DMAG or YPD DMT members who participated in meetings or calls	31	10
Total # of meeting participants who were not members of the CW DMAG or YPD DMT	14	11

Catawba-Wateree DMAG Members	
American & Efird	Duke Energy
Bessemer City	International Paper
Bowater	Invista
Catawba River WTP	Lincoln County
Charlotte Mecklenburg Utilities	Lugoff-Elgin Water Authority
Chester Metropolitan District	NCDWQ
City of Belmont	NCDWR
City of Camden	NCWRC
City of Cherryville	SCANA
City of Gastonia	SCDHEC
City of Hickory	SCDNR
City of Lenoir	Siemens Westinghouse
City of Lincolnton	Springs Industries
City of Marion	The Greens of Rock Hill
City of Morganton	Town of Dallas
City of Mount Holly	Town of Granite Falls
City of Newton	Town of Longview
City of Rock Hill	Town of Mooresville
City of Statesville	Town of Valdese
Clariant Corporation	USGS

Yadkin-Pee Dee DMT Members	
APGI	Progress Energy
Duke-Buck Steam Station	USFWS
High Rock Lake Association	

Members of both the CW DMAG and the YPD DMT	
NC DWQ	SC DHEC
NC DWR	SC DNR
NC WRC	

Table 4.6 Basin-level drought management meetings, 2007-2009

Catawba-Wateree			
Year	**Month**	**Day**	**Type**
2007	September	4	call
2007	September	11	call
2007	September	18	call
2007	September	25	call
2007	October	2	call
2007	October	11	meeting
2007	October	16	call
2007	October	23	call
2007	October	30	meeting
2007	November	13	call
2007	November	27	meeting
2007	December	12	meeting
2008	January	9	call
2008	January	15	meeting
2008	February	13	meeting
2008	April	1	meeting
2008	April	17	meeting
2008	May	20	meeting
2008	June	25	meeting
2008	July	10	call
2008	July	31	meeting
2008	August	13	call
2008	August	26	meeting
2008	September	24	meeting
2008	November	24	call
2008	December	18	call
2009	January	28	call
2009	February	25	call
2009	March	25	call
2009	April	7	call
2009	May	7	meeting
2009	June	8	call
2009	September	8	call
Totals: 33 Events (19 calls, 14 meetings)			

Yadkin-Pee Dee			
Year	**Month**	**Day**	**Type**
2007	June	29	call
2007	August	22	call
2007	August	30	meeting
2007	September	6	call
2007	September	13	call
2007	September	20	call
2007	September	25	call
2007	October	4	call
2007	October	10	call
2007	October	18	call
2007	October	25	call
2007	November	1	call
2007	November	8	call
2007	November	15	call
2007	November	29	call
2007	December	6	call
2007	December	13	call
2008	January	3	call
2008	February	7	call
2008	March	6	call
2008	April	3	call
2008	May	1	call
2008	June	5	call
2008	June	19	call
2008	July	3	call
2008	July	17	call
2008	July	31	call
2008	August	14	call
2008	August	28	call
2008	September	11	call
2008	October	9	call
2009	March	5	call
2009	October	1	call
2009	November	12	call
Totals: 34 Events (33 calls, 1 meeting)			

CHAPTER 5

CONCLUSION

This chapter provides a synthesis of the major findings of this dissertation, focusing on how an improved understanding of institutions and the interplay across levels can be used to shape and inform drought adaptations. The author then suggests some implications for drought policy, planning, and management. Then, the author discusses several observations and reflections to highlight relevant insights and contributions to climate adaptation research from this case study. The chapter concludes with recommendations for future research.

5.1 Synthesis of Findings

This research was motivated, in part, by practical concerns that society's capacity to cope with and prepare for drought needs to be improved. The challenges and needs are illustrated by the severity and extent of impacts, the persistent reactive approach to response, and limited capacity to coordinate or integrate with other planning or management processes in a proactive way. The myriad changes that will be necessary to support a risk management approach have been articulated in the literature. However, in practice, efforts often narrowly focus on technical and managerial solutions to addressing short-term risks, rather than examine whether the existing approaches sufficiently address the full range of current, and future, drought risks.

Research related to resource management, environmental governance, and climate adaptation has demonstrated the importance of institutions in shaping how different actors and organizations perceive and address climate risks. However, the drought research and planning community has not deeply engaged with questions regarding the institutional components of drought response, planning, and management. Attention centers primarily on the formal aspects of institutions, e.g., drought plans, water allocation systems, and organizational arrangements.

The central premise of this dissertation, supported by the case study findings, is that a more concerted attention focus on the informal components of drought-related institutions and the broader institutional context is also needed. Improved understanding of the complexities of the institutional environment can help to reveal which drought adaptations will be considered legitimate, appropriate, and feasible by diverse groups and identify the mechanisms through which institutional change might be supported in order to advance the adoption and implementation of new drought management strategies. Further insights are demonstrated in the individual dissertation chapters.

Chapter Two highlights how several shifts in drought management occurred during the study period and the types of institutional changes that were necessary to support new adaptations. Shifts in drought management included the expansion of new tools to secure and augment water supplies, adoption of customer-oriented and demand-side policies, the development and implementation of state and local drought response plans, and the establishment of basin-level protocols and organizations to guide drought monitoring and response. However, considerable diversity was evident in terms of the new strategies and tools adopted, particularly at the local level where the characteristics of place affected system thresholds, stresses, and opportunities to adapt.

This chapter demonstrates the importance of the underlying institutional framework in determining where and how new drought management strategies were ultimately implemented. Findings showed how the implementation of new strategies occurred only when the three institutional components (normative, cultural-cognitive, and normative) were in place. New strategies related to demand management, drought response, and basin-level cooperation all required a range of institutional changes. These changes included not only the more tangible tools (e.g., conservation programs, response plans) but also evolving perceptions of drought and water management, new attitudes about water use, and the reevaluation of the underlying norms and assumptions that inform drought policies at multiple scales.

Chapter Three demonstrates how multiple institutional logics, and interactions across different logics, affected the implementation and coordination of drought response planning efforts across the state and local levels. During the study period, state-level adaptation efforts focused on developing state processes for drought response, improving drought monitoring and communication of drought conditions, and providing technical assistance to local water systems and communities. Many communities and water systems adopted or updated drought response plans, but most efforts at the local level centered on enhancing their capacity to manage supply and demand, through measures such as upgrading infrastructure or improving system efficiencies. While the adaptations made during the study period did provide a more formal structure and process for drought response, the actual implementation of response actions (i.e., water use restrictions) was disjointed and not well-coordinated across the local and state-local landscapes.

This chapter reveals some of the practical challenges involved in introducing a new institutional logic into existing systems of managing and preparing for drought. Drought response plans (i.e., water restrictions) introduced a fundamentally different approach to drought and water management that was not easily reconciled on the local level, contributing to questions regarding the legitimacy of top-down structures for drought decision making. The 2007-2008 drought experience also exposed the tensions between certainty (e.g., the rules in response plans) and local autonomy to use system- and community-specific information and expertise to respond to drought conditions. In addition, the overall complexity of the institutional environment, and presence of intersecting institutional logics, narrowed the local decision space. This ultimately constrained the flexibility and ability of local water managers to consider and implement new proactive approaches to drought response. As a result, this study suggests that new strategies and tools need to assess how they fit with established institutional and organizational contexts.

Chapter Four highlights the importance of the interplay between the formal and informal dimensions of institutions in shaping the development of cross-scalar and collaborative drought management structures and processes. Adaptations in the two study basins (i.e., the Catawba-Wateree and Yadkin-Pee Dee) have contributed to increased stakeholder engagement in decision making, more coordinated response, and collective approaches to drought management in those basins. These shifts occurred in conjunction with the stakeholder engagement opportunities provided by the FERC relicensing processes after the 1998-2002 drought. Changes included the development of formal tools (i.e., response protocols, drought management groups) and collective learning that enabled new relationships and understanding of drought issues. However, the actual implementation of the new plans and protocols in 2007-2008 revealed differences in the extent to which drought response is coordinated across the different levels of decision making in the two basins.

Study findings indicate different trajectories of institutional change in the study basins. These differences are attributable to the unique nature of risks and vulnerabilities in the two basins as well as the distinct social processes, relationships, collective understandings that evolved in the course of relicensing and in the subsequent response to the 2007-2008 drought. In the Catawba-Wateree, the relicensing process was designed to encourage ongoing dialogue among stakeholders across both states and provide opportunities for learning about the Catawba-Wateree as an integrated system. As a result social capital, trust, and "systems-thinking" emerged and could then be mobilized in 2007 when formal drought plans and protocols were implemented. In the Yadkin-Pee Dee, although the relicensing process did foster awareness of other stakeholders and interests in the basin, the extent to which the process has resulted in longer-term social learning appears to be limited. The value of relicensing was in its utilitarian function. Beyond the development of plans and protocols to ensure a balanced approach to drought response and adequate supplies for upstream and downstream water users, there was little need or incentive to participate in basin-level activities more deeply. These findings highlight the importance of more refined thinking the ways in which formal and informal institutions reinforce one another. In the Carolinas, new formal drought laws, decision-making processes, and organizational arrangements were implemented most effectively when there was concomitant change to the informal institutions that govern collective practices.

5.2 Implications for Drought Policy, Planning, and Management

It is well recognized and discussed in the drought planning and research community that a more proactive approach to drought management is needed to reduce the substantial adverse impacts of drought and to improve society's capacity to respond and prepare for drought events in a proactive manner. However, few studies have conducted in-depth analysis of the diverse processes through which drought adaptations occur. The author argues here that such analyses are necessary to improve understanding of how to develop the mechanisms and processes that will support a more proactive approach to drought management. This case study is particularly salient for water-rich regions, such as the southeastern United States, that have previously benefitted from abundant water supplies and operated under the assumption of stationarity. However, many such areas are now experiencing a variety of water resources stresses, stemming from population growth, increasing demands due to development, changing water quality conditions and requirements, and climate variability and change. The imperative for policy makers is to develop and facilitate processes that will enable water managers across multiple scales and levels to implement adaptations prior to drought, rather than waiting for a crisis or extreme event to occur.

Findings from the dissertation suggest ways that drought policy, planning, and management efforts could be enhanced and avoid reactive responses to future drought events. First, more attention and resources should be directed toward developing cross-scalar planning processes. Second, greater efforts to incorporating drought response and management into other are also warranted.

The case study demonstrates the importance of paying attention to the multiple scales of drought planning and management and how those efforts interact. In both North Carolina and South Carolina, the different state and local approaches to drought response and planning contributed to tensions within and across jurisdictions. Although stakeholder and public participation in drought plan development and implementation is considered "best practice," findings suggest that the extent to which affected entities have been involved in the drought planning processes is limited. A lack of representation in planning, legislative, and regulative processes appeared at both the state and local levels. Without such representation, the legitimacy of new plans was questioned and difficult to enforce.

The example of drought management in the Catawba-Wateree basin displays the value of processes such as FERC relicensing that engage multiple stakeholders and interests and sustains that engagement over an extended period of time. This process was valuable not only for the changes made to the formal aspects of water management and hydropower operations but also for the social learning that occurred. Social learning enabled stakeholders to take a longer-term and broader view of the basin's vulnerabilities and subsequently supported the capacity of communities and water systems in that basin to adopt more proactive drought measures. One implication of this outcome is that as drought response has been put into practice, new norms of behavior are emerging. Communities across the basin follow the same, basin-specific triggers, revealing a sense of shared responsibility for the impacts and risks associated with drought.

While the Catawba-Wateree might be considered a "success story" in this regard, it should be noted that these basin-specific triggers do not always or necessarily coincide with state or local triggers or drought declarations. Although drought response is coordinated within the Catawba-Wateree basin, state, basin, and local efforts to manage drought continue to be fragmented when considering the entire landscape of drought management. This case study therefore also indicates the value of incorporating drought response into broader water planning and management processes. For example, the drought experiences in North Carolina and South Carolina revealed the challenges of implementing new stand-alone drought plans, particularly when they were disconnected from traditional water management practices and other institutional demands on water resources.

The case study reinforces the assertion that no one panacea exists to resolve and mediate drought and drought-related risks. Even within the study area discussed in this dissertation, differences emerged in terms of the specifics of how each community, basin, or state responded to and managed drought, suggesting that a multi-pronged approach to improving drought response and management will be most appropriate. For example, there are many existing management and planning processes through which federal, state, and local policy makers could incentivize or require the integration of drought into those processes. In North Carolina and South Carolina, ongoing water basin modeling and planning efforts by the states do represent an important change in state-level water management and can be attributed to learning gained from the recent droughts. Furthermore, they can be a significant mechanism for addressing both the short-term risks associated with drought events as well as building longer-term resilience by addressing the challenges associated with social, environmental, and climate changes.

Meanwhile, it will also be important to support regional and local initiatives, such as comprehensive plans and hazard mitigation programs, to ensure that drought response and planning connect to efforts that are salient and relevant to local water managers and to the communities to which they provide water and wastewater services. Such efforts will require the support and involvement of the policy communities, professional associations, and other networks that work in those fields. Although the United States lacks a national drought policy, national-level drought programs such as NIDIS can help build state-, basin-, and local-level capacities and commitment to implement more proactive strategies by engaging in a more focused manner with a variety of sectors and decision makers to identify the most effective mechanisms for addressing drought risks and identifying the potential thresholds at which transformational change needs to occur.

5.3 Contributions and Insights for Climate Adaptation Research

This dissertation research was motivated not only by drought management needs but also by questions identified in climate adaptation and institutional literature. While foundational work shows that institutions matter, more research is needed to understand the mechanisms through which institutions change, how they change, and how those changes can support society's efforts to respond to emerging conditions and stresses. This is a particularly salient question for climate change adaptation, as it is expected that the impacts and associated challenges will require fundamental shifts in our existing approaches to managing climate risks and vulnerabilities.

In Chapter 1, the dissertation explores what it means to be "drought resilient," highlighting how the appropriate institutional framework must be in place to enable and facilitate transformational change. As in other sectors, the predominant use of the term “resilience” has contributed to drought planning and management approaches that focus on immediate and localized risks rather than the broader, and institutional, sources of vulnerability. Many drought adaptations were initiated during the study period, helping to build adaptive capacity across the two states. However, existing institutional structures continue to frame drought planning, particularly at the local level. Consequently, while some expect such drought “crises” to drive transformational change, many adaptations came from a suite of familiar practices, and fewer represent what might be considered innovational or fundamental change.

The severe drought pressures resulted in transformational change in only two of the drought management adaptations, and this type of change required specific institutional innovations for support. These strategies include the coordination of drought response in the Catawba-Wateree and community-level efforts to reduce overall water demand. The entities that demonstrated these changes shared some common characteristics. First, interviewees from organizations involved in these changes noted that fundamentally different approaches to drought management were necessary as their systems were approaching thresholds at which existing strategies would not continue to mitigate drought risks and impacts. Second, one of the primary barriers to implementation of new approaches was not necessarily related to having appropriate data, information, or technical tools. On an operational level, individual resource managers were keenly aware of the vulnerabilities of their systems. The greater challenge was in increasing public awareness of the problem and building the broader institutional capacity to support new strategies for water and drought management. Study findings reinforce the idea that developing resilience will require longer timeframes and processes that entail the adoption of different beliefs and values, gradual shifts in behaviors, and questioning of the status quo and existing relationships.

However, expanding these transformational changes and institutional innovations across the broader landscape will be difficult. For example, the case study also demonstrates how reducing overall water use counters local governments' traditional methods of conducting business. On the basin-level, coordination and collaboration required that individual organizations and jurisdictions give up some authority and autonomy over drought decision making to an external group. The implication is that a range of capacities and types of resilience will likely persist without incentives or crises, such as the approaching of system thresholds, to adopt new management approaches. It also suggests that within a crisis period, the implementation of new rules and practices provides an additional opportunity to build the commitment to new approaches.

Chapters 2 and 3 highlight the importance of "institutionalization," or the process through which new values, norms, and ideas are integrated into drought response, planning, and management. Institutionalization entails not only the adoption of formal rules and policies, but also the implementation of those rules and policies. It is through practice that changes and innovations are reinforced and become standard, routine, or expected by the actors involved.

For example, in the study basins, participation in the FERC relicensing processes increased stakeholders' knowledge of water resources issues and drought vulnerabilities which subsequently contributed to the development of formal protocols to guide drought response. This shared learning then enabled decision makers to put basin-level planning into action in 2007-2008. However, as the experiences of the 2007-2008 drought also indicated, implementation of new policies may expose contradictions and inconsistencies with existing approaches. These findings suggest that climate adaptations involving broad-scale systemic changes and innovation will require that the appropriate institutional framework (both the formal and informal components) and capacities needs to be in place. An enabling framework is necessary to support not only the adoption, but also the implementation, of new strategies.

5.3 Future Research Directions

Findings from this study suggest that the topic of institutional complexity will need to be addressed in drought planning and research in order to facilitate the implementation of proactive strategies and coordination of existing practices that vary considerably across spatial and temporal scales, political jurisdictions, and different management levels. Two areas of inquiry could support progress in improving understanding of adaptation processes as well as in the applications of drought planning and management.

The first line of inquiry would investigate further what it means to be "drought resilient." Specific to the Carolinas, while the drought management landscape has expanded, suggesting that the capacity to cope with drought has increased, an interrogation of how new strategies and tools contribute to long-term resilience is warranted. By only focusing on specific threats and managing for stability, water systems may be less resilient in the long-term if they are not also developing the capacity and flexibility to adapt to emerging challenges and changing conditions. Future work should seek to identify and assess examples where framings of social-ecological resilience (rather than "engineering resilience") are used to inform longer-term perspective on water resources and drought issues. Such work could also include in-depth analyses of future drought risks and consider how to incorporate such assessments into long-term drought planning processes. Such processes will be more likely to build greater institutional capacity and the ability to implement a broader suite of drought adaptations.

A second line of inquiry would examine further the institutional mechanisms and processes through which collaboration can be enabled and advanced. As demonstrated in Chapters 2 and 3, there are many barriers that constraint the effective coordination of drought response and planning across multiple scales and management levels. As drought continues to threaten extensive areas of the United States, a concerted focus on institutional issues will be necessary to better align national, state, and local policies and capacities. This research could also focus on formulating strategies to incorporate drought issues and risks into other sectors and planning processes, such as all-hazards and comprehensive community processes. Insights and findings from this type of endeavor could be a valuable interim step in identifying opportunities for, and informing, climate change adaptation.

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Appendix A

Semi-Structured Interview Questions

The following list of questions was used to guide semi-structured interviews with representatives from federal agencies, state agencies, non-profit organizations, community groups, regional planning organizations, consulting firms, and industry. Where appropriate, interviewees were asked to expand upon their answers.

Basic Information about the Interviewee and the Interviewee's Organization

- Describe your position and responsibilities with your organization.
- What are your/your organization's primary interests in water resources and drought management?
- How are you/your organization involved in water management?
- How are you/your organization involved in drought management?

2007-2008 Drought

- Describe what you/your organization view as the major impacts and management issues of the current (2007-2008) drought.
- What are the similarities or differences with the 1998-2002 drought? Please explain.

1998-2002 Drought

- What do you consider the major impacts? Which resources were most affected?
- Were any lessons learned as a result of the drought?
- If yes, please explain.

- Were any changes made or actions taken after the 1998-2002 drought to improve management of future droughts?
- If yes, please explain. Would you consider these efforts successful, based on the 2007-2008 drought experience? What factors contributed to success? If no, what were the barriers to successful development or implementation?

Interests in Weather and Climate/Weather- and Climate-related Information

- What weather and climatic events are of concern to your organization? Why?
- What weather- and climate-related information does your organization use? How, when, and for what purpose(s) is this information (including drought information) used? From what source(s) and how does your organization obtain this information?
- Are there any additional drought-related information or technologies that would benefit your organization?

FERC Relicensing

- Were you/your organization involved in the FERC relicensing processes? Which ones?
- What was your role or responsibility?
- What were your organization's major interests in FERC relicensing? Were those interests addressed in the relicensing process? Successfully or unsuccessfully?
- What did you/your organization learn about drought and drought-related issues through the relicensing process?
- What did you/your organization learn about broader basin-wide (water, environmental) issues through the relicensing process?
- In your opinion, how effective have basin-level activities been in 2007-2008?

- What does your organization consider to be the advantages and disadvantages of the Low Inflow Protocol (LIP)/Drought Contingency Plan (DCP)? Does the LIP/DCP conflict with other regulations, policies, or practices already in place in your organization?

Concluding Thoughts about Water Resources and Drought Management

- What do you/your organization consider to be the most significant pressures and factors (positive or negative) influencing water resources management in your state (South Carolina, North Carolina), and your basin?
- What do you/your organization consider to be the most significant drought-related issues?
- What additional actions or measures would you recommend to improve water managers' ability to deal with this or future droughts?

Other

- Could you recommend other managers who might have a different perspective?
- Who else do you/your organization work with on a regular basis, for example, municipalities, other downstream users, state agencies, federal agencies? What are the most important relationships for you/your organization in terms of water or drought management?

APPENDIX B

INTERVIEW QUESTIONS FOR WATER SYSTEM MANAGERS

The following list of questions was used to guide interviews with public water system managers and other local officials. Where appropriate, the interviewees were asked to expand upon their answers.

Background Information

- Water system name
- Municipality/county
- Basin and/or sub-basin
- State
- Interviewee name
- Position
- How long have you worked with the water system or organization?
- How long have you worked in this position?
- Which of these does your system manage? Water, water/wastewater (including storm water), other (please specify)?
- What is your primary source of water?
- Where are system intakes located?
- If you have one, what is your secondary source?
- Do you have interconnections with other systems?

- If yes, with what systems and what is the purpose of the interconnection?
- What is your system's daily average withdrawal? In millions of gallons per day (mgd)?
- How many connections/customers are in your system?
- What is the (residential) population that your system serves?
- What percentage of your water goes to the following user groups? Residential, industrial, commercial, institutional, other (please specify)?

Drought Impacts and Response

- **2007-08 drought**
  - Has your system, municipality, or county experienced problems during the 2007-2008 drought?
  - If yes, specify the problems your system, municipality, or county has experienced and how you/your organization responded.
    - <u>Prompts</u>: financial, water supply, meeting water quality standards, wastewater discharge restrictions, declining groundwater levels, conflicts among users, saltwater intrusion
- **1998-2002 drought**
  - Did your system, municipality, or county experience problems during the 1998-2002 drought?
  - If yes, specify the problems your system, municipality, or county experienced and how you/your organization responded.

- Prompts: financial, water supply, meeting water quality standards, wastewater discharge restrictions, declining groundwater levels, conflicts among users, saltwater intrusion

- **Comparison of the 2007-2008 and 1998-2002 droughts**
    - Describe any differences or similarities between the two droughts as experienced by your system, municipality, or county.

Adaptations and Adaptive Capacity

- **After the 2002 drought, what actions did your system, municipality, or county take to improve drought management?**
    - Prompts: develop drought management and/or water shortage plan(s), promote changes in local ordinances, conduct vulnerability assessments or plans, develop new water supplies, develop new infrastructure, promote public awareness and education, develop water conservation programs, improve drought monitoring, seek new data and sources of information, pursue financial support for new programs or infrastructure, increase water rates or change rate structure, change organization's approach to water management, seek community involvement in water policy and management decisions, participate in regional planning and management efforts
- **What actions has your system, municipality, or county taken, or is considering, as a result of the 2007-2008 drought?**
    - Prompts: develop drought management and/or water shortage plan(s), promote changes in local ordinances, conduct vulnerability assessments or plans, develop new water supplies, develop new infrastructure, promote public awareness and

education, develop water conservation programs, improve drought monitoring, seek new data and sources of information, pursue financial support for new programs or infrastructure, increase water rates or change rate structure, change organization's approach to water management, seek community involvement in water policy and management decisions, participate in regional planning and management efforts

- **Can you identify any positive attributes, or assets, of your system, municipality, or county that have facilitated the drought management actions just discussed?**
  - Prompts: finances, funding; information and knowledge about drought; technologies, monitoring tools, communication networks; population and demographic changes; economic status, growth and development; public and/or political support, other community characteristics or concerns; laws, regulations; social capital, existing organizations and networks
- **Can you identify negative attributes of your system, municipality, or county that have constrained or hampered drought management actions?**
  - Prompts: finances, funding; information and knowledge about drought; technologies, monitoring tools, communication networks; population and demographic changes; economic status, growth and development; public and/or political support, other community characteristics or concerns; laws, regulations; social capital, existing organizations and networks
- **What have you, or your system, municipality, or county learned from these drought experiences?**

Use of Drought Information

- **What information does your system, municipality, or county use to monitor drought conditions?**
  - Prompts: drought indices, U.S. Drought Monitor, streamflow, precipitation, lake or reservoir levels, groundwater levels, local indicators, state declarations
- **On what basis does your system, municipality, or county decide to implement water use restrictions? What indicators do you use?**
  - Prompts: drought indices, U.S. Drought Monitor, streamflow, precipitation, lake or reservoir levels, groundwater levels, local indicators, state declarations
- **From what sources does your system, municipality, or county obtain drought-related information?**
  - Prompts:
    - Federal agencies and sources (USGS, NOAA, National Weather Service, U.S. Drought Monitor)
    - State agencies (NC DENR Divisions of Water Quality, Water Resources; NC Drought Management Advisory Council; NC State Climate Office; SC DHEC Bureau of Water; SC DNR Hydrology Section, State Climatology Office)
    - Dam operators (APGI, Duke Energy, Progress Energy)
    - Professional organizations (AWWA, Rural Water Association)
    - Regional government and planning organizations
    - Water utility director
    - TV, radio

Participation in, and learning from, regional and/or basin-related activities

- **FERC Relicensing**
  - Did your system, municipality, or county participate in a FERC dam relicensing process?
  - If no, please explain why your system, municipality, or county did not participate. (If no, go to next section.)
  - If yes, in which process(es) did your system, municipality, or county participate? (APGI, Duke Power, Progress Energy)
  - How would you describe your system's, municipality's, or county's attendance at relicensing meetings?
    - Prompts: always attended, usually attended, attended about half the time, rarely attended, never attended
  - How would you describe the importance of the relicensing process to your system, municipality, or county?
    - Prompts: very important, important, moderately important, of little importance, unimportant
  - What were your system's, municipality's, or county's major interests in relicensing? If possible, please rank your top 3, with 1 being the most important.
    - Prompts: water quality, water supply, flood control, recreation, economic impacts, improved coordination and balance among resource users, shoreline management, cultural resources, dam operations, low inflow management, fish and wildlife, public information and safety

- In which advisory, resource, or technical groups did you (or your system, municipality, or county) participate?
- Did you (or your system, municipality, or county) sign the final license agreement?
- How successful was the process in meeting system's, municipality's, or county's interests? Please explain.
- To what extent do you agree or disagree with the following statements? (strongly agree, somewhat agree, neither agree or disagree, somewhat disagree, strongly disagree) Participating in the FERC dam relicensing process has given your system, municipality, or county:
  - New long-term relationships with other stakeholders. If agree, with whom?
  - A better understanding of other stakeholders' perspectives. If agree, provide example(s).
  - A better understanding of the physical or biological processes in watershed. If agree, provide example(s).
  - New information or insights that have led to water policy and/or management changes in your system, municipality, or county. If agree, provide example(s).
- The Low Inflow Protocol (LIP) is a new component of the operating licenses developed during the relicensing process. The LIPs establish procedures for adjusting dam operations and water withdrawals during periods of low flow or drought. To what extent do you agree or disagree with the following statements? (strongly agree, somewhat agree, neither agree or disagree, somewhat disagree, strongly disagree)

        - Developing a Low Inflow Protocol was an important component of the FERC dam relicensing process.
        - The LIP has changed, or will change, how water resources are managed during drought by my system, municipality, or county. If agree, provide example(s).
        - The Low Inflow Protocol benefits my system, municipality, or county. If agree, provide example(s).
        - The LIP conflicts with other regulations, policies, or practices already in place in my system, municipality, or county. If agree, provide example(s).
    - Please share other comments or observations you have regarding the FERC relicensing process or the LIP.

- **Participation in other regional or basin-level activities**
    - In what regional or basin-related water and/or drought management activities do you or your system, municipality, or county currently participate? (If none, go to "Additional Information" section.)
    - How would you describe the importance of such activities to your system, municipality, or county?
        - <u>Prompts</u>: very important, important, moderately important, of little importance, unimportant
    - Please explain the purpose or objectives of participation.
        - <u>Prompts</u>: information, water supply and infrastructure, networking
    - How successful is your system, municipality, or county in meeting these objectives? (very successful, somewhat successful, not successful) Please explain.

- What have you/your organization learned from participation in such activities?

Additional Information

- What are the primary concerns and needs (outside of drought) currently facing your system, municipality, or county? Rank the three most pressing issues, and if applicable, describe the proposed or actual actions taken to date.
- Does your organization have planning documents or reports relevant to drought, or other related water resources or climate issues?
- If yes, please specify if and how they can be made available to the researcher.

APPENDIX C

CONSENT FORM FOR INTERVIEWEES

The following information was provided to individuals prior to their participation in an interview.

Doctoral Dissertation Research:

Institutional Adaptation and Drought Management in the Carolinas

Investigator: Kirsten Lackstrom, Ph.D. Candidate, University of South Carolina

Introduction

The aim of this dissertation research is to examine how diverse water resources stakeholders in North and South Carolina have adapted to drought risks and are developing new and innovative strategies to improve responses to and management of future droughts. You are being asked to participate in this study due to your role as a decision-maker and/or water resources stakeholder. Please read this form carefully and ask the researcher about any questions or concerns you might have related to this study before you decide whether or not to participate. A copy of this consent form will be provided to you for your records. If you would like, the researcher will provide you with a final project report detailing the study findings at the completion of the research.

Purpose of Study

The researcher will use the 1998-2002 drought and the dam relicensing processes in the Catawba-Wateree and Yadkin-Pee Dee River basins as a starting point from which to examine the evolution of drought management across the Carolinas. The researcher seeks to investigate the measures taken by local-, basin-, and state-level decision-makers and the purpose(s) or driving factor(s) behind these measures; the scientific and/or technical information used by decision-makers to manage drought; the collective efforts to improve drought management and response; and, the role of learning in affecting changes in drought management.

This research project will advance understanding of decision-makers' needs for climate- and drought-related data and technical support and will illuminate the barriers to and incentives for efforts to improve drought coordination across local-, basin-, and state-boundaries.

Study Procedures

You will be asked to participate in an approximately 30- to 90-minute interview which will be recorded and transcribed by the researcher. Follow-up questions required for clarification or elaboration of information will be conducted via telephone or email.

Confidentiality of Records and Risks of Participation

The results of this research study, including statements made by interviewees, may be presented at meetings or in publications. The researcher expects that the information you provide will not differ greatly from your actions and viewpoints already made in the public arena. Every effort will be made to represent your viewpoint accurately. However, due to the small number (40) of interview participants in the Catawba-Wateree and Yadkin-Pee Dee basins, as well as the nature of the information to be collected, you may have social concerns regarding participation if your statements deviate from previous actions and statements. To reduce the risk that such statements will be directly attributable to you, the researcher will summarize such statements, limit the use of direct quotations, and make every effort not to include potentially identifiable information.

Voluntary Participation

Participation in this study is completely voluntary. You may choose not to participate in this study or opt out at any time. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner and will not be used in the final study.

Contact Persons

For more information about this research, please contact: Kirsten Lackstrom, Department of Geography, University of South Carolina, Columbia, SC 29208, 803-777-5235 or 803-315-3156, lackstro@mailbox.sc.edu; or Dr. Kirstin Dow, Department of Geography, 803-777-2482, kdow@sc.edu.

If you have questions about your rights as a study participant, please contact: Tom Coggins, Office of Research Compliance, University of South Carolina, Columbia, SC 29208, 803-777-7093.

APPENDIX D

CODING CATEGORIES FOR DATA ANALYSIS

The categories used to code and analyze data obtained through interviews, observation of drought and water management meetings, and document review are provided below.

<table>
<tr><th colspan="3">Drought Adaptation Processes</th></tr>
<tr><th colspan="2">Coding categories</th><th>Descriptions and examples</th></tr>
<tr><td rowspan="3">Trigger mechanism</td><td>Drought-specific impacts</td><td>• Water supply
• Raw water quality
• Financial concerns
• Conflicts across users
• Wastewater
• Meeting demand</td></tr>
<tr><td>Other stresses</td><td>• Growth and development
• Broader economic conditions
• Water supply or quality concerns
• Environmental concerns</td></tr>
<tr><td>Opportunities</td><td>• FERC Relicensing
• Public awareness and support</td></tr>
<tr><td rowspan="6">Intent of adaptation</td><td>Coping</td><td>• Address and ameliorate the immediate impacts created by drought conditions</td></tr>
<tr><td>Reduce vulnerability</td><td>• Prevent impacts</td></tr>
<tr><td>Improve coping capacity</td><td>• Improve the ability to manage future drought events</td></tr>
<tr><td>Improve adaptive capacity</td><td>• Changes to system attributes to improve the ability to manage and/or adapt to future drought hazards
• Changes to system attributes to improve the ability to manage and/or adapt to other stresses</td></tr>
<tr><td>Collective action</td><td>• Balance losses by sharing risks and impacts</td></tr>
<tr><td>Opportunities</td><td>• Take advantage of positive opportunities</td></tr>
</table>

Drought Adaptation Processes (continued)		
Coding categories		**Descriptions and examples**
Form(s) of adaptation and adaptation assets	Material resources and infrastructure	• Access to normal and emergency supply • Physical assets (dams, reservoirs, water treatment plants, distribution systems) • Infrastructure status (age, capacity to meet current and future demand)
	Economic and financial resources	• Economic health and vitality of individual communities or water systems • Availability of grants, loans • Financial incentives for proactive drought management • Rates and rate structures that generate adequate revenues
	Information and technology	• Access to and use of appropriate, state-of-the-art technologies to treat and distribute water, monitor water use and improve efficiency • Availability of drought monitoring systems • Access to data and information • Tools and technologies that facilitate communication and information networks
	Human capital	• Knowledge, expertise, skills of water managers • Risk perceptions and awareness of drought of elected officials, public, water customers • Knowledge and type of expertise used in drought decisions (scientific, technical, managerial, local)
	Social capital	• Networks and relationships that facilitate interactions across stakeholders • Incentives for participation in social networks • Trust
	Political capital (drought governance structures)	• Accessibility and accountability of drought decision-making processes • Participation in decision making • Legitimacy and fairness of management decisions • Public and political support • Leadership
	Institutional capacity	• Existence, use of drought response plans, protocols • Best practices of drought management • Ability and willingness to adopt innovations • Institutional arrangements that cross scales, levels

Drought Adaptation Processes (continued)		
Coding categories		**Descriptions and examples**
Adaptation pathways	Organizational change	• Decision makers make changes to improve their system's effectiveness, functions, abilities
	Planned adaptation	• Stakeholders make adaptation decisions through formal, analytic-deliberative, planning processes
	Adoption of innovation	• Occurs as stakeholders produce and acquire new data and information, gain access to new technologies, and develop the capacity to use and incorporate that information into drought management practices
	Institutional adaptation	• Occurs as stakeholders: • 1) introduce and implement new institutions in terms of changes to laws, regulations, protocols, organizational agreements • 2) reconfigure water resource and drought management through changes in social practice and to the dominant norms and understandings that underpin rules and practices
	Political process	• Stakeholders make adaptation decisions through political processes characterized by conflicts, contestations, and negotiations over resource management and drought risk-sharing issues
Type and extent of change	Incremental change	• Adjustments in routines and activities • Changes occur within existing rules and procedures
	Transformational change	• Changes reflect examination of the underlying conditions, behaviors, or assumptions that created problems or concerns in the first place • Adaptation actions integrate new practices, procedures, or values
	Social learning	• Occurs as stakeholders engage in collective decision-making and management processes • Learning goals include 1) producing shared knowledge about the physical or natural resource and social processes and 2) integrating that knowledge into the management and/or governance of social and ecological systems • Social learning is characterized by the development of shared perceptions of problems, recognition of mutual dependencies and interactions, new stakeholder relationships, ongoing group participation and collaboration

Drought Management Institutions		
Coding categories		**Descriptions and examples**
Degree of formality or informality	"Rules-on-paper"	• Sanctioned and enforced laws, rights, constitutions • Public or private organizational arrangement
	"Rules-in-use"	• Routines, standard operating procedures, habits • Shared customs and understandings
Type of incentive provided	"Logic of consequences"	• Actors behave based on a utilitarian determination of costs and benefits
	"Logic of appropriateness"	• Actors behave based on what is considered fair, just, legitimate, socially acceptable
How are roles and interactions reinforced	Regulatory institutions	• Prescribe or prohibit certain behaviors • Establish resource rights and allocation systems
	Procedural institutions	• Provide forums for collective decision-making or conflict resolution
	Generative institutions	• Promote shared norms, understandings, and practices
Institutional Interactions		
Coding categories		**Descriptions**
Institutional components of drought management strategies	Regulative	• Formal legal structures, regulatory frameworks • Serve an administrative function by providing explicit rules, e.g., for allocating and monitoring resources and enforcing compliance
	Normative	• Dominant and overarching values and norms that establish which behaviors and actions are considered fair, legitimate, and desirable to pursue management goals and objectives
	Cultural-cognitive	• Ideas and understandings about "best practices" • Knowledge frameworks, mental models, and types of expertise used to formulate problems and solutions • Includes technologies, routines, material objects, symbolic systems
Factors influencing information use	Credibility	• Scientific, technical adequacy of available data
	Salience	• Information is relevant to the needs of decision makers
	Legitimacy	• Information is perceived as unbiased, fair and has considered stakeholder beliefs and values
Institutional interactions and challenges	Scale	• Environmental phenomena are assumed to occur, and to be best managed, at a single scale and decision making level. Scalar challenges occur when different management regimes that are produced through different institutional logics, values, and norms interact. • Solutions include efforts to overcome scale challenges, e.g., through communication or cooperative activities.

	Fit	• The extent to which a political jurisdiction or management authority matches the scale at which an environmental process or problem occurs • Challenges occur when the political jurisdiction or management authority conflicts with the scale at which an environmental process or problem occurs
	Interplay	• The extent to which the operation of one set of institutions affects the results of another • Horizontal interplay includes interactions across the same level of social organization • Vertical interplay entails interactions among different levels of social organization