

Integrating communication and collaboration: A study of Kansas water scientists and interdisciplinary teams

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Abstract

Water scarcity is a growing global concern, and in Kansas, issues such as limited precipitation and increasing pressure on both surface and groundwater resources have made water research and management a critical priority. Because agriculture accounts for most water use in the state, effective communication from scientists is crucial for supporting informed decision-making among issue holders. The following studies explored how Kansas water science experts communicate their findings and efforts to public audiences, as well as how an interdisciplinary water research team engages in collaborative, transdisciplinary work.

This thesis consisted of two qualitative studies. In Study 1, semi-structured interviews were conducted with 21 water science experts across Kansas to identify communication practices, challenges, and perceptions. Findings from this phase informed Study 2, a case study exploring how members of the Kansas Water Institute (KWI) collaborate, exchange knowledge, and engage with issue holders. The case study included nine individual interviews and a focus group that incorporated a visual network mapping activity to better understand team and issue holder relationships.

Results indicated that while many water science experts lack formal communication training, they actively adapt and “figure out how to get it done” through experience and collaboration. Their audiences span a diverse range of groups, including producers, policymakers, and the public. The water industry itself is inherently interdisciplinary, and the KWI team was intentionally assembled by the institute’s leadership based on complementary skills and team dynamics. Participants identified barriers to communication and collaboration at internal, external, and structural levels, but also emphasized the importance of leadership and interpersonal relationships in supporting networking and team success.

Findings suggest that the water science industry could benefit from increased emphasis on science communication training to strengthen outreach and public engagement. Future interdisciplinary research teams should prioritize intentional formation and collaboration strategies. Additionally, future research could expand on visual methods for mapping social networks and examine how experts' perceptions of water issues influence their communication priorities and strategies.

Key words: water science, natural resources, collaboration, interdisciplinary, science communication

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Dedication

I dedicate this thesis to my puppy, Bandit, and my Papaw Chuck. I know they are smiling down from heaven, proud of me. Their love, joy, and memory continue to inspire me every day, and I hope I have made them proud.

Chapter 1 - Introduction

Overview

Chapter 1 provides an introduction and context for this study by outlining water across the globe, nation, and state, and discussing collaboration in addressing natural resources issues. This chapter establishes a foundation for the two complementary studies that comprise this thesis: the first explored Kansas water scientists' communication and collaboration experiences and, the second builds on those findings through a case study of the Kansas Water Institute, an interdisciplinary group supporting water research across the state. Together, these studies contribute to a deeper understanding of the role communication and collaboration in Kansas water science efforts.

Background and Context

Water Challenges

Addressing water challenges requires understanding how water availability and quality intersect with the growing impacts of extreme weather and the policies guiding long-term management. In Kansas, as in many parts of the world, increasing pressure on both water resources and governance systems underscores the need for coordinated, science-informed management.

Quantity

Global water use has been steadily increasing, rising by roughly 1% per year over the past four decades (Food and Agriculture Organization of the United Nations, n.d.). This increase in water demand is linked to population growth, economic development, and shifting consumption patterns. Although the total volume of freshwater on Earth remains constant, the amount available per person continues to decline in nearly every region, as populations expand

faster than renewable supplies can replenish (United Nations, 2023). Water scarcity is unevenly distributed across the world: about 80% of people experiencing high water stress live in Asia, with northeast China, India, and Pakistan facing particularly acute challenges (Vanham et al., 2021).

In North America, the abundance of freshwater resources has not prevented high water demand. The region records some of the world's highest per capita water withdrawals, reflecting intensive agricultural production, widespread industrial use, and high domestic consumption (Food and Agriculture Organization of the United Nations, 2022). *Water withdrawal* refers to the removal of water from a stream, aquifer, lake, or other water body for any use (Food and Agriculture Organization of the United Nations, 2022). In 2015, California and Texas had the highest total water withdrawals in the nation—32,200 and 23,800 million gallons per day, respectively—with most of California's water used for irrigation and most of Texas's used for thermoelectric power (Dieter et al., 2018). Kansas ranked 30th nationally, withdrawing about 4,510 million gallons per day. Overall, water use in the western United States is primarily for irrigation, while in the eastern states it is dominated by thermoelectric power (Dieter et al., 2018).

Water is limited across Kansas. In 2025, every county in the state was under a drought watch, with 40 counties in warning status and three in emergency status (Kansas Water Office, 2025). This scarcity is a particularly pressing issue, as water losses can be irreversible, and climate change continues to accelerate and intensify existing threats (Kansas Water Office, 2022). One major factor exacerbating these dry conditions is Kansas's highly variable rainfall. Between 1895 and 2015, the western third of the state averaged only 21 inches of annual precipitation, compared to 37 inches in the eastern third (Lin et al., 2017). This persistent rainfall

deficit contributes to the chronic dryness of western Kansas, which is the only region in the state to have experienced an overall drying trend over the past 60 years (Lin et al., 2017).

Quality

Global efforts to improve access to clean water, sanitation, and hygiene are ongoing, yet progress remains slow. At the present rate, improvements would need to quadruple to meet the 2030 goal of safely managed water and sanitation for all (World Health Organization et al., 2022; World Health Organization & United Nations Children's Fund, 2020, 2021). A range of water quality concerns threaten human, animal, and plant health, including biological, physical, and chemical contaminants. Microbiological pathogens from fecal contamination represent one of the most widespread global concerns (World Health Organization et al., 2022). Physical contaminants, such as garbage and debris, also degrade water quality. A less common contaminant is chemical components, which result less often in significant public health concerns (World Health Organization et al., 2022). While chemical contaminants are less often linked to acute public health crises, they remain a significant concern depending on their concentration. For instance, excessive fluoride can harm bones and teeth, and increasing attention has been drawn to lead, iron, pesticides, and microplastics in drinking water (World Health Organization et al., 2022).

Although the United States lacks uniform national water quality guidelines, the Environmental Protection Agency (EPA) oversees the water quality standards (WQS) established by states, territories, or authorized tribes (U.S. Environmental Protection Agency, 2025b). Under the Clean Water Act (1972), the EPA reviews these standards and approves or denies them. If a state fails to meet the requirements of the Act, the EPA has the authority to implement federal WQS in its place.

At the state level, the Kansas Department of Health and Environment (KDHE) establishes and enforces WQS through the Kansas Administrative Regulations (K.A.R.) 28-16-28b through 28-16-28h. These standards set numeric and narrative criteria to protect designated surface water uses, such as aquatic life support, recreation, and irrigation. For example, Kansas WQS prohibit the discharge of hazardous or toxic materials, as well as discarded solid waste such as trash and debris, into surface waters to maintain water quality and safeguard public health (Kansas Department of Health and Environment, 2023).

Sedimentation is a major concern for both water quantity and quality (Kansas Water Office, 2022). Sedimentation occurs gradually as soil and other particles settle to the bottom of water bodies, reducing storage and flow. The state's primary sedimentation challenges occur in lakes, where sediment has been accumulating at an alarming rate (Kansas Water Office, 2022). For example, by 2020, Tuttle Creek Lake had lost roughly 50% of its storage capacity, significantly diminishing its water storage capabilities. This level of sedimentation can also degrade ecosystem health and influence the frequency and intensity of storms (U.S. Environmental Protection Agency, 2025a).

Vulnerability to Extreme Weather

Extreme weather events are becoming more frequent and severe across the nation (Su & Marvel, 2023). Rising temperatures and prolonged drought intensify rainfall, increasing the risk of floods and storm surges. Since the 1980s, the western U.S. has experienced more frequent and intense heat waves, while the eastern half has seen heavier and more frequent precipitation, resulting in greater river and stream flooding (Su & Marvel, 2023).

The *Kansas Water Plan* identifies reducing the state's vulnerability to extreme weather as a high priority (Kansas Water Office, 2022). Since the beginning of the century, Kansas's

average temperature has risen by 1.5°F, contributing to higher evaporation rates and worsening drought conditions. Sedimentation and flooding are closely linked as sediment accumulation can increase flood risk by reducing storage capacity, while flooding can, in turn, transport and deposit additional sediment. Extreme weather also affects agricultural production; for example, in 2011, drought-related crop damage cost Kansas an estimated \$1.8 billion (Kansas Water Office, 2022).

Agriculture accounts for the vast majority of water use in Kansas, with approximately 88% of the state's water allocated for irrigation (Kansas Department of Agriculture, 2017). In 2017, about 3.1 million acres across the state were irrigated, primarily in western Kansas, where rainfall is insufficient to support crops without supplemental water. As a result, western Kansas faces significant climatic risk. The devastating drought of the 1930s demonstrated the region's vulnerability, and today, the rapid drawdown of the High Plains Aquifer continues (Lin et al., 2017). Agriculture in this region is heavily dependent on groundwater, further increasing stress on the aquifer. Research has identified a clear relationship between groundwater depletion and agricultural land use, particularly along the aquifer's edge, where water supplies are limited and land is more likely to undergo transformation (Kettle et al., 2007).

Water Policy and Governance

In the U.S., several initiatives have been developed to address growing concerns surrounding water use, quality, and availability. Foundational legislation such as the *Clean Water Act* (1972) and the *Safe Drinking Water Act* (1974) established frameworks for regulating water quality and protecting public health. The U.S. Geological Survey's National Water Census further advances these efforts by providing comprehensive data on water availability and use to help decision-makers understand supply and demand at regional and national scales (U.S.

Geological Survey, n.d.). Collectively, these initiatives demonstrate an ongoing commitment to science-based water governance.

Recognizing the importance of this resource, the Kansas Water Office developed the Kansas Water Plan to protect public health, aquatic and animal life, and ensure long-term water sustainability (Kansas Water Office, 2022). The strategic plan identifies five guiding principles: conserve and extend the High Plains Aquifer, protect Kansas reservoirs, improve water quality, reduce vulnerability to extreme events, and increase public awareness of water resources. Complementing these goals, Kansas has enacted several regulatory frameworks to support long-term water management and conservation. The Kansas Water Appropriation Act regulates groundwater and surface water, establishing water rights under the doctrine of “first in time is first in right” (Kansas Water Appropriation Act, 1945). However, this system has led to over-appropriation, where more water rights are issued than the resource can sustain. This is especially evident with the Ogallala Aquifer, where excessive withdrawals depleted the resource and hindered its natural recharge (Kansas Water Office, 2022).

To address groundwater depletion, the Kansas Department of Agriculture (KDA) implemented the Water Transition Assistance Program (WTAP) in 2021 to help reduce withdrawal rates (Kansas Department of Agriculture, 2025). Between 2021 and 2024, WTAP facilitated the permanent retirement of 20 irrigation water rights across Wichita and Greeley counties. These retirements represent a cumulative reduction of roughly 1,260 acre-feet of historic consumptive water use and over 5,000 acre-feet of annual water appropriation, with total investments exceeding \$2.7 million (Kansas Department of Agriculture, 2025). Through voluntary participation, landowners in targeted areas were compensated for discontinuing

groundwater withdrawals, contributing to the long-term conservation of the Ogallala Aquifer (Kansas Department of Agriculture, 2025).

Additionally, Kansas statutes aim to provide guidance for statewide management. The Kansas Water Plan Storage Act provides guidance for storing water in federal reservoirs, while the Kansas Water Resources Planning Act authorizes development of the Kansas Water Plan (Kansas Water Office, 2022; State Water Plan Storage Act, 1975; State Water Resources Planning Act, 1981). Together, these frameworks form a foundation for collaborative water planning and conservation across the state.

Interdisciplinary Work

Interdisciplinary collaboration is essential for addressing complex natural resource challenges. Effective collaboration allows teams to integrate science, policy, and local knowledge to create solutions that no single discipline could achieve alone. However, contrasting viewpoints, limited institutional support, and constraints on time or resources can prevent teams from moving beyond surface-level partnerships (Klein, 2014).

In the context of water management, interdisciplinary efforts have enabled innovative approaches to water conservation across Kansas. For example, Local Enhanced Management Areas (LEMAs) empower local issue holders to design water-reduction plans, while Water Conservation Areas (WCAs) allow water-right owners to create management strategies to reduce withdrawals (Kansas Water Office, 2022). Similarly, Intensive Groundwater Use Control Areas (IGUCAs) help identify regions where groundwater decline has reached critical thresholds, prompting targeted action. The Kansas Water Plan further supports collaboration through public–private partnerships that introduce new practices to producers and promote water-saving

behaviors (Kansas Water Office, 2022). Together, these efforts highlight both the potential and necessity of interdisciplinary collaboration for sustainable water resource management.

Strong communication is the cornerstone of successful teamwork, especially in natural resource contexts where decisions affect diverse and often competing issue holders. Science communication principles help translate complex data into digestible knowledge for farmers, policymakers, and the public (Burns et al., 2003). The Kansas Water Office identifies a wide network of partners who must coordinate to achieve conservation goals, such as groundwater management districts, public water suppliers, and nonprofit organizations, including, but not limited to, Friends of the Kaw, Ducks Unlimited, Pheasants Forever, and the Kansas Rural Center (Kansas Water Office, 2022). Effective communication among these groups is critical for building trust, aligning strategies, and ensuring that scientific insights inform practical water management decisions.

Study 1 Purpose

The purpose of this study was to gather initial insights into how water scientists and subject-matter experts in Kansas communicate their work, engage with public audiences, and collaborate on interdisciplinary teams for water science research and communication. The following research questions (RQs) guided the study:

RQ1: What communication resources and knowledge are used by water science experts?

RQ2: How do water experts generate and share scientific information with issue holders?

Study 2 Purpose

The purpose of this case study was to explore the process of interdisciplinary teams within the Kansas Water Institute. By examining how this team was built, how its network is fostered, and how information circulates among members, the study seeks to provide insight into

the organizational practices and relationships that support effective research on complex water issues. The following research questions (RQs) guided the case study:

RQ1: How are interdisciplinary teams within the KWI formed, and how do team dynamics influence their perceived effectiveness and efficiency?

RQ2: How does the Kansas Water Institute develop and interact with networks and collaborations?

RQ3: How do participants' self-constructed social networks reveal patterns of collaboration and information flow within the Kansas Water Institute?

Need for Study

Despite growing recognition of the benefits of collaborative, interdisciplinary approaches in addressing complex water challenges (Lopez et al., 2022; Tidwell & van den Brink, 2008), gaps remain in understanding how these approaches are operationalized in practice. While existing research often highlights technical or policy solutions (Sophocleous, 2010; Steiner et al., 2021), it offers limited insight into how interdisciplinary teams integrate knowledge and engage issue holders effectively.

This gap is particularly evident in contexts where water scarcity is coupled with agricultural and natural resource issues, which require balancing ecological, social, and economic considerations. By examining the experiences and perceptions of water science experts and interdisciplinary team members, this study seeks to explore the factors that support or hinder effective collaboration.

Significance

The findings of these studies **would be of interest** to extension personnel, water scientists, conference organizers, and individuals working in other natural resource contexts. Together, the

studies advance understanding of how science communication and team dynamics influence collaboration and knowledge sharing. The results may also benefit those addressing other “wicked problems”, defined as issues that are complex, interdependent, and resistant to simple solutions (Rittel & Webber, 1973). Water is one such wicked problem, as its management involves balancing interconnected social, environmental, and policy challenges.

Chapter 2 - Literature Review

Overview

Chapter Two reviews existing literature related to water science and management, science communication, and interdisciplinary collaboration. Examining this body of work helps situate the current studies within ongoing conversations in these areas. Specifically, this chapter provides context on Kansas water, communication approaches that connect science with practice, and interdisciplinary collaboration to address complex environmental problems.

Water Science and Management

Kansas faces mounting water resource challenges, particularly in the western part of the state, where the Ogallala Aquifer is experiencing severe depletion driven by a combination of agricultural and municipal demands. According to the Kansas Water Office (2022), restoring portions of the Ogallala Aquifer would require Groundwater Management Districts (GMDs) 1, 3, and 4 to reduce water use by an average of 30 percent, with some high-use areas needing even greater reduction. These combined pressures underscore the urgent need for sustainable management strategies and cross-sector solutions—collaborative efforts that bring together multiple sectors to address complex environmental problems spanning ecological, economic, and social dimensions (Datta et al., 2023; Maxwell et al., 2019).

Research on sustainability initiatives offers several lessons for addressing water management and sustainability challenges. Cross-sector efforts—projects involving multiple sectors (Maxwell et al., 2019)—highlight four key strategies for success: finding the right combination of top-down and bottom-up institutional approaches, clarifying project objectives, applying social science methods, and engaging multiple issue holders. Similarly, Datta et al. (2023) emphasize that developing sustainable agricultural practices requires balancing

productivity with minimizing environmental impacts, illustrating how science-informed practices can align with local water and resource management goals. A recurring lesson across these studies is the importance of issue holder engagement to ensure that scientific insights translate practically to support local solutions (Datta et al., 2023).

In Kansas, institutions such as the Kansas Water Institute (KWI) play a pivotal role by supporting research on high-priority water resource problems and advancing objectives identified in the Kansas Water Plan (Kansas Water Institute, 2025). Together, these efforts highlight the need for integrated science, policy, and community action to sustain the state's critical water resources.

Science Communication

Effective science communication is critical for connecting scientific knowledge with its practical application. Research shows that the use of technical jargon and complex presentation formats can reduce comprehension and increase resistance to new information, limiting the public's ability to understand and use scientific findings (Bullock et al., 2019). In a survey of 650 U.S. adults, Bullock et al. (2019) found that paragraphs containing jargon reduced processing fluency and made participants less receptive to information. Complex communication tools, such as intricate graphs, were also shown to impair understanding, highlighting the challenges of conveying science to diverse audiences.

Public engagement strategies are increasingly used by scientists to connect with diverse audiences. According to a survey of 3,748 members of the American Association for the Advancement of Science (AAAS), 43% of respondents viewed media coverage as an important way to communicate their research to the public (Rainie et al., 2015). However, 52% also expressed concern that engagement through the media can lead to oversimplification of scientific

findings. The AAAS (n.d.) defines public engagement as meaningful, intentional interactions that promote mutual learning between scientists and the public.

Public engagement can also take place through extended, structured interactions, such as those implemented in classroom programs. During the 2012-2013 school year, McLaughlin et al. (2018) implemented a sustained public engagement program involving students in their final two years of high school (ages 16–18). Through multiple interactions across the school year, the research team introduced science topics aligned with the students' curriculum. At the end of the program, students self-reported increased interest in science, greater engagement, and, in some cases, tentative improvements in academic performance. This study illustrates how sustained engagement can lead to measurable increases in students' awareness and participation in science.

Even with sustained interactions, misunderstandings or uneven access to information can create communication gaps between scientists and their audiences. Similar gaps can also exist among experts themselves, particularly in interdisciplinary and cross-agency contexts. Papa et al. (2025) examined forest carbon science and found that scientists, agency staff, and non-governmental organizations (NGO) experts often hold differing information and perspectives. Participants expressed a strong interest in learning from other disciplines and organizations, underscoring the importance of structured communication strategies to facilitate knowledge exchange within the scientific community.

In complex domains such as water management, strategies like modeling and interactive approaches have been identified as effective for improving understanding and collaboration (Tidwell & van den Brink, 2008). Modeling tools, such as simulations and visualizations, allow scientists and community members to explore management decisions and understand different strategies. Interactive approaches, including workshops and participatory modeling, engage issue

holders directly in the learning and decision-making process, helping to build trust and shared understanding across disciplines and interests (Tidwell & van den Brink, 2008). Addressing public and inter-expert communication gaps is essential for informed decision-making, effective interdisciplinary collaboration, and the practical application of scientific knowledge in natural resource management (Fischhoff, 2013; Maxwell et al., 2019).

The importance of science communication extends beyond information delivery—it shapes how society understands, evaluates, and responds to scientific issues. Baram-Tsabari and Lewenstein (2017) argue that scientists play a central role in cultivating public understanding and trust, and that communication practices directly influence the legitimacy and perceived relevance of science. This aligns with long-standing research showing that public trust is central to how scientific information is interpreted and acted upon (National Academies of Sciences, Engineering, and Medicine, 2017). Trust, in turn, is a prerequisite for effective public engagement and for people’s willingness to use scientific information when making decisions (Fischhoff, 2013; Weingart & Guenther, 2016). Without trust, even accurate and well-intentioned communication efforts may fail.

Science communication also has direct implications for behavior and policy. Gustafson and Rice (2020) emphasize that clear, credible communication supports better decision-making by helping people assess risks, weigh options, and choose evidence-based actions. Research in risk and environmental communication similarly shows that understanding is higher when scientific information is communicated with clarity and contextual relevance (Maxwell et al., 2019; National Academies of Sciences, Engineering, and Medicine, 2017). When scientists communicate effectively—especially about issues like water quality, resource management, or

climate impacts—the public and decision-makers are better equipped to evaluate information and take appropriate action.

Taken together, prior research suggests that improving science communication is not simply a matter of professional skill; it has practical consequences for public understanding, civic trust, interdisciplinary collaboration, and the application of scientific knowledge. Improved communication is associated with increased mutual learning between scientists and communities (American Association for the Advancement of Science (AAAS), n.d.), stronger trust in scientific institutions (Weingart & Guenther, 2016), more informed policy decisions (Fischhoff, 2013; Gustafson & Rice, 2020), and more effective collaborations among experts (Papa et al., 2025). In fields such as water management—where problems are complex, urgent, and distributed across agencies and disciplines—effective communication is an essential pathway to better outcomes (Maxwell et al., 2019; Tidwell & van den Brink, 2008).

Interdisciplinary Collaboration

The divisive and complex nature of water issues (Ajaz et al., 2020; Gleick, 1993; Tidwell & van den Brink, 2008) calls for approaches that address their multiple dimensions. Gleick (1993) emphasizes that water conflicts often emerge from competing demands between agricultural, municipal, industrial, and ecological needs. Tidwell and van den Brink (2008) further explain water management as inherently uncertain and requiring intentional, inclusive, and transparent communication. More recently, Ajaz et al. (2020) identified agriculture and natural resource management as critical areas where water scarcity creates challenges that benefit from team-based problem-solving. Collectively, these studies underscore that water challenges require collaborative and interdisciplinary approaches.

Multidisciplinary, interdisciplinary, and transdisciplinary approaches represent different levels of integration across fields. Multidisciplinary work aligns perspectives side by side, while interdisciplinary approaches blend concepts and methods to develop cohesive solutions (Maxwell et al., 2019). Transdisciplinary approaches extend further by engaging practitioners, policymakers, and other issue holders in co-producing knowledge that is both rigorous and relevant (Page, 2017). Although these distinctions are acknowledged, the term *interdisciplinary* will be used throughout this study for consistency.

Interdisciplinary collaboration fosters creativity, supports holistic problem-solving, and leads to solutions that are more readily applicable in practice (Amabile, 1988; Foley et al., 2011). Maxwell et al. (2019) emphasize that integrating social and environmental sciences enhances both understanding and practical relevance, producing outcomes that are more actionable for pressing water and agricultural issues. Within the water sector, such collaboration is vital for connecting scientific research with the policy, management, and community dimensions of water use and sustainability.

While studies have highlighted the importance of communication and trust in water management (Breetz et al., 2005; Tidwell & van den Brink, 2008), few have examined how internal social dynamics of interdisciplinary teams influence decision-making and problem-solving outcomes.

Chapter 3 - Study 1: Engaging Water Experts: A Qualitative Exploration of Kansas Water Science Communication and Outreach

Overview

Water resources are essential yet increasingly vulnerable to overuse. Despite the importance of effective water management, public understanding of water-related issues remains limited, often due to communication barriers between scientists and diverse audiences. This study addresses this communication gap by exploring how water scientists in Kansas communicate their science, perceive water challenges, and collaborate with interdisciplinary teams. Thematic analysis was used to uncover key insights from 21 qualitative interviews. Findings revealed that water experts regularly engage with diverse audiences and collaborate across disciplines; however, most lack formal communication training. Based on these results, it is recommended for organizations and institutions to partner to design and implement targeted communication training programs for water experts. These programs should emphasize audience engagement, message clarity, and collaboration to strengthen the public's understanding of water science and support more informed water-related decision-making.

Introduction

Water science is a critical field of study in Kansas, a state characterized by its vast plains and a strong agricultural economy that depends heavily on water for irrigation, livestock, and urban demands (Kansas Water Office, 2022). As water demand rises, effective management of water resources is crucial for sustaining the economy and resolving key issues such as declining water quality, increasing drought, and the impacts on water availability for agricultural practices.

Kansas State University's Next-Gen strategic plan identified several critical issues facing the state, with sustainable water use designated as a high priority for advancing a more resilient and sustainable future (Kansas State University, 2023). In response to the water-related issues outlined in the plan, the Kansas Water Institute was established to coordinate research and outreach efforts. The institute focuses on conserving and restoring reservoirs and the Ogallala Aquifer while advancing initiatives to improve water quality (Kansas Water Institute, 2025). Addressing these challenges—including water availability, quality, and sustainability—is essential to ensuring long-term water accessibility (Kansas Geological Survey, 2023; Kansas Water Office, 2022). The American Association for Agricultural Education ([AAAE, 2023](#)) emphasizes the importance of advancing public knowledge of agriculture, natural resources, and food systems to support informed decision-making. Understanding how water scientists communicate is essential to achieving this goal, as effective science communication equips audiences with the knowledge they need to make informed and responsible decisions about water-related issues (Burns et al., 2003).

Fostering public understanding of water resource depletion and the importance of conservation is vital to protect Kansas's future water supply (Kettle et al., 2007). However, while advancements in water science have improved our understanding of water resources, communicating these findings effectively to the public and policymakers remains challenging (Sophocleous, 2010).

The importance of water conservation in Kansas is further compounded by a widespread lack of awareness about the complexity and vulnerability of water systems. The technical nature of water science creates a barrier for the public, as specialized language often hinders understanding (Nelkin, 1996; Tanner, 2004). Despite the urgent need for sustainable practices,

water science remains a complex field that is often inaccessible to the public, resulting in a communication gap (Burns et al., 2003; Metcalfe, 2019). Public communication can take many forms, including outreach, journalism, research partnerships, and informal education (Baram-Tsabari & Lewenstein, 2017). Public engagement entails intentional two-way interactions that promote mutual learning between scientists and the public (American Association for the Advancement of Science [AAAS], n.d.). Effective water science communication fosters mutual understanding between scientists and the public, promoting collaboration and informed participation in water conservation efforts (Baram-Tsabari & Lewenstein, 2017).

The dynamic and multifaceted nature of water resource management creates challenges for effective knowledge sharing among experts and issue holders (Tidwell & van den Brink, 2008). These challenges are best addressed through interdisciplinary collaboration, integrating diverse perspectives and expertise (Maxwell et al., 2019). Collaborative efforts across disciplinary and organizational boundaries have become increasingly recognized as essential for advancing scientific research (Cummings & Kiesler, 2005). In Kansas, collaborative governance initiatives—such as the implementation of voluntary producer management led Local Enhanced Management Areas (LEMAs)—have shown promise in fostering locally driven water conservation (Zwickle et al., 2021). However, continued efforts are needed to strengthen collaboration to achieve long-term sustainability (Zwickle et al., 2021).

Purpose

The purpose of this study was to gather initial insights into how water scientists and subject-matter experts in Kansas communicate their work, engage with public audiences, and collaborate on interdisciplinary teams for water science research and communication. The following research questions (RQs) guided the study:

RQ1: What communication resources and knowledge are used by water science experts?

RQ2: How do water experts generate and share scientific information with issue holders?

Conceptual Framework

The conceptual framework for this study is grounded in the Theory of Planned Behavior, Social Cognitive Theory, and the dialogue and participatory models of science communication. The Theory of Planned Behavior was used to describe the perception and experiences of water science experts. Social Cognitive Theory serves to identify the factors influencing these experts' communication efforts. Additionally, science communication models were employed to understand how they share science knowledge with public audiences. Figure 3.1 illustrates the conceptual framework used in this study.

Figure 3.1: Study 1 Conceptual Framework Model

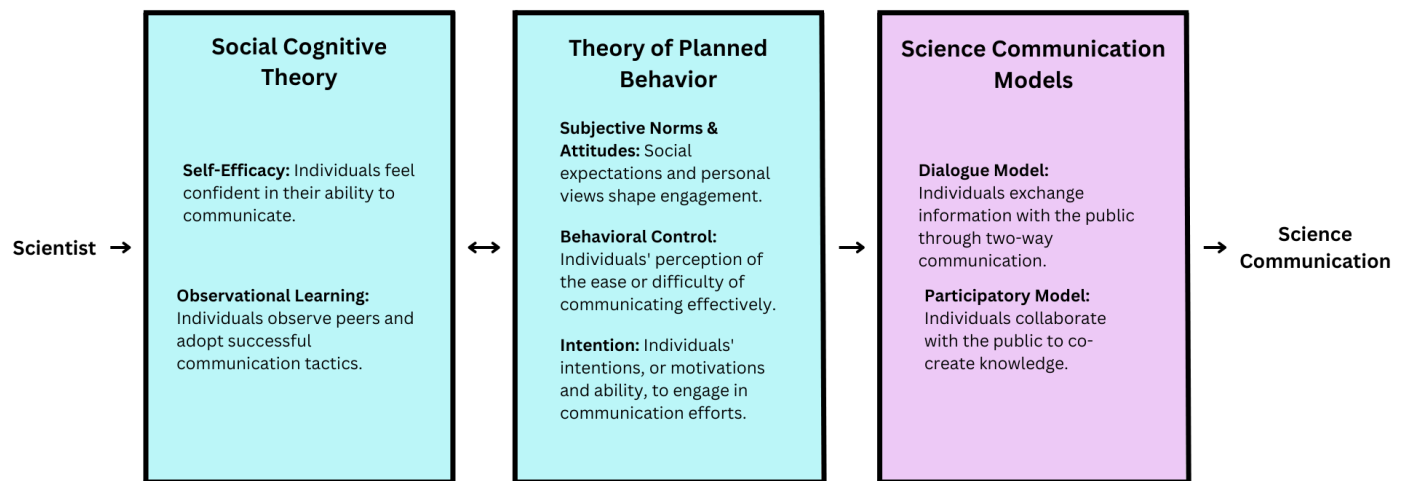


Figure 3.1 shows how scientists begin engaging in communication behaviors after observing peers or colleagues successfully adopting similar practices. According to Social Cognitive Theory, individuals who develop confidence in their ability to perform a task, known as self-efficacy, are

more likely to enact that behavior (Nickerson, 2025). As scientists gain exposure to effective communication strategies, their perceived capability to engage in similar efforts increases.

Concurrently, scientists evaluate the social norms and expectations surrounding communication within their professional communities. They consider how their actions may be perceived and whether communication aligns with disciplinary or institutional standards. The Theory of Planned Behavior posits that behavioral intention is shaped by attitudes toward the behavior, perceived social norms, and perceived behavioral control (Ajzen, 2020). Thus, when scientists view communication as normative, feasible, and aligned with their motivations, they are more likely to engage in the behavior.

Finally, scientists make decisions regarding the mode of engagement. Some may choose to adopt a dialogue model, emphasizing two-way exchange between scientists and audiences, while others may move toward a participatory model, which requires deeper collaboration and shared decision-making with the public (Metcalf, 2019). Together, these theoretical perspectives illustrate how scientists' confidence, perceptions of norms, and motivational factors collectively influence both their decision to communicate and the approach they choose.

Theory of Planned Behavior

The Theory of Planned Behavior (TPB) was derived from the Theory of Reasoned Action by Icek Ajzen in 1991 (Ajzen, 2020). A central factor in the theory is the individual's intention to perform a given behavior (Ajzen, 1991). TPB is used to predict and explain individuals' intentions to engage in a behavior at a specific time and place. Individuals' actions can depend on motivation and ability, also referred to as intention and behavioral control (LaMorte, 2022b). According to TPB, attitudes, subjective norms, and perceived behavioral control collectively determine an individual's behavioral intention (Ajzen, 2020).

An individual's attitude toward a behavior, combined with the standards of their industry and their perceived control over the behavior, shapes their intention or willingness to engage in that behavior. Attitude toward a behavior refers to the individual's evaluation of the behavior as favorable or unfavorable (Ajzen, 1991). Subjective norms encompass the social pressures and expectations surrounding the behavior. TPB introduces perceived behavioral control, or an individual's perception of how easy or difficult the behavior is to perform. Intentions are indicators of how much effort an individual is willing to exert for the behavior — a stronger intention increases the likelihood of the behavior occurring (Ajzen, 1991).

Perceived behavioral control is conceptually compatible with Bandura's construct for self-efficacy from the Social Cognitive Theory, as both describe an individual's judgment of their capability to execute a specific behavior (Ajzen, 1991; Bandura, 1986).

Social Cognitive Theory

Social Cognitive Theory (SCT) explains how individuals learn through observation (Bandura, 1986). SCT emphasizes the interaction of behavioral, environmental, and cognitive factors in shaping human behavior (Nickerson, 2025). This theory exists in social contexts with dynamic interactions of person, environment, and behavior, with an emphasis on social influence (LaMorte, 2022a). Individuals are not solely shaped by internal forces or external factors but through a combination of behavior, environment, and cognition (Bandura, 1986). SCT is comprised of six constructs: reciprocal determinism, behavioral capability, observational learning, reinforcements, expectations, and self-efficacy.

Reciprocal determinism describes how cognitive factors, behavior, and the environment interact simultaneously to influence and be influenced by one another (Nickerson, 2025).

Behavioral capability refers to an individual's knowledge and skills required to perform a

behavior (LaMorte, 2022a). Observational learning highlights how people acquire knowledge through others in addition to direct experience. Bandura and Walters (1963) identified four cognitive processes that must occur for observational learning to take place: attention, retention, motor reproduction, and motivation. Attention involves noticing the behavior, while retention refers to recalling the observation (Nickerson, 2025). Motor reproduction, also referred to as initiation, reflects an individual's ability to execute the behavior, both cognitively and physically. Lastly, motivation represents an individual's desire to perform the behavior. Reinforcements—outcomes following the behavior—and expectations—anticipated consequences—shape whether the behavior is carried out. Self-efficacy refers to an individual's confidence or belief in their ability to perform the behavior (Nickerson, 2025). Self-efficacy is a central component of SCT, representing the process of moving from knowledge to action.

Science Communication Models

Three major science communication models are deficit, dialogue, and participatory science communication (Metcalf, 2019; Metcalf et al., 2022). The deficit model emphasizes the spread of scientific knowledge from experts to the public, assuming that public understanding will increase when information is delivered clearly (Bartock, 2015). While this model has historically guided science communication, it does not account for public perspectives, feedback, or engagement.

In contrast, the dialogue model, also known as the public understanding of science, focuses on two-way communication between scientists and the public (Bartock, 2015). Emerging in the 1980s in response to public unease about science (Metcalf, 2019), this model emphasizes three key steps: scientists preparing to engage in dialogue, scientists preparing to listen to the public, and scientists recognizing the value of public input. Advantages to the dialogue model

include addressing growing public mistrust of science, fostering discussion of scientific uncertainties, and facilitating collaborative approaches through stronger connections between scientists and issue holders (Irwin, 2021; Metcalfe, 2019; Stocklmayer, 2012).

Building on the dialogue model, the participatory model positions scientists and the public as equal partners in sharing and creating knowledge, a process often referred to as knowledge co-production (Metcalfe, 2019). Unlike the dialogue model, which maintains scientists as the primary drivers of communication, the participatory model emphasizes shared power between scientists and the public. By acknowledging and valuing public knowledge (Metcalfe et al., 2022), scientists can better understand societal needs, enhance the relevance of research, and improve the uptake of scientific findings.

Literature Review

The following literature review examines existing research related to water resources, the specific context of water resources in Kansas, and principles of science communication.

Water Resources

Water is a vital component of agricultural operations, supporting the health and growth of plants and animals. Agriculture is responsible for nearly 70% of freshwater use (United Nations, 2023). Inefficient irrigation practices further contribute to the depletion of water resources (Foley et al., 2011). Foley et al. (2011) examine the challenges of meeting global food demand while minimizing environmental degradation and advocating for sustainable agriculture practices. The challenges associated with water quantity, quality, and agricultural use highlight the need for sustainable management strategies to ensure equitable access to this vital resource for current and future generations.

Water Resources in Kansas

Western Kansas experiences dry conditions, receiving significantly less rainfall than the rest of the state, a factor contributing to groundwater depletion and influencing agricultural practices (Kettle et al., 2007). Water availability in Kansas is influenced by seasonal and annual variations in precipitation, with drought periods exacerbating strain on both surface and groundwater resources. Climate change is expected to alter precipitation patterns and increase temperatures (Steward et al., 2013). Unpredictable rainfall paired with rising temperatures can lead to higher evaporation rates and a reduced water supply. These climatic variations significantly impact agricultural practices, which are heavily reliant on the state's primary water sources.

Western Kansas relies on the Ogallala aquifer for water, a vast groundwater reservoir that provides 70-80% of the state's water needs, predominantly for irrigation (McGuire, 2014). Agriculture is the largest consumer of water in the state; irrigation accounts for 85% of Kansas' total water usage (Kansas Department of Agriculture, n.d.). Given the amount of water agriculture requires, Kansas heavily depends on management strategies and policies to guide the state's water use. The Kansas Water Office leads these planning and coordination efforts through the Kansas Water Plan, bringing together scientists, policymakers, and issue holders to improve conservation and management practices (Steiner et al., 2021).

Beyond water quantity concerns, Kansas also faces water quality challenges that affect both surface and groundwater systems. Nutrient runoff, sedimentation, and bacterial contamination impact reservoirs and rivers, while nitrate contamination poses risks to drinking water and groundwater supplies (Kansas Water Office, 2022). To address these interconnected issues, the Kansas Water Plan outlines statewide priorities for conserving and extending the High

Plains Aquifer, protecting and restoring reservoirs, improving water quality, reducing vulnerability to extreme events, and increasing public awareness of water resources (Kansas Water Office, 2022).

Water Science Communication

Science communication connects the public with scientific knowledge. It is defined as the process of sharing scientific knowledge with practitioners, peers, or the public to promote awareness, enjoyment, and understanding of scientific concepts (Burns et al., 2003). According to Gilbert and Stocklmayer (2012), the primary goal of science communication is to enhance scientific literacy. Additionally, it can help guide decision-making processes (Baram-Tsabari & Lewenstein, 2017; Fischhoff, 2013). Effective science communication provides the audience with the necessary information to make informed decisions. Despite its critical role, science communication faces several obstacles that can limit its effectiveness, such as misinformation, low trust in experts, and the complexity of scientific language (Bullock et al., 2019). Addressing these challenges often requires building trust and aligning communication with the values and priorities of different audiences.

While effective science communication is essential across many disciplines, communicating water science can present distinct challenges that require tailored approaches. Water science communication conveys knowledge and research to diverse audiences, including policymakers, resource managers, educators, industry professionals, and the public, to support informed decision-making and sustainable water management. This type of communication often integrates scientific information with policy perspectives and public engagement, aiming to address complex water issues (Corner et al., 2018).

Effective science communication strategies are crucial to facilitate understanding between scientists and the public. Different media platforms can help serve a specific purpose in scientific communication. For example, Martin and MacDonald (2020) conducted a social media analysis that discovered Instagram supports visual and personal content, such as selfies and short videos, which encourages a conversational tone. Conversely, X, formerly Twitter, is more commonly used to share short, timely information, making it more useful for sharing timely scientific findings (Martin & MacDonald, 2020). However, the same platforms that facilitate engagement can also amplify misinformation, particularly around complex or controversial topics such as water use and climate change. Research emphasizes that authentic and interactive communication builds credibility and trust, which can help counter misinformation and confusion (Bullock et al., 2019; Martin & MacDonald, 2020). Communicators must use these tools intentionally, balancing accessibility and accuracy to foster understanding and trust among diverse audiences.

Scientists can use a variety of communication approaches to connect with their audience. Dahlstrom (2014) explains that narratives effectively illustrate cause-and-effect relationships to keep readers engaged, offering examples such as conversations, testimonials, case studies, and television programs. However, he notes the downsides, including the risk of oversimplifying or misrepresenting scientific information (Dahlstrom, 2014). As narratives use storytelling to foster engagement, message tailoring can be used to adapt communication strategies to connect with specific audiences (Burns et al., 2003; Dahlstrom, 2014). Burns et al. (2003) suggest experts should not only tailor the content of the message but also the medium. While these tactics play a critical role in effective communication, understanding public opinions and attitudes can enhance the impact of the message (Koswatta et al., 2022).

Clear communication about water science is crucial for raising awareness of issues like scarcity, pollution, and the impacts of climate change. By fostering informed attitudes toward water management, communication can build long-term, trust-based relationships (Dean et al., 2016). Dean et al. (2016) highlight the importance of community engagement in water management, emphasizing the need for collaborative approaches to address water-related challenges. Building on the importance of trust and informed attitudes in water management, it is also essential to consider the underlying factors that shape public perspectives (Corner et al., 2014). Core values, such as security and equality (Maio, 2016), along with their political ideologies (Corner et al., 2014), drive people's views on scientific topics, shaping how they interpret water science (Corner et al., 2018). Corner et al. (2018) suggest that framing the message to align with the values and interests of audiences can make it more engaging and impactful. Their research highlights that people's values and political views have a greater impact on their attitudes about climate change than their level of scientific knowledge (Corner et al., 2018).

Ultimately, aligning water science communication with widely shared public values is key to improving understanding and promoting effective engagement.

Methods

Design

This study utilized an exploratory qualitative design to answer the research questions. This research design is appropriate when the study aims to explore and understand people's experiences and perspectives. Qualitative research design encourages a data collection environment where the researcher acts as the primary instrument (Abrams & Meyers, 2010). Exploratory qualitative research allows data to emerge from the participants while respecting the

uniqueness of each situation (Ormston et al., 2013). Institutional Review Board (IRB) approval was obtained prior to conducting the research (see Appendix A). The study's qualitative design was further informed by the Theory of Planned Behavior, Social Cognitive Theory, and science communication models, which collectively guided the focus on participants' communication intentions, learning experiences, and engagement approaches.

Participants

Participants were recruited via email (see Appendix B) using a non-probability purposive sampling technique. Purposive sampling is used to find participants with a specific set of characteristics (Rai & Thapa, 2015). The inclusion criteria for this study were based on career paths, disciplinary expertise, and professional engagement in water-related research, education, or policy. To identify eligible participants, I created a list of potential experts using the Google search engine and preexisting lists of Kansas-based water researchers. Additional input was provided by the Director of the Kansas Water Institute, whose expertise in statewide water research and collaboration helped ensure a representative selection of disciplines and institutions.

Based on these parameters, I invited 40 water experts to participate. For this study, 'experts' included researchers, faculty, and extension professionals engaged in the water industry. This number reflects the total pool of individuals who met the established inclusion criteria and allowed for broad disciplinary coverage while remaining feasible for qualitative interviewing. Qualitative methodologists emphasize that sample adequacy is determined by the depth and richness of information rather than numerical size (Creswell & Poth, 2018; Patton, 2002). Of the 40 experts, 21 agreed to voluntarily participate in the study. Nonparticipants either did not respond or indicated schedule constraints; no additional information was collected to maintain voluntary participation.

Although the sample was not stratified to mirror the statewide population of water professionals, purposive sampling was used to intentionally include participants from multiple Kansas regions facing different water issues, using extension-defined regional boundaries to guide recruitment. The inclusion of experts with varied communication roles and levels of experience aligned with TPB and SCT, which emphasize examining attitudes, social expectations, and learning pathways that influence communication behavior.

The participants included water science experts from 15 organizations across Kansas. Participants' work focused on a range of disciplines, including data collection, policy creation, outreach, and education. Participants came from diverse areas of expertise with knowledge or experience in education, engineering, research, outreach, and more. After conducting the interviews, I removed all personal identifying information (PII) to de-identify the data, and participant numbers were assigned. Table 3.1 summarizes the demographic information of Study 1 participants.

Table 3.1 *Overview of Study 1 Participant Demographics*

<u>Participant Number</u>	<u>Gender</u>	<u>Kansas Area</u>	<u>Area of Focus</u>
1	Male	Northeast	Education
2	Male	Northeast	Hydrology
3	Female	Northeast	Water Policy
4	Male	Northwest	Education - Biology
5	Female	Northeast	Advocacy
6	Male	Northeast	Policy/Water Rights
7	Female	Northeast	Wastewater/Bioenergy
8	Male	Southeast	Aquatic Science

9	Male	Northeast	Geology
10	Female	Northeast	Agronomy
11	Male	Northeast	Water Quality
12	Female	Northwest	Advocacy
13	Male	Southwest	Groundwater
14	Male	Northeast	Water Storage
15	Female	Southeast	Aquatic Science
16	Male	Northeast	Storm Water
17	Female	Northwest	Groundwater
18	Female	Northeast	Education - Engineering
19	Male	Northeast	Conservation
20	Female	Northeast	Natural Resources
21	Male	Southcentral	Groundwater

To categorize participants geographically, each individual was assigned to a Kansas region using established regional boundaries from K-State Research and Extension (K-State Research and Extension [KSRE], 2025). These regions distinguish broad areas of the state, for example, Northwest, North central, Southwest, etc. Additional demographic characteristics were included in Table 3.1 to provide context for interpreting communication perspectives within the expert sample. Gender was recorded to reflect representation within the water science and outreach workforce. The Kansas region was included because geographic context influences local water challenges, issue holder engagement patterns, and communication priorities. Participants' area of professional focus was documented to capture disciplinary breadth within the sample, as expertise in research, policy, engineering, education, or outreach may shape how

individuals perceive and practice water communication. These characteristics support understanding the diversity of expertise and positionality represented in the study.

Data Collection

To address the research questions, I used qualitative, semi-structured interviews with 21 experts in the summer of 2024. The interview questions focused on overarching categories, including involvement in science communication, communication challenges, issue holder interaction, and collaborative efforts. The interview protocol included questions such as: How did you first become involved with water science communication? What are some challenges you have faced while communicating water science, and what solutions have you seen? (see Appendix C). Interview questions were shaped by TPB constructs—attitudes, subjective norms, perceived behavioral control—, SCT concepts such as observational learning and self-efficacy, and science communication models to explore how experts engage in deficit, dialogue, or participatory practices. All participants provided informed consent, and measures were taken to ensure their confidentiality and well-being throughout the study. Each interview was conducted via Zoom and lasted 45-60 minutes. Using Zoom allowed participants from across the state to join without travel, increasing accessibility and scheduling flexibility, though it may have limited the ability to observe some nonverbal cues typically available in in-person interviews. An undergraduate student helped conduct interviews, completing ten of them. All interviews were audio recorded and transcribed using Zoom’s transcription features.

Data Analysis

Transcripts were reviewed against recordings for accuracy, with necessary edits made. I then employed qualitative thematic analysis to identify and report patterns in the data (Braun &

Clarke, 2006). Inductive codes were developed based on emerging patterns using an open coding approach. During this initial stage, I broke down the data to identify concepts or categories by generating codes that captured the main ideas present in the interviews (Glaser & Strauss, 1967). To ensure consistency and agreement, I coded 10% of the data with guidance from my advisor.

Following open coding, I used axial coding to establish connections and linkages between concepts. I selected this approach because clusters of related ideas began to emerge during open coding, and axial coding allowed me to more intentionally examine how those categories related to one another and contributed to the broader phenomenon under study (Glaser & Strauss, 1967). The resulting codes were then refined and generalized into themes, which were reviewed and confirmed by the research team, my advisor, and an assisting undergraduate student, to establish validity.

Throughout the process, I used the constant comparative method to analyze the data, allowing concepts to develop through the simultaneous coding and analysis of data (Taylor & Bogdan, 1998). This integrated approach helps express the data in a clear and coherent form (Conrad et al., 1993). During analysis, TPB, SCT, and science communication models served as interpretive lenses, guiding the identification of themes related to communication intentions, skill development, self-efficacy, and the communication models participants described.

Positionality

For this study, an undergraduate assisted with data collection. Additionally, a faculty member assisted with the data analysis process. The undergraduate student has an agricultural background, specifically in the livestock sector, but no prior experience with water science. The

faculty member specializes in science communication research within agricultural and natural resources contexts.

As the lead researcher, I come from an agricultural background and have professional experience in agricultural communication. My familiarity with agricultural communities influenced how I approached interviews and interpreted participants' descriptions of collaboration and outreach. Specifically, I was more attuned to issues related to producer engagement, relationship-building, and practical communication strategies, which shaped the types of probing questions I asked and the themes that stood out during analysis. At the same time, my limited direct experience in water governance positioned me as a partial outsider, encouraging curiosity and prompting clarification during data collection and analysis.

This combination of perspectives positioned our team simultaneously as insiders to agriculture but outsiders to water governance. These shared and differing experiences informed the types of questions asked, the aspects of collaboration that stood out, and the meanings we attributed to participants' accounts.

Reliability

Before data analysis, the research team established a common coding framework by collaboratively analyzing 10% of the data, two transcripts, ensuring agreement on the approach. This preliminary step was crucial for enhancing validity, as it allowed all team members to align their understanding of the thematic categories that would guide the analysis (Braun & Clarke, 2006). To further strengthen validity, rich, thick descriptions were used to convey results, enhancing the depth and context of the findings (Creswell & Creswell, 2018). Throughout the research process, multiple meetings were held to discuss findings and ensure consistency. These collaborative discussions played a vital role in maintaining reliability by providing opportunities

for members to voice opinions. After the data was analyzed, codes were cross-checked to confirm the organization of the findings. This rigorous process further solidified reliability by ensuring that codes were applied consistently across all transcripts.

Findings

RQ1: What communication resources and knowledge are used by water science experts?

Water experts rely on experiential learning and collaboration to build communication skills in the absence of formal training.

This theme illustrates that water experts acquire communication skills through experience-based learning rather than formal education. Participants emphasized learning by observing peers and through trial and error. Their communication competence developed out of practical need, with strategies such as visual aids, message tailoring, and collaboration with subject matter experts.

Many water science experts shared that they do not have formal training in the field of communications. Most expressed their reliance on ‘on-the-job’ learning to help them with their communication tactics. Participant 15 said, “I think a lot of it is learned by doing it, and you can learn a lot by experience.” Although Participant 15 acknowledged that sometimes this isn’t always the easiest or quickest way to learn. Participant 6 stated, “Throughout my career, I’ve had a lot of interactions with a lot of people who deal with communication and outreach, and I have certainly gotten some coaching from them.”

Participant 15 further explained the need for hands-on experience: “You can’t learn to be a good baseball player by reading a book about playing.” Water science experts have a robust educational background in the various fields of science. Many participants have completed

graduate and doctoral programs in their field; however, few have participated in communication training. Participant 7 explained, “Communications is something that you don't get a lot of technical training in. I have a bunch of training in project management, but communication is trickier.”

In addition to stating they are inexperienced in communication efforts, they mentioned frustrations that come with unsuccessful communication tactics. Participant 4 states, “You can spend a lot of money advertising and not be very effective with getting the word out.”

Although participants have little experience, they shared several tactics frequently used. Participants identified the need to include subject matter experts in their communication efforts. Some participants call on staff members with different educational backgrounds and experience. Participant 19 said, “In a public meeting, we try to always have a subject matter expert available to speak about the science.” Participant 18 agreed, “I think you need different experts in the room when you start to think about communicating because people come at it from different angles.”

In addition to subject matter experts, participants utilized communications staff members to enhance their efforts. Participant 6 stated they hope to increase their connection with communication staff, “We hope to involve more communications staff in more of our day-to-day operations.”

Water science experts pair communication experts with various tactics to communicate effectively. Participant 4 stated, “As far as communication tactics, we've tried to do as many different things as possible.” Participants identified successful tactics they have executed in their efforts, such as using online media. Participant 2 shared, “The web has really helped us out with that because it's a great way to get information out there and let people access it.”

Due to the complexity of the topics, many participants try to include visuals to keep their audience's attention. Participant 14 stated, "We use a lot of graphic creation to try to put things in a visual way. I think that's the most effective way to explain how systems operate."

Participants described the need to cater to many differing audiences as water issue holders are diverse. One strategy utilized by participants is understanding the audience they are targeting. Participant 6 said, "When we interact with them, we try to kind of meet them where they're at to some degree."

Experts aim to adapt their communication for diverse audiences, as not everyone has a background in water science or an understanding of these complex topics. Several participants emphasized the need to tailor messages to specific groups, which often involves removing jargon and using plain language. Participant 11 noted the challenge of explaining research, "Every field has vocabulary or vernacular that's a big part of your role."

Participants stressed the importance of catering messages without reducing the meaning or offending the target audience. Participant 15 stated, "You have to change the level in which you're speaking to fit the audience to what you're speaking so that they don't feel like you're talking down to them because nobody likes that."

Many science fields require vigorous education to gain an in-depth understanding of their field. Some participants stated that this can make it difficult to communicate with a general audience. Participant 16 explains:

I went to school for 6 years, learning it. I've been doing it for 12 years, and I'm still learning. And then I'm supposed to talk to people that have no previous knowledge of it and have little understanding.

Many participants find it challenging to communicate with the public due to their level of expertise. Participant 11 explained, “I think we struggle because you're typically trying to convey a technical, nuanced topic.” They also face the challenge of balancing how much information to share. Participant 21 described a thin line between under- and overcommunicating, “I think one communication challenge is sort of the difference between giving too much information and not enough. You can lose people in the details, in the weeds fast.”

RQ2: How do water experts generate and share scientific information with issue holders?

Water scientists communicate with diverse audiences.

This theme illustrates that water experts share information with a wide range of audiences, requiring them to adapt how they communicate across technical, professional, and public settings. Participants emphasized that audience diversity shapes how information is framed, delivered, and received.

Many participants expressed that the water science discipline has many broad, diverse audiences. Participants described that the key issue holders value different information. Participant 17 said, “Everybody is a water user, so everybody is a stakeholder in some way, shape, or form.” Participants emphasize the importance of addressing the needs of water users and issue holders in the field. Participant 18 stated, “That is probably the most important thing, being able to communicate with both the professional side, like my colleagues in engineering, and with other stakeholders.”

Working with such a diverse audience presents a challenge when connecting with different issue holders. Participant 4 explained:

It's tough trying to communicate to different audiences because you're trying to provide for all. I don't know if that's possible when it's that diverse of users in the area, but we try to cater to those different groups.

Experts shared that building connections with fellow water science professionals and working together is a valuable approach for addressing complex challenges in the field. As Participant 15 noted, “It would be impossible to get anything done if we didn't all work together, because we are multi-faceted.”

The water science discipline is interdisciplinary and encourages collaboration.

This theme highlights that collaboration serves as a primary mechanism for generating and sharing information among water experts. Participants described how interdisciplinary teamwork allows them to combine expertise, share resources, and learn from one another.

Many participants shared that the water science industry is multifaceted and encourages experts to work together. Participant 2 noted, “We collaborate on almost everything we do,” while Participant 15 added, “Science is collaborative and takes a village.”

Participants shared that working together across disciplines and with fellow subject matter experts can help science be successful. “I have things that I'm familiar with in my expertise, but when you add somebody else's expertise, we have doubled our knowledge. Science works best when it's collaborative,” said Participant 15.

Participants described drawing on each organization's strengths and resources to enhance collaborative efforts and advance shared water management goals. Participant 11 noted:

We have a fairly collaborative mindset among the agencies when it comes to water. We work together frequently, and there is a consistent effort to include the other agencies and understand where they are experts compared to where we are.

Participants consolidate their research teams by joining forces, creating a collaborative environment that enables subject matter experts to work closely together. Participant 20 notes the importance of sharing resources, stating, “We use research groups to pull together our resources and expertise. It has worked really well and allows the subject matter experts to all work together side by side.”

Additionally, a collaborative science approach allows experts to learn from one another. These coordinated efforts build interdisciplinary connections. Participant 11 said, “It often comes down to knowing who to talk to more than more so than knowing how to do it yourself.”

This highlights the value of networking and communication to advance knowledge within scientific communities. Beyond collaborating with one another, participants noted they frequently consult other agencies for advice and support. Many experts utilized various resources, such as government organizations, educational institutions, and professional network connections. These connections play a vital role in advancing scientific efforts.

Discussion and Conclusions

This study explored the experiences of Kansas water science experts in communicating with public audiences, collaborating on research teams, and addressing water challenges and solutions. The participants were highly educated professionals from diverse disciplines and represented various regions across Kansas, offering a comprehensive perspective on the state’s water issues. Three critical themes emerged from the data: communication tactics, diverse audiences, and interdisciplinary collaboration.

Despite limited formal communication training, water scientists employed various tactics to effectively convey complex concepts to a diverse audience. Participants emphasized the

importance of visual aids, noting that they increase their audience's attention. These experts often explained complex topics, and visuals play a role in simplifying complex scientific topics (Burns et al., 2003). These patterns mirror broader science communication research showing that jargon, complexity, and dense formats can undermine comprehension and reduce an audience's willingness to engage (Bullock et al., 2019; National Academies of Sciences, Engineering, and Medicine, 2017). The use of visuals, analogies, and accessible language reflects strategies known to increase clarity and support better decision-making, especially in environmental and risk-related contexts (Gustafson & Rice, 2020). These findings also reflect the Theory of Planned Behavior: participants demonstrated intentions to communicate effectively but were constrained by limited training, time, and institutional support, all of which influenced their perceived behavioral control.

The diversity of water science audiences presented challenges for tailored messaging (Burns et al., 2003). As many participants noted, water impacts diverse audiences, which broadened the target audience but complicated efforts to connect with issue holders who had differing needs and priorities. These challenges reflect science communication scholarship that emphasizes mutual learning and dialogue as essential for building understanding and trust (American Association for the Advancement of Science (AAAS), n.d.). Participants often learned communication strategies by observing colleagues, aligning with the observational learning component of Social Cognitive Theory. Their desire for relationship-centered, two-way interactions parallels research showing that trust is central to how scientific information is interpreted and acted upon (Baram-Tsabari & Lewenstein, 2017; Weingart & Guenther, 2016). The communication gaps participants described are also consistent with findings from interdisciplinary environmental domains, where even experts hold uneven information—

underscoring the need for structured communication strategies that support alignment and clarity (Papa et al., 2025).

The interdisciplinary nature of water science promotes collaboration, with many participants sharing experiences working together, creating opportunities for more accurate and clear messaging (Gilbert & Stockmayer, 2012). Participants emphasized that progress in the water field depends on collective effort, as no single expert or organization can effectively address such a multifaceted challenge. These findings align with Social Cognitive Theory, as participants built self-efficacy and confidence by observing and learning from colleagues, reinforcing collaboration as a social and professional learning process. This mindset fosters teamwork and ensures that diverse perspectives are integrated in water management strategies (Fischhoff, 2013).

This study highlights an opportunity to enhance water science experts' communication efforts by strengthening collaboration and providing targeted, accessible communication support. These findings suggest that while experts value engagement and collaboration, many lack formal training and face uncertainty about where to access existing resources. Tailored, practical approaches—such as visible training opportunities, peer learning, and structured collaboration spaces—can help address these gaps (Baram-Tsabari & Lewenstein, 2017; Fischhoff, 2013; Gustafson & Rice, 2020).

Extension specialists should consider making training opportunities in science communication more visible and accessible to practitioners across the water industry. Several participants indicated uncertainty about what science communication resources were available or how to access them. Specialists could improve awareness by curating and promoting a centralized list of trainings, workshops, and online modules. As participants noted their

preference for in-person training options, specialists should prioritize supporting meaningful collaboration and peer learning rather than self-paced or virtual alternatives. Extension offices should also consider developing brief, targeted sessions for specific science communication challenges, such as engaging audiences or tailoring messages.

Water experts should continue leveraging peer learning by observing colleagues' communication approaches and asking reflective questions about what works in different contexts. This informal, experiential learning emerged in the findings as a key strategy among professionals who lack formal communication training. Institutions could reinforce this culture by normalizing observation and feedback, such as through peer review or short reflection group sessions after to make knowledge more explicit and transferable.

Conference and workshop organizers in the water and natural resource fields could enhance the value of their events by incorporating structured opportunities for collaborative work. A time to exchange strategies and practice communication could benefit participants, instead of only passively listening to presentations. Dedicated sessions for small-group work or peer review encourage interdisciplinary interaction and provide a space for scientists to refine their communication approaches in real time. Organizers might also prioritize maintaining in-person elements, even within hybrid formats, since these facilitate trust-building and nuanced dialogue that virtual settings sometimes limit.

Although this study focused on the water sector, the findings have implications for other natural resource contexts that rely on effective cross-sector communication. Forestry, soil health, and climate adaptation professionals face similar challenges in translating complex science to diverse audiences. Programs in these areas could adapt the recommendations above, particularly

the emphasis on peer learning and accessible training, to strengthen their communication ecosystems and foster more collaborative, interdisciplinary problem-solving.

While the findings are not intended to be generalized, the strength of this qualitative approach lies in its ability to explore experiences in depth and provide nuanced insight into a specific context. Future research should include larger and more diverse samples to better represent the Kansas water science community. Expanding the scope to other regions could also reveal whether communication strategies and collaboration patterns are consistent or context-specific.

Finally, future work should further investigate how experts' perceptions of water issues influence their communication priorities and strategies, as this study found that many participants framed water challenges as primarily technical or management problems rather than communication or social engagement issues. This perspective appeared to shape how they tailored messages, chose audiences, and collaborated with others. Examining these perceptions more closely could deepen understanding of how conceptual frameworks like TPB, SCT, and science communication models interact in practice.

Chapter 4 - Study 2: Exploring Interdisciplinary Team Processes and Collaboration within the Kansas Water Institute

Overview

Interdisciplinary collaboration is essential for addressing complex water management challenges, yet the processes that enable effective team-based research remain underexplored. This case study addresses this gap by examining how the Kansas Water Institute (KWI) forms interdisciplinary teams, fosters collaboration, and develops networks to support research and outreach. Semi-structured interviews with nine team members and a focus group with three leadership staff, combined with a social network mapping activity, were used to uncover key insights. Findings revealed that KWI teams are intentionally formed through purposeful recruitment, shared motivations, and leadership that facilitates complementary expertise. Team effectiveness relies on active relationship-building, frequent communication, and leveraging members' networks to connect with internal and external issue holders, despite structural barriers such as limited time, resources, and institutional silos. Based on these results, it is recommended that organizations prioritize intentional team formation, strategic leadership, and relational infrastructure to enhance interdisciplinary collaboration. Tools such as social network mapping can support reflection, strengthen connections, and improve team functioning, ultimately enabling research teams to address complex water challenges more effectively.

Introduction

Scientific teams have been integral to knowledge creation since the early days of modern science, but their prevalence has significantly expanded across disciplines (Trochim et al., 2008; Wuchty et al., 2007). While traditionally established in physics and biomedical research, team-based approaches have shown increasing presence in engineering, social sciences, and patent

creation (Settles et al., 2019; Wuchty et al., 2007). This shift reflects an increasing recognition that modern research challenges require diverse expertise and interdisciplinary collaboration (Curry et al., 2012). Research teams today are strategically designed to incorporate varied backgrounds, fostering innovative problem-solving approaches and enhancing scientific discovery. Effective collaboration, however, depends not only on assembling diverse expertise but also on managing the communication, conflict, and relationship-building processes that sustain team functioning (Bennett & Gadlin, 2012). Funding agencies and global organizations increasingly prioritize interdisciplinary collaboration through institutional policies and grant structures (Maxwell et al., 2019; National Academy of Sciences, 2024).

Structures and Dynamics Influencing Team-Based Research and Innovation

Funding for research and development (R&D) is essential across the university, government, and private sectors, though the funding systems vary significantly between them. In universities, research is funded through performance-based research funding systems (PRFSs) and competitive grants alongside internal support (Hicks, 2012; Wang et al., 2018). Globally, there has been a shift away from traditional block funding models toward PRFSs (Bloch & Sørensen, 2015). Government funding typically comes from legislative appropriations or grants, while private-sector R&D relies on internal budgets or investor support (Gerpacio, 2003).

A recent study in Japan found that competitive funding, where researchers apply for grants, led to more novel research compared to internal block funding, which is automatically allocated to researchers within an institution (Wang et al., 2018). In contrast, concerns in the U.S. suggest that current systems may discourage innovation. PRFSs and competitive grant systems can unintentionally promote conservative research, as scholars aim to meet established performance criteria rather than pursue novel or high-risk ideas (Hicks, 2012; Wang et al., 2018).

Total research funding has increased significantly in many countries, often across all funding types when measured in absolute terms (Bloch & Sørensen, 2015). However, the number of researchers competing for that funding has also grown substantially, potentially reducing individual chances of receiving support (Bloch & Sørensen, 2015; Hicks, 2012). For researchers seeking to maximize the impact of their proposals, collaborative interdisciplinary teams offer a promising strategy to navigate competitive funding environments.

While team-based approaches have been successful, the effectiveness of scientific teams depends on team climate—the shared perceptions, views, and attitudes among team members. A positive team climate enhances knowledge generation, but team structure and interactions significantly influence outcomes (Settles et al., 2019). Communication and relationship management are particularly critical, as Bennett and Gadlin (2012) note that successful scientific teams must actively navigate differences in goals, work styles, and interpersonal expectations. Transdisciplinary teams perform best when they balance frequent interaction with structured autonomy (Stokols et al., 2008a). Tightly organized teams foster close collaboration, whereas loosely organized teams offer independence but may limit mentorship (Feldman et al., 2009, 2013). Identifying practices that foster effective teams is essential for advancing scientific innovation.

Team composition also significantly affects outcomes. Transdisciplinary teams often produce more successful research, with team-authored papers receiving higher citation counts (Wuchty et al., 2007). Yet this approach is not without criticism: applying group problem-solving to tasks better suited to independent work can reduce productivity (Stokols et al., 2008a). Successful teams require balancing scientific expertise with management capabilities (Trochim et al., 2008), with the Principal Investigator guiding direction and administration. However,

multi-university partnerships with numerous PIs can hinder innovation by diluting focus (Cummings & Kiesler, 2005).

Interdisciplinary teams play a critical role in fostering collaboration and generating innovative solutions to complex scientific problems (Maxwell et al., 2019; Page, 2017). However, much literature emphasizes leadership, organizational structures, or team size, rather than specific practices that enhance transdisciplinary effectiveness. This gap is particularly relevant in agricultural research, where addressing sustainability and resource management requires collaboration across diverse disciplines.

Cummings & Kiesler (2005) note the need for research on how different sciences coordinate within teams, emphasizing the importance of communication and collaboration strategies. Organizational boundaries, geographic distance, and conflicting academic schedules also pose challenges.

While team science has been extensively studied in fields such as healthcare and engineering, comparatively little research has examined how team-science principles operate within water-focused research contexts (Hall et al., 2012). The Kansas Water Institute (KWI), which serves as the focus of this case study, provides a unique opportunity to examine the dynamics of interdisciplinary collaboration and team development in water research. Understanding how KWI integrates diverse expertise into a cohesive, high-functioning unit is essential for improving transdisciplinary collaboration in water science (Hall et al., 2012; Stokols et al., 2008a).

Effective transdisciplinary teams require not only expertise and leadership but also strong interpersonal connections and representation (Settles et al., 2019). Yet little research explores how these dynamics shape team development or contribute to organizational goals. While

transdisciplinary collaboration has been studied from leadership perspectives (Gray, 2008), less empirical work examines individual team members' experiences. This study addresses that gap by examining KWI's team-building strategies and how they foster collaboration among diverse backgrounds.

Moreover, existing studies on team dynamics often focus on outcomes such as productivity or innovation (Klug & Bagrow, 2016; Wuchty et al., 2007), yet they overlook the underlying processes that enable these successes within transdisciplinary settings. Understanding how individual behaviors, informal leadership, and communication practices influence the team's success is crucial for replicating or improving similar organizational structures (Stokols et al., 2008b). Thus, this study will provide a deeper understanding of how one transdisciplinary team developed, functions, and contributes to scientific advancement in water management.

One pressing area that benefits from team-based problem-solving is agriculture and natural resources management, particularly related to water scarcity (Ajaz et al., 2020; Lopez et al., 2022). Innovation, defined as the creation and implementation of new ideas (Amabile, 1988), often arises from teams integrating multiple disciplines. Diverse perspectives promote innovation (Cummings & Kiesler, 2005), and team-based approaches have led to irrigation technologies such as drip systems, soil moisture sensors, and precision sprinkler systems (Evans & King, 2010; Schaible & Aillery, 2012). However, technology alone is insufficient.

Collaborative, team-based approaches that engage diverse issue holders are key to effective group management (Hall et al., 2012; Stokols et al., 2008b), and these practices are increasingly vital in water management contexts. One example of a collaborative approach is the Local Enhanced Management Area (LEMA) program implemented in Kansas that empowers farmers to work cooperatively with local and state officials to address groundwater depletion

challenges (Lopez et al., 2022). This collaborative framework has yielded tangible results, with one LEMA achieving a 31% reduction in water use over five years compared to control areas (Deines et al., 2019). Similarly, California's Groundwater Sustainability Agencies show the value of interdisciplinary coordination (Newman et al., 2018). These cases illustrate the power of team science in addressing water-related challenges.

Case Study Context: The Kansas Water Institute

This case study focuses on the Kansas Water Institute (KWI), housed on the campus of Kansas State University. In 2023, K-State launched its *Next-Gen K-State Strategic Plan*, which elevated the former Kansas Water Resources Institute (KWRI) to its status as the Kansas Water Institute (Kansas Water Institute, 2025). Originally established in 1964 under the Water Resources Research Act, KWRI's transition to KWI reflects a broader institutional shift. The *Next-Gen K-State Strategic Plan* emphasizes sustainability, including water and natural resource management as key priorities (Kansas State University, 2023). This strategic shift has enabled more time and resources for the KWI to expand its reach by supporting innovative research faculty from universities across Kansas and addressing critical water resource issues facing the state (Kansas Water Institute, 2025).

Purpose

The purpose of this case study was to explore the process of interdisciplinary teams within the Kansas Water Institute. By examining how this team was built, how its network is fostered, and how information circulates among members, the study seeks to provide insight into the organizational practices and relationships that support effective research on complex water issues. The following research questions (RQs) guided the case study:

RQ1: How are interdisciplinary teams within the KWI formed, and how do team dynamics influence their perceived effectiveness and efficiency?

RQ2: How does the Kansas Water Institute develop and interact with networks and collaborations?

RQ3: How do participants' self-constructed social networks reveal patterns of collaboration and information flow within the Kansas Water Institute?

Conceptual Framework

The conceptual framework for this case study is grounded in the Decision-Making Model for ANR Science and Technology, Tuckman's Stages of Group Development, and the Transdisciplinary Team Science Model. The Decision-Making Model for ANR Science and Technology provides context for understanding how agricultural research teams form and act on decisions related to science and technology. Tuckman's Stages of Group Development is used to examine how groups progress through stages of team formation and collaboration. The Transdisciplinary Team Science Model guides the analysis, highlighting how interdisciplinary teams integrate diverse expertise to address complex water challenges. Figure 4.1 presents the model of the conceptual framework applied in this study.

Figure 4.1: Study 2 Conceptual Framework Model

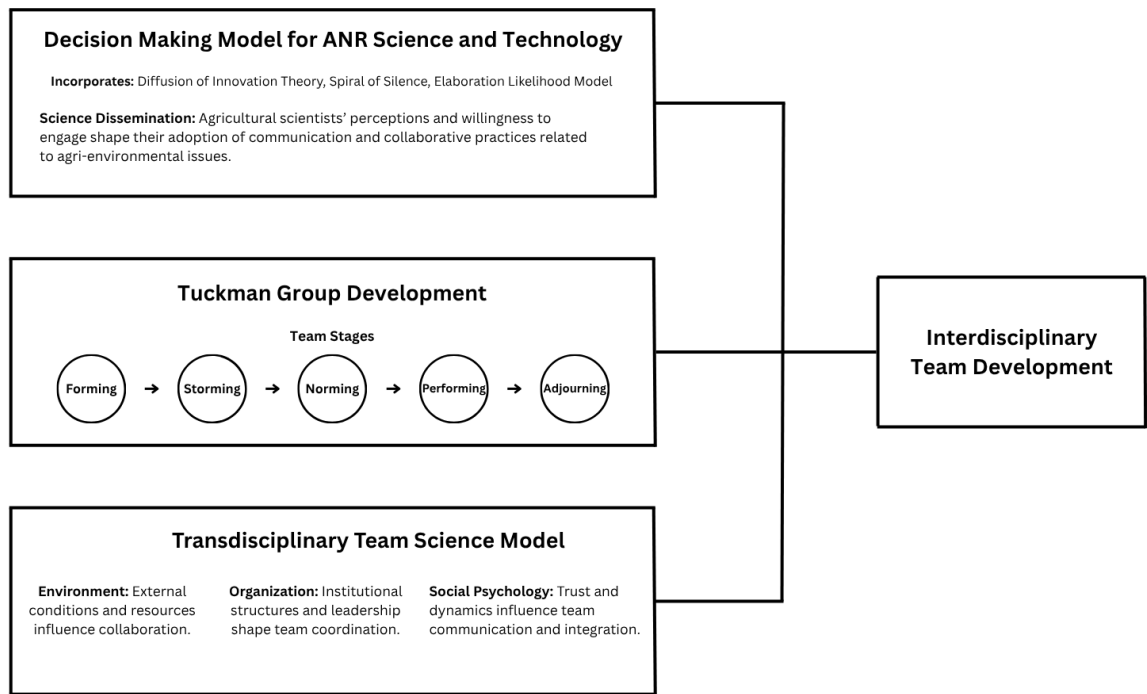


Figure 4.1 illustrates how interdisciplinary teams integrate decision-making models, group development stages, and transdisciplinary team science approaches to support coordinated action and knowledge co-creation. The model combines three frameworks that together explain how individuals decide to engage, how teams evolve, and how broader contextual factors shape collaboration within the KWI.

The Decision-Making Model for Agriculture and Natural Resources (ANR) Science and Technology is positioned at the beginning of the process, capturing how individual scientists assess their willingness to participate in new interdisciplinary initiatives. This model also extends to later phases, as members will continually evaluate and adopt communication practices within the team. Elements of the spiral of silence and elaboration likelihood model illustrate how communication practices are adopted or resisted, depending on the member's perceptions of credibility, relevance, and peer acceptance.

Tuckman's Group Development Model provides guidance that spans the entire process, outlining how teams evolve through each step: forming, storming, norming, performing, and adjourning. In the forming stage, members establish relationships and define shared goals. During storming, differences in disciplinary perspectives or communication styles may emerge. Through norming, teams build trust and develop common procedures, while the performing stage represents a high-functioning phase characterized by effective collaboration and shared productivity. In the context of institutional teams like KWI, adjourning often looks different; it may not mark the dissolution of the team but rather transitions tied to contract cycles, funding availability, or project milestones.

Finally, the Transdisciplinary Team Science Model highlights how collaboration is shaped by environmental, organizational, and social-psychological factors throughout the team's lifespan. This model emphasizes that team effectiveness is not only a product of individual and group processes but also of institutional structures, leadership support, and resource access. Within KWI, these contextual influences, such as university policies, funding mechanisms, and issue holder engagement, create both opportunities and barriers to transdisciplinary collaboration.

Together, these three frameworks explain how individual decision-making, team development, and contextual systems interact to shape the formation and functioning of interdisciplinary research teams within the Kansas Water Institute.

Decision-Making Model for ANR Science and Technology

According to Ruth et al. (2018), the Decision-Making Model for Agriculture and Natural Resources (ANR) Science and Technology integrates concepts from the Diffusion of Innovation theory, the Spiral of Silence, and the Elaboration Likelihood Model to explain how individuals

evaluate, adopt, and communicate scientific findings. This model was originally designed to help practitioners disseminate scientific information more effectively and to understand how the public uses scientific information about ANR to make informed decisions.

Key components of the model include perceptions of public opinion, attitudes toward ANR innovations, and willingness to engage with scientific communication, factors that collectively influence whether scientific information is accepted or rejected (Ruth et al., 2018). Within the context of this study, the model is used to understand how individual scientists within the KWI decide whether to participate in interdisciplinary collaborations and adopt new communication practices. These individual-level decisions represent the foundation of team formation and set the stage for how scientific knowledge is shared, interpreted, and applied across disciplines.

Tuckman's Stages of Group Development

Tuckman's (1965) model of group development is a widely recognized framework that describes the stages teams typically progress through as they form and mature. The model identifies four initial stages: forming, storming, norming, and performing. These stages represent the evolution of team dynamics from orientation and conflict toward cohesion and productivity. In the forming stage, team members get acquainted and establish initial expectations. During storming, conflicts and power struggles may arise as members assert their ideas and roles. The norming stage is characterized by the development of shared norms, stronger relationships, and clearer roles. Finally, in the performing stage, the team operates efficiently toward achieving its goals. This model helps explain how teams navigate interpersonal challenges and build effective collaboration over time. Later, Tuckman added a fifth stage called adjourning to address team dissolution after task completion (Tuckman & Jensen, 1977).

Within the context of this study, Tuckman's model provides a framework for understanding how interdisciplinary research teams, such as those within the KWI, develop over time. It highlights how initial uncertainty and negotiation evolve into coordinated collaboration, illustrating the interpersonal processes that underlie effective team functioning. This model complements the Decision-Making Model by shifting the focus from individual decision-making to group-level development, thereby bridging the transition from personal engagement to collective performance.

Transdisciplinary Team Science Model

The conceptual framework developed by Stokols et al. (2008a) offers a comprehensive approach to understanding transdisciplinary team science. It highlights how multiple factors at different levels, environmental, organizational, and social-psychological, influence team functioning and outcomes. Environmental influences include institutional policies and funding mechanisms that shape the research context. Organizational factors encompass leadership, team structure, and resource distribution, which facilitate or hinder collaboration. Social-psychological elements such as trust, communication, and shared understanding play a critical role in fostering effective teamwork. This framework serves as a foundational guide for exploring the complexities of collaboration across disciplines and provides a basis for designing strategies to support successful transdisciplinary research.

Within the context of this study, the Transdisciplinary Team Science Model offers a useful framework for analyzing how the Kansas Water Institute (KWI) supports collaboration among researchers from multiple scientific domains. This approach helps illuminate how KWI's institutional structures, leadership styles, and interpersonal dynamics contribute to or constrain transdisciplinary integration. As Stokols et al. (2008a) argue, effective team science requires

alignment between contextual factors and team-level practices, a relationship particularly salient in complex, water-focused research where environmental and policy pressures are high (Gray, 2008). This model complements both the Decision-Making Model for ANR Science and Technology and Tuckman's Group Development Model by situating individual decision-making and group interaction within the broader organizational and environmental systems that shape collaborative research outcomes.

Literature Review

Conceptualizing Disciplinary Collaboration

Definitions of collaboration across disciplines vary, with terms such as multidisciplinary, interdisciplinary, and transdisciplinary often used interchangeably but carrying distinct meanings (Stokols et al., 2008a). Interdisciplinary research involves integrating knowledge, methods, and perspectives from two or more disciplines to address a common problem (Stokols et al., 2008a). In contrast, multidisciplinary approaches involve researchers working in parallel within their own fields, while transdisciplinary collaboration goes further by transcending traditional disciplinary boundaries to create new frameworks and knowledge. Some initiatives, such as the NIH Roadmap, treat interdisciplinary and transdisciplinary research as essentially equivalent, reflecting the evolving and overlapping nature of these concepts (Stokols et al., 2008b). As outlined in Chapter 2, this thesis acknowledges these distinctions but uses *interdisciplinary* as a consistent term for clarity. Corresponding with this conceptual development, there has been a notable rise in the use of interdisciplinary teams to address complex scientific challenges (Settles et al., 2019).

Team Science: Structures, Dynamics, and Outcomes

Research shows that interdisciplinary teams benefit from larger size and broader disciplinary representation. Teams composed of four to six disciplines at a single university generate more ideas and achieve greater outreach outcomes compared to smaller teams of one to three disciplines (Cummings & Kiesler, 2005). Similarly, Klug and Bagrow (2016) found that team success rates increased by 300% as membership grew from one to ten individuals. This advantage may stem from a larger pool of contributors driving the work or from successful projects attracting additional collaborators. However, despite larger teams producing more overall output, a small subset of members typically generates the majority of contributions (Klug & Bagrow, 2016).

Beyond size, team diversity, leadership, and organizational structures shape collaborative outcomes. Because universities and research institutions are typically organized along disciplinary lines, interdisciplinary teams must navigate boundaries that complicate coordination (Cummings & Kiesler, 2005). Adding more principal investigator (PI) universities has been shown to negatively affect the generation of new ideas and knowledge, suggesting that too much diversity may hinder coordination (Cummings & Kiesler, 2005). At the same time, successful teams often rely on a clear leader, with one member contributing disproportionately to the group's progress (Klug & Bagrow, 2016). Diversity of work also plays a critical role: while teams composed of individuals with prior collaboration experience tend to exhibit low diversity, greater variation in members' backgrounds correlates positively with success, regardless of team size (Klug & Bagrow, 2016). These findings highlight the delicate balance between diversity, leadership, and coordination in shaping team outcomes.

Despite these benefits, group-based research presents recurring challenges. Cummings and Kiesler (2005) found that interdisciplinary workshops of teachers faced frequent setbacks, including scheduling conflicts and differing views on project objectives. Such findings illustrate how logistical and conceptual challenges can limit collaboration across disciplinary boundaries. These barriers underscore that while team science offers unique benefits, it also requires intentional structures and processes to manage conflict, coordinate efforts, and sustain progress over time.

Methods

Design

This study utilized a qualitative single case study design, defined as the Kansas Water Institute (KWI) interdisciplinary working group. Case studies are used to provide an in-depth description and analysis of a bounded system (Merriam & Tisdell, 2016) and are appropriate for examining complex processes within a real-world context where boundaries between the phenomenon and the setting are blurred (Yin, 2018).

This design was appropriate for the goals of the project, as this study sought to understand how individuals make decisions about collaboration, as captured in the Decision-Making Model for ANR Science and Technology, and how interdisciplinary teams develop over time, as described by Tuckman's stages of group development. I selected this group as they play a formal role in coordinating cross-college, water-related initiatives at Kansas State University and its partner campuses. Prior research highlighted the interdisciplinary nature of water science, guiding the selection of a team engaged in interdisciplinary water-related work. This design aligned with the study's aim to understand the dynamics of interdisciplinary collaboration in a

water science context. Prior to conducting the research, I obtained Institutional Review Board (IRB) approval (see Appendix D).

Participants

This research specifically examined the KWI and the dynamics within the interdisciplinary working group. I selected participants using purposive sampling, a method that intentionally chooses individuals based on their knowledge, experience, or involvement relevant to the research focus (Patton, 2002). Because the conceptual framework emphasized how individual decision-making, group development, and organizational context shape collaboration, purposive sampling ensured that those most directly embedded in these processes were included. In this study, the criterion for inclusion was that participants must be members of the current KWI interdisciplinary working group.

Participants, including professors and associate deans with expertise in areas such as program evaluation, conflict resolution, environmental geology, and biological science, were recruited via email (see Appendix E). Members of the KWI leadership team were also recruited via email (see Appendix F) for a focus group. The purposive sampling ensured participants possessed the relevant knowledge to provide meaningful insights to the research questions. The final sample included nine participants.

After conducting the interviews, I removed all personal identifying information (PII) to de-identify the data and numbers were assigned to each research participant. Because the KWI interdisciplinary working group is relatively small, additional demographic or identifying information about participants is not reported, as doing so could risk compromising their confidentiality.

Data Collection

To answer the research questions, I conducted semi-structured interviews with nine Kansas Water Institute (KWI) team members in the spring of 2025. Semi-structured interviews allow for a flexible yet focused conversation, with predefined questions that were adapted based on the participant's responses (Braun & Clarke, 2006). Questions were shaped by the study's conceptual framework, particularly the Decision-Making Model's focus on attitudes and willingness to engage, Tuckman's emphasis on team processes, and Stokols' transdisciplinary model highlighting contextual influences. The interview protocol included questions such as: How would you describe team relationships at KWI? When perspectives differ, how does the team navigate and resolve conflicts? (see Appendix G). Each interview was conducted via Zoom and lasted 30-60 minutes. The audio was recorded and transcribed using Zoom features.

Three KWI leadership staff members participated in a focus group that included semi-structured questions and a social mapping activity (see Appendix H). The social mapping component was designed to provide insight into KWI's internal network. Participants used the Mural platform to individually create a qualitative social network map. The in-person focus group lasted approximately 60 minutes and was recorded and transcribed using OtterAi.

Data Analysis

The interviews and focus group were transcribed using Zoom and Otter.ai, respectively, and I cross-checked transcripts against the original recordings to ensure accuracy. Transcripts were then imported into NVivo 15 for analysis. An inductive approach guided the coding process. Initial analysis involved descriptive coding with memoing to capture key topics and reflections. Descriptive coding uses a word or short phrase to summarize the basic topic of a passage (Saldana, 2009). During this stage, particular attention was given to instances where

participants described decision-making processes related to collaboration, consistent with the Decision-Making Model for ANR Science and Technology, as well as moments that illustrated group development dynamics aligned with Tuckman's stages. Next, I employed axial coding to identify relationships among the initial codes and explore how these connections contribute to understanding the broader phenomenon (Glaser & Strauss, 1967). The resulting codes were organized into themes, which were reviewed with the research team to establish validity.

Reliability

To enhance credibility, emerging codes were periodically reviewed and discussed with my advisor. This process aligns with recommendations for analyst triangulation and peer debriefing (Creswell & Creswell, 2018; Patton, 2002) and supports reflexive dialogue during coding (Braun & Clarke, 2006).

Following Lichtman's (2013) personal criteria for qualitative research, which emphasize clarity of researcher role, methodological transparency, relevance of topic, and convincing presentation of findings, this study uses those criteria as the foundation for ensuring research quality. This aligns with broader qualitative validity scholarship that highlights credibility, reflexivity, coherence, and transparency as key indicators of rigor (Lincoln & Guba, 1985).

Findings

RQ1: How are interdisciplinary teams within the KWI formed, and how do team dynamics influence their perceived effectiveness and efficiency?

The Kansas Water Institute was intentionally formed through strategic recruitment and collaborative leadership, fostering strong interdisciplinary team dynamics.

This theme illustrates that the Kansas Water Institute's success stems from deliberate team design leadership that prioritized collaboration. These purposeful choices shaped both team structure and the strong interdisciplinary relationships that support its success.

The formation and structural development of the Kansas Water Institute emerged as a central theme in participants' interviews. The group emerged through shared motivations, purposeful recruitment, and leadership that fostered collaboration across disciplines. This intentionality shaped membership and strengthened team dynamics.

Participants described the team's initial formation as beginning with a broad call of interest, followed by a more deliberate process of adding to the group. Additions were made through group discussions focused on identifying strengths and gaps. Participant 8 explained, "The group spent a few hours thinking before they curated that list of who should be at the table." Participant 8 further noted, "We sent out invitations to anybody who was interested in solving problems around water at the University."

Participants consistently emphasized the importance of forming a team with a diverse range of individuals. Participant 3 advised others, "to cast the net widely when you're thinking about members for an interdisciplinary group. Don't just think about the kind of close connections around you." Participant 6 shared a similar view regarding the recruitment of motivated team members, noting, "Choose people with passion and that are broadly networked already or

integrated in their area.” This emphasis on passion and shared purpose was echoed by Participant 9, who reflected, “We all firmly believe in what the Water Institute is about and what we’re trying to do.” Others echoed that working on water issues connects to the university’s strategic goal and is a topic the group is passionate about.

Leadership also played a key role in forming and supporting the group’s structure. Several participants acknowledged that a strong leader was necessary for fostering collaboration. Participant 9 shared, “We’re incredibly fortunate to have a director whose talent is partnering people up.” Others described the intentionality of “matchmaking” people with complementary expertise to strengthen interdisciplinary collaboration.

While participants emphasized the importance of forming a strong, well-rounded team, they also reflected on how the group manages internal dynamics, particularly when it comes to disagreement. Many participants agreed there were minimal disagreements. Some natural differences in opinions are expected when a group is working together. Participant 1 explained, “We’re not always all on the same page”. However, members acknowledged that disagreement can be beneficial: “Difference of opinions is a catalyst for new ideas coming up,” said participant 3. Participants suggested this dynamic might be influenced by existing relationships or career stage. Participant 4 explained, “It’s unlike people at that level to really fight with each other. I mean, you wouldn’t rise to be a leader in academia unless you can, you know, understand your roles to get along with people.”

Despite shared motivation, interdisciplinary collaboration at the Kansas Water Institute is limited by institutional silos, time constraints, and inadequate structural support.

This theme illustrates that while Kansas Water Institute members share a strong motivation to collaborate, institutional realities often limit their efforts. Time constraints and siloed systems further highlight the tension surrounding interdisciplinary efforts.

Participants identified several external and structural challenges that threaten the effectiveness and efficiency of interdisciplinary teams. These challenges often stemmed from limited time, strained resources, and the difficulty of navigating institutional systems not designed for cross-disciplinary collaboration.

One recurring comment was the strain on time and resources. Faculty availability and motivation were mentioned frequently as key limitations: “faculty time [and] faculty interests are the number one and two reasons why [collaboration] doesn't happen,” said participant 3. Participants noted that interdisciplinary work often requires more coordination and flexibility than traditional disciplinary efforts, which can stretch already limited schedules. Financial barriers were also described as subtle but significant. “There's a lot of little financial things that stand as barriers to interdisciplinary work,” participant 8 explained. While resource constraints were a challenge, some participants acknowledged that having financial support made collaboration much easier. Participant 3 shared that the Kansas Water Institute's resources helped facilitate cooperation: “The reality is that when you have resources for people to work with, it makes working across disciplines a lot easier.”

Beyond time and money, participants also described how rigid thinking and disciplinary habits can make interdisciplinary work more difficult. Participant 5 observed, “Sometimes people get stuck in the way they want to do things, and this is the way they've done them,”

highlighting how this can create friction in collaborative settings. In some cases, too many conflicting ideas and priorities within a group could become counterproductive. Participant 8 noted, “It is a challenge when there are too many voices.”

A larger structural issue participants described was the siloed nature of higher education. Many saw this as a systemic barrier to collaboration, one that requires intentional effort to overcome. Participant 3 explained, “Higher education is siloed. People get in their own silos and aren’t able to talk across those silos.” Participants acknowledged that academic institutions often reinforce separation by college, department, or program, which can limit communication and cooperation. Participant 4 echoed this, saying, “It’s a very siloed place,” and pointed out how this structure makes cross-college collaboration more difficult. Still, participants praised efforts like the Kansas Water Institute’s working group for proactively breaking down these barriers. “It gives us that ability to break down some of those natural walls and silos that are between programs or disciplines,” Participant 3 stated.

Even when participants were motivated to collaborate, the demands of their individual roles often made it difficult. “Everybody’s really busy,” participant 6 and participant 5 noted, and participant 8 added that “people that we work with in different parts of the college also have incredibly busy schedules.” Despite these barriers, participants showed an awareness of the challenges and a commitment to addressing them, particularly when structures like the Kansas Water Institute provided the support and space to do so.

RQ2: How does the Kansas Water Institute develop and interact with networks and collaborations?

The Kansas Water Institute builds and sustains collaborative networks through intentional, long-term connections across disciplines, sectors, and regions.

This theme highlights the Kansas Water Institute’s intentional approach to building and sustaining networks that bridge diverse fields and partners. By prioritizing enduring relationships and shared goals, KWI strengthens collaboration and broadens its collective impact.

Participants described KWI as intentional in how it builds and maintains collaborative networks. Through research, programming, and outreach, KWI connects a wide range of issue holders across disciplines, sectors, and geographic scales. Its approach emphasizes long-term engagement, shared goals, and practical impact.

KWI fosters connections through both formal and informal avenues. Students play a key role, with graduate and undergraduate researchers actively involved in projects. Faculty often develop external relationships through student collaboration. As participant 3 noted, “faculty make connections through our students,” and these efforts “help build relationships between students.” Events like Water Wednesday also give students a chance to expand their networks.

Beyond campus, KWI engages with a broad array of issue holders, including internal university partners, communities, government officials, and national and international collaborators. Participant 3 described these relationships as spanning “communities, external issue holders, internal K-State issue holders,” while participant 6 emphasized the reach is “statewide, but nationally, and then internationally.”

The Kansas Water Institute collaborates outward by leading inward, using strong internal coordination and trust to sustain external partnerships.

This theme demonstrates that effective external collaboration at the Kansas Water Institute depends on a cohesive internal foundation. Through trust-building, coordinated leadership, and consistent engagement, KWI strengthens both its internal network and its external partnerships.

Participants emphasized that strong leadership plays a critical role in sustaining projects and ensuring connection. As participant 2 noted, “A lot of research projects die because nobody knows who to give it to or who’s responsible. Having a good understanding of the types of research helps prevent that.” Participant 3 explained, “The bigger group that you can get, the better. And I think, especially with the strong leader, that a bigger group doesn’t become more unmanageable.”

Meetings were described as essential for building trust, maintaining connections, and fostering camaraderie. Participant 3 reflected, “I think that meeting schedule has really allowed us to settle into a bit of trust between the different groups.” Despite having most meetings online, participant 1 still feels connected to the group due to frequent additional interactions. Participant 1 said, “Just that frequency of interaction...whether it’s through those water Wednesdays or the different events that are going on is helpful.”

Additionally, the group’s diversity of expertise was also viewed as a strength. Participant 6 recognized “It’s exciting to be able to work with a bunch of people that have a whole bunch of great ideas to solve a really important problem.” Participant 3 expanded on this, “The combination of kind of our working group has led to a lot of interesting partnerships.”

Participants described using each other’s networks to connect with issue holders. Participant 1 explained they often asked themselves, “Who do we have that can make those connections? Or

do we need to go one step out beyond our group?” Participant 1 further explained, “We might not know anybody at this particular unit or agency, but the extension agent knows somebody that works there.” Participant 7 described this action as strategic, stating, “It's kind of like strategically placing ourselves in those situations and staying connected. There are people that you deploy to keep those relationships.”

RQ3: How do participants' self-constructed social networks reveal *patterns of collaboration and information flow* within the Kansas Water Institute?

Participants' visual network maps revealed a diverse and interconnected range of issue holders within the Kansas Water Institute. Across the focus group, several key groups consistently appeared on individual maps, underscoring their central roles in KWI's network. These included the advisory board, faculty members, and the working group, each identified by all participants as important nodes. Government entities were also commonly mentioned, reflecting KWI's engagement beyond academia. Additionally, extension professionals, other colleges within the university, and student fellows appeared as vital contributors to the network. This diverse composition highlights the multifaceted nature of KWI's collaborative environment and provides insight into how information and resources circulate across different roles and organizational units.

Relationships are the mechanism that sustains collaboration and dissolves disciplinary boundaries within the Kansas Water Institute.

This theme highlights how strong connections form the foundation of KWI's collaboration, supporting knowledge exchange, bridging disciplines, and maintaining engagement across its diverse network.

Participants described these connections as dependent on active relationship-building. As participant 7 explained, “None of these relationships happened overnight. It takes people who are very intentional about showing up and building that network continuously.” Participant 9 echoed this point, “lots of people say interdisciplinary work is really cool, but it’s very hard to put it into practice, and so it does take a lot of time and effort and calendaring and meeting people.”

These efforts also expand opportunities for collaboration. Participant 7 highlighted how shared conference participation helps build inter-institutional connections: “This year we’re going to send about 10 K-Staters [to a conference], and we have Emporia State and Wichita State... that’s a new kind of enhanced network.” Similarly, participant 9 pointed to invitations from regional partners as evidence of growing relational capital: “We were just asked by the Water Institute in Nebraska to help support and be part of their state water conference... through the efforts of all the people on the team to be able to make those meaningful connections.”

Beyond expanding networks, participants emphasized the way relationships dissolve silos. Participant 7 reflected that “the interdisciplinary thing is just so second nature to us. I almost stop thinking of people being in different colleges and departments,” while participant 8 added, “I don’t always know what department they’re from. I just know they deal with water in one shape or another.” Together, these reflections position relationships as the mechanism that makes collaboration possible, turning diverse issue holders into an interconnected network.

Beyond identifying key actors, the network mapping activity created opportunities for reflection and comparison among participants. Several individuals commented on each other’s maps, noting differences in structure and organization. Participant 9, for example, remarked, “Yours is more organized,” while describing their own as “crazy looking.” These comments demonstrated that participants viewed and discussed their maps in relation to one another.

During this process, they described thinking about how they connect with others, what kinds of relationships they maintain, and how their personal networks relate to the broader KWI structure.

Participants also used a range of visual elements to represent their networks. Some incorporated stars, arrows, and color-coding to emphasize key collaborators or frequent communication partners, while others used creative features to represent teamwork or shared goals. Across several maps, participants chose to highlight others' contributions more prominently than their own. This pattern appeared in the use of bright colors, symbols, or labels identifying colleagues rather than themselves. Through these design choices, participants portrayed collaboration as a shared and relational process. The mapping activity, therefore, provided both a visual record of network connections and a glimpse into how participants represented their relationships within KWI.

Discussion and Conclusions

This study found that interdisciplinary teams were intentionally formed, with careful consideration of member dynamics to enhance their effectiveness and overall success. However, barriers such as limited resources and competing priorities affected the group's effectiveness. These findings echo the broader science communication literature, which emphasizes that collaboration is not solely structural but also communicative—requiring trust, shared understanding, and ongoing negotiation of perspectives (Baram-Tsabari & Lewenstein, 2017; Weingart & Guenther, 2016). Similar to other interdisciplinary settings, participants navigated uneven information across organizational or disciplinary boundaries, underscoring the need for structured communication strategies that facilitate alignment (National Academies of Sciences, Engineering, and Medicine, 2017; Papa et al., 2025). These early decisions about whether to participate or engage reflect the Decision-Making Model for ANR Science and Technology,

which emphasizes how perceived benefits, social cues, and attitudes inform willingness to adopt new practices such as interdisciplinary work (Ruth et al., 2018).

Participants' reflections also emphasized how structural constraints—particularly limited funding—shaped team dynamics, communication, and overall capacity. Instead of referring to financial barriers in general terms, participants described concrete ways that a lack of resources constrained interdisciplinary work, including the “little financial things” that slow progress (Participant 8) and the added pressure that shortages place on already limited faculty time. At the same time, participants noted that access to Kansas Water Institute resources “makes working across disciplines a lot easier” (Participant 3), indicating that funding supports the relational and communicative practices—such as regular meetings, shared planning, and flexible engagement—that interdisciplinary collaboration requires. These insights align with research demonstrating that material support is essential for sustaining positive team climate and enabling transdisciplinary practices (National Academies of Sciences, Engineering, and Medicine, 2017; Stokols et al., 2008b). Funding, therefore, is not merely a logistical consideration but a foundational condition that allows teams to enact the collaborative behaviors associated with effective interdisciplinary science. This aligns directly with the Transdisciplinary Team Science Model, which highlights how environmental and organizational supports—such as funding—enable the social-psychological processes needed for collaboration (Stokols et al., 2008b).

The network mapping activity deepened understanding of how participants perceive and represent collaboration, emphasizing that relationships are both a structural and emotional foundation for interdisciplinary work. Participants' visual and verbal reflections revealed collaboration as an evolving process shaped by mutual recognition, role negotiation, and shared identity. These relational insights correspond with science communication frameworks that

highlight social and emotional dimensions—particularly trust-building and identity—as essential for effective engagement (American Association for the Advancement of Science (AAAS), n.d.; Weingart & Guenther, 2016). Future research could extend this approach by examining whether similarly rich representational patterns emerge in other collaborative environments.

The visual maps also illuminated specific practices that enhanced or constrained team effectiveness—an area that scholars identify as underdeveloped in team-science research (Bennett & Gadlin, 2012; Klein, 2014). While prior literature outlines broad conditions for collaboration, fewer studies detail the everyday practices through which teams maintain relationships and communicate across disciplinary boundaries. This study helps fill that gap by showing how routine actions—such as regular check-ins, spontaneous brainstorming, shared field experiences, and open discussions of expectations—supported interdisciplinary interaction. These practices reflect movement through Tuckman’s (1965) stages—initial uncertainty (“forming”), negotiation and tension (“storming”), and the development of shared expectations (“norming” and “performing”).

The study also highlighted uneven participation within teams. Many members deferred to the “expert” in a given domain, echoing hierarchical patterns documented in interdisciplinary settings (Stokols et al., 2008b). At the same time, some participants described hesitancy to challenge ideas or “rock the boat,” suggesting that psychological safety and team climate remain critical—but fragile—components of effective interdisciplinary collaboration, especially where status differences shape who feels able to contribute. These hesitations also align with the Decision-Making Model’s integration of Spiral of Silence dynamics, where perceived norms influence whether individuals choose to speak up (Ruth et al., 2018).

Extension systems are well-positioned to foster interdisciplinary collaboration by providing structured opportunities for learning and relationship-building. Implementing workshops focused on teamwork, communication, and interdisciplinary project development could mirror the collaborative environment modeled by the Kansas Water Institute's *Water Wednesday* events. These could be tailored for both academic and industry audiences to encourage cross-sector dialogue. Additionally, resources or workshop sessions on conflict management and resolution would help teams navigate differing perspectives productively, reinforcing collaboration as an ongoing process rather than a one-time event.

Water experts can apply these findings by approaching team formation and maintenance with deliberate attention to both technical expertise and interpersonal dynamics. When assembling teams, members should balance passion with disciplinary depth and take time to build mutual understanding. Regular meetings help maintain trust and accountability across projects. Establishing a culture that encourages open discussion of differing opinions, framed respectfully and professionally, can strengthen team resilience and innovation.

Importantly, the findings reinforce that these interpersonal practices cannot be separated from structural conditions such as funding availability. Teams with stable support were able to maintain consistent communication rhythms and develop shared identity, whereas teams with limited resources described fragmentation, delayed progress, or diminished motivation. This aligns with literature demonstrating that team climate—especially psychological safety, shared norms, and open communication—is strengthened when teams have the financial resources to engage meaningfully (Bennett & Gadlin, 2012; Stokols et al., 2008b). In the language of the Transdisciplinary Team Science Model, inadequate resources disrupt alignment between

organizational context and team processes, making it harder for groups to progress toward effective collaboration (Stokols et al., 2008a).

Professional gatherings in the water and natural resource sectors can be reimagined as spaces for collaboration rather than solely for presentation. Organizers should consider incorporating sessions for active co-development—structured working time for interdisciplinary brainstorming, peer review, or team planning. Addressing the reality of dysfunctional teams through facilitated conflict resolution workshops or panels could also enhance long-term collaboration. Incentives such as small seed grants or recognition awards for successful interdisciplinary teams could further motivate participants and encourage continued engagement beyond the event itself.

The lessons from this study extend beyond water science. Other sectors, such as soil health, forestry, and climate adaptation, can benefit from embedding collaboration into institutional expectations. Including interdisciplinary engagement and teamwork within job descriptions, performance evaluations, or promotion criteria could help normalize and reward collaborative behavior. Leaders in these sectors can also model cross-disciplinary engagement by participating in or establishing fellowships, working groups, and partnerships that demonstrate the value of shared expertise.

As this research centers on a single case, the findings are not meant to be generalized; rather, the strength of this approach lies in its depth of analysis and its ability to illuminate the complexities of collaboration in context. Compared to existing literature on collaborative work groups, these findings reinforce that trust-building, role clarity, and shared identity are essential components of effective interdisciplinary work—a pattern also emphasized in team-science scholarship (Bennett & Gadlin, 2012). The challenges participants described—limited resources, time constraints, and competing priorities—likewise mirror commonly documented barriers to

collaborative research and Extension environments (Stokols et al., 2008b). Viewed through the study's conceptual framework, the findings highlight collaboration as an ongoing relational process rather than a fixed structure. The network maps and participant reflections made visible the framework's emphasis on identity negotiation, mutual recognition, and the emotional dimensions of working across disciplines, aligning with literature that characterizes collaboration as iterative and socially constructed (Klein, 2014). Future research could examine other universities' water institutes or interdisciplinary initiatives to compare how these relational and structural dynamics unfold. Including visual network analysis in comparative studies may reveal meanings and dynamics that traditional qualitative methods overlook.

Overall, this study adds a more granular view of how interdisciplinary teams operate, highlighting the everyday practices that sustain collaboration and the interpersonal and structural conditions that shape it. By integrating insights on funding, team climate, and patterns of voice and silencing, it responds to calls for closer attention to the lived, day-to-day experiences of interdisciplinary team members (Bennett & Gadlin, 2012; National Academies of Sciences, Engineering, and Medicine, 2017).

Chapter 5 - Conclusions

Overview

This chapter discusses the findings and implications of both studies. This chapter also presents recommendations for future research. The findings of this research aim to explore water scientists' communication efforts and understand the team formation of the interdisciplinary Kansas Water Institute team.

Integration of Findings

These two studies illuminate how individual communication practices enable team collaboration within Kansas water science. Study 1 established that water scientists, despite often lacking formal communication training, employ diverse tactics to engage interdisciplinary colleagues and varied audiences, demonstrating both the centrality of communication to their work and the collaborative nature of the field itself. The findings align with Baram-Tsabari and Lewenstein (2017), who emphasize that communication competence is essential for effective science practice, even in the absence of formal training. The recognition of collaboration as essential to Kansas water scientists' work aligns with findings by Maxwell et al. (2019), who observed that integrating social and environmental science relies heavily on communication to bridge disciplinary divides.

Building on this foundation, Study 2 examined how individual communication practices manifest at the team level, revealing that effective collaboration depends on intentional relationship-building, strategic team formation, and internal leadership that facilitates external engagement. These findings align with Breetz et al. (2005), who found that trust and communication mechanisms are central to collaborative participation in water management.

While structural and external barriers exist, successful teams sustain collaborative networks by treating relationships as the fundamental mechanism of collaboration—prioritizing connections and leading inward to collaborate outward.

Together, the studies demonstrate a critical progression: individual scientists value communication as more than a peripheral skill, and high-functioning teams operationalize this understanding by embedding relational practices into their collaborative infrastructure. This comprehensive view across individual and team levels reinforces Tidwell and van den Brink's (2008) findings that cooperative modeling and communication are essential to linking science with water planning. Collectively, these insights demonstrate how communication functions as the connective tissue that enables Kansas water scientists to address complex water challenges through sustained interdisciplinary collaboration.

At both the individual and team level, these findings reinforce broader scholarship showing that science communication is not only about transmitting information, but also about creating the relational, cognitive, and institutional conditions that make collaboration possible (Fischhoff, 2013; National Academies of Sciences, Engineering, and Medicine, 2017). Strong communication practices help align expectations, build shared mental models, and cultivate mutual trust—all foundational elements for interdisciplinary water work.

These findings align with McLaughlin et al. (2018), who emphasize that effective water governance and collaboration depend on continuous dialogue and mutual learning among scientists and issue holders. Programs like Kansas's Local Enhanced Management Areas (LEMAs) provide a concrete example, where farmers and officials collaboratively develop water-reduction strategies, fostering communication and shared learning. More broadly, this reflects core principles of public engagement, where sustained and purposeful communication

fosters mutual understanding and lasting connections between scientists and their audiences (American Association for the Advancement of Science (AAAS), n.d.; McLaughlin et al., 2018). The relational focus observed among Kansas water scientists illustrates how the same communicative principles that enable meaningful public engagement also sustain interdisciplinary collaboration within teams.

Strong communication practices improve the functioning of scientific teams and strengthen collaboration among water professionals (Bennett & Gadlin, 2012), suggesting that investments in communication capacity can enhance coordination and information-sharing across the water management system.

Together, the integrated findings also directly reinforce the theoretical framing: Study 1 reflects individual-level processes emphasized in Social Cognitive Theory and the Theory of Planned Behavior, while Study 2 demonstrates how these individual tendencies scale into collective patterns consistent with Tuckman's stages and the Transdisciplinary Team Science framework. This alignment shows how communication behaviors first emerge from individual motivation and self-efficacy and then become structured within team norms, shared identity, and collaborative routines.

Integrated Theoretical Framework

The key findings from these studies are best understood through a layered theoretical framework that moves from individual to collective action. At the individual level, Social Cognitive Theory and the Theory of Planned Behavior explain how water scientists develop communication practices and form intentions to collaborate despite lacking formal training. These individual motivations and behaviors then scale to the team level, where Tuckman's model and the Transdisciplinary Team Science framework illuminate how groups navigate formation,

establish norms, and achieve functional collaboration through intentional relationship-building. Finally, science communication frameworks and the Decision-Making Model for ANR Science and Technology connect internal team dynamics to external engagement, revealing how effective inward leadership enables scientists to communicate outward with diverse issue holders and publics.

Collectively, these theories illustrate that addressing complex water challenges requires a systems approach: developing strong individual communication skills, strategic team processes, and building collaborative structures that connect scientific expertise with public decision-making. The interplay among these levels, individual, team, organizational, and public, demonstrates that sustainable water science collaboration is not merely about assembling experts, but about creating interconnected systems where communication functions as both the catalyst and the sustaining force.

Together, the combined findings and frameworks demonstrate that communication is the central process linking individual action, team collaboration, and public engagement in Kansas water science. At the individual level, scientists' motivations and learned behaviors shape how they approach communication and collaboration, while at the team level, these practices evolve into intentional structures that foster trust and shared purpose. The theoretical frameworks collectively explain how these layers build upon one another: individual intentions and behaviors inform team processes, which in turn enable outward engagement with broader publics and decision-makers. Viewed through this perspective, communication emerges as a dynamic force that connects internal collaboration with external impact, strengthening both scientific practice and its relevance to society.

Integrating these theoretical lenses also highlights a broader implication supported by research: communication capacity at one level (individual, team, organizational, public) can reinforce or constrain capacity at the others. Prior work in team science shows that internal communication quality influences coordination, trust, and a team's ability to engage outwardly (Bennett & Gadlin, 2012; National Academies of Sciences, Engineering, and Medicine, 2017). These insights align with participants' experiences in this study, who described both the benefits of strong team-level communication and the challenges posed by unclear or inconsistent internal exchanges. Taken together, the literature and current findings suggest that strengthening communication may serve as a strategic intervention point for improving collaborative water research and engagement.

Thus, the implications that follow—recommendations for training, team structure, and institutional support—directly map back onto the theoretical model: they address individual-level skill development, team-level processes of norm-building and cohesion, and broader systems that enable transdisciplinary integration and public engagement.

Practical Implications

Effective collaboration requires structure and sustained support. Findings from these studies highlight that interdisciplinary efforts rely on systems that support team formation, relationship-building, and integration across disciplines. The Kansas Water Institute (KWI) exemplifies how purposeful recruitment, shared motivations, and strategic leadership can foster a cohesive, effective team. Its deliberate approach to planning and membership selection strengthened team dynamics and helped bridge expertise across disciplines. These organizational practices directly reflect Tuckman's emphasis on structured norm-setting in the forming and norming stages, as

well as Team Science guidance on designing environments that support transdisciplinary collaboration.

A key implication is the need for more visible, accessible, and practice-oriented communication training. Many water professionals rely on informal, experiential learning because they are unsure what resources exist or how to access them. Extension specialists and institutions can address this by curating centralized lists of trainings, offering brief targeted sessions on common communication challenges, and prioritizing in-person formats that enable peer learning. Normalizing observation, feedback, and reflection—through peer review opportunities or structured reflection time—can further strengthen communication skills and help make tacit knowledge more explicit. These recommendations connect directly to Social Cognitive Theory, as they enhance self-efficacy and observational learning—two mechanisms that Study 1 showed to be central to how water scientists learn communication.

Because communication shapes not only interpersonal relationships but also credibility, public trust, and the uptake of scientific information (Fischhoff, 2013; National Academies of Sciences, Engineering, and Medicine, 2017), improving communication training has implications that extend far beyond skill development. Enhanced communication capacity positions water scientists to contribute more effectively to policy processes, community partnerships, and collaborative water-reduction initiatives like LEMAs. Thus, communication training is an investment in both scientific excellence and practical impact.

Professional gatherings in the water and natural resource fields can also serve as powerful venues for collaboration when designed intentionally. Incorporating small-group work, peer review, co-development sessions, or interdisciplinary brainstorming can transform conferences from passive listening environments into active learning spaces. Maintaining in-person elements,

integrating conflict-management opportunities, or providing incentives such as seed grants or recognition awards can extend collaborative momentum beyond the event itself. These recommendations draw from Tuckman's emphasis on interaction and team development, as well as Team Science insights that structured collaborative activities strengthen shared mental models and promote integration across disciplines.

Finally, institutions can support long-term interdisciplinary engagement by embedding collaboration into organizational expectations and recognizing it as meaningful professional work. This includes valuing both technical expertise and interpersonal skills when assembling teams, creating space for regular interaction, and supporting systems—such as Extension workshops or cross-sector working groups—that reinforce relationship-building and open dialogue. These strategies extend beyond water science to other natural resource fields facing similar communication and coordination challenges. Institution-level support reflects core principles from the Transdisciplinary Team Science framework, which emphasizes that collaboration is sustained not merely through individual willingness but through organizational structures and incentives.

Overall, these findings indicate that strengthening interdisciplinary collaboration may require parallel investments in communication training, structured collaborative opportunities, and institutional cultures that reward shared work. Together, these investments may support the development of more resilient and effective systems for addressing complex water and natural resource issues.

Limitations

Several considerations should be kept in mind when interpreting these findings. Although the small sample size limits transferability, this is also a strength of qualitative research, which

prioritizes depth of understanding and rich, contextual insight over broad representation. The focus on Kansas scientists and teams within the Kansas Water Institute situates the findings within a specific geographic and institutional context, which may limit transferability.

Additionally, Study 2 employed a single case study design that narrows the scope of the conclusions. While this bounded approach constrains transferability, it also enabled a detailed examination of team formation, collaboration, and leadership within a real-world setting.

Directions for Future Research

Future research should continue exploring how communication functions as the foundation of interdisciplinary collaboration across various contexts and systems. This study focuses on Kansas water science; expanding inquiry to additional regions and settings would help establish similar patterns. Larger and more diverse samples, including different geographical areas and career stages, could also reveal differences. Additionally, future studies can test and refine methodological tools for mapping and visualizing team dynamics. Application of visual network mapping could help identify the relationship between collaboration, leadership, and information.

Further work could also investigate how communication training programs shape scientists' long-term collaboration habits, how organizations build communication-supportive cultures, and how communication practices influence public trust and policy uptake in water management. Studying these broader outcomes would help clarify the systemic impact of communication—answering not only how scientists communicate, but why improving communication ultimately matters for water sustainability.

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Appendix A - Study 1 IRB Approval



TO: Jacqueline Aenlle
Communications & Ag Education

Proposal Number: IRB-12038

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 02/06/2024

RE: Proposal Entitled, "The Future of Kansas Water: A Qualitative Exploration of Kansas Water Experts' Perceptions of Water Issues, Engagement with Water Stakeholders, and Communicating Water Science."

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §104(d), category:Exempt Category 2 Subsection ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

Electronically signed by Lisa Rubin on 02/06/2024 4:21 PM ET

Appendix B - Study 1 Recruitment Email

Hello Dr./Mr./Ms. (NAME),

I hope this email finds you well!

My name is Rebecca Donaldson, and I am a graduate student at Kansas State University. I am with the Department of Communications and Agricultural Education and am part of a team working on a project focused on the experiences of water science experts who create and/or disseminate science information on water issues to issue holder audiences.

The goal of this project is to determine current water challenges within the state, barriers to communication with issue holders, best practices for outreach, and areas of opportunity.

You are receiving this email because we would like to invite you to participate in a Zoom interview to discuss your experiences in this area!

The interview would take no more than 60 minutes, and is completely voluntary, you can withdraw from the study at any time.

If you are interested in participating, I have included some potential dates/times below. Please let me know 2-3 times within these blocks that would work best for you.

Thank you, and if you have any questions, please reach out!

Best,

Rebecca Donaldson

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Appendix C - Study 1 Interview Questions

1. What is your name, current role, and how did you get involved in water science and conservation?
2. How did you first become involved with water science communication, if at all?
3. What are some challenges you have faced while communicating water science and what solutions have you seen?
4. What types of interactions have you had with issue holders about water?
5. What types of science communication and public engagement training have you had?
 - a. What kind of training do you think should be offered?
6. What resources do you need to continue/begin communicating about water?
7. In your area, how have you seen the culture, conversation, and practices surrounding water evolve in recent years? (harmonious conversation, annual reports, etc.)
8. What entities have had the most successful collaborative efforts in your discipline/field?
What were they and what made them successful?
9. Have you worked in teams on water outreach projects and when you do, what are common collaborations or resources you use?

Appendix D - Study 2 IRB Approval



Office of Research Integrity,
Compliance and Security

TO: Jacqueline Aenlle
Communications & Ag Education

Proposal Number IRB-12670

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 03/07/2025

RE: Approval of Proposal Entitled, "Social Network Analysis: Water Science Teams."

The Committee on Research Involving Human Subjects has reviewed your proposal and has granted full approval. This proposal is **approved for three years from the date of this correspondence.**

APPROVAL DATE: 03/06/2025

EXPIRATION DATE: 03/05/2028

In giving its approval, the Committee has determined that:

No more than minimal risk to subjects

This approval applies only to the proposal currently on file as written. Any change or modification affecting human subjects must be approved by the IRB prior to implementation. All approved proposals are subject to continuing review, which may include the examination of records connected with the project. Announced post-approval monitoring may be performed during the course of this approval period by URCO staff. Injuries, unanticipated problems or adverse events involving risk to subjects or to others must be reported immediately to the Chair of the IRB and / or the URCO.

Electronically signed by Lisa Rubin on 03/07/2025 12:37 PM ET

Appendix E - Study 2 Recruitment Email

Hello Dr./Mr./Ms. (NAME),

My name is Rebecca Donaldson, and I am a graduate student at Kansas State University. I am conducting research as part of my thesis in the Department of Communications and Agricultural Education. My work focuses on understanding the experiences of water science experts who create and/or share science information on water-related issues with issue holder audiences, with an emphasis on how these experiences contribute to team-building efforts.

The goal of this project is to explore transdisciplinary team building by exploring how the Kansas Water Institute develops its team, nurtures individual members, and leverages team skills to enhance program development and outputs.

You are receiving this email because we would like to invite you to participate in a Zoom interview to discuss your experiences in this area!

The interview will last about 60 minutes and is completely voluntary; you may withdraw from the study at any time. Additionally, we would love your participation in a second, optional 60-minute group activity with the team.

If you are interested in participating, I have included some potential dates/times below. Please let me know 2-3 times within these blocks that would work best for you.

Thank you, and if you have any questions, please feel free to reach out!

Best, Rebecca Donaldson

Appendix F - Study 2 Focus Group Recruitment Email

Dear all,

I hope you're doing well. I am reaching out to invite you to participate in a focus group discussion as part of my research exploring how the Kansas Water Institute develops its team, supports individual members, and leverages team skills to enhance program development and outputs.

This discussion will last approximately one hour and is planned for late May or June. Your perspectives and experiences as water science professionals who create or share science information on water-related issues would be highly valuable to this project. Participation is completely voluntary.

If you are interested, please reply with your general availability during that timeframe so we can identify a date and time that works best for everyone.

Thank you for considering this invitation and for your time and support of this research.

Best regards,
Rebecca Donaldson

Appendix G - Study 2 Interview Questions

RQ1: How are interdisciplinary teams formed, and how do team dynamics influence their perceived effectiveness and efficiency?

1. How would you describe team relationships at KWI?
 - a. What strategies help build trust, cohesion, and mutual respect among members?
2. What challenges has the KWI team faced?
 - a. How has the team approached solving them?
3. When adding new people (or when building) to the team, how does KWI determine the areas of expertise needed?
 - a. Have specific disciplines been targeted to enhance team effectiveness?
4. When perspectives differ, how does the team navigate and resolve conflicts?
5. What factors contribute to the KWI team's success, and how does its interdisciplinary nature influence its ability to achieve research and programmatic goals?
6. How do your skills and strengths contribute to the team, both within and beyond your official job description?

RQ2: How does KWI develop and interact with networks and collaborations?

8. Who are KWI's primary issue holders, and how does the team identify and prioritize its target audiences?
9. How does KWI build and sustain professional networks and partnerships over time?
10. What key factors contribute to the success of KWI's networking and collaborative efforts?
11. What advice would you give to other organizations looking to develop strong, effective networks and collaborations in the field of water research?

RQ3: How does KWI's network shape (team formation/collaboration/the development of interdisciplinary research initiatives)

12. Can you share an example of a partnership that did not go as planned? What challenges arose, and what lessons did KWI take from the experience?
13. Can you share an example of an interdisciplinary project where team dynamics either enhanced or hindered efficiency? What lessons were learned?

Appendix H - Study 2 Focus Group Activity

Group Activity:

1. Introduction:

Please draw a network diagram that represents your view of the Kansas Water Institute (KWI) team and its issue holders. You can use circles, lines, and arrows to represent people and the flow of communication, influence, or collaboration.

Activity Instructions:

1. Start by placing your name in the center of the diagram.
2. Add team members and issue holders you interact with directly. (Can use a different shape or color for team members vs. issue holders.)
3. Connect the team members and issue holders with lines to show interactions. (You can use arrows to indicate the direction of communication or influence.)
 - a. Indicate the strength or frequency of each connection with line thickness or color (e.g., thick line = frequent communication, dashed line = occasional communication, thin line = minimal).
4. For each connection, label it with a brief description of the relationship (e.g., "collaborate on projects," "receive updates from," "provide advice," etc.).
5. Highlight the top four issue holders you believe are most important to the success of the team (or we can have the team pick the top four together). Use a different shape or color to make them stand out.