Livestock production, water scarcity, and the potential for collaborative water governance in northwest Iowa

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Livestock production, water scarcity, and the potential for collaborative water governance in northwest Iowa

by

Maggie Norton

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Co-majors: Rural Sociology; Sustainable Agriculture

Program of Study Committee:
J. Gordon Arbuckle Jr., Major Professor
Carmen Bain
Kathleen Hunt

The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa

2019

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DEDICATION

This work is dedicated to my niece and others in her generation. With the experience I have been fortunate to gain over the past two years, I hope to contribute to a more equitable and resilient future for her and others.
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ACKNOWLEDGMENTS

Thank you to all the participants that picked up the phone or emailed me back! Without you, this research would not be possible. I am grateful you chose to generously share your time with J. and me. For those who met with us informally at the onset of the project – when we still thought irrigation was a ‘thing’ in Iowa – thank you for providing the insight needed to get us on the right track. To the DNR staff that spent copious amounts of time helping me interpret data or answer random questions, thank you. A big thank you to all the rural water systems and livestock associations who provided a springboard into the bulk of our in-depth interviews. Thank you to the service providers, municipal water systems, and processors who not only took the time to meet but welcomed me to tour your facilities. And thank you to the livestock producers who opened your homes to us. Unlike other stakeholder groups interviewed, your jobs and lives are inextricably intertwined – your livestock operations, production choices, and insights are both business and personal and I am deeply appreciative of your participation because of that.

I am also grateful for the support of my partner, family, friends, small-but-mighty cohort, and advisors over the past two years. For dealing with crankiness, missed texts, venting, and late submissions – thank you. For providing constructive feedback and encouragement, guidance in research, and championing my efforts – thank you. An additional thank you to the AFRI Minnesota team – working on this interdisciplinary project has been a valuable learning experience. And last, an acknowledgement of Ray Arritt – our greatly missed Iowa State AFRI counterpart, climate-model guide, and a fellow solitaire enthusiast.
ABSTRACT

After a severe drought in 2012, stakeholders in northwest Iowa (NW Iowa) began exploring strategies to increase the resiliency of the region’s groundwater resources and distribution systems. The lead actor in the effort, the Iowa Department of Natural Resources (DNR), uses an emerging collaborative governance approach to engage stakeholder groups. We conducted in-depth interviews to explore NW Iowa stakeholders’ perceptions of current and future water supplies, water beliefs, values, and behaviors, interactions with other stakeholders, and preferences for groundwater governance and management. A stakeholder analysis is employed to characterize stakeholder groups and their positions of influence, levels of interest, and patterns of communication with other stakeholder groups. A governance regime analysis then characterizes the four structural dimensions of the current governance system for comparison against a spectrum of governance regime ideal types. Our analysis identifies opportunities to form coalitions, raise awareness among less engaged stakeholders, and encourage social learning; decreasing the uncertainty in the system should be prioritized. We find that under circumstances of pervasive uncertainty and in the absence of effective governance institutions, stakeholders in NW Iowa have developed shared assumptions about groundwater resources to fill the institutional gaps. The assumptions are counter-productive to the collaborative governance effort and will require strategic attention to overcome.
CHAPTER 1. GENERAL INTRODUCTION

If we have a situation where the water dries up, there’s no way we’ll be able to truck enough water in for those animals, and no way to truck all of those animals out. If the water runs out, the public will ask the rural water systems, “Where's my water,” then they'll go to the state and say, “How could you let this happen?”

Chuck Gipp, Former Director, Iowa Department of Natural Resources

2018 Iowa Rural Water Association

The case study presented in this thesis is an exploration and analysis of developing collaborative governance efforts within a complex socio-ecological system (SES) in northwest Iowa (NW Iowa). In this SES, social systems including government agencies, water suppliers, and livestock producers interact interdependently with ecological systems critical for delivering ecosystem services such as water, food, and energy (Berkes and Folke 1998, Anderies et al. 2004). The specific set of interactions we explore revolve around the rising demand for groundwater from the livestock industry in NW Iowa, future water supply and climate projections for the region, and emerging groundwater governance efforts. Following a 2012 drought that disproportionately affected NW Iowa, the Iowa Department of Natural Resources (DNR) has engaged regional stakeholders and other government agencies to discuss drought planning and water system resiliency.

The primary incentive for drought and resiliency planning is centered around concern for animal welfare and potential mortality implications during future droughts.
Continued intensification of livestock production and consequent demand for rural water leading up to and since 2012 strain rural water systems’ distribution and treatment capacity (Hillacker 2012; Interview: RWS 10, 2018). Complicating matters, groundwater in NW Iowa is limited to two groundwater sources with divergent characteristics: shallow alluvial aquifers provide limited rechargeable quantities of typically high-quality groundwater whereas the deep Dakota cretaceous aquifer offers a large volume of poor-quality groundwater (Prior et al. 2003). The aquifers’ differences result in distinct management challenges, which are heightened by the effects of climate change. Climate change is an overarching influence that infiltrates both the social and ecological systems in NW Iowa.

Climate models predict an overall decrease in precipitation events in Iowa but an increase in event intensity, leading to increased flooding and potentially drought-susceptible landscapes (Pryor et al. 2014; Arritt 2016; Interview: GOV 06, 2019). Droughts with similar conditions to the 2012 event have historically occurred roughly once a decade but models indicate a slight increase to one every nine years (Arritt, n.d.). Increased magnitude and frequency of heat waves will negatively impact livestock and elevate water demand for cooling and hydration (Pryor et al. 2014). The biophysical systems that support livestock and grain production in NW Iowa will also be affected due to impacts on the region’s climate (e.g., precipitation for groundwater recharge, conditions for livestock husbandry and crop production, etc.) and hydrogeology (e.g., aquifer structure and recharge, groundwater quality, soil moisture, etc.).

Climate change introduces uncertainty into groundwater governance efforts. Modeling is inherently based on the understanding that climate data and predictive
capacity are limited and imperfect. When climate data requires contextualization or comprehension within a diverse collaboration, uncertainty is again introduced but manageable. The unavoidable uncertainty is embedded within Iowa’s climate future of more sporadic and localized extreme weather events (Interview: GOV 06, 2019). Research on the governance of groundwater and SESs indicate collaborative and adaptive governance approaches foster constructive management of uncertainty (Akamani 2016; Huijtema et al. 2009; Hurlbert and Gupta 2016; Pahl-Wostl 2011; Smidt et al. 2015). Groundwater professionals also recognize that the “barriers to agreeing upon a strategy to address many of the world’s thorniest water challenges are those related to the human dimensions” rather than technology or financing (Megdal 2018:2).

Research on the social dimensions of groundwater governance and management confirm that stakeholder engagement encouraging dialogue, learning, and action build beneficial human and social capital (Gerlack and Heikkila 2007; Huijtema et al. 2009; Stern and Baird 2015; Curtis et al. 2016). Human and social capital has been found to be foundational to a community’s resiliency and adaptability (Cundhill and Rodella 2012; Curtis et al. 2016). The growing number of case studies of groundwater governance also reveal insight about the pitfalls of collaborative and adaptive governance processes. Power asymmetries between actors, agency capture, and disagreements on the validity of technical data can derail collaboration (Krester et al. 2018; Running et al. 2019). A lack of shared vision and conflicting demands can also deteriorate relationships essential for productive collaboration (Solís 2005; Feldman 2008; Armstrong and Jackson-Smith 2017).
Case studies are useful to ascertain favorable or potentially harmful characteristics within the developing collaborative governance effort in NW Iowa; the application of which may be useful in the short term. To gauge and support long-term success of collaborative governance, a higher-level examination of the case is more appropriate. Identifying structural elements of a governance system and relationships to collaborative and adaptive momentum provides critical feedback for system improvement; though, this level of feedback is harder to action. Governance system structures that encourage and facilitate successful collaborative and adaptive groundwater management are still not well understood (Mitchell et al. 2012; Chaffin et al. 2014). More research is also needed to understand and identify drivers of leading actors’ capacity to experimentally manage and coordinate across multiple levels (Chaffin et al. 2014). After all, “resource management is a political process and the implementation of all policies is to some extent an experiment” (Pahl-Wostl 2009:355).

The emerging collaborative governance effort in NW Iowa is early in its development, presenting an opportunity to document the collaborative governance process as it progresses and compare observations from the onset of the effort to outcomes in later stages. The research questions guiding this exploratory case study attempt to reveal diverse perspectives on water beliefs, values, and behaviors, current and future water supplies, preferences for governance and management of groundwater resources, and structural features of the current governance system. We employ a stakeholder analysis (Chapter 2) and governance regime analysis (Chapter 3) of data collected through in-depth interviews and archival documents to explore these elements of the NW Iowa case study.
The stakeholder analysis in Chapter 2 explores and documents the functioning of early collaborative groundwater governance processes at the individual and group levels. The crux of the analysis asks, “How do stakeholder groups relate to the resource challenge and to one another?” The stakeholder analysis framework follows three steps: identify the stakeholders to determine context, categorize the stakeholders based on interest and influence typologies, and identify relationships linkage between groups (Reed et al. 2009). At the stakeholder analysis stage, emergent themes regarding stakeholder dynamics, decision-making processes, and limitations in awareness or knowledge become visible.

The governance regime analysis in Chapter 3 takes a wider view of the case study to understand how the collaborative governance effort functions on a structural level. Using a spectrum of ideal type governance regimes for evaluation, the analysis explores the question, “What are the characteristics of the existing governance system in NW Iowa and how do they conform, or not, to the three ideal types?” Comparing the structural dimensions of the case study to the ideal types enable some determination of strengths and weaknesses relative to the ‘Goldilocks’ regime, adaptive-and-integrative. The influence of uncertainty on governance also becomes recognizable at this level of engagement with the data.

Chapter 4 provides a synthesis of the two analyses, concluding remarks on the case study, and suggestions for future research. This research was funded by the USDA National Institute for Food and Agriculture, Agriculture and Food Research Initiative’s Water for Agriculture award. The research outlined in this thesis contributes to an interdisciplinary project with colleagues at the University of Minnesota to map future
groundwater use and climate predictions in the upper Midwest, explore agricultural stakeholders’ perceptions of risk and water behaviors, and co-create shared governance frameworks. Data analysis was conducted by Maggie Norton, a graduate student at Iowa State University under the advisement of J. Gordon Arbuckle Jr., Professor in the Department of Sociology at Iowa State University. The research received approval from the Institutional Review Board in 2017 (Appendix A).

References


CHAPTER 2. STAKEHOLDER ANALYSIS

INFORMING EQUITABLE COLLABORATIVE GOVERNANCE EFFORTS IN NORTHWEST IOWA

Abstract

A drought in 2012 pushed water suppliers and large water users to their limits in portions of northwest Iowa. The event exposed vulnerabilities pertaining to increased livestock numbers and lagging rural water system infrastructure. As private and public wells neared depletion, livestock producers struggled to provide daily minimum water requirements for their animals. Government agencies, rural water systems, and the agricultural community were compelled to address a rising concern for animal welfare. Fortunately, timely rains replenished the shallow alluvial aquifers and the crisis was averted. Since 2012, livestock production has continued to increase, and climate scientists predict another drought in the near to medium term. The Iowa Department of Natural Resources (DNR) has attempted to bring stakeholders together to develop collaborative water management strategies for the region, but with limited success. This paper uses a collaborative governance framing to understand the DNR’s ongoing efforts and a stakeholder analysis to characterize relevant stakeholders and their positions of influence, levels of interest, and patterns of communication with other stakeholder groups.

Introduction

In 2012, a drought impacted agricultural communities and stakeholders across Iowa. Though the drought was considered brief by state standards, it was an intense event. July of that year was the fourth hottest and fifth driest July in 140 years of state
climate records (Hillacker, 2012). Crops and pasture that year were generally rated the worst since 1989 and livestock producers experienced high feed costs and reduced weight gain from the excessive heat (Hillacker, 2012). Additionally, rural water systems, a major water supplier for livestock producers, experienced unprecedented pressure within their systems prompting concern for animal welfare. Some of the event's worst effects were concentrated in the northwest region of the state. This research uses a selection of 19 counties in northwest Iowa (NW Iowa) as a case study to understand how major water providers, water regulators, agricultural communities and other stakeholders perceive, react, and adapt to changing water availability and sustainable groundwater use planning. We used the 2012 drought during interviews as a benchmark event to reflect on water scarcity in the region and expand the interview conversation to explore stakeholders’ thoughts on the region’s current and future water supply. A total of 60 interviews were conducted with five major stakeholder groups representing government agencies, water suppliers, livestock producers, industry, and advocacy groups. Water suppliers and industry were further categorized into subgroups: rural water systems and municipal water systems, and livestock associations, service providers, and processors, respectively.

This paper reports the results of a stakeholder analysis employed to organize and characterize the stakeholder groups’ levels of interest around the issue of changing water availability, positions of influence, and patterns of communication with other stakeholder groups. Our guiding research questions to this were:

1. What are stakeholders’ perceptions of current and future water supplies?
2. What are stakeholders’ water beliefs, values, and behaviors?
3. How do stakeholders communicate and interact with other stakeholders?
4. What forms of water supply governance and management do stakeholders prefer?

In this case study, collaborative governance refers primarily to the Iowa Department of Natural Resources’ (DNR) efforts to engage non-state stakeholders in a consensus-oriented decision-making process regarding groundwater management. Since the 2012 drought, the DNR has attempted to bring stakeholders together to develop collaborative water management strategies for the region, but with limited success. The purpose of this study is to utilize a stakeholder analysis to document a breadth of perspectives on the nascent issue of water availability in NW Iowa and to encourage and inform further development of collaborative governance efforts in the region.

This paper outlines the ramifications of the 2012 drought and the importance of investigating collaborative groundwater governance in NW Iowa. The reasons and justification for choosing a collaborative governance framework and stakeholder analysis to examine this case study are followed by an explanation of the methods. We explain the context of the case study, participant selection criteria, stakeholder characterization, and actor-linkage matrix. In the results section, quotes from stakeholder interviews are shared to demonstrate how interview data was used to score stakeholders’ major characterizations - interest, influence, impact, and position - and general observations about stakeholder networks in the actor-linkage matrix. The quotes also illustrate the complexity of perspectives and concerns around the issue of groundwater management and future water use. The discussion section relates the findings to one another and establishes a baseline understanding of current collaborative governance efforts.
Drought and livestock in northwest Iowa

Record low precipitation and record high temperatures at the end of 2011 and through much of 2012 resulted in the worst drought experienced in Iowa since 1988 (Hillacker 2012). The lack of precipitation caused water levels in shallow alluvial aquifers to drop and the high temperatures increased the demand for water to keep livestock cool and hydrated. The combination of the two drought effects exposed the vulnerability of water access and supply in NW Iowa. As private wells dried up or failed to provide adequate volumes of water to users, the rural water systems were increasingly relied on as a primary water source. Two issues complicated the rural water systems’ capacity to meet the unprecedented demand. One, some rural water systems relied on shallow alluvial wells that experienced the same drop in water levels as the private wells. Two, the rural water systems' infrastructure was not originally built to handle such demanding conditions (Hillacker 2012).

Rural water systems experienced a surge in development after a major drought in 1988, to provide alternative water access to rural water users and municipalities (Hillacker 2012). Customers’ water use needs have changed dramatically since that period, however. Livestock production in 1988 occurred on a smaller scale and confined animal feeding operations- designed to house and feed livestock in a lot, yard, corral, building or other area for 45 days or more- were not commonplace (DNR n.d.; Hillacker 2012). The expansion of confined animal feeding operations has increased the concentration of animal production across the state. In 1988 the density of livestock (beef cattle, dairy cattle, hogs, chickens, and turkeys) was approximately 584 animals per square mile (NASS 1992). According to the most recent USDA Census of Agriculture
data, the density of animals per square mile is closer to 931 animals per square mile- a 59% increase in total livestock animals in Iowa, compared to a 14% increase in the human population during that time (NASS 2019, US Census Bureau 1996, 2019).

Livestock production is particularly high in NW Iowa. Approximately 44% of the state’s animal feeding operations are within the NW Iowa study area (Figure 1) (NASS 2019).

The increase in animal feeding operations has also increased the demand for water in the region. Rural water system managers estimate that animal production accounts for 50-90% of their systems’ volume in NW Iowa (Interview: RWS 01, 03, 04, 05, 2018).

The load from livestock production can strain rural water system infrastructure during peak usage, particularly in dry and hot conditions. During dry and hot periods, livestock producers are limited in their capability to conserve water, as the animals require more

![Map of animal feeding operations in Iowa. Each dot is an animal feeding operation. The case study region is highlighted in the NW corner of the state (Iowa Geodata: Animal Feeding Operations, DNR, 2018).](image)

**Figure 1.** Map of animal feeding operations in Iowa. Each dot is an animal feeding operation. The case study region is highlighted in the NW corner of the state (Iowa Geodata: Animal Feeding Operations, DNR, 2018).
water for hydration and cooling. Water suppliers explain that livestock operations at the periphery of rural water systems or on smaller diameter water lines—typically the older portions of the system—are most vulnerable to experiencing limited availability during peak use (Interview: RWS 10, 2018).

Climate scientists predict the Midwest is likely to experience another major drought in the near to medium-term (Melillo et al. 2014). Yet, livestock production continues to grow in the region and rural water systems struggle to keep up with infrastructure and source water demands. This precarious situation requires changes in resource management strategies to minimize future contention over scarce water supplies. If not for timely rains replenishing aquifers, the consequences of the 2012 drought could have led to major livestock mortalities. Iowa DNR staff are attempting to keep the issue of water scarcity at the forefront of stakeholders’ minds, and ideally, establish contingency plans to prepare for the next drought occurrence. To this point, however, no formal plans have been established and opportunities to collaborate on the issue have not been promoted among stakeholders evenly. Since 2012, the DNR has organized 13 events to discuss drought concerns and water sustainability and resiliency planning. Table 1 lists the dates, locations, and stakeholders that are known to have been invited or attended a DNR drought or groundwater planning event. The documents used to produce the table were inconsistent and the table may not reflect the stakeholder group attendance.
Table 1. List of events organized by the DNR to address drought and water planning in Iowa after the 2012 drought and attending stakeholder groups.

<table>
<thead>
<tr>
<th>DATE</th>
<th>LOCATION</th>
<th>Government</th>
<th>Water Suppliers</th>
<th>Service Providers</th>
<th>Research Institutions</th>
<th>Livestock Producers</th>
<th>Commodity Groups</th>
<th>Advocacy</th>
</tr>
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<tbody>
<tr>
<td>2012 March 27</td>
<td>Sioux Center</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 March 13</td>
<td>Storm Lake</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2013 May 07</td>
<td>Ft. Dodge</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2013 May 11</td>
<td>Storm Lake</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>2013 May 14</td>
<td>Storm Lake</td>
<td>x</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2015 January 06</td>
<td>Sheldon</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>2015 January 13</td>
<td>Sheldon</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>2016 December 22</td>
<td>NA</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2017 July 31</td>
<td>Cherokee</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2018 February 12</td>
<td>IRWA</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 June 28</td>
<td>Des Moines</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>2018 July 26</td>
<td>Sheldon</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>IRWA</td>
<td>x</td>
<td></td>
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*IRWA, Iowa Rural Water Association annual conference; NA, Not available*

accurately for each occasion. Events have primarily targeted water suppliers but other government agencies have participated because of their technical expertise and role in the 2012 drought response. Research institutions and service providers have also provided expertise at events. Livestock producers, livestock associations and other commodity groups, and advocacy stakeholder attend to a lesser extent.

We know from interviews and field notes that at least three of the events were considered productive. In 2017, the DNR organized the “NW Iowa Drought Conditions Meeting” in Cherokee County to address growing drought conditions in the region. The meeting was open to the public and included presentations from various government experts: Iowa Geological Survey and National Weather Service hydrologists, DNR environmental specialists and engineers, Director of the USDA Midwest Climate Hub, State Climatologist, and Water Resources Bureau Chief from Iowa Department of
Agriculture and Land Stewardship (NW Iowa Drought Conditions Meeting, 2017). A livestock producer that attended described the event as having a good turnout (Interview: LP 11, 2019). Unfortunately, the 2017 drought meeting in Cherokee is one of only two meetings we know of where livestock producers were in attendance. The following two meetings were organized for rural water system managers and related stakeholders (i.e., engineers, board members, etc.) at the IRWA annual meeting in February 2018 and 2019. Both years were well attended, and discussions were viewed as productive by the DNR (Field Notes: IRWA meeting, 2018, 2019). Although the core stakeholders – water regulators, suppliers, and users – have engaged in some amount of discussion at these DNR drought meetings, broader stakeholder engagement has been lacking.

This research uses a collaborative governance framework to examine the DNR’s planning efforts and a stakeholder analysis to inform and contribute to the collaborative process. Collaborative governance is one of many frameworks used to analyze and support diverse stakeholders’ participation in natural resource management planning. In the context of the NW Iowa case study, our aim is to expand the breadth of the DNR’s planning approach to actively include stakeholders beyond rural water systems. The collaborative governance framework allows us to understand, theoretically, how water resource management could be accomplished in NW Iowa. The stakeholder analysis provides an additional framework to compile, organize, and understand, data relevant to the collaborative governance process.
Theoretical Framework

Collaborative governance

The collaborative governance literature spans policy, development, and natural resources management disciplines (Crona and Parker 2012). Within the natural resources literature, it overlaps with other multi-stakeholder management or governance approaches such as adaptive governance, participatory management or governance, collaborative management, and stakeholder partnerships (Larson 2008; Pahl-Wostl 2009; Halbe et al. 2018). While the terminology differs, the objectives are similarly focused on systems, stakeholder engagement, and adaptation. The principal aim of these approaches is to establish management policies that are holistic and equitable. The research presented in this article draws heavily from the natural resources literature specifically pertaining to water resources to understand and validate the role of collaborative governance in groundwater management for our NW Iowa case study. The definition of collaborative governance used to frame this work comes from Ansell and Gash (2008). In their 2008 meta-analysis of the collaborative governance literature, they define collaborative governance as:

a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets (Ansell and Gash 2008:554).
Evidence indicates that structured decision processes are important for organizing diverse values and trade-offs when determining complex environmental policy choices (Gregory and Keeney 2002). From a resource manager's standpoint, the ability to lead a collaborative governance effort allows an organization to leverage resources, incorporate peripheral actors, work across policy sectors, gain input from clients, involve affected parties, and enable alternative actions (Scott and Thomas 2017). The benefits of a collaborative governance approach are shared with other participating individuals, groups, and organizations. Farmers may view participation in collaborative water governance efforts as a way to reduce the likelihood of government regulation and as an opportunity to educate non-farming participants about agriculture (de Loë et al. 2015). From the perspective of firms in the natural resources sector, research indicates that participation in collaborative water governance is perceived to create opportunity for interactive and relationship-driven decision making, provide exposure to other perspectives, and lead to better community relationships (de Loë et al. 2016). In general, stakeholder participation increases the public trust in decision making processes, embraces the co-generation of knowledge from a diversity of perspectives, and is more democratic (Reed 2008; Sullivan et al. 2019).

The collaborative governance approach to resource management enables actors to recognize and address power imbalances between stakeholders and navigate management decisions alternative to typical top-down governance methods (Billgren and Holmén 2008; Reed 2008; de Loë et al. 2016). Power imbalances can be highly unproductive or counterproductive to the process if they enforce unequitable stakeholder influence (Ivey et al. 2004; Krester et al. 2018). In any collaboration, different stakeholders bring
different expectations, interests and influence to the table (Stanghellini 2010). Using a stakeholder analysis to characterize the stakeholder groups' positions of influence is one way to confront this concern (Grimble and Wellard 1997). A primary motivation of the NW Iowa stakeholder analysis is to help participants currently engaged in collaborative efforts (i.e., DNR and rural water systems) to better understand the wider stakeholder landscape and foster additional participation. As a resource, this stakeholder analysis is intended to inform an equitable and productive continuation of the DNR’s early collaborative governance effort.

**Stakeholder analysis**

A stakeholder analysis is a holistic and iterative evaluation method used to understand the impact of change on a system by identifying and assessing key stakeholders and their interests (Grimble and Wellard 1997; Reed 2008). Like collaborative governance, stakeholder analysis is used across the disciplines of policy, organizational management, development, and natural resources management. Its origins in political and policy science and management theory contribute to the stakeholder analysis methodology's development as a systematic tool with clear steps (Brugha and Svarvasovszky 2000). The general outline of a stakeholder analysis includes establishing the context of the analysis, identifying the stakeholders, differentiating between stakeholder groups, investigating relationships between stakeholders, and suggesting further actions (Reed 2008).

An early and critical decision that researchers must make in a stakeholder analysis is determining which stakeholders to include. The choices, which may change as additional information is gathered, ultimately determine how representative the analysis
will be. Stakeholders can include any person, group, or organization that has an interest or stake in a particular issue due to experienced effects, the influence they have, or their knowledge and experience on the subject (Grimble and Wellard, 1997; European Commission, 2003; Stanghellini 2010). Natural resources management is complex and decision making involves a diversity of actors from various sectors depending on the targeted resource, geographic setting, and cultural expectations of the stakeholders (Billgren and Holmén 2008; Lienert et al. 2013). The determination of the key stakeholders is a subjective assessment typically based on the stakeholders' relative influence or legitimacy (Mitchell et al. 1997; Colvin et al. 2016).

Grimble and Wellard (1997) offer six characteristics that, when present, identify appropriate conditions for a stakeholder analysis: cross-cutting systems and stakeholder interests, multiple uses and users, market failure, nonrenewable resources, multiple objectives and concerns (i.e., economic, social, and environmental), and poverty and underrepresentation. The NW Iowa case study exhibits most of the characteristics; groundwater and aquifers are cross-cutting systems; there are a range of users and uses, although agricultural purposes are dominant; the existing rate structure used by rural water systems incentivize large-volume users (Field Notes: IRWA annual meeting, 2019); in NW Iowa, groundwater from deep aquifers is non-renewable (Famiglietti 2014) and the shallow aquifers rely on precipitation for recharge; and the social, environmental, and economic objectives, concerns, and values are wide ranging.

The water resources governance literature describes the use of stakeholder analyses as part of formal collaborative processes (Mushove and Vogel 2005; Prell et al. 2009; Stanghellini 2010). During the time we interviewed stakeholders, there was no
formal process in place to collaboratively address NW Iowa’s water availability concerns. Our exploratory stakeholder analysis may support formalization of the process by documenting, raising awareness, and ultimately increasing the legitimacy of stakeholders’ existing concerns. Agricultural water users, regulators, and suppliers, as well as service providers, industry, and advocacy stakeholders are characterized based on their levels of interest and influence. Interest and influence are used to classify each stakeholder’s position to understand the stakeholder groups’ relative engagement in the issue. The analysis also identifies linkage (i.e., communication and collaboration) between stakeholder groups. Definitions and methods to evaluate interest, influence, position, and linkage between the stakeholders are outlined in the following section.

**Methods**

Our stakeholder analysis primarily follows the methodology outlined by Reed et al. (2009): determine the analysis context, identify the stakeholders, differentiate between stakeholder groups, investigate the relationships between stakeholders, and suggest actions. The authors also outline three rationales for conducting a stakeholder analysis; descriptive, instrumental, and normative (Reed et al. 2009). This research utilizes a combination of the instrumental and normative approaches (Figure 2). The instrumental approach is pragmatic and typically used to understand how leading actors can manage stakeholder behavior for a specific outcome while the normative approach is meant to
emphasize stakeholder participation and empowerment in the decision-making process by raising awareness and knowledge-sharing among stakeholders (Reed et al. 2009). By virtue of conducting interviews on the topics of water scarcity and groundwater management, the research raises awareness among contributing stakeholder groups. An additional objective of the research is to lay the groundwork for future workshops and other meetings that bring stakeholders together to engage in networking and planning activities that encourage equitable groundwater governance in NW Iowa.

**Context**

Identifying the research focus and system boundaries are the basis of the analysis context. This research is funded under a grant examining the impact of changing water availability on agriculture in the Upper Midwest of the United States. To examine the interactions between water and agriculture, three study areas were designated between Iowa and Minnesota. The selection of NW Iowa was determined based on the region's
exposure to substantial water scarcity concerns during the 2012 drought and a significant agricultural presence. In interviews, we used the drought as a benchmark event to begin discussions on changing water availability and how water resources are perceived currently and in the future. The geographic bounds were delineated after more information about groundwater in NW Iowa was gathered in early interviews. A total of 19 counties are included within the study area: Buena Vista, Calhoun, Carroll, Cherokee, Clay, Crawford, Dickinson, Emmet, Ida, Lyon, Monona, O’Brien, Osceola, Palo Alto, Plymouth, Pocahontas, Sac, Sioux, and Woodbury. Inclusion was based on a combination of the presence of rural water systems, high agricultural-related water demands, and severity of the 2012 drought effects.

**Application of stakeholder analysis methods**

The three main steps of the stakeholder analysis are to identify the stakeholders, differentiate and categorize stakeholder groups, and identify relationships between groups (Reed et al. 2009). A number of methods can be utilized to achieve selection, categorization, and identification. We used semi-structured interviews and snowball sampling to identify stakeholders, an interest-influence matrix to categorize stakeholder groups, and an actor-linkage matrix to identify relationships between the groups (Figure 2). Justification and further description of each of the strategies follows.

Stakeholder identification was an iterative process using in-depth, semi-structured interviews (Figure 2). Initial contact at the end of 2017 with early interview participants was purposive, based on their knowledge of groundwater issues in Iowa or their involvement in the 2012 drought response. We targeted the DNR, the USDA Midwest Climate Hub, Iowa Geological Survey, and rural water systems for initial exploratory and
formal interviews. Successive interviews were based on early responses and suggestions, leading to a mix of snowball (suggestions gleaned from existing participants) and purposive sampling. Over the course of 60 interviews, a total of 76 participants were interviewed representing six stakeholder groups: government, water suppliers, industry, livestock producers, service providers, and advocacy (Table 2).

During early interviews, it became apparent that the leading stakeholder on the topic was the DNR. As an actor in an emerging collaborative governance effort, we consider the DNR to be the leading public agency, and groundwater as the public asset for management consideration (Ansell and Gash 2008). Though the DNR’s efforts are not formalized, they are deliberative and revolve around building consensus between stakeholders.

The DNR is in a unique position to lead water resource governance efforts in NW Iowa for two reasons. One, through the use of technical assistance, permitting, and compliance programs, the agency ensures compliance with state and federal laws that protect land, air, and water resources in Iowa (DNR 2019). Two, interviews with stakeholders indicated that the DNR field office in NW Iowa has a productive and respected relationship with water suppliers in the region. The DNR is one of four state-level agencies represented within the government stakeholder group.

<table>
<thead>
<tr>
<th>STAKEHOLDER</th>
<th>CODE</th>
<th>n</th>
</tr>
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<tbody>
<tr>
<td>Water suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural water systems</td>
<td>RWS</td>
<td>9</td>
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<tr>
<td>Municipal water systems</td>
<td>MWS</td>
<td>4</td>
</tr>
<tr>
<td>Industry</td>
<td></td>
<td></td>
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<td>Livestock associations</td>
<td>LA</td>
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</tr>
<tr>
<td>Processors</td>
<td>PRC</td>
<td>3</td>
</tr>
<tr>
<td>Livestock producers</td>
<td>LP</td>
<td>20</td>
</tr>
<tr>
<td>Government</td>
<td>GOV</td>
<td>8</td>
</tr>
<tr>
<td>Service providers</td>
<td>SP</td>
<td>6</td>
</tr>
<tr>
<td>Advocacy groups</td>
<td>ADV</td>
<td>4</td>
</tr>
</tbody>
</table>

N = 60
Water suppliers are the next major stakeholder group in discussions surrounding future water management and drought in NW Iowa. We have divided this stakeholder group into two subgroups: rural water systems and municipal water systems. Rural water systems in NW Iowa are a major water provider to residents outside of municipality or city limits, particularly for livestock producers. These systems are privately owned utilities run under the guidance of a board and with revenue generated from their customers. They serve a far greater geographic region than a traditional municipal water system; a single rural water system can provide water across multiple counties. Engineers that work closely with rural water systems are also included within this subgroup. In contrast, city and municipal systems serve a smaller area, are publicly owned, and able to utilize tax revenue for operational costs.

Livestock producers and livestock service providers are two more stakeholder groups interviewed for the stakeholder analysis. Livestock producers in NW Iowa are major water consumers and were, in certain subregions, severely impacted by the 2012 drought. We interviewed a selection of livestock producers in NW Iowa that raise hogs, beef and dairy cattle, chickens, and turkeys. Service providers are private or public organizations, businesses, and agencies that support livestock producers in NW Iowa. Their services include but are not limited to assistance with manure management plans, nutrition and animal health, well drilling and maintenance, site permitting, and labor management. Stakeholders in this group interact with livestock producers on a frequent basis.

Service providers, livestock producers, water suppliers, and government cooperate to varying degrees with two industry subgroups: livestock associations and
processors. Livestock associations are member-driven organizations that allocate their resources toward lobbying efforts, research, and education that supports their respective livestock sector. Processors in the case study are businesses reliant on animal or grain inputs and large volumes of water for operation. Examples of processors include dairy- or meat-product manufacturers and ethanol facilities. The final stakeholder group is advocacy and they represent the interests of socially and environmentally focused organizations working in Iowa.

Interviews were conducted between January 2018 and July 2019. An average interview lasted 44 minutes and was typically conducted in person, though two were conducted over the phone and two by email. Interview guides were developed for each interview and evolved as the diversity of stakeholders and perspectives increased. A core question set in each interview guide asked stakeholders to reflect on current and future water supply risk perceptions, experiences in 2012, planning processes, connection to, or communication with, other stakeholders, thoughts on current water governance, and opportunities for participation in a collaborative process. All but four of the interviews were recorded, transcribed verbatim, and analyzed in NVivo. The coding process in NVivo was iterative. Initial coding was based on a set of analytical categories generated from the interview guide questions. As additional analysis and interviews took place, the coding scheme expanded to capture emergent themes.

To differentiate and categorize the stakeholders, Reed et al. (2009) highlights two strategic approaches: analytical (top-down) or reconstructive (bottom up). Both approaches can be accomplished using a variety of methods but the general difference between the categorization approaches is who leads the process; analytical methods are
carried out by the actors conducting the analysis and reconstructive by the stakeholders themselves (Reed et al. 2009). Given the exploratory nature of this research, wide geographic distribution of stakeholders, time limitations, and DNR’s existing leadership role, we use an analytical approach called an interest-influence matrix.

The interest-influence matrix is based on the evaluation of individual stakeholders’ relative interest in the issue of groundwater governance and their ability to influence the governance process. Based on the quadrant of the matrix a stakeholder fall within, stakeholder groups are labeled as player, context setter, subject, or crowd (Ackermann and Eden 2011). The matrix is valuable early in stakeholder engagement processes to identify which stakeholders are required to produce a credible assessment of the case study, opportunities for coalitions, and potential conflicts by revealing which stakeholders have the most to gain or lose and who has the most or least influence in relevant decision-making processes (Bryson et al. 2011).

In our analysis, ‘interest’ refers to the level of attention or concern a stakeholder expresses about the issue of water availability in NW Iowa. A stakeholder’s level of interest generally reflects their stake in the issue; stakeholders most likely to be impacted by insufficient water resources have higher levels of interest. ‘Influence’ is defined as demonstrating at least one of the following sources of power: position power resulting from organizational authority and potential control over rewards, punishment, information, and environment (natural or man-made); or political power derived from a vested ability to control or influence decision processes (Bourne and Walker 2005).

We evaluated and scored the transcripts along a 5-point scale to determine levels of interest and influence: low (1), medium-low (2), medium (3), medium-high (4), and
high (5). A high interest score indicates the stakeholder expressed explicit concern about water resources. A low interest score was given when stakeholders were dismissive of the issue. Stakeholders received a high influence score in cases where they exhibit the ability to successfully advocate for their own interests and a low score when they exhibit an inability to do so.

The position for each stakeholder group was determined by plotting the interest and influence scores on a two-by-two matrix (Figure 3). Stakeholder groups categorized as players are both interested and capable of influencing organizational and planning efforts (Ackermann and Eden 2011). Context setters also have higher levels of influence and can potentially affect the overall context of organization and planning efforts but have a low level of interest (Ackermann and Eden 2011). Subjects are stakeholders with higher levels of interest but low influence, and stakeholder groups in the crowd category are considered disengaged because of their lack of interest and influence (Ackermann and Eden 2011). The strength of this strategy is the explicit outlining of power dynamics to understand which stakeholder groups have a greater ability to influence management decisions (Bryson et al. 2011).

The final component of the stakeholder method requires an investigation of the relationships between stakeholder groups (Figure 1). This research uses the actor-linkage matrix method, scoring interview participants’ relationships with other stakeholders on a 5-point scale: no relationship but aware of stakeholder’s role (1), do not regularly work together but have experience working together (2), intermittently work together (3), active relationship unrelated to water scarcity issues (4), and active relationship that
addresses issues of water scarcity (5). The linkage score represents the stakeholders’ relationship networks between and within stakeholder groups.

The actor-linkage matrix method is fitting because of its ease of use and the resulting visual illustration of relationships between actors (Biggs and Matsaert 1999). A completed matrix is a useful tool for identifying key linkages, acknowledging communication gaps, and it can be used as an evaluative tool to monitor the change in communication patterns between groups over time (Biggs and Matsaert 1999). Under circumstances where there are many linkages, the actor-linkage matrix can become confusing and difficult to use. In the NW Iowa case study, there are a manageable number of groups to account for when individual interviews are merged into the appropriate stakeholder groups (Table 2).

A hypothetical actor-linkage matrix worksheet, provided in Table 3, demonstrates how we recorded linkages between stakeholders. The worksheet lists actors and their respective stakeholder groups and subgroups down the first columns and across the first rows of the table; each cell corresponds to a relationship between actors. The actors in the first column of the matrix are the stakeholders that have been interviewed. The actors across the top row of the matrix include stakeholders that were interviewed as well as additional stakeholders referenced in interviews.

After scoring the interview transcripts, the final results were calculated by averaging the group score by the number of interviews in that group. Averaging the scores by the number of interviews accounts for the uneven distribution of interviews between stakeholder groups (e.g., livestock producers, n=20; service providers, n=6,
Table 1. The scores were then normalized to fit a 0 to 5 scale for clarity and consistency with the other stakeholder analysis scales. A higher score indicates a greater level of networking and communication between the stakeholder groups and a low score signifies little to no interaction. Two additional descriptive categories illustrate the general flow of communication for each stakeholder group by calculating row and column sums. The “Self-described linkage” score represents the magnitude to which a stakeholder group perceive their own communication with other stakeholders. The “Linkage described by others” score represents the magnitude to which other stakeholders are referencing a particular stakeholder group. The categories enable us to make general observations.

Table 3. Actor-linkage matrix worksheet for a hypothetical stakeholder analysis. Empty cells are filled based on the participants expressed relationship with actors along a 5-point scale.
about how specific groups perceive their own linkage versus how the other stakeholder groups perceive that stakeholders’ linkage.

**Actions**

The last stage of a stakeholder analysis is dedicated to the dissemination of findings and suggestions to enhance stakeholder engagement (Reed et al. 2009). The manner in which this portion of the analysis reveals itself is highly dependent on the circumstances of the research scope and resources. The aim of this stakeholder analysis is to inform and support the ongoing collaborative governance efforts led by the DNR. Potential contributions are discussed in more length later.

**Results**

**Stakeholder characterization table**

The stakeholder characterization table organizes data for each of the eight stakeholder groups and subgroups into four categories: involvement, interest, influence, and position (Table 4). The involvement column provides a brief description of the stakeholders’ relevance to the issue of water availability in NW Iowa. The interest and influence columns present the average scores for each stakeholder group. The final column lists the position of the groups (Figure 3): *players*, stakeholders with high interest and high influence; *context setters*, stakeholders with low interest but high influence; *subjects*, stakeholders with low power but high interest; and *crowd*, stakeholders that have low interest and low influence (Ackermann and Eden 2011). Because interest and influence directly relate to the position of the stakeholder group, the following
Table 4. The stakeholder characterization table outlines the involvement, interest, influence, impact, and position of the eight stakeholder groups. Interest, influence, and impact scores are based on transcript analysis. Position is based on the interest-influence matrix scores (Figure 2).

<table>
<thead>
<tr>
<th>STAKEHOLDERS</th>
<th>CHARACTERISTICS</th>
<th>Interest Low (1) - High (5)</th>
<th>Influence Low (1) - High (5)</th>
<th>Position Interest-Influence Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Water Systems</td>
<td>Water supplier for rural customers in northwest Iowa</td>
<td>4.2</td>
<td>3.8</td>
<td>Players</td>
</tr>
<tr>
<td>Government</td>
<td>Responsible for water resource management and regulation</td>
<td>3.4</td>
<td>3.8</td>
<td>Players</td>
</tr>
<tr>
<td>Livestock Associations Industry</td>
<td>Represent and support livestock producer-members’ interests</td>
<td>2.2</td>
<td>4.8</td>
<td>Context Setters</td>
</tr>
<tr>
<td>Advocacy Groups</td>
<td>Focus on environmental sustainability of farming in Iowa and water quality issues</td>
<td>2.3</td>
<td>3.8</td>
<td>Context Setters</td>
</tr>
<tr>
<td>Service Providers</td>
<td>Work closely with livestock producers (e.g., manure management, permitting)</td>
<td>2.7</td>
<td>3.0</td>
<td>Context Setters</td>
</tr>
<tr>
<td>Livestock Producers</td>
<td>Primary rural water consumer by volume (e.g., hog, cattle, and poultry producers)</td>
<td>3.1</td>
<td>2.3</td>
<td>Subjects</td>
</tr>
<tr>
<td>Processors</td>
<td>Reliant on livestock production for inputs and a large water user</td>
<td>1.7</td>
<td>2.7</td>
<td>Crowd</td>
</tr>
<tr>
<td>Municipal Water Systems</td>
<td>Water supplier for city and municipality customers in northwest Iowa</td>
<td>2.3</td>
<td>2.0</td>
<td>Crowd</td>
</tr>
</tbody>
</table>

Figure 3. Interest-influence matrix with stakeholder groups plotted based on interest and influence scores (Table 4). UL: Subjects, UR: Players, LL: Crowd, LR: Context Setters (Figure 2). Adapted from Eden and Ackermann (1998).

description of results is organized by position. Organization by position also emphasizes how groups given the same position view water availability issues in NW Iowa and relate to stakeholder groups in other positions.
Players

Based on average interest and influence scores, rural water systems and government stakeholder groups are classified as players in the interest-influence matrix (Figure 3). The medium-high and medium interest scores are representative of the concern expressed about water availability in NW Iowa and the efforts both stakeholders have made to discuss issues of water resource management post-drought (Table 4). Aside from continued interest in the issue, the groups received medium-high scores for influence. The medium-high influence scores for both stakeholder groups result from a combination of influence levels interpreted in the interview data. Rural water systems that received high scores described being more connected to external resources (e.g., technical expertise) and supportive boards. The DNR, compared to other government agencies, have some statutory leverage to address water resources management issue, as well as have ownership over aspects of the AFO permitting processes. Despite higher levels of interest and influence relative to other stakeholder groups’ scores, not all participants within the rural water systems and government groups expressed elevated concern or ability to manage water availability challenges. The remainder of this section draws from the interview data to illustrate the complexity of perspectives represented in the player stakeholder groups and the infrastructure and uncertainty challenges faced.

Since 2012, the DNR has attempted to address groundwater management issues raised during and after the drought. The DNR recognizes that another drought event could be catastrophic if contingency plans are not adequately implemented. In a meeting organized by the DNR at the 2018 Iowa Rural Water Association (IRWA) conference, the DNR Director addressed a room of rural water managers saying:
If we have a situation where the water dries up, there’s no way we’ll be able to truck enough water in for those animals, and no way to truck all of those animals out. If the water runs out, the public will ask the rural water systems, “Where's my water?” then they'll go to the state and say, “How could you let this happen?” (Field Notes: IRWA, 2018)

Rural water systems appear willing to engage in activities that address the issue of future drought and groundwater planning. They, like the DNR, feel pressure to find solutions that ensure sustainable water service to their customers. The rural water systems’ challenges are multifaceted; accessibility of aquifers, aquifer quality, customer demands, infrastructure, and relationships between management and boards all help or hinder a systems ability to respond to extreme drought conditions. The 2012 event revealed each of the systems’ vulnerabilities. The worst consequence of the drought was the threat of mass livestock mortality; a reality that isolated AFOs tragically experienced. A rural water manager and government employee explain, respectively:

That was a nightmare…. We were pumping 24/7. We could see the water levels in our wells going down. We put out water conservation measures. We told the farmers to start trucking the water if they could- marketing their hogs at a lighter weight….If you empty out a barn, don’t refill it. We’re not going to guarantee that you’re going to get water. People come before pigs. People that own pigs don’t necessarily see that. And I get it- I get it. It’s tough. (Interview: RWS 06, 2018)
We had some huge chicken and poultry losses during the drought. Those are temperature and water availability related. Chickens and turkeys need a lot of water to survive during heat...we were routinely hearing that they'd lose a quarter of the population in a barn because of heat and because of they just couldn't get water to them fast enough.

(Interview: GOV 04, 2019)

The previous quote alludes to infrastructure complications; even water systems adequately prepared from a source standpoint struggled to provide customers with the volume of water required because of capacity or treatment limitations. Another DNR-organized meeting for rural water system managers took place at the following 2019 IRWA annual conference. During the meeting, rural water managers described a leveling-off of new livestock customers but a continued struggle to finance infrastructure upgrades to ensure adequate supply during peak use. One rural water manager said, “It’s a real struggle to get the high users to pay. They cost us money…. Higher users are used to paying less for more. They want it to be a certain way. But water is becoming a precious commodity,” (Field Notes: IRWA, 2019). In a separate interview, a rural water manager explains why rural water systems confront this barrier:

[O]ur issues- and I think it’s with all rural water- is the systems when they were first built were built for the people that signed up at the time. So now we’ve got two- and three-inch water lines out there trying to feed the same ones that originally signed up but then we also have four, five, six hog barns and maybe somebody increased in, ya know, in cattle in there, and [we’re still using] that same line. (Interview: RWS 4, 2018)
A compounding issue related to infrastructure is planning for future demand. Aside from accessing adequate funding for upgrades, rural water systems struggle to project their system’s future usage and how a ‘worst case scenario’ will manifest itself in coming years. A rural water manager expressed this frustration during the 2019 IRWA meeting when they said:

“We spend a pile of money on that one day a year. It’s a moving target. What’s good enough? Do you need 1000 gal/min above regular load? We all live with [weather variability] each and every day. We can have treatment going 24 hours a day and have the same conditions for five days and we’re like [crosses fingers].”

When the potential restraints imposed by financing options faced by RWSs are considered, additional hurdles that may limit a rural water system’s ability to adapt over the short and long terms can be appreciated. An engineer explained that many systems take out 40-year loans when they finance. However, “there’s some push to say, ‘Let’s project this out to 40 years to see where we’re going to be’. Nobody knows what that’s going to be…. That’s kind of the approach we take- is to take a 20-30 year look forward and realize that anything past 15-20 is kind of a crap shoot,” (Interview: RWS 10, 2018).

Overall, rural water systems and government—the players—are invested in their endeavor to adapt to systems’ growing demands and the uncertainty that comes with it. Most participants from the two groups were eager to engage in our research and learn from the case study’s findings. At this current time, the DNR is actively supporting a workshop event that will bring a diverse group of stakeholders together to discuss NW Iowa’s water challenges.
Subjects

*Subjects* in the interest-influence matrix are characterized by high levels of interest but low levels of influence (Figure 3). In the NW Iowa case study, livestock producers were the only stakeholder group that scored within the *subject* parameters (Figure 3). The group received a medium-low influence score due to a lack of evidence to suggest otherwise (Table 4). In the occasions where an interview received a score of 3 or 4, the participants either served on boards (e.g., livestock associations, rural water, etc.), described having a diverse network of resources, were exceptionally knowledgeable on the interview topics, operated a large enterprise, or some combination of those observations. The group’s influence score was only higher than the stakeholders classified as being a part of the *crowd*- the low-interest and low-influence category.

Livestock producers received a medium interest score, the third highest of all stakeholder groups (Table 4). The relatively high interest score is due to a range of perspectives. Livestock producers’ experiences range from encountering water shortages themselves to never having considered water scarcity a possibility. Along that spectrum however, livestock producers conveyed a conscious effort to monitor water consumption as well as a sense of caution about the growth of the livestock industry.

As a group dependent on reliable, good-quality water for their livelihoods, livestock producers have a vested interest in the issue. Similar to water suppliers, livestock producers’ perspectives on groundwater availability are greatly influenced by their proximity to shallow or deep aquifers, operation size, and access to supplementary water sources like rural water. Given the small sample of producers interviewed (n=20, Table 1), it is difficult to generalize for such a broad combination of factors within a large
population. Still, the livestock producers in our sample were mindful of their operation’s consumption of water resources. Producers explained the economic necessity of minimizing water usage for manure storage capacity as “another incentive not to waste water,” (Interview: LP 05, 2019). To remove and transport manure from storage is costly. By limiting the amount of water in the manure pit, the producers are able to transport and apply a more nutrient-concentrated product to fields cost effectively. Additionally, if a producer is utilizing rural water as a primary water source, conservation directly effects water expenses.

It is also important to understand that in hot weather conditions, common during a drought, livestock producers are limited in their ability to conserve. A livestock association representative said, “[I]t’s almost a double whammy. If you have a drought and the water supply’s not there, we’re not just talking about drinking the water, we’re talking about lowering that temperature in the barn and the environment for our animals” (Interview: LA 05, 2019). Elevated temperatures increase animals’ water needs for hydration and cooling (e.g., misters, cooling cells, etc.) and producers recognize that the animals’ wellbeing directly relates to the success of their operation:

When it gets dry and extremely hot, [the animals] consume 30% or 40% more water. It just takes a lot. You have to take care of the animals if you're gonna make a livin' and you gotta supply them with good water and good feed and make 'em comfortable. If you're shortin' them water, you're shortin' yourself. (Interview: LP 03, 2018).

Most livestock producers interviewed look for opportunities to make their operations more resilient by drilling additional wells or hooking up to rural water for
back-up if it is not their main source. The following livestock producer quotes illustrates the changing water availability in the region and the desire to rely on rural water as a backup source:

My concern, today, well our current growers- we’ve had 2- 3- 4 times- that the wells have run dry and they’ve had to drill a new well or drill deeper. We’ve experienced low to no water. Building these new farms, we’ll put in two wells. Availability becomes an issue at highest peak use in the summer…. We had three where we ended up trucking water to supplement the wells. This has been happening over the past couple of years. (Interview: LP 10, 2019)

[T]here's been two things of always having a backup water supply so when maybe our well goes down or our pump goes out or whatever we cannot have these hogs without water. So instead of trucking water in to supply that, hooking up to rural water, that was kind of our safety net. (Interview: LP 18, 2019)

Some producers questioned continued livestock expansion in NW Iowa, “If we're in an area where there's issues finding enough water maybe we just need to be a little more cautious on further major livestock expansion….If you've got a problem there's no sense making a situation worse than it already is,” (Interview: LP 02, 2018). There are also livestock producers less concerned about current and future water supply in NW Iowa. Those that are skeptical about the future groundwater levels tend to compare Iowa to states known for having groundwater limitations, “I've never thought of Northwest
Iowa as an area with water issues, like folks from California or Texas, or Kansas” (Interview: LP 08, 2019).

Livestock producers in our sample were generally supportive of efforts addressing the water challenges faced in NW Iowa. For ongoing collaborative governance efforts, this is an important finding. The level of interest a given participant expressed in interviews seemed to depend on a number of factors. For instance, a producer’s location influences the type of groundwater they have access to and determines which rural water system they can connect to, if any. In our interviews, livestock producers that rely exclusively on wells had the highest levels of interest in water availability issues. Another contributing factor was whether the producer experienced or was aware of the 2012 drought impacts.

In terms of influence, the medium-low influence score is based on evidence from the transcripts indicating that livestock producers as individuals lack influence beyond that level (Table 4), despite a possible bias in our sample is biased towards more engaged producers because of our reliance on snowball sampling. In which case, the influence-level of the group would likely be lower in reality. As will be described further in the next section, livestock associations have a contrastingly high level of influence and low interest in the issue despite their position as representatives of livestock producers. The finding raises questions about communication and engagement between producers and associations. Why are associations largely uninterested in efforts to understand and/or govern water availability in NW Iowa? Are members raising water availability concerns with their associations? And would producers be more empowered if their representative associations played a more active role in water supply governance efforts?
Context setters

The characteristics that define the context setter group are high influence and low interest (Figure 2). Advocacy and livestock associations are clearly within the context setters quadrant based on our interest and influence scores, whereas service providers fall between the context setters and crowd quadrants. We have labeled service providers as a context setter because of the group’s similarities with livestock associations and an extensive network of customers and collaborators. Service providers, advocacy, and livestock associations all received a medium-low interest score (Table 4). The influence scores were less consistent between the three groups; they received medium, medium-high, and high scores, respectively.

These groups have a medium-low interest score because of their apparent lack of concern or awareness around water availability issues, especially those related to the 2012 drought. Of the 14 combined interviews, only four interviews received a score of 3 or higher (one service provider, one livestock association, and two advocacy). Service providers and livestock association participants were usually unaware of the 2012 drought’s impact on livestock, as exemplified in this extreme case, “To be honest, the first time I’ve heard of the [2012] drought situation or water scarcity as an issue was when you brought it up” (Interview: LA 03, 2018). In other situations, stakeholders were aware of the intensity of the 2012 event but dismissed it to refocus on other pressing issues such as excess water concerns. “When you're getting too much rain, it's hard to think about scarcity issues,” another livestock association employee commented (Interview: LA 07, 2019). During the time of our interviews, Iowa experienced above average rainfall and significant flood events. Reports indicate that 2018 was the wettest
year in Iowa’s recorded history (Glisan 2018). In 2019, February was logged as the snowiest February on record and March charted historic flooding along the Missouri river- Iowa’s western border (Glisan 2019a, 2019b).

Participants skeptical about water availability issues in Iowa often compared Iowa to other states or regions that are better known for their water constraints. The stakeholders classified as context setters are particularly inclined to demonstrate the emergent theme:

You know, I think that's one of the fortunate things we have in Iowa is- it just seems like there's usually an abundance of water. I lived and worked [out west]. There was a whole different perspective on water and stress…. So yeah, I'm familiar with pressure as a result of insufficient water but I've never felt that same as an issue here in Iowa. (Interview: LA 06, 2018)

Context setters, especially the advocacy group, also had a tendency to focus more on issues of water quality rather than quantity. One advocacy participant said, “About supply? I mean, water quality, sure. I mean, water scarcity- I'm not trying to avoid it and it's just when I think of water scarcity, I think of the southwest and deserts” (Interview: ADV 01, 2018). Another advocacy participant portrayed an analogous sentiment, “[W]hat I hear more from people is, ‘What's it going to mean for us as a farmer if Iowa's going to get serious about cleaning up our waters?’” (Interview: ADV 02, 2018). Under circumstances where an organization strategizes their mission and objectives to serve their members, it is important that livestock producers with water availability concerns are communicating that concern effectively to their representative organizations. Another
livestock association sympathized with the aim of our research but explained that, “As a grassroots organization, we go whatever direction our membership points us in and this has not been a topic that has come up” (Interview: LA 02, 2018).

Though limited, some participants within the context setter stakeholder groups were aware of the complicated groundwater issues in NW Iowa and highly supportive of efforts to plan for future drought events. Another livestock association participant also used comparison but rather than using the comparison to undercut the seriousness of water availability concerns, the stakeholder made the point that the state is fortunate and should be doing more to protect the resource:

[Y]ou come back to Iowa and ya say anything about water supply and people go, “Pfft!”

It just amazes me….We need to manage it and be careful because where there’s water you can raise food. Where there’s not water, you can’t….We see it as a nuisance rather than an asset. I feel it needs to be changed. We need to look at it as an asset. (Interview: LA 5, 2018)

Stakeholders who contradict the context setter’s dominant characteristics could be important for bridging between context setters and players in collaborative efforts. Because context setters have generally higher levels of influence, building coalitions between context setters and players may benefit the overall success of the governance effort. Aside from service providers and one advocacy participant, all other participants in the context setter category expressed an explicit mission to influence policy to advance their members’ interests. This observation contributes to the groups’ relatively high influence scores. They also received high scores due to their ability to disseminate
information and their connections to other organizations. The following quote from one livestock association describes collaboration among multiple stakeholder groups:

> We’re fortunate in Iowa. We have a group…of executive directors like myself and usually our presidents, and we’re basically…issue-driven….We’ve done everything from general issue papers early on that- really- we saw some quick adaptation into the legislature to…labor and rural workforce….And so the group is designed to present information in a broad base and then we all take it back into our own groups and if we feel it’s something that needs to be lobbied, we each do it as an individual for our groups. (Interview: LA 05, 2018).

That said, water availability does not appear to be a priority for these groups. Though context setters sometimes exhibit peripheral interest in the topic, the issue of water availability in the region directly relates to the long-term success of their members, customers, and industry. For the success of collaborative governance in NW Iowa, “buy in” from these context setters’ may increase broader stakeholder participation and support (Margerum and Robinson 2015).

**Crowd**

The final matrix category is crowd. Stakeholders that fall within the crowd category are characterized as having low interest and low influence (Figure 2). Processors and municipal water systems were both scored as medium-low for interest and influence (Table 4). Municipal water systems and processors are distinctly different water suppliers and water users compared to their rural water system and livestock producer equivalents.
Municipal water systems operate as a public utility and service customers within a smaller geographic region relative to rural water systems. In our sample, some municipal systems distribute far lower volumes of water to fewer customer than rural water systems. Larger cities, however, may supply comparable volumes of water to the rural water systems, but with less even distribution. In two NW Iowa cities, a single processor consumed greater than half of their respective municipal water system’s volume annually (Interviews: MWS 01, PRC 03, 2019).

City systems that we interviewed were less interested in issues of water availability in NW Iowa because of their confidence in current and future water supplies. One municipal water system participant expressed the same concern as an earlier livestock association quote when they described excess water as, “probably our biggest issue right now” (Interview: MWS 04, 2019). In all municipal water system interviews, participants were confident in their ability to supply adequate water in the future because of their source. With the exception of one system that plans to use deep aquifer wells exclusively into the foreseeable future, the other cities are able to access rural water systems. Two cities purchase their water from rural water systems, and two are able to access the new Lewis and Clark Regional Water System that pipes water from South Dakota to areas of NW Iowa and southeast Minnesota. The ability to hook into the Lewis and Clark pipeline provides a sense of security for cities. A participant explained, “I feel much more comfortable now that we have [the Lewis and Clark] connection. And the capacity there to move quantity if we have to,” (Interview: MWS 02, 2019). There is also less reason to be concerned when the overall demand in a system is in decline. One municipal water system clarified that, “Due to a processing plant shutting down, and the
town slowly shrinking as a whole, the current trend is showing the town is using slightly less water than it was 5 to 7 years ago” (Interview: MWS 05, 2019).

In the few processor interviews conducted, participants shared comparable perspectives to other lower-interest stakeholder groups. One processor mirrored a previous municipal water system quote when they said, “That was a thought- that water could be restricting but being connected to the Lewis and Clark water line has alleviated that concern” (Interview: PRC 02, 2018). The other two processors conveyed confidence in their municipal water systems’ ability to supply water despite drought events. One said, “[I]t sounds like we don’t necessarily have a backup plan. We are relatively certain that the city would have a plan, but the two of us have never heard it” (Interview: PRC 01, 2018). And another articulated similar confidence while also echoing concerns about quality and excess:

As far as relationship with the city and getting our water from them, scarcity hasn't been a problem…. The majority of the conversations I've been involved with regarding water in any kind of municipality or the DNR have been… floodwaters type stuff, just how they're handling runoff water and floodwater and storm events. (Interview: PRC 03, 2019).

Municipal water systems and processors are large water consumers in NW Iowa. Yet, based on our interviews, they seem to be distanced from the issues of changing water availability experienced by rural water systems and livestock producers. In the case of processors that rely on animal feeding operations in the region for inputs, it may be beneficial to raise awareness about water availability in NW Iowa so that they have an understanding of the challenges encountered by their counterparts in production. That is
particularly the case for dairy processors. Dairies in NW Iowa can be the largest customer a rural water system serves; “[I]f one of those dairies come on, they can take 200K gal/day…if they add one dairy like that, that’s a 20% increase on that entire system” (Interview: RWS 10, 2018). However, a dairy processor noted that they “do not discuss any water related questions or issues with our dairy farms. It has not been a concern in our area” (Interview: PRC 01, 2018).

While it may be the case that municipal water systems and processors are considered part of the crowd (i.e., low interest and low influence), there may be value to including the two groups in governance efforts to build a rapport and awareness around the issue. Municipal systems face their own finance challenges, leading some to believe that municipal and rural water systems will eventually become more regionalized and share resources; “there's going to come a time when the facilities in some of these communities or in the rural waters that have not been maintained- that there's no way they're going to be able to charge enough to maintain it” (Interview: MWS 02, 2019).

Engagement could expand the lines of communication between the groups and potentially lead to a shift in position on the interest-influence matrix,

**Actor-linkage matrix**

The actor-linkage matrix provides a coarse representation of the overall relationships existing between and within stakeholder groups; the results help identify key linkages, communication gaps, and, if applied periodically, can monitor changes in communication patterns between groups (Table 5) (Biggs and Matsaert 1999). Using a worksheet similar to the example in Table 2, we scored each transcript along a 5-point scale. The higher the value, the greater the described linkage, or communication and
collaboration, among stakeholder groups. There are three differences between the stakeholders listed in the interview participants column and those listed in the ‘referenced actors’ headings at the top of the table. In the ‘referenced actors’ stakeholder groups, ‘water suppliers’ refers to rural and municipal water systems and any groundwater-related associations mentioned; ‘commodity groups’ includes all the livestock associations but also additional associations that operate similarly (i.e., Corn Growers Association and Iowa Soybean Association); and ‘research institutions’ was added due to frequent reference of research conducted by individuals and centers at public and private research institutions (i.e., Iowa State University and University of Iowa). Iowa State University Extension is considered a service provider in our analysis.

Table 5. Actor-linkage matrix lists the participating stakeholders down the first column and actors that they have referenced in interviews along the first row. The cells of the table indicate relative levels of interaction between the stakeholder groups. The higher the value (darker the cell), the greater the described linkage. Bold values are the linkages occurring within a stakeholder group.

<table>
<thead>
<tr>
<th>INTERVIEW PARTICIPANTS</th>
<th>ACTORS REFERENCED IN INTERVIEWS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Government</td>
</tr>
<tr>
<td>Government</td>
<td>3.8</td>
</tr>
<tr>
<td>Rural Water Systems</td>
<td>2.6</td>
</tr>
<tr>
<td>Municipal Water Systems</td>
<td>2.1</td>
</tr>
<tr>
<td>Livestock Producers</td>
<td>0.7</td>
</tr>
<tr>
<td>Livestock Associations</td>
<td>2.3</td>
</tr>
<tr>
<td>Processors</td>
<td>0.7</td>
</tr>
<tr>
<td>Service Providers</td>
<td>3.0</td>
</tr>
<tr>
<td>Advocacy Groups</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Linkage described by others | 10.3 | 15.7 | 10.7 | 10.0 | 3.7 | 3.4 | 2.8 | 3.0
Two additional measures were also added, the ‘Self-described linkage’ and ‘Linkage described by others’ scores. The ‘Self-described linkage’ sums the scores across each row to indicate how interview participants describe their own interactions with stakeholders. The ‘Linkage described by others’ sums each column to get an idea of how the stakeholder groups cumulatively describe interactions with a particular group. It is important to consider that because our case study was exploratory, interview guides were modified marginally over the course of the two years to accommodate new understandings. The core research questions remained throughout, but variation could influence the types of actors that participants mention in interviews. The actor-linkage matrix in our case study provides an imperfect baseline understanding of linkages between groups that can be built on in the future.

Some linkage scores given in the actor-linkage matrix (Table 5) correspond with the positions that stakeholder groups have on the interest-influence matrix (Figure 2). For instance, government and water suppliers were labeled as players because of their higher levels of interest and influence (Table 4). In the actor-linkage matrix, they have the highest ‘Linkage described by others’ totals meaning that participants within the groups and participants in other stakeholder groups described greater communication and collaboration with government and water suppliers on average. Connections between stakeholder groups in the context setter and subject positions from Table 3 and their scores in the actor-linkage matrix are not as clear (Table 5). The combination of low and high interest and influence values for livestock producers, livestock associations, service providers, and advocacy appear to translate into varied linkage scores that are
ungeneralizable. However, there are some interesting observations to make about the service provider and advocacy groups.

The median percentage difference between a stakeholder’s ‘Linkage described by others’ and ‘Self-described linkage’ is 31% and the lowest percent difference is 13% (livestock associations). The service provider and advocacy groups each ended up with a nearly 300% difference between how they perceive their own communication with stakeholders and how the other stakeholders perceive their communication. In each case, they self-described a higher overall linkage than the other stakeholders reciprocated back in the ‘linkage described by others’ scores. There are a number of reasons this may be the case for the two groups.

Service providers engage with a wide array of stakeholder groups. They are the only group in Table 4 that received more than two scores greater than 2.0. Aside from their obvious interaction with livestock producers, service providers described close relationships with government agencies and livestock associations. One service provider described their relationship with the DNR as both professional and personal, “I've always had a good relationship with the DNR…I have a lot of good friends that work with the DNR. So, I don't look at them as outsiders…. Whenever I have a question I will call and talk to them” (Interview: SP 02, 2018). Another service provider explains how they interact with other service providers and associations:

[O]ur grow-finish department, when they're talking to farmers that are looking at expanding or building a new facility, they recommend that they visit with [Coalition to Support Iowa Farmers]. And then we also have some contact with, like, the Corn
Growers Association, Soybean Association, and a huge contact of course with Pork Producers. And even somewhat with the Cattlemen. (Interview: SP 01, 2018)

Yet, despite service provider’s varied interactions with other groups, the other stakeholder groups do not express the same level of interaction with service providers. In our case study, that difference may be attributable to the focus of our research. We asked stakeholders about their relationships with other stakeholders within the context of water availability and resource governance and therefore, service providers may not be thought of as relevant to the discussion.

The advocacy group received similar unbalanced scores. Like service providers, it is likely the case that ‘Self-described linkage’ is higher because they interact with a broad selection of stakeholders. The following advocacy quote demonstrates a diversity of collaborative relationships:

I mean, so we have a lot of different stakeholders between governmental agencies like [Natural Resources Conservation Service] and [Soil and Water Conservation Districts], DNR, Fish and Wildlife, private like Soybean Association, Corn Growers, you know, some of those ag folks and then conservation folks as well like Nature Conservancy and then farmers and landowners. So, it's a real diverse pool of stakeholders. (Interview: ADV 03, 2018)

The reason for the disparity between ‘Self-described linkage’ and ‘Linkage described by others’ in advocacy’s case is different from service providers. Advocacy efforts related to water in NW Iowa generally focus on water quality and stakeholders may not
immediately think of advocacy stakeholders when considering water quantity issues. Two, advocacy stakeholders, do not have a well-esteemed reputation among some participants interviewed:

I guarantee you there's people out there thinking we live in a cesspool up here if they know how much livestock we feed. But look at this place. And you go to all the towns, they all got four or five feed stores, four or five banks, and there's eight high schools in Sioux County…. [S]ome of these counties, they got to share them… “Well do a little work and feed some livestock,” that's what I always say. But people won't let them do that either. That's some of the problem- [Iowa Citizens for Community Improvement] or whatever. (Interview: LP 15, 2019)

The unfavorable affiliation extends beyond advocacy stakeholders to city-based stakeholders in general. The Des Moines Water Works (DMWW) lawsuit was referenced on a number of occasions. In 2015, the Board of Trustees for the DMWW, the public water supplier for Iowa’s capital city, filed a lawsuit against thirteen drainage districts in three counties in NW Iowa (Buena Vista, Sac, and Calhoun). The lawsuit was intended to hold upstream drainage districts accountable for nitrates entering the Raccoon River, DMWW’s water source, but the suit was eventually dropped after early favorable opinions for the drainage districts. A reaction shared among stakeholders that brought up the lawsuit is embodied by the following rural water system quote, “[T]here’s been a huge, ya know, push against the farmer for ‘doing this’ and ‘doing that’…. I don’t think they got a fair shake- that whole Des Moines suing counties further north. That wasn’t right,” (Interview: RWS 03, 2018).
In another interview, a livestock producer articulated their feelings about city-based stakeholders when asked about who should be included in collaborative governance processes:

"Some of the stuff that we do, if not managed properly, can be more harmful to the environment, and I think we should always be seeking the best ways of doing stuff, but it's kind of like, ‘Before you point your finger at me, look what you guys did. You guys tore down all these trees. You're worried about climate change and you guys have black-topped your entire 30 acres of your city.’ So that's where I kind of chuckle a little bit. But I do believe that they need to be at the table, too, as well as some of us common-folk farmers. (Interview: LP 18, 2019)

The livestock producers’ linkage scores have the lowest ‘Self-described linkage” score after processors (Table 4). Linkage with other livestock producers was their highest score, closely followed by commodity groups, water suppliers, and service providers. Livestock producers- a subject in our analysis- have relatively higher linkages to the livestock-related context setters in our analysis, compared to their linkage with other groups like government (player), processors (crowd), advocacy (context setter), and research institutions (Figure 3). Commodity groups, though member-driven organizations, describe more communication with other commodity groups and government than they do with livestock producers. What the actor-linkage matrix may be illuminating in this situation is a gap in communication between livestock producers and livestock associations- as previously questioned in the “Subjects” section. If the case, producers- a low interest, low influence group- are missing an opportunity to leverage
livestock associations- an influential group- to advocate on their behalf. “That's how [a livestock association] works. I know how it works. You show up and then you can get your message heard. But if you want to sit out here and complain all the time, I don't have two cents for you,” (Interview: LP 15, 2019).

The actor-linkage matrix provides a crude visualization of interactions between stakeholders (Table 5). Yet, the broad brush strokes still enable important interpretations of how stakeholder groups relate to one another, where the strengths or gaps in communication exist, and what relationships or questions to explore further. The actor-linkage matrix and stakeholder characterization table (Table 4) create a foundation for understanding diverse perspectives and determining the next steps in a collaborative governance process in NW Iowa.

Discussion

The 2012 drought catalyzed the DNR and rural water systems to reexamine groundwater management and drought planning in NW Iowa. The groups’ continued efforts, seven years on, to build more resilient water systems is a testament to the gravity of the 2012 drought’s effects and unease surrounding the next major drought event. As the government agency tasked to manage Iowa’s natural resources, the DNR’s leadership role in the ongoing governance effort, selective engagement with stakeholder groups, and reliance on expert resources could be interpreted as a continuation of traditional, top-down governance. The DNR appears eager, however, to collaborate with more diverse stakeholders through a variety of events, continuing to build off the work they have conducted thus far (Personal communication: DNR, 2019). The agency’s motivation to facilitate diverse stakeholder participation in decision-making processes and reach
consensus-oriented solutions align with the definition of collaborative governance from Ansell and Gash (2008).

A commonly expressed perception of Iowa was that the state is “ag friendly” which seemed to correspond with participants’ general skepticism or reluctance toward regulatory actions that potentially impact the livestock industry (Interview: RWS 10, 2018). Despite pressure from DNR leadership to provide reassurance of animal welfare in future droughts, the DNR field staff expressed that they “don’t foresee DNR utilizing a blanket mandate” and that facilitating and being available at such meetings is “our way to help” (Field Notes: IRWA, 2019). It may be the case that DNR is in a governing position that ultimately relies on strategies able to build momentum at the grassroots level to enact change from the bottom up.

The relationship between the case study players- DNR and rural water systems- appears to be primarily productive in regard to water planning, but some systems explicitly expressed frustration with the DNR’s livestock permitting processes- evidence of a common misalignment between water management and land use planning (Carter et al. 2005). Systems are generally discontent with AFO customers’ general lack of communication and view the AFO permitting process as a missed opportunity to ensure oncoming producers have confirmed rural water can provide adequate service to their location. Livestock producers’ awareness of water availability concerns vary: some express openly that water is viewed as “one of those taken for granted things” (Interview: LP 19, 2019) while others stress the importance of confirming “water needs first because if you can't supply the animals with water, you can't have animals” (Interview: LP 01, 2018). As subjects, livestock producers are the stakeholders likely to be most impacted
by governance decisions and should be represented in governance processes so that their perspectives are accounted for (Bryson et al. 2011; Kucher et al. 2016).

To gain support and encourage participation from livestock producers, particularly those unaware of potential drought impacts, rural water limitations, or express uncertainty about groundwater limitations in NW Iowa, coalition formation between players and context setters may be useful. Comparatively, the context setter service providers received relatively high self-described actor-linkage scores across a greater number of groups; potentially serving as a bridging organization in collaborative efforts (Table 5) (Horning et al. 2016). Another context setter stakeholder group to consider in collaborative efforts is livestock associations. Though the group received a low interest score due to a general lack of awareness or dismissal of the issue, livestock associations are the most influential group type interviewed. With increased awareness, livestock associations may be willing to participate and contribute to the collaborative governance effort in NW Iowa.

The third context setter stakeholder group is advocacy groups. However, the actor-linkage matrix results raise questions about the group’s utility as a stakeholder in the collaborative governance process (Table 5). Besides government and advocacy, no other stakeholder group referenced them enough- or in a positive manner- during interviews to receive a linkage score. It may be appropriate at this time for DNR to prioritize engagement with livestock associations and service providers and re-evaluate advocacy’s potential role at a later state of collaboration.

The crowd stakeholder groups- municipal water systems and processors- are the most detached stakeholders from the rural water dynamic in NW Iowa. Municipal water
systems expressed confidence in their ability to handle future drought, especially systems that are connected, or projected to be connected, to the Lewis and Clark pipeline. One system described the connection as enabling “unlimited growth potential and possibly an opportunity to sell water in bulk to systems that aren’t as fortunate as us” (Interview: MWS 05, 2019). Some municipal systems already sell to rural systems and vice versa. For a more resilient and comprehensive water distribution system in NW Iowa, municipal systems should also be active in collaborative governance.

Processors we interviewed receive water from municipal systems and trust that no supply disruptions would occur during drought events. However, processors have a significant stake in maintaining the viability of livestock production and reliable, quality water in rural NW Iowa is part of that equation. For operational and financial purposes, it is critical to ensure a “consistent steady supply” of inputs; at one facility, one hour of non-production equates to greater than 100K pounds of lost product (Interview: PRC 02, 2018). Similar to livestock associations, processors in NW Iowa- or depending on inputs from NW Iowa- may require more information to understand the potential repercussions of a severe drought on production. If mobilized, processors could bring substantial resources to the collaborative table.

The results of the interest-influence matrix and actor-linkage matrix offer a useful first impression of the collaborative groundwater governance landscape in NW Iowa. It is our hope that the DNR and other interested stakeholders are able to utilize this information, as well as additional reports or content stemming from the stakeholder analysis. It may be beneficial to reevaluate or revisit the matrixes at later stages of the collaborative governance process as a tool to monitor changes in stakeholder dynamics.
and gauge progress (Bryson et al. 2011). Now that a foundational understanding of stakeholder groups in NW Iowa has been compiled, a structured interview question set may be more effective in subsequent evaluations of stakeholders’ positions in collaborative processes as well as changes in linkage between stakeholder groups. Aside from supporting collaborative governance, future longitudinal analysis would contribute to the water governance literature.

Our exploration of NW Iowa stakeholders’ perceptions of water supply, water values, interactions with other stakeholders, and governance preferences has resulted in a rich and diverse dataset that reveals opportunities and obstacles. The stakeholder analysis allowed us to organize the data in a meaningful way to understand stakeholder groups’ relative interest in the issue of water availability in NW Iowa, their ability to advocate on behalf of their interests, and measures of communication between groups. Planning for drought and water scarcity events is critical to the livelihoods and well-being of residents, farmers, and livestock in NW Iowa. The products of this stakeholder analysis are one tool to help address these concerns.

References


CHAPTER 3. GOVERNANCE REGIME ANALYSIS

EVALUATION OF AN EMERGING COLLABORATIVE GOVERNANCE SYSTEM AGAINST A ‘GOLDILOCKS’ IDEAL TYPE

Abstract

After a severe drought in 2012, stakeholders in northwest Iowa began exploring strategies to increase the resiliency of groundwater resources and distribution systems. The lead actor in the effort, the Iowa Department of Natural Resources (DNR), uses an emerging collaborative governance approach to engage stakeholder groups. This paper characterizes the four structural dimensions of the current governance system for comparison against a spectrum of governance regime ideal types. The ‘Goldilocks’ zone of the spectrum leverages a balance of characteristics that increase adaptive capacity, enabling more effective management of resources in complex social-ecological systems. The adaptive-and-integrated regime is the standard our case study is compared to in order to identify strengths and weaknesses of the current system. Our analysis suggests that under circumstances of extensive uncertainty and an absence of governance institutions, stakeholders in NW Iowa have developed shared assumptions about groundwater resources to fill the institutional gap. It may be possible through awareness raising and collaborative activities, that social learning can begin to fill the institutional gaps problematic to groundwater governance in the region.

Introduction

Iowa’s climate and water resources are essential to the success of the state’s agricultural industry. Precipitation throughout the growing season and generally plentiful
groundwater supplies sustain intensive production and processing of row crops and livestock. In 2018, Iowa ranked first in the nation for corn production and second for soybeans (NASS 2019). The abundance of cheap grain for feed, among other factors, contributes to Iowa’s extensive livestock industry. The state is ranked number one for hog and egg production and has the highest export value of animal products (NASS 2019). In 2018, Iowa producers raised over 25 million hogs- the next leading state, North Carolina, raised 18 million (NASS 2019). Without adequate and reliable groundwater supplies, livestock producers experience disruptions in productivity. The severity of those consequences was experienced by rural water systems and livestock producers in northwest Iowa (NW Iowa) during a 2012 drought (Hillacker 2012).

The northwestern corner of Iowa has the highest concentration of animal feeding operations (AFO) in the state and the water demand from AFO’s in several rural water systems far exceeds the demand from human populations. The 2012 drought exposed vulnerabilities in the region’s groundwater resources and distribution systems. With limited alluvial groundwater supplies and unprecedented peak usage, rural water systems struggled to meet their customers’ needs (Hillacker 2012). Considerable distress over a potential mass mortality event lead to a multi-agency emergency response effort. Ultimately, timely rains averted a crisis, but since that incident, livestock numbers have continued to grow. In anticipation of the next drought, the Iowa Department of Natural Resources (DNR) is endorsing a collaborative governance effort to address future drought and resiliency planning with stakeholders. The DNR’s statutory mission in Iowa is to protect, manage, and monitor the state’s natural resources; providing the agency with a level of legitimacy and authority to elicit participation and lead the nascent effort
The challenge will be convincing stakeholders of the seriousness of the issue and balancing potentially divergent interests.

Water resource governance systems, as with management of other natural resources, have historically utilized top-down, expert-led governance approaches that can be characterized as ‘mechanistic’ or ‘technocratic’ (Pahl-Wostl et al. 2010, 2011). However, as social systems and ecological systems increasingly interact and management becomes more nuanced, advocates of a new water governance paradigm have identified inadequacies within conventional governance approaches (Susskind 2013; Schoeman et al. 2014; de Loë and Patterson 2017).

Research indicates that governance of complex social-ecological systems would benefit from a transition toward adaptive-and-integrated management strategies (Akamani 2016; Huitema et al. 2009; Hurlbert and Gupta 2016; Pahl-Wostl 2011; Smidt et al. 2015). Adaptability is especially important as extreme weather events become more frequent and variable; exacerbating the level of uncertainty and unpredictability in the system. Proponents of adaptive governance champion collaboration between stakeholders at important stages of planning and management processes. Governance systems able to incorporate stakeholder input, prepare for uncertainty and unpredictability, and learn though experimentation are better equipped to confront contemporary water resource management challenges (Huntjens et al. 2012; Chaffin et al. 2014; Bodin 2017; Newig et al. 2018; Reed et al. 2018).

In this research, the DNR’s and other organizations’ efforts to explore and encourage resilient groundwater planning in NW Iowa are framed as an emerging collaborative governance process; a deliberative and consensus-oriented decision-making
processes led by state actors that engages non-state actors (Ansell and Gash 2008). Such collaborative approaches to water governance prioritize broad stakeholder engagement to democratize the governance process, improve community relationships, and achieve better outcomes (Holley and Sinclair 2013; Susskind 2013; de Loë et al. 2016). Collaboration is an important element to adaptive-and-integrated resource governance, but a second critical mechanism in complex systems is an iterative cycle of experimentation, learning, and revision to anticipate and manage governance shortcomings (Pahl-Wostl et al. 2007).

This paper uses a conceptual framework adapted from Pahl-Wostl (2009) to characterize the current water governance system in NW Iowa and compare it to three governance regime ideal types: prediction-and-control, adaptive-and-integrated, and community-driven. The three regimes typify a spectrum of approaches from exclusive participation in rigid hierarchies to inclusive participation in informal, fragmented networks, respectfully. We analyzed 60 stakeholder interviews to describe the four structural dimensions of a governance system: role of state and non-state actor groups, presence of multi-level interactions, formality of institutions, and governance mode (Pahl-Wostl 2009). Through methodical evaluation of the nascent collaborative governance effort, we seek to understand 1) where the NW Iowa case study aligns within the spectrum of three ideal types based on characterizations of the four structural elements, 2) strengths and weaknesses in the existing governance system relative to the adaptive-and-integrated regime, and 3) opportunities for adaptive capacity and multilevel learning.
Case study: NW Iowa groundwater management

High temperatures, low precipitation, and falling water tables during the 2012 drought led to unprecedented peak usage in rural water systems as AFOs increasingly relied on rural water to hydrate and cool animals (Hillacker 2012). The drought event—the worst experienced in Iowa since 1988—exposed vulnerabilities in NW Iowa’s groundwater resources and distribution systems (Hillacker 2012). At the drought’s peak, rural water systems struggled to provide AFOs with daily minimum water requirements, producers trucked water from alternative sources, fire departments had been called to hose down cattle to cool them, and state agencies were preparing emergency mass mortality plans (Hillacker 2012; Interview: GOV 04, 2019). With “days left,” as a rural water system described it, the rain fell, aquifers replenished, and the crisis was averted (Interview: RWS 06, 2018).

Since that time, the DNR has organized 13 events with various groups to discuss drought contingency planning and to stay abreast of developing drought conditions (Table 1). Rural water systems have been a primary target for engagement due to their unique position as a critical water source for the high concentration of livestock in NW Iowa; 43% of the state’s AFOs are located in the region (NASS 2019). Livestock producers require large volumes of good-quality water for animal health and operational success. In NW Iowa, rural water systems are commonly a primary or secondary water source for AFOs, accounting for 50-90% of a rural water systems’ volume (Interview: RWS 02, 03, 04, 05, 2018).
Despite the DNRs efforts to address the unresolved issues raised during and after 2012, not all stakeholders have maintained interest or have justifiably moved on to more pressing concerns. Ironically, a surplus of water happens to be one of those concerns. Over the past two years alone, Iowa has experienced above average rainfall and significant flooding events: 2018 was the wettest year in Iowa’s recorded history and March 2019 charted historic flooding along the Missouri river, Iowa’s western border (Glisan 2018; Glisan 2019a; 2019b). The recent overabundance of water makes it challenging to engage stakeholders in collaborative drought and water scarcity planning. As one livestock association participant said, “When you're getting too much rain, it's hard to think about scarcity issues,” (Interview: LA 07, 2019).

Table 1. Events organized by the Iowa Department of Natural Resources (and attending stakeholder groups) since 2012 that address drought and groundwater planning.

<table>
<thead>
<tr>
<th>DATE</th>
<th>LOCATION</th>
<th>Government</th>
<th>Water Suppliers</th>
<th>Service Providers</th>
<th>Research Institutions</th>
<th>Livestock Producers</th>
<th>Commodity Groups</th>
<th>Advocacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 March 27</td>
<td>Sioux Center</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 March 13</td>
<td>Storm Lake</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>2013 May 07</td>
<td>Ft. Dodge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 May 11</td>
<td>Storm Lake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 May 14</td>
<td>Storm Lake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015 January 06</td>
<td>Sheldon</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2015 January 13</td>
<td>Sheldon</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016 December 22</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017 July 31</td>
<td>Cherokee</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2018 February 12</td>
<td>IRWA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 June 28</td>
<td>Des Moines</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>2018 July 26</td>
<td>Sheldon</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>2019 February 19</td>
<td>IRWA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

IRWA, Iowa Rural Water Association annual conference; NA, Not available
Theoretical Framework

To investigate and describe groundwater resource governance in NW Iowa, we use an adapted conceptual framework developed by Pahl-Wostl (2009) to examine adaptive capacity in resource governance regimes. This section explains the functionality of governance regimes to characterize governance systems, describes the four structural dimensions of a governance system, and outlines regimes’ relationships to adaptive capacity and multi-level learning. Important concepts that support our main theoretical framework are social-ecological systems and collaborative governance. For clarity, the definitions of supplementary concepts as well as resource management, water governance, water governance system, and water governance regime are given below and proposed relationships between them outlined in Figure 1;

- **Social-ecological system (SES)** are nested, multi-level arrangements of interdependent societal (human) systems and ecological (biophysical) systems that provide critical services such as water, food, fiber, etc. (Berkes and Folke 1998, Anderies et al. 2004). Major system forces such as climate change, globalization, technological change, and political change can also be accounted for; variables capable of radically elevating uncertainty and complexity (Colding and Barthel 2019).

- **Collaborative governance** is a “governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets” (Ansel and Gash 2008).
• **Resource management** refers to the “activities of analyzing and monitoring, developing, and implementing measures to keep the state of a resource within desirable bounds” (Pahl-Wostl 2009:355).

• **Water governance** is the “social function that regulates development and management of water resources and provisions of water services at different levels of society” and the **system** refers to the organization interconnected institutions and actors that perform the function of water governance (Pahl-Wostl 2015:26).

• **A water governance regime** is the interdependent set of formal and informal guiding principles that generate an “internal logic” and determines the governance system’s main structural functionality; the regime is conceptualized as the motivating paradigm (Pahl-Wostl 2007, 2009, 2015).

Figure 1. Relationship of water governance regime framework within a social-ecological system. Adapted from Pahl-Wostl 2015.
Governance regimes

This research employs a conceptual framework developed by Pahl-Wostl (2009), with minimal modification, to analyze and describe the NW Iowa collaborative governance case study against three governance regime ideal types. The conceptual framework adapted in this paper falls under the umbrella of the Management and Transition Framework (MTF), a conceptual and methodological framework created specifically to analyze water systems, governance regimes, and the transformational role of multi-level learning and adaptive capacity in regime change (Pahl-Wostl 2009, 2015; Pahl-Wostl et al. 2010). The MTF uses a static representation, or class diagram, to define classes of elements and identify attributes and relations. We use the dynamic view instead to capture process cycles and activities such as policy and learning cycles that occur formally or informally (Pahl-Wostl et al. 2010). Binder et al. (2013) identified the MTF to be one of three analysis-oriented SES frameworks that study the interchange between social and ecological systems and the duality between social structure and agency.

Pahl-Wostl (2009) asserts that the guiding paradigm of a water governance system is indicative of a system’s ability or inability to deal with contemporary water issues and plan for future unknowns. Her work explicitly addresses the novel and daunting challenges water system managers face as climate change and globalization progressively influence SESs (Pahl-Wostl 2007, 2009, 2015). We frame the NW Iowa case study as a SES to recognize and explain the complex interactions between the social systems (agricultural production, regulatory agencies, water suppliers, etc.) and ecological systems (hydrology, landscape, climate, etc.).
Governance paradigms (Table 2) are conceptualized as three ideal types: prediction-and-control, adaptive-and-integrated, and community-driven (Pahl-Wostl 2009; Halbe et al 2015). Each of the regimes’ governance systems can be characterized by four structural dimensions (Figure 1); the role of state and non-state actor groups, nature of multi-level interactions, influence of formal and informal institutions, and governance mode (Pahl-Wostl 2009).

Actors may be state or non-state, and roles are normative descriptions of the actor’s influence or participation in resource governance processes. Actor coordination is

<table>
<thead>
<tr>
<th>Table 2. Structural and learning process characteristics and description of uncertainty management for the three ideal type governance regimes.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GOVERNANCE REGIMES</strong></td>
</tr>
<tr>
<td><strong>STRUCTURAL CHARACTERISTICS</strong></td>
</tr>
<tr>
<td><strong>Role of actors</strong> state, non-state</td>
</tr>
<tr>
<td>State dominated</td>
</tr>
<tr>
<td><strong>Institutions</strong> formal and informal</td>
</tr>
<tr>
<td><strong>Governance modes</strong> hierarchies, markets, networks</td>
</tr>
<tr>
<td><strong>Multi-level interactions</strong></td>
</tr>
<tr>
<td>Centralized</td>
</tr>
<tr>
<td><strong>LEARNING CHARACTERISTICS</strong></td>
</tr>
<tr>
<td><strong>Multi-loop learning</strong></td>
</tr>
<tr>
<td>Single-loop</td>
</tr>
<tr>
<td><strong>applied to Governance regime</strong></td>
</tr>
<tr>
<td>Policy cycle</td>
</tr>
<tr>
<td><strong>MANAGEMENT OF UNCERTAINTY</strong></td>
</tr>
<tr>
<td>Used to justify non-action; reliance on science to find solution, reduce uncertainty; improve predictive capabilities</td>
</tr>
</tbody>
</table>

captured in the multi-level interaction field and distinguishes the scale and scope of a governance system spatially, temporally, vertically, and horizontally (Table 2) (Pahl-Wostl 2015). The combination of characteristics determines the centers of decision making and types of coordination practiced in the governance system (Pahl-Wostl 2009). Our research only accounts for vertical and horizontal interactions where vertical interactions refer to coordination between administrative levels and horizontal interaction occurs across sectoral boundaries. Systems with high vertical integration are classified as centralized, while system using primarily horizontal integration are considered fragmented. The system is classified as polycentric when neither horizontal nor vertical interactions dominate the system. Polycentric systems are integrated and multifaceted self-organizing systems of distinct governance units; the nested hierarchy distributes decision making authority across multiple levels (Pahl-Wostl 2009).

The term Institutions refers to the rules governing actors’ behavior rather than physical structures or organizations (Table 2). Formal institutions are associated with the official channels of governmental bureaucracies, are codified in legal documents, and enforceable through legal measures. Informal institutions refer to the social and cultural norms that guide actors and are not codified or enforceable through legal means. The dominant institutions typically parallel the role and type of actors involved (Pahl-Wostl 2009).

The governance modes are classified as either bureaucratic hierarchies, markets, networks, or hybrid and “denote different ways of coordinating collective action and operate under different logics” (Pahl-Wostl 2018). Each of the modes can be described based on a selection of differences (roles of government, choice of actor, power, steering,
dominant actor type, motive of sub-ordinate actor, and roles of knowledge) and governance functions (knowledge generation, policy framing, resource mobilization, conflict resolution, rule making, and monitoring and evaluation) (Pahl-Wostl 2018). Chiefly, bureaucratic hierarchies use formal processes, steering is based on authority, and power correlates to an actor’s position within the hierarchy; networks rely on informal institutions, steering is based on trust, and power is based on an actor’s role in the network; markets use formal and informal institutions, steering is dependent on price and economic incentive, and power comes from wealth and resource access; and hybrid governance occurs when the modes are balanced in the system (Pahl-Wostl 2018).

The combination of these four dimensions-- multi-level interactions, actor roles, institution formality, and governance mode --constitute a governance system. The prediction-and-control regime refers to a system characterized by top-down bureaucratic hierarchies reliant on centralized interactions, formal institutions, and high involvement from state actors (Table 2) (Pahl-Wostl 2009). The community-driven regime is representative of systems with informal, bottom-up networks of non-state actors. The prediction-and-control regime and the community-driven regime are characterized as the inverse of one another and represent the two ends of the governance regime spectrum.

The middle ground of the ideal types is the adaptive-and-integrated regime. An adaptive-and-integrated regime is typified as interconnected networks of state and non-state actors with overlapping roles, polycentric interactions, a balance of formal and informal institutions, and governance modes operating parallel to one another (Table 2) (Pahl-Wostl 2009). A consequence of integrated, polycentric systems with distributed influence, is a blurred distinction between “those who govern and those who are
governed” (Pahl-Wostl 2015:85). Important new actor roles and functions also emerge, such as boundary spanners acting simultaneously across numerous levels and knowledge brokers facilitating knowledge exchange (Pahl-Wostl 2009). The more diverse and complex the governance regime is, the greater its adaptive capacity to plan for and cope with complexity and uncertainty in SESs (Pahl-Wostl 2009; Pahl-Wostl et al. 2010).

**Governance regimes as learning processes**

Adaptive capacity refers to the ability of a governance system to adjust processes and structural dimensions of a system in response to changes in the SES (Pahl-Wostl 2009). Pahl-Wostl (2009) applies the concept of triple-loop learning developed by Hargrove (2002) in organizational theory to a water governance context to demonstrate levels of adaptive capacity. The learning aspect of adaptive capacity is conceptualized as an exploratory and purposeful stepwise process where change happens at group and structural levels (Pahl-Wostl 2009). With each consecutive loop (e.g., step) of the multi-loop learning process, shown in Figure 2a, the adaptive capacity of the system increases. In single-loop learning, the priority is to improve performance without questioning established routines or guiding assumptions; double-loop learning is realized when the frame of reference changes and assumptions are questioned; and triple-loop learning promotes a paradigm shift following substantial reevaluation of assumptions, values and beliefs, and existing structural contexts (Pahl-Wostl 2009, 2015).

In Figure 2b Pahl-Wostl (2009) reconceptualizes multi-loop learning to differentiate between formalized policy cycles and informal learning cycles. The policy cycle is represented as three generalized phases of policy and management processes (i.e., identification of the water resource desired state and establishment of strategic
goals, development of an actionable legal framework with operational goals and measures, and implementation and evaluation); while learning can occur in the policy cycle, it is limited to single-loop learning that seeks incremental improvements in the system with minimal critical reflection (Pahl-Wostl 2009, 2015, Pahl-Wostl et al 2010). The reframing learning cycle—the analog of double-loop learning—focuses on the reevaluation of action plans based on outcomes of the implementation and evaluation phase; the beginning of reframing and questioning established institutions (Pahl-Wostl 2015). Triple-loop learning and the transformation of the reigning paradigm occur in the transforming learning cycle where strategic goals and policy formulation are greatly questioned, eventually effecting operational goals and measures (Pahl-Wostl 2015).

Depicting the learning loops as formal and informal cycles emphasizes the role of informal institutions and shadow networks within learning processes. Informal institutions and networks serve an important function to support innovation and prepare systems for change by exploring alternative systems thereby inspiring double and triple-loop learning while formal policy cycles persist in single-loop learning (Pahl-Wostl 2009, 2015). Strict bureaucratic hierarchies, centralized economic systems, and insufficient public access to policy formation are barriers to learning processes (Mostert et al. 2007; Tippet et al. 2005). The relative rigidity of formal policy cycles is more apt to encourage bargaining between actors rather than open innovative discourse (Pahl-Wostl 2009).

Reliance on policy cycles and single-loop learning is characteristic of the prediction-and-control regime where governance is formal, hierarchical, and centralized (Table 2). The community-driven regime, inversely, is informal, network-based, and fragmented, therefore more closely, but imperfectly, aligned with shadow networks and
Figure 2. a) Schematic of multi-loop learning (Hargrove 2002; Pahl-Wostl 2009); b) Schematic of links between formal policy and informal learning cycles. Dashed arrows denote the sequence of three generalized policy phases. Bold arrows identify links bet
double-loop learning. Shadow networks here refer to the informal networks that exist behind the scenes; though capable of supporting learning cycles, shadow networks have limited influence on policy (Pahl-Wostl 2007, 2009).

The Goldilocks zone of regimes is adaptive-and-integrated. The adaptive-and-integrated regime utilizes double and triple-loop learning and the reframing and transforming learning cycles in governance. The adaptive-and-integrated regime is able to engage in higher levels of learning due to integration of state and non-state networks and roles, polycentric structure, balanced institutional formality, and co-existing governance modes (Pahl-Wostl 2015).

Identifying the structural dimensions and processes that promote internal evaluation can help governance systems establish feedback mechanisms and transition away from single-loop learning and the policy cycle (Pahl-Wostl 2009). The following section outlines the analytical framework used to evaluate the NW Iowa case study and compare the existing collaborative governance effort to the governance regime ideal types. Assessment of the case study relative to the regimes and structural characteristics is useful for understanding current learning processes and identifying opportunities to develop adaptive capacity.

**Methods and Analytical Approach**

Qualitative interview data is used to analyze and compare the NW Iowa collaborative governance case study to three governance regime ideal types. From January 2018 to July 2019, purposive and snowball sampling were used to recruit participants for 60 semi-structured, in-depth interviews. In total, six stakeholder groups were represented: government, water suppliers, industry, livestock producers, service
providers, and advocacy organizations (Table 3). Each of the rural water systems in our study region agreed to participate. All but four interviews were recorded and transcribed verbatim; two interviews were hand transcribed during the interview and two were conducted over email. Interviews averaged 44 minutes and were conducted in person with exception of the four over phone or email.

Interview protocols containing a core question set were developed for each interview; stakeholders were asked to reflect on current and future water supply risk perceptions, experiences during the 2012 drought, planning processes, communication with other stakeholders, thoughts on current water governance, and opportunities to participate in collaborative processes.

In addition to the 60 interviews, archival data (a mixture of agendas, attendance sheets, and presentations) from 11 DNR-hosted drought-related events were acquired. Further, observational data from two additional DNR-sponsored meetings with rural water system managers and engineers were collected at the 2018 and 2019 Iowa Rural Water Association (IRWA) meetings. Interview data and event documents were coded in NVivo based on a coding structure that characterizes the structural dimensions of the governance system (Table 2). An explanation of how each item is coded follows.

<table>
<thead>
<tr>
<th>STAKEHOLDER</th>
<th>CODE</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water suppliers</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rural water systems</td>
<td>RWS</td>
<td>9</td>
</tr>
<tr>
<td>Municipal water systems</td>
<td>MWS</td>
<td>4</td>
</tr>
<tr>
<td>Industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock associations</td>
<td>LA</td>
<td>6</td>
</tr>
<tr>
<td>Processors</td>
<td>PRC</td>
<td>3</td>
</tr>
<tr>
<td>Livestock producers</td>
<td>LP</td>
<td>20</td>
</tr>
<tr>
<td>Government</td>
<td>GOV</td>
<td>8</td>
</tr>
<tr>
<td>Service providers</td>
<td>SP</td>
<td>6</td>
</tr>
<tr>
<td>Advocacy groups</td>
<td>ADV</td>
<td>4</td>
</tr>
</tbody>
</table>

N = 60
Examination of the normative role of actors and interactions focus on characteristics and patterns measurable at the individual level. Each stakeholder group is categorized as state or non-state depending on the overall composition of the individual participants. Similarly, a brief description of the stakeholder group is also provided. The institutions that govern actor behavior are representative of numerous processes of development, codification, communication, and enforcement, this analysis focuses on communication structures and channels. Within interview transcripts, instances that capture communication between stakeholders individually or as a group are compiled and examined for themes that describe generalizable interaction trends such as communication through the ranks of government agencies, coordination across livestock-related group, or the private sector collaborating with the public sector. In addition, the drought event documents and IRWA field notes are useful to determine which actors are targeted for attendance and which actors are given a platform to share expertise.

The final two structural characteristics are institutions and governance mode. Formal and informal institutions are identified in transcripts and supplemental data in two ways. Formal institutions are revealed by coding references to or descriptions of and policies, rules, or regulations that determine how stakeholders interact with water resources, directly or indirectly. Formal institutions can be enforced by state or non-state actors. Informal institutions are coded thematically through iterative interpretation to understand any underlying social or cultural norms associated with water resource use, management, or governance in NW Iowa. The governance mode is ascertained by an evaluation of four differences: key concept, power, steering, and choice of actor; and three functions: knowledge generation, rule making, and monitoring and evaluation.
Data from interviews transcripts and supplemental documents that demonstrates the qualities in listed in Table 4 was coded and cumulatively evaluated to determine which modes are active in the NW Iowa case study.

The conceptual framework adapted from Pahl-Wostl (2009) to examine the current water governance system in NW Iowa is complex and capable of evaluating water governance case studies to great depth. However, within the regime framework outlined, this paper focuses on identifying the four structural characteristics of a governance system. The issue of water governance related to scarcity and the DNR’s collaborative governance efforts are novel and emerging, therefore some elements of the governance system in NW Iowa lack development to document with available data. The results section examines how actors, interactions, governance mode, and institutions compare to the adaptive-and-integrated regime.

Table 4. Characterization of a selection of differences and functions for three governance modes: hierarchical, network, and market.

<table>
<thead>
<tr>
<th>GOVERNANCE MODE</th>
<th>Differnces</th>
<th>Network</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key concept</strong></td>
<td>Public goods</td>
<td>Public value</td>
<td>Public choice</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>Position in formal hierarchy</td>
<td>Centrality of the role in network</td>
<td>Degree of wealth, market share</td>
</tr>
<tr>
<td><strong>Steering</strong></td>
<td>Authority</td>
<td>Trust</td>
<td>Price, economic incentives</td>
</tr>
<tr>
<td><strong>Choice of actors</strong></td>
<td>Controlled by written rules</td>
<td>Free, ruled by trust and reciprocity</td>
<td>Free, rules by price and negotiation</td>
</tr>
</tbody>
</table>

Adapted from Pahl-Wostl (Table 5.1 and Table 5.2, 2015:90-92)
Results

Our coding of interview transcripts, field notes, and archival documents, supplemented with additional documents to outline industry standards or clarification of legislative responsibilities, provide insight about the nature of groundwater governance in the NW Iowa case study. As expected, the characterizations of the four governance system dimensions are complex and do not neatly fit within the parameters of any one of the three ideal types. The following sections describe the actor groups interviewed in NW Iowa and their role as a water user and/or participant in water governance efforts, the formal and informal institutions that influence governance, a characterization of the governance mode, and multi-level interactions between actor groups.

The actors section provides more detail about the stakeholder groups with normative descriptions of roles related to water use and governance and clarifies their position as a state of non-state role. The institutions section divides the observed institutions that govern water use and management by formal institutions and assumptions that fill institutional gaps. As described more in the section, a lack of formal and informal institutions leads to guiding assumptions. The governance mode section outlines how eight elements (i.e., mode differences and functions) of the NW case study align with characteristic traits of the three modes- hierarchy, market, and network. The following section discusses the overall interactions of stakeholders related to water governance as dominantly fragmented with minimal centralized coordination. The final section outlines where in the spectrum of regimes the NW Iowa governance effort falls based on the observations of the four structural dimensions.
Actors

Among the eight stakeholder groups analyzed in the case study (Table 5), we refer to three as the core group most relevant to groundwater governance in NW Iowa: water suppliers, water users, and water regulators— or, rural water systems, livestock producers, and the DNR\(^1\), respectively. The three groups are considered most relevant because of their responsibility to provide and ensure safe water suppliers and in water scarcity events, are the most immediately impacted. Rural water systems are non-state actors that provide rural customers with drinking water. The rural water systems are actively engaged in collaborative efforts and demonstrate interest in exploring strategies to build resiliency in their systems. Livestock producers account for 50-90% of a system’s outgoing volume in NW Iowa and many rely on rural water as either a primary or secondary, back-up, water source.

Livestock producers are also non-state actors and in interviews were largely supportive of collaborative governance and recognize the value of proactive drought planning. A producer said, “Let’s not be shooting from the hip, so to speak. It'd be nice if we have given this a little forethought of exactly how would this work…. These are good discussions…Have we had them? No,” (Interview: LP 05, 2019). Producers’ experiences with water availability varied tremendously for a number of factors but corresponded to their perception drought planning’s value.

The third ‘core group’ is water regulators, the DNR agency is included in the government stakeholder group- one of only two groups categorized as state actors. The

\(^1\) The DNR is the only government stakeholder group that will be referred to directly in the proceeding results and discussion due to their leadership in drought preparedness and water planning.
government stakeholder group represents a total of four state-level agencies with responsibilities related to natural resource management, livestock production, emergency management, and economic development. During the 2012 drought response, a variety of government agencies were involved to coordinate resources. Since the event, the DNR has continued to engage with stakeholders while other agencies transitioned back to other responsibilities. The DNR is considered the leader in collaborative governance efforts and has organized a number of events (Table 1).

The second state actor is the municipal water systems stakeholder group. Municipal systems are publicly owned and able to utilize tax revenue for operational costs unlike rural water systems. They are also different in terms of distribution and customer demand. Municipal systems serve smaller systems spatially and, in our sample, do not have livestock customers. The largest customers in municipal systems tend to be processors- non-state actors- or rural water systems; rural and municipal systems are not

Table 5. Role of actors in NW Iowa case study, categorization as state or non-state with descriptions of relevance to case study and description of current engagement in collaborative governance of water resources.

<table>
<thead>
<tr>
<th>STAKEHOLDER GROUPS</th>
<th>ROLE OF ACTORS</th>
<th>General description</th>
<th>Involvement in water governance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>State, non-state</td>
<td>Responsible for water resource management and regulation</td>
<td>Lead actor in collaborative effort, initiated planning and drought monitoring events (DNR events), major involvement in 2012 drought response</td>
</tr>
<tr>
<td>Rural Water Systems</td>
<td>Non-state</td>
<td>Water supplier for rural customers in northwest Iowa</td>
<td>Active participant in collaborative effort, pursuing strategies for increased system resiliency</td>
</tr>
<tr>
<td>Municipal Water Systems</td>
<td>State</td>
<td>Water supplier for city and municipality customers in northwest Iowa</td>
<td>Aware of distribution challenges in northwest Iowa, collaborate with rural water systems, variable participation in DNR events</td>
</tr>
<tr>
<td>Livestock Producers</td>
<td>Non-state</td>
<td>Primary rural water customer by volume (e.g., hog, cattle, and poultry producers)</td>
<td>Variable awareness of water scarcity concerns, minimal participation in DNR events</td>
</tr>
<tr>
<td>Service Providers</td>
<td>Non-state</td>
<td>Work closely with livestock producers (e.g., manure management, permitting)</td>
<td>Variable awareness of water scarcity concerns, minimal participation in DNR events</td>
</tr>
<tr>
<td>Livestock Associations</td>
<td>Non-state</td>
<td>Represent and support livestock producer-members’ interests politically</td>
<td>Major involvement in 2012 drought response, minimal involvement in collaborative effort, variable interest</td>
</tr>
<tr>
<td>Processors</td>
<td>Non-state</td>
<td>Reliant on livestock production for inputs, a large water user</td>
<td>Minimal awareness of water scarcity concerns, no known participation in DNR events</td>
</tr>
<tr>
<td>Advocacy Groups</td>
<td>Non-state</td>
<td>Focus on environmental sustainability of farming in Iowa and water quality issues</td>
<td>Minimal awareness of water scarcity concerns, minimal participation in DNR events</td>
</tr>
</tbody>
</table>
generally linked but some systems sell water to one another and overall water suppliers explain that they “often help each other troubleshoot a problem or borrow a piece of equipment” (Interview: MWS 05, 2019). For municipal systems that rely on rural water or are a significant supplier for rural water, there is increased motivation to participant in collaborative water-planning processes.

The livestock associations and service providers, both non-state actors, also have a vested interest in water planning. As representatives of their producer-members, livestock associations have the ability to advocate on livestock producers’ behalf and potentially provide political resources and leverage. In 2012, the associations were actively engaged with response activities but like the majority of government stakeholders, moved on to other obligations when the crisis was averted. One association described that period as, “It started to rain, the aquifers filled back up and everyone went, ‘Phew!’ and life went back on…it wasn’t as if anything changed, there was just a lot of meetings, a lot of discussions, a lot of ‘what-if’s,’” (Interview: LA 05, 2018). Service providers were only aware of the drought’s consequences if they were working with producers that experienced resulting hardship. The group has participated in DNR events to a minimal degree.

Advocacy groups have also been less active than most other groups in groundwater governance efforts. Advocacy groups in our sample use various approaches to support sustainable agriculture and healthy landscapes in Iowa. A shared characteristic between organizations is an emphasis on water quality. Advocacy participants expressed little, if any, awareness of water quantity concerns in NW Iowa and have engaged in DNR events minimally. For the purpose of conciseness and the groups’ marginal
awareness or engagement thus far, advocacy groups and processors are not discussed in
great detail though the remainder of the paper. Likewise, less attention is also given to
municipal water systems due to their periphery relationship to the core stakeholders.
While these three stakeholder groups are important, their interactions with remaining
stakeholder groups and participation in governance require more explanation than can be
adequately provided in this paper.

Institutions

The groundwater governance institutions identified in NW Iowa are limited to a
combination of formal processes required by state and non-state actors. The formal state
institutions are mandated at the federal and state-level with the intent to protect public
water resources and are enforced at the state-level by the DNR. The DNR is also
responsible for programs that regulate AFO siting, construction, and operation to, among
other things, protect surface water quality and account for activities that have potential to
contaminate groundwater. Livestock-focused stakeholders (i.e., livestock producers,
service providers, and livestock associations) interact more consistently with the DNR’s
AFO regulatory structures, and two additional formal institutions: Pork Quality
Assurance Plus® (PQA Plus®) national auditing program and contractual agreements
with rural water systems. Each of the three institutions is described as or observed to be
inadequate for present groundwater governance challenges.

No informal institutions emerged from our data analysis. In lieu of effective
formal or informal institutions, a set of assumptions about groundwater resources and
management seem to have formed. The first assumption is that water scarcity is a concern
experienced in other regions of the country, not in ‘water-rich’ Iowa. Related, a majority
of livestock producers are resolute in their assumption that rural water is a guaranteed safety-net. The last assumption characterizes a disconnect between rural water systems and livestock producers, and livestock producers and their respective livestock associations and service providers. Livestock-related stakeholders assume that because water is a crucial resource for livestock production, producers are confirming water availability prior to expanding their operation or building new facilities. The next subsections provide more description of the current formal institutions, evidence indicating their ineffectiveness, and the assumptions adopted by stakeholders that we term ‘institutional gaps’.

*Formal water use institutions*

Federal laws guiding water resource management in Iowa are the Safe Drinking Water Act and Clean Water Act (DNR 2019). A rural water manager explained, “There's not a lot of policy development [in Iowa]….it tends to be following the mindset, ‘Thou shalt not have regulations in the state of Iowa that are more prescriptive than what the Federal government is already laying upon our shoulders’” (Interview: RWS 08, 2018, Megdal 2018). Nevertheless, the DNR Water Quality Bureau is responsible for allocating Iowa’s groundwater resources based on the principles of beneficial use, preventing unreasonable use and waste, promoting conservation, and protecting minimum instream flows (DNR 2019). A number of programs monitor ambient groundwater quality in the state, authorize construction permits for water infrastructure such as wells, treatment facilities, and distribution, and certify environmental labs, water operators, and well drillers (DNR 2019). The DNR Field Service and Compliance Bureau is responsible for
enforcing compliance, conducting inspections and site surveys, as well as any other field activities (DNR 2019).

As public water suppliers, rural water systems in NW Iowa are broadly aware of the regulatory requirements protecting and managing groundwater resources. Rural water managers work with DNR staff for regular permitting and certification needs as well as special projects, verifying appropriate hydraulic pressure in the system, source water protection, and technical assistance (Interview: RWS 05, 2018; GOV 04, 2019).

Livestock-focused stakeholders have a less nuanced understanding of Iowa groundwater governance. Producers and service providers are generally familiar with well construction requirements and support the well permitting process, “they need to have those permits so they know where the wells are located and to protect the groundwater” (Interview: LP 01, 2018).

An additional Water Use Permit is required when an applicant anticipates usage greater than 25,000 gallons a day. The Water Use Permits lists the allowable withdrawal volume, requires submission of an annual report, and is valid for ten years (DNR 2019). Aside from dairies, most AFO’s are far from meeting the threshold- “it takes a lot of pigs to get to 25,000 gallons” (Interview: GOV 05, 2019). For reference, the only producer interviewed (excluding two dairies) to meet the threshold stated that they “usually have like 25,000 [hogs] on hand at a time” (Interview: LP 16, 2019). Some stakeholders take issue with the Water Use Permit system as this rural water manager explains,

Why 25,000? Why don’t we lower that number to 5,000 gallons a day or something?

Yeah, it’s going to create more jobs or more problems for DNR to manage and stuff but
we’ve got a tool in place and to manage it. There are a lot of systems that use several thousand gallons a day but they’re not regulated in that way…. If DNR is charged with the task of keeping track and doing a good job of managing our resources, that would be one area I think they could improve. (Interview: RWS 02, 2018)

Beyond well construction for volumes less than 25,000 gallons a day, most AFO operators have minimal reason to further interact with formal state institutions on issues of groundwater use and management. Unlike public water supply systems, the DNR does not require water quality testing for private wells so there is no ongoing water monitoring relationship between the well owner and state government (DNR 2019).

Livestock-related stakeholders are more familiar with formal processes regarding AFO siting and construction permitting and manure management plans; “There’s about 200 pages that apply to the average livestock farm today. We make sure that they’re exceeding those rules” (Interview: SP 03, 2018). Unfortunately, there is a lapse in communication between livestock producers verifying a water source in AFO construction permits and actual confirmation with the rural water system- a key issue of an assumptions described at more length later. “[Service providers] don't really talk about water sources…it's more [talk about] lagoon pumping and, you know, that kind of stuff” (Interview: LP 13, 2019). Manure management regulations have an indirect role in water management; producers monitor the water going into manure storage structures because it becomes increasingly “more expensive to haul and the nutrients are less concentrated,” (Interview: SP 01, 2018). Per DNR regulations, there are restrictions on appropriate conditions for manure application so “you really only get two windows throughout the
year when you can apply that to the land so if you’re not managing that properly, you’re going to have some issues” (Interview: LA 01, 2018).

Apart from the DNR, another formal quasi-state institution affecting water management in NW Iowa is an industry auditing system developed by the National Pork Board and Pork Checkoff called PQA Plus®. We consider PQA Plus® to be a quasi-state program because the National Pork Board is itself a program administered under the USDA’s Agriculture and Marketing Service. However, PQA Plus® is not technically compulsory; the Pork Checkoff website explains that “more than 71,000 farmers and farm personnel have voluntarily embraced the program by earning PQA Plus® certification,” (Pork Checkoff, 2019). In reality, “everybody” (Interview: LA 01, 2018) participates in the program because “you have to be PQA certified to sell to [pack houses]” (Interview: LP 07, 2019). Water management is briefly addressed in three areas of the PQA Plus® assessment: under ‘Daily Observations’ it recommends recording water usage; the ‘Feed and Water Access’ section requires “all pigs must have free access to water at least once each day,”; and the ‘Emergency Action Plan’ encourages producers to establish contingency plans for critical system failures (Pork Checkoff, n.d.:19, 27, 36).

The following livestock association quote explains the significance of monitoring daily water intake and facility temperatures:

Writing down the high/low temp…and what the water meter readings were- There’s a couple of values for that to the farmer… if all of a sudden…you’re using 6,000 gallons more than you did the day before, you know you have an issue. Or if you’re using
significantly less, you may have a health challenge that’s early on and you can catch that early- get the animals to recover quicker. (Interview: LA 01, 2018)

However, poultry, cattle, and dairy producers also regarded environmental monitoring as an essential management practice, suggesting that the water management criteria in PQA Plus® does not provide direction beyond what is already standard best practice in the industry. Despite regular references to the use of generators and rural water system hook-ups as safety-net strategies, only the large hog producer previously mentioned discussed a formal emergency action plan and it was for disease and biosecurity rather than water (Interview: RWS 16, 2019).

To varying extents, livestock producers also make water-management decisions based on suggestions or requirements from their rural water system. Governing structures imposed by rural water systems include on-site storage requirements, contractual obligations, and rate structures for billing. Each system is managed differently depending on their relationship with the board, customer demands, infrastructure challenges, etc. For instance, a subset of rural water systems in the region ask oncoming customers to meet minimal on-site storage requirements before providing service. “I always recommend [storage]. Do I require it? On some places I do. Depends upon the pressures and the hydraulic analysis” (Interview: RWS 06, 2018). While other rural water systems managers feel otherwise: “We don’t believe in on-site storage. Other than it solves a short-term problem” (Interview, RWS 03, 2018).

The user agreements signed when customers initially come onto a system are an opportunity to set user boundaries and expectations. The DNR urges systems to be more specific in the agreements by explicitly outlining volume commitments and/or adding a
clause that requires producers to check with the system prior to expanding their operation “rather than all of a sudden get to the June, July, Augusts when water is needed everywhere and finding that this person has increased his lot size,” (Interview: GOV 04, 2019).

Producers’ reliance on rural water as a back-up source is problematic for rural water systems. Per the DNR’s standards, rural water systems have to ensure source and treatment for all customers during peak demand. “It's a real challenge when they've got these emergency connections because…they've already put the cost in on the source and treatment side and the piping side, but they're not getting any income from that” (Interview: GOV 04, 2019). Some systems have decided against adding customers that only plan to use rural water as a back-up while others “force the customer to buy 15% of anticipated usage…. We can reserve water, but they need to pay for it” (Field Notes: IRWA, 2019).

One strategy to increase revenue is to restructure billing, but rural water systems struggle internally with rate structures. The standard approach used is a declining rate structure, meaning “the more gallons you use, the cheaper it gets per gallon….it would be more economical per gallon for me to use a lot of water than to have two sites using the same amount of water but lower volumes,” (Interview: LP 20, 2019). However, “It’s a real struggle to get the high users to pay…. [they’re] used to paying less for more” (Field Notes: IRWA, 2019). A producer predicts that there “would be a big resistance…if they're going to start charging me a lot more then… ‘Okay. I can afford to do the well.’ And try and maintain a well as opposed to using the water.” Rural water systems “don't think that they'd ever survive that at an annual meeting” (Interview: GOV 04, 2019).
Institutional gaps

The institutional gaps are a set of assumptions that seem to fill the void where formal and informal institutions should ideally be present to guide water-related behavior and management. The first of the three assumptions is that ‘water scarcity is a concern for other regions or states, not water-rich Iowa.’ This first assumption is a likely driver of the following two assumptions which include, ‘rural water systems are a reliable safety-net’ and ‘livestock producers confirm water availability prior to expansion or new construction.’ The three assumptions contradict the premise of DNR’s collaborative governance effort in NW Iowa.

At the 2019 Iowa Rural Water Association meeting between DNR and rural water stakeholders, an engineer said, “It was once water-rich where everyone’s pushing water out the door but now there’s no longer a water surplus. It’s a massive perspective shift. Larger customers used keep us going, now they’re starting to break systems.” For rural water managers, they struggle with the perception that “people in general just think that water should be free” (Interview: RWS 03, 2018); “A lot of people are still used to water being free. It's just not that case” (Interview, RWS 09, 2019). In interviews with stakeholder groups less intimate with Iowa’s groundwater resources, the sentiment is expressed differently- ‘Water availability is important, but here?’

An advocacy group that spends considerable time on water quality issues in Iowa said, “I mean, water scarcity, it's like, you know, I'm not trying to avoid it and it's just when I think of water scarcity, I think of the southwest and deserts,” (Interview: ADV 01, 2018). Livestock producers typically said things like, “I feel that it's probably good that it's on the radar, but realistically, you look around the country and- I have a hard time...
this will be the last place we have to think about losing our water” (Interview: LP 06, 2019); water availability is something that “folks from California or Texas, or Kansas” (Interview: LP 08, 2019) and farmers over the Ogallala aquifer deal with (Interview: LP 12, 2019). Another producer quote captures how precedent frames their perception of water resources:

The first year my father farmed, he lost his crop to a hailstorm, and since 1949, there has never been a crop failure where I live…. never lost a crop because it was too dry. We always got a decent crop one way or the other…that becomes my mindset… ‘Okay. Water. We got water.’ I talk to some of my friends that are out west, and they say, ‘You have no clue what this is like’…. Everything they do is based on a water decision…I'm thinking, ‘Wow. I don't even have to think about that. It's going to rain.’ (Interview: LP 12, 2019)

The perception of the resource’s abundance in NW Iowa likely contributes to the belief that rural water is a guaranteed back-up water source and a limited awareness of source and distribution nuances. A government agency participant speculates that “there's still the attitude that if there's a rural water line that runs by, I can tap into that no matter what the size of it is and I can get water. There's still the mindset that I'm on a rural water so I'll always have water” (Interview: GOV 04, 2019). A rural water manager stated, “Everybody thinks that there's so much water, and everybody can have what they want, but that's just not true” (Interview: RWS 09, 2019). For systems that are exclusively dependent on alluvial sources, they are able to modify distribution and raise the water
Livestock producers express confidence in rural water systems’ ability to provide a safety-net for their water needs- ensuring animal welfare. When asked if producers in the area would be prepared for more frequent drought, a participant said, “I think so just because of the rural water system….they’ve done a lot of work on it and I think they're preparing probably for that too” (Interview: LP 16, 2019). If “power goes out-[producers] might flip on rural water for a couple thousand gallons” (Interview: LP 19, 2019) “instead of trucking water in.” (Interview: LP 18, 2019) Using rural water also means less responsibility and time spent on maintaining and fixing pumps or other supply infrastructure; they “let rural water worry about that” (Interview: LP 12, 2019). Overall, the feeling is that “it'd be nice for everybody to have the opportunity to hook up to rural water, for safety” (Interview: LP 03, 2018).

Unfortunately, producers do not always communicate their water use intentions- for expansion or new construction- with rural water systems. The lack of communication is a frustration shared among nearly all rural water systems. One manager said, “More times than not [producers] call up and say, ‘We’re going to populate the building in two weeks. When are you going to get the water here?’ Ya know, it’s the first we’ve heard of it” (Interview: RWS 02, 2018). Another manager replied when asked about such scenarios, “That’s not an uncommon occurrence- these people need to plan ahead. Talk to the water seller before they do anything” (Interview: RWS 06, 2019). There is tremendous frustration around the issue and how it’s possible that a “livestock producer can put down on a piece of paper that they’re going to get water from the [system]
without ever talking to them or getting any acknowledgement that that water is available” (Interview: RWS 10, 2018). Managers have approached zoning offices to ask for a “sticky note or anything saying, ‘Hey, what are you going to do for water? Are you going to put your own well in? If you’re going to use rural water [and] the barn is going to be built in such and such township…. Here’s the system’s number, you might want to touch base with them’” (Interview: RWS 04, 2018).

Stakeholder groups like services providers, livestock associations, and some government agencies- who support and represent producers- assume appropriate measures are taken by producers to secure a water source. Common statements included ones such as, “any producer that's planning expansion should look at all those possibilities. And I think a lot of them usually do of is there an adequate water supply? What's the future look like? Could there be situations where I might have shortages?” (Interview: GOV 07, 2019); and “Yeah, it’s got to happen somewhat early in that planning stage, ya know. You’re not going to build a barn and then figure out where you’re going to get water” (Interview: LA 01, 2018). When a producer was asked if they communicate with rural water prior to expansion, they admitted, “That's a fair question. And I would say probably not” (Interview: LP 15, 2019). For perspective, a producer recalled a time when they turned the back-up rural water on to conducting maintenance on their own system, when someone from rural water called to check up because it “looked like a little city turned on out there” (Interview: LP 11, 2019).

**Governance mode**

Governance mode signifies how a governance system uses various rationalities to coordinate operations and actions (Pahl-Wostl 2018). A governance mode can be
classified as hierarchy, market, or network, depending on a number of functions and differences (Table 4), and the mode is considered hybrid when multiple modes occur simultaneously with comparable influence (Pahl-Wostl 2018). The seven items (i.e., differences and functions listed in Table 4) we use as mode indicators are *key concept, power, steering, choice of actors, knowledge generation, rule making*, and *monitoring and evaluation*. The remainder of this section outlines the indicators present in the data for each mode. The hierarchy mode is denoted by the type of *power, key concept, steering, choice of actors, and monitoring and evaluation* observed. We identified the market mode based on observations that align with the mode’s *power, steering, choice of actors, rule making*, and *monitoring and evaluation* indicators. The network mode of governance was less prevalent; we identified characteristics that support the *power, knowledge generation, and rule making* indicators.

**Hierarchy**

“EPA is God, DNR is Jesus, and I’m just a disciple” according to one rural water manager, echoing the sentiment of many RWS managers interviewed (Interview: RWS 04, 2018). In NW Iowa, a number of the differences and functions that emerged through analysis were closely aligned with a hierarchal governance mode. The differences and functions observed include *power, key concept, steering, choice of actor, and monitoring and evaluation* (Table 4). *Power* in the hierarchy mode stems from a position of authority and is represented by government, specifically the administrative level of the DNR. At the 2019 IRWA meeting, a participant said, “DNR leadership keep coming to us and ask, ‘What happens if we have another drought? Can we get water to all the critters?’” The
administrative pressure is “truly the driving force why DNR has met with the rural water managers two years in a row” (Interview: GOV 04, 2019).

The *key concept* of the hierarchy mode is to manage public goods. In Iowa, water is considered the wealth of the people and permits dictate water ‘use’ rather than ‘ownership’ of the resource (Drought Event Documents: Cherokee Presentation, 2017). Governance *steering* is based partially on authority; the DNR utilizes a permitting system for water users and places additional reporting responsibilities on water users exceeding 25,000 gallons a day. The 1985 Water Plan provides guidelines for severe droughts that require prioritized allocation of water resources. Overall, it is the view of the DNR that “decisions about water use, location, and priorities best take place at the local level-guided by DNR science, data, and technical assistance” (Drought Event Documents: Cherokee Presentation, 2017).

In a hierarchical governance mode, the *choice of actors* and *monitoring and evaluation* are partially controlled by written rules and compliance with regulation and standards respectively. Livestock-focused stakeholders and rural water systems are both quick to lament frustration over government rules and regulations. One rural water manager said, “the people that are running the DNR right now are probably very educated, but they have no idea what it’s like to run a system…They want to regulate from a book, and you can’t do that. There’s got to be more common sense brought into this” (Interview: RWS 06, 2018). However, stakeholders concede that regulations are not “necessarily a bad thing. You don't want a free for all” (Interview: LP 08, 2019). Another producer described the DNR “like a police officer - nobody really wants to talk to him. But they're just out doing a job…. I mean, if you've done something wrong with your
operation and they got mad at you, well then maybe you shouldn't have done that” (Interview: LP 07, 2018).

**Market**

The indicators observed that demonstrate a market governance mode in NW Iowa include *power, steering, choice of actors, rule making, and monitoring and evaluation* (Table 4). Market mode *power* is represented by rural water systems’ market share of water utilities in the region. Additionally, as a rural water system is a private business, the DNR has limited authority over their actions (Interview: GOV 04, 2019; Drought Event Documents: Cherokee Presentation, 2017). As a dominant player in decision-making processes about groundwater distribution and management in NW Iowa, rural water system boards partially *steer* the direction of groundwater governance based on price and economic incentives. “The board of directors govern the whole association and end up to being fairly unregulated” (Interview: RWS 08, 2018). The rural water boards are “the representative[s] for their customers and their system. They bring any concerns they have, or customers might have, to the meetings and we address them” (Interview: RWS 09, 2018).

Price, negotiation, minimal rules, and cost-benefit calculations are market mode drivers of *actor choices, rule making, and monitoring and evaluation* in NW Iowa water governance (Table 4). Rural water systems talk about operational decisions in terms of finances: “We can incur more debt and pass that debt on to all the existing customers we have. We can hope and pray we get some grant money from somebody- like growth development- that’s getting harder and harder. Or we can just tell people that we can’t have any more water. So those are your options,” (Interview: RWS 06, 2018). Decisions
to impose additional costs on the customer is commonly viewed as walking a “fine line…they might leave, and you need that revenue” (Field Notes: IRWA 2019). The livestock stakeholders also reflect back to price and trade-off when discussing water management or drought planning: “We'd have to feed less livestock because you couldn't afford to buy the corn, there wouldn't be the availability” (Interview: LP 15, 2019) but ultimately the shared sentiment is, “I think they'd find ways, you know? Yeah, I think if they looked at that as a major cost, they'd find ways to limit it.” (Interview: LP 14, 2019).

**Network**

Interview and event documentation illustrate a network governance mode for *power, knowledge generation and rule making* indicators (Table 4). Aside from hierarchical power, the DNR field staff demonstrate *power* from their central role in the network between government, rural water systems, livestock producers, and service providers in NW Iowa. The relationships the field staff have developed with other stakeholder groups enable the DNR to organize events with those groups. Efforts to coordinate with rural water systems are of particular importance as they are the other dominant actor. *Knowledge generation* in the NW Iowa case study is demonstrated by an ongoing effort to understand different types of knowledge, and encourage knowledge sharing and generation. Of the events organized by the DNR, the IRWA meetings have been particularly important for rural water systems to candidly discuss management challenges. Participants on both sides have expressed in the meeting that “I’m glad we’re talking about this” and “It’s nice to be able to talk” (Field Notes: IRWA, 2019).

From interviews, stakeholders perceive limited incentive to use legislative measures for governance efforts; *rule making* is intended to be negotiated (Table 4). The
rural water systems and livestock-related stakeholders view additional rules and regulations unfavorably and the DNR does not show interest engage the political process. At the IRWA meeting in 2019, DNR stated “Being here is our way to help.” When asked about making modifications to existing policy a government participant said, “We're a pretty ag friendly state and it's just not going to probably gain popularity…people are going to complain no matter what you do, but it's kind of working” (Interview: GOV 05, 2019).

There is no one dominant governance mode observed in NW Iowa and labeling the mode as a hybrid would be a mischaracterization. Hierarchy and market exhibit similar influence in the governance structure but demonstrate more weight than the network mode. The lack of institutions likely contributes to the disjointed governance modes and it could be interpreted that network is the mediating governance mode between hierarchy and market.

**Interactions**

Interactions describe how stakeholders coordinate vertically through administrative levels and horizontally across sectors to gauge where decision making primarily takes place (Table 2). When centralized (high vertical) and fragmented (high horizontal) interactions are balanced, polycentricity prevails and decision-making authority is distributed across multiple levels (Pahl-Wostl 2009). Interactions in the NW Iowa case study are predominantly fragmented between stakeholders, with the exception of some description of centralized interactions within the government and rural water stakeholder groups. The instances of fragmented and centralized coordination are not integrated enough to consider the current governance structure polycentric.
Livestock-related stakeholder groups interact with one another and government stakeholder groups to varying degrees. Livestock producers have fewer interactions with other groups in general but many of our participants were active members of livestock associations and describe a reliance on service providers. The described relationships indicate that decision making is distributed between service providers for assistance navigating formal institutions such as permitting and manure management plans, and livestock associations who lobby for policy decisions on their behalf. Minimal interaction with rural water systems takes place aside from annual reports, billing, and occasional maintenance notifications are the extent of interaction described by producers.

Within the government stakeholder group, a combination of vertical and horizontal coordination is present. When discussing planning and response to drought, participants describe centralized procedures that keep agencies and employees “in their lane” so as to avoid “confusion, inefficiency” or taking the response in the wrong direction (Personal Communication: IDALS, 2019). The permitting systems that water suppliers, livestock producers, and service providers work within are also types of centralized interaction.

Simultaneously, government participants speak highly of collaborative opportunities. When asked about support for collaborative efforts, government stakeholders expressed sentiments such as, “Absolutely, we always do” (Interview: GOV 08, 2019), “We're not an island unto ourselves…Collaboration is the only way to solve large scale problems” (Interview: GOV 06, 2019), and;
You really don't know what the people need, or what they want…they're just doing their
day to day, with this reality that they think is true about drought. Or, their water in
general. You get them in the room, and they start explaining their rational or their ideas
and, it's really amazing. Just the educational opportunity. (Interview: GOV 02, 2019).

The DNR staff in NW Iowa have developed respected relationships with water suppliers.
One rural water manager described DNR staff as “very knowledgeable…very good to
work with. [They have] gone to bat numerous times in Des Moines for NW Iowa
systems- not only rural water systems but community and public water supplies as well”
(Interview: RWS 02, 2018). This quote demonstrates an instance where the unidirectional
flow of authority in a partially centralized system shifts due to the agency employee’s
advocacy on behalf of the water systems (Pahl-Wostl 2009).

Rural water systems as a group are fairly siloed but decision making is ultimately
dependent on approval through vertical interaction, whether that occurs through the
DNR, Army Corp. of Engineers, or as a rural water manager explained, “the board of
directors govern the whole association” (Interview: RWS 08, 2019). Within their
stakeholder group however, rural water managers express similar gratitude for peer
relationships and “the fact that we communicate with each other and talk about a number
of different issues. (Interview: RWS 02, 2019). The fragmentation observed in Iowa
aligns with the general conclusion of a national survey of state agency officials to
understand the extent and scope of groundwater use, laws, regulations, tools, and
strategies that groundwater governance in the United States is fragmented (Megdal et al.
2015).
Governance regime

Analysis of the four structural dimensions of a governance system - role of actors, institutions, governance mode, and interactions - provides a methodical approach to critically evaluating the current water governance system in NW Iowa. How the case study is positioned within the spectrum of ideal type regimes is valuable to understanding strengths and weaknesses relative to the Goldilocks zone of resource governance. Within the range of ideal types, from a highly structured, formal, state-dominated prediction-and-control regime to a minimally structured, informal, non-state-dominated community-driven regime, the ‘Goldilocks’ of the three regimes is adaptive governance and considered to be the balance between the two. As expected, our case study does not meet all the structural criteria for any one of the three regimes, nor does the case study share a majority of characteristics with one of the regimes.

The position of actors is most closely aligned with the adaptive-and-integrated regime because of the involvement by state and non-state actors with the caveat that more non-state actor participation is required to represent more perspectives in collaborative processes. The findings for institutions are difficult to place because of the lack of robust institutions around water use and management, formal or informal. The governance mode is a hybrid of mainly hierarchy and market modes with some elements of network. Once more, it is difficult to align this structural element within the regime spectrum. Though there are characteristics shared with each of the modes, it seems inappropriate to consider the mode a hybrid because of the lack of coordination between the mode. The last structural characteristic mirrors the observation for governance mode. While it is the case that centralized and fragmented interactions are taking place, the vertical and horizontal
coordination do not complement each other and are not representative of a polycentric governance system.

Overall, the analysis indicates that participating stakeholders perceive groundwater management and governance in NW Iowa to be a function of limited formal state institutions and individual economic-related decisions based on cost-benefit analysis. The determination of a decision’s value for livestock producers and rural water systems is quantifiable in dollar terms; for producers, that the impact on animal health and selling price, for rural water systems, it is the tradeoffs of modifying rates and user conditions for system investment versus potentially losing support of the board and customers.

The absence of institutions and abundance of uncertainty, or awareness, about the state of groundwater resources and infrastructure in the region reveal a number of institutional gaps that impact management of water resources. Assumptions about water planning, result in a governance system reliant on reactive mechanisms to deal with water shortages. Collaborative efforts— a component of the adaptive-and-integrated regime-around groundwater governance in NW Iowa are identifiable at the individual and group-level but characteristics at the system-level are sparse or absent.

**Discussion**

No real governance system is expected to fit neatly within the parameters of an ideal type governance regime (Table 2). Still, the NW Iowa case study was more of a struggle to classify than expected. Three of the dimensions exhibited combinations of characteristics that allude to an adaptive-and-integrated regime: state and non-state actors, centralized and fragmented interactions, and a combination of hierarchy, market,
and network governance modes. Yet, labeling the NW Iowa governance system as adaptive-and-integrated would be inaccurate. Ascertaining the current learning process is also difficult. There are few formal institutions, and evidence from our data to suggest a policy cycle is taking place - as outlined by Pahl-Wostl (2009)- is nonexistent; at best, we suggest the system is dominated by single-loop learning and only a minority of stakeholders exhibit qualities reflective of double- or triple-loop learning. We attribute the case study’s currently nebulous governance structure to two conditions: pervasive uncertainty and an absence of robust institutions. Uncertainty is unavoidable in SESs, but with a lack of institutions to structure water use and management, uncertainty flourishes.

Both epistemic (due to limited knowledge) and ontological (due to intrinsic variability of SES) forms of uncertainty emerged in the NW Iowa case study. Epistemic uncertainty included a lack of awareness of past and potential drought impacts on livestock production, knowledge of rural water system limitations, inaccurate understandings of basic hydrology, and confusion regarding groundwater laws and priority allocations. Ontological uncertainty is more complex. Rural water systems are limited in their planning capabilities when the conditions of a “worst case scenario” are unknown. Their planning also depends on magnitude of future livestock production in each system; a single large dairy hooking onto a system has the potential of increasing demand output by 20% (Interview: RWS 10, 2018). A lack of concrete evidence pertaining to future climatic conditions and industry demands in the region complicates planning for appropriate operational changes and makes it more challenging to gain support from boards of directors.
Events coordinated by the DNR since 2012 (Table 1) have attempted to lessen some uncertainty around water scarcity and water system resiliency planning. A majority of the events appear to have utilized an information deficit model of communication whereby climatology, hydrology, and natural resource management experts provided non-expert participants with information, resources, and opportunities to ask questions and raise concerns. The deficit model has been criticized as a strategy to increase knowledge, but in the context of our case study—where the level awareness and knowledge related to water resources and management challenges is so low—the strategy may function to promote awareness (Cvitanovic et al. 2014, Fernández 2016). The model is likely an unsuitable long-term strategy, however, if the DNR is committed to collaborative governance. We suspect the DNR is in a political position that requires finesse and the collaborative governance approach allows them to act on their responsibility as stewards of Iowa’s water resources by gaining “buy-in” from the communities affected. Beyond the relationships previously described between DNR and water suppliers, the agency generally attracts suspicion among agricultural stakeholders—some wielding significant political influence.

Iowa is a major agricultural state and as an earlier quote stated, “Thou shalt not have regulations in the state of Iowa that are more prescriptive than what the Federal government is already laying upon our shoulders” (Interview: RWS 08, 2018). The political climate in Iowa is portrayed by interview participants as regulation-averse and “ag friendly” which appears to complicate management of this critical resource for livestock production (Interview: GOV 05, 2019). Proposals for any type of “governance” could be interpreted as threatening to the industry- and economy- and therefore unlikely
to see success. Stakeholders go so far as to question the probability that existing groundwater policies will be observed in the event of a water scarcity event:

I don't know that I will ever get anybody in state government- if they're providing water to livestock users- to say, ‘They've hit their triggers, we're going to shut them off.’ Politically, I don't know that that will ever happen because the first thing that's going to happen is the legislators and the governor’s office is going to get involved. (Interview: GOV 04, 2019)

Manure hits the fan, I am curious, who is the ones that are- is it the supervisors of Cherokee County that are going to say, “You've got to cut your livestock?” And, “Even though it's the money that keeps this county running, you're going to have to cut your numbers in half.” (Interview: LP 11, 2019)

The potential consequences of drought in NW Iowa are devastating and despite pressure from DNR leadership, the DNR field staff expressed that they “don’t foresee DNR utilizing a blanket mandate” (Field Notes: IRWA, 2019). The DNR clarify that they are unable to “go to a [water] system and say ‘You must do X, Y, Z.’…We have authority to say, ‘You can't hook somebody up because…hydraulically, you just can't get that amount of water there.’…we have some leverage there, but we just don't have a lot” (Interview: GOV 04, 2019). The lack of formal influence is an additional incentive for a collaborative governance approach; the DNR may need to build momentum at the grassroots level and encourage actors to make voluntary changes on their own.
Previous research indicates that the adaptive-and-integrated regime is viewed as the ideal governance system to manage complex resource challenges in SESs. In the case of NW Iowa groundwater governance, it is difficult to project what type of governing system is possible when current institutions are so lacking. It is our expectation, however, that the case study findings point to areas where institutions, governance modes, and actor interactions may be tweaked or transformed to work toward a governance regime that is closer to the ideal type adaptive-and-integrated model. Observations we interpret as strengths include the existence of respected informal networks, core stakeholders are invested and engaged, some livestock producers have transformative questions about the status quo, opportunities exist to make “low-hanging fruit” changes (Interview: RWS 10, 2018), and service providers and livestock associations may function well as bridging organizations.

The challenge is recognizing opportunities to leverage these strengths. The 2012 drought was a catalyst for critical evaluation of the existing groundwater governance system and response support extended to stakeholder groups that exhibited marginal concern during interviews. “Short memories” is a barrier to the collaborative effort, “People tend to forget past events and it’s a vicious circle” (Interview: PRC 02, 2019). It is especially difficult to foster support for scarcity-related issues when stakeholders are distracted by contradicting concerns: “I don't think it's even on the radar. I mean especially when you have record flooding in the last couple years. We have short term memories. It seems like we have forgot about the droughts” (Interview, LP 20, 2019).

Identifying ‘windows of opportunity’ will be an invaluable skill for collaborative leaders. Windows of opportunity, like the 2012 drought, can refer to disruptions in the
norm (e.g., natural disasters, political elections, etc.) that increase mobilization and action around a social or political goal; if actors are prepared, these windows can be exploited to advance water governance strategies (Sullivan et al. 2019). Windows of opportunity can also refer to occasions when stakeholder groups have a shared interest or common goal and individual actors can “bridge” between groups to constructively share knowledge and resources (Cockerill and Carp 2009).

With limited formal institutional support and an absence of informal institutions, windows of opportunity can provide a catalyst for social learning between diverse actors that gradually fill the institutional gaps recognized in the NW Iowa case study. Through the process of social learning, perspective and value changes occurring at the individual level extend upward and outward to be expressed as the view or understanding of entire groups or communities (Pahl-Wostl 2007). Social learning does not immediately translate to adaptive capacity in a system, but emerging informal institutions could function as a framework to encourage critical reflection. With momentum, the governance effort could advance to multi-loop learning and learning cycles, eventually developing the adaptive capacity necessary to confront the complex challenges posed in NW Iowa’s social-ecological system.

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Iowa Department of Natural Resources. 2017. “Strategic Plan 2017-2020.”


CHAPTER 4. GENERAL CONCLUSION

We used the northwest Iowa (NW Iowa) case study to explore stakeholder’s perspectives of current and future water suppliers, water beliefs, values, and behaviors, linkages between stakeholder groups, and preferences for groundwater governance. Using the 2012 drought as a benchmark event, our investigation of impacted regional stakeholders—particularly rural water systems, livestock producers, and the Iowa Department of Natural Resources (DNR)—exposed a complex system of interacting interests, expectations, knowledge, and biophysical variables. To evaluate NW Iowa stakeholders and their interests, influences, and interactions, we conducted a stakeholder analysis. The results of the stakeholder analysis offer insight into the positions and relationships between stakeholder groups and emergent contextual themes relevant to the collaborative governance effort led by the DNR. To evaluate the evolving collaborative governance structure itself, we conducted a governance regime analysis. The regime analysis evaluates the structural dimensions of the current governance system against a spectrum of ideal type governance regimes. The ‘Goldilocks’ of the regimes—integrated-and-adaptive—is the preferred standard to achieve resilient groundwater management. The following sections outline a summary of the analyses, outlook and observations for collaborative action, remaining questions about the governance effort, research limitations, and opportunities for future research.

Summary

The general conclusions from the stakeholder analysis (Chapter 2) suggest that rural water systems and government stakeholders (i.e., the players) and livestock
producers (i.e., *subjects*) express the most concern and awareness around issues of water scarcity. We consider these three groups the core stakeholders of the case study—the water regulators, water providers, and water users, respectively. Stakeholders considered to be *context setters*—high influence and low interest—may be important for future coalition building and useful for transferring knowledge and ideas between groups. Of the *context setters*, livestock associations received the highest level of influence, followed by advocacy, and service providers. Advocacy groups, interestingly, were the least engaged with other groups in the actor-linkage matrix; a finding that paralleled regularly expressed unfavorable sentiment toward ‘environmental’ and ‘city-based’ actors.

Municipal water systems and processors— the *crowd*— were least concerned about water scarcity in NW Iowa. With effort however, they have potential to be important partners due to shared infrastructure challenges and resource access, accordingly. The stakeholder analysis also revealed themes within the data important for understanding the context of water scarcity challenges in NW Iowa.

Emergent themes indicate an array of complications relevant to collaborative groundwater and drought planning. An immediately evident obstacle is variable levels of awareness and concern among stakeholder groups and individuals. Within the livestock producer group, awareness and concern were dependent on personal water-scarcity experience, knowledge of others’ challenges, and the participant’s location relative to available aquifers and rural water. Producers’ unfamiliarity with source and distribution challenges exacerbate strain on rural water systems. Nearly all rural water systems commented on producers’ inclination to ‘build first, ask later’ which introduces unplanned demand on the system. Rural water struggles to balance upgrade expenses
with the need to increase customers and rates for revenue. Rural systems grapple with future demand projections due to unexpected customer expansion and changing climate conditions. The profuse uncertainty underlying the emergent themes in the stakeholder analysis is observed further in the governance regime analysis.

The governance regime analysis (Chapter 3) examines the NW Iowa case study from a higher level by assigning the governance system as the unit of analysis. Within the spectrum of regime ideal types (i.e., prediction-and-control, adaptive-and-integrated, and community-driven) the NW Iowa case study fails to fit criteria for any of the three regimes due to a lack of effective formal and informal institutions. Of the few institutions identified, the formal state institutions have remained nearly unchanged since the 1985 Water Plan despite dramatic shifts in water use, demand, and impact of climate and land use changes (IDNR, 2009). Policy comprehension among stakeholders ranged from full support of the status quo to comments of inadequate permitting to paranoia about ‘animals versus people’ in the unlikely event of cut-offs. In the absence of robust institutions to guide resource management and water user behaviors, uncertainty flourishes and a set of assumptions have filled the institutional gap.

Three assumptions were pervasive among stakeholder groups: ‘water scarcity is a concern for other regions or states, not water-rich Iowa,’ and two previously mentioned, ‘rural water systems are a reliable safety-net’ and ‘livestock producers confirm water availability prior to expansion or new construction.’ It is true that Iowa is a water-rich state. Precipitation throughout the growing season and high moisture retaining soils result in some of the most productive agricultural systems on the planet (Guanter et al. 2014). Northwest Iowa has undergone over a century-worth of landscape modifications to shed
excess water from the landscape and exploit the favorable agricultural conditions; alternations include stream channelization, extensive installation of subsurface drainage, and the elimination of wetlands (Cronon 1991; Bishop et al. 1998). To further complicate matters, climate models predict fewer but more intense precipitation events and increased flooding (Pryor et al. 2014). During the span of our interviews, Iowa experienced significant flooding events and above average rainfall (Glisan 2018; Glisan 2019a; 2019b). Stakeholders struggle to recognize the vulnerability of groundwater in relation to demand and distribution systems in NW Iowa- possibly because of its invisible nature as opposed to surface water. The ‘water-rich’ perception contradicts the drought and resiliency planning mission.

**Optimism and low-hanging fruit**

The DNR has a long journey ahead of them to foster productive collaborative governance around groundwater management. It is hopeful however, that the core stakeholders are the most interested and that DNR and rural water systems have continued to organize drought and resiliency discussions since 2012. Generally, the further removed a participant is from direct interaction or reliance on rural water supply in NW Iowa, the less concern they express. Nonetheless, stakeholders expressing low levels of concern- even those admitting having “taken water for granted”- typically offer a mixture of clear and vague comments related to the value of preparedness and hope that some semblance of emergency plan exists. A majority of participants expressed support for the research; two livestock associations have agreed to join a multi-disciplinary drought workshop planning team- a major accomplishment to expand the breadth of the collaborative effort.
Beyond the 2020 drought workshop, a number of actionable ‘low-hanging fruit’ items have been observed. The first is to raise awareness among less engaged stakeholders through purposeful targeting. For instance, rural water managers have mentioned concern about raising scarcity alarms with customers because “it’s just got to be communicated in the right way, so you don’t start a panic” and “everyone wants to go fill their bathtubs” (Field Notes: IRWA, 2019; Interview: RWS 09, 2019).

Communicating with customers about drought protocols and impacts (e.g., how drought impacts the water source, at what point actions are taken, how actions impact customers, etc.) well ahead of drought events would provide transparency and potentially increase mutual confidence (Ferreyra and Beard 2007; Ross 2016; Krester et al. 2018). Another opportunity is the organization of a pamphlet outlining water rights in the state, priority allocation, and other relevant information. Similar information has been communicated during DNR drought events but a more accessible format could reach a greater number of stakeholders.

Another ‘low-hanging-fruit’ item- requiring more involvement- is to resolve the communication gap between livestock producers and rural water systems. One of the three assumptions recognized in the regime analysis is that stakeholder groups like the livestock associations and service providers are under the impression that producers are proactive in their water planning. Regardless of how widespread or isolated such cases are relative to total producers in NW Iowa, collaborating across stakeholder groups could build rapport between context setters and players while also improving rural water systems’ planning capabilities.
Relationship building across sectors and collaborative problem solving present opportunities for social learning. Collaborations, allow the perspectives, knowledge, and opinions of isolated groups to be exposed, understood, and considered by actors outside the group; as individual ideas are communicated, groups are more likely to embrace new shared perspectives and expectations (Pahl-Wostl et al. 2007; Reed et al. 2010). The process of social learning could help formulate institutions to replace the problematic assumptions currently filling the institutional gap. Leveraging ‘windows of opportunity’ should also be considered in order to fast-track social learning processes, gain resources and approval otherwise unavailable, build relationships, and set expectations (Cockerill and Carp 2009; Young et al. 2013; Gunderson et al. 2017).

**Lingering questions**

It would be beneficial from a structural perspective to fully understand the extent of the DNR’s formal authority, leadership capacity, and intentions for long-term collaborative groundwater governance. As speculated in Chapter 3, the DNR is in a politically precarious position. Outside the individual-level relationships between NW Iowa stakeholders and the DNR field staff, the DNR is primarily viewed with skepticism by the agricultural community because of the agency’s regulatory position. In reality, perceived authority may differ from the agency’s actual statutory authority and/or political capacity. Government stakeholders have expressed reluctance when regulation and convey views suggesting formal strategies are politically unfavorable (Interview: GOV 04, 05, 08 2019). Despite disapproval for formal mandates, the DNR is responsible for managing the state’s groundwater and ensuring adequate distribution during drought events, (i.e., avoiding mass mortality events due to lacking water). This is an exceptional
task to accomplish without formal authority and therefore exceedingly important for the collaborative governance approach to succeed.

The lack of institutions in this situation could be an asset, barrier, or both. With no institutions, the collaborative governance essentially has a ‘clean slate’ to build from. However, a substantial amount of time and energy would be required to effectively cultivate or support new institutions and the DNR has a mixed reputation (Huitema et al. 2009; Young 2013). It is also unknown how problematic the dominant guiding assumptions would prove to be. Presently, the collaborative governance effort has momentum; a drought workshop will take place next year, our research has raised awareness with a variety of previously disengaged stakeholders and brought previously inaccessible perspectives to light, and the results of our analyses hopefully provide useful for governance leadership.

Looking ahead to consider the longevity of the collaborative governance approach, how long the DNR will be involved? Does the agency have intentions to remain a central, active governing figure, and if not, how does the agency plan to continue serving the governance effort? The DNR is ostensibly the only participating state actor; state actors conventionally provide the framework of authority, oversight, and centralizes management expectations required to maintain basic functions of the system (Pahl-Wostl 2015; Kirchoff and Dilling 2016). If the agency is unable to offer the qualities typical of a prediction-and-control regime (i.e., formal, hierarchy, and centralized), would governance become less characteristic of the adaptive-and-integrated regime and more characteristic of the community-driven regime: dominated by non-state actors, informal institutions, network governance mode, and fragmented interactions?
Moving forward, crucial questions need to be considered for governance to be successful, with or without the DNR. Stakeholders may want to consider deliberation over leadership expectations, stakeholder responsibilities, capacity for self-regulation, preferences for formal or informal processes, and mechanism for problem solving and conflict resolution (Baehler and Biddle et al. 2018). Perhaps the major uncertainty, after all, is the long-term role and capacity of the DNR.

**Limitations**

Given the early stage of the collaborative governance effort’s development, the results of the stakeholder analysis and governance regime analysis record the preliminary characteristics of stakeholder groups and dimensions of the governance system. The analyses are not a comprehensive overview of the governance effort and are best suited as a baseline for later monitoring and evaluation of the ongoing governance process and examination of the collaborative governance process itself. The six stakeholder groups are not an exhaustive representation of actors and a number of the stakeholder groups were represented by less than five participants. The analysis also failed to capture critical drivers of decision making adequately. The SES and governance regime frameworks partially acknowledge biophysical and economic influences but failed to demonstrate their interlinked significance.

The geologic conditions determine the accessibility and characteristics of aquifers. The shallow alluvial aquifers and deep Dakota cretaceous aquifers have drastically different qualities which influence water systems’ and water users’ management choices of which are determined through cost-benefit analysis. To illustrate, suppose a livestock producer builds a new operation, they can choose between digging a
well, hooking up to rural water, or both. Digging a well is expensive, requires maintenance, good quality water is not a guarantee, but the water is ‘free’. If the well is shallow, the water quality is usually good but the well is more vulnerable during drought and susceptible to contamination. If the well is deep, the quality of the water is likely poor, potentially requires additional treatment, and impacts equipment functionality. Connecting to rural water, depending on the system, requires an initial investment to cover all or partial construction costs and usage is billed based on volume, the water is high quality, does not require electricity for use on the operation, and the rural water system is responsible for maintenance. High quality water equates to less maintenance expenses and better animal health; healthier animals gain weight faster and make more profit. These critical water decisions are not captured in the analyses and deserve attention in governance processes.

**Future opportunities**

The interviews conducted for this case study are rich with data. Apart from additional research questions and considerations raised at previous points in the text, there are a multitude of paths suitable for exploration. Analysis of livestock producers’ responses based on demographics may upturn interesting findings. I surmise age and experience impact the degree of concern expressed and attitudes toward solving water availability problems. It may also prove valuable to reevaluate the data with a framework that explores the effect of ownership structures and placement in the agricultural value chain. A number of producers were unconvinced by the intensification and integration of the livestock industry. However, to build off current work, additional interviews, participant observation, or general monitoring and evaluation to document the
transformation of the collaborative groundwater governance process would be a valuable contribution to the literature.

References


Iowa Department of Natural Resources. 2009. *Iowa Water Plan - Iowa’s Water Planning History*.


APPENDIX: IRB APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
2420 Lincoln Way, Suite 202
Ames, Iowa 50014
515 294-4566

Date: 8/11/2017
To: Dr. J Gordon Arbuckle Jr.
303C East Hall

From: Office for Responsible Research

Title: Understanding and building capacity to address changing water availability in the upper Corn Belt

IRB ID: 17-276

Study Review Date: 8/11/2017

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

• (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  • Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  • Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:
• You do not need to submit an application for annual continuing review.

• You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.