Securing the Ogallala Aquifer: A stakeholder-based needs assessment for developing a Kansas Master Irrigator program

by

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Abstract

The Ogallala Aquifer is a vital freshwater resource that supports agricultural production in the High Plains. Due to intensive irrigation, climate change, and low recharge rates, the Ogallala Aquifer is facing severe generational depletion. To address this water crisis, educational programs and initiatives must be created to equip producers with practical and economically viable water management tools and strategies. The purpose of this study was to identify key structural components of curriculum and delivery that are necessary to inform the development of a potential Master Irrigator program in Kansas.

This study utilized Malcolm Knowles's Adult Learning Theory as a conceptual framework. Stakeholder preferences and motivations were evaluated through the "Super Six" principles, need to know, self-concept/self-direction, role of prior experiences, readiness to learn, problem orientation, and intrinsic motivation. A sequential multimethod design using survey data and qualitative follow-up interviews was utilized for this study. Quantitative data was gathered through an online Qualtrics survey. Participants of the survey included producers, Groundwater Management District (GMD) managers and members, university faculty, and state agency representatives. To expand survey trends, qualitative interviews were conducted with seven water stakeholders in Kansas.

The Quantitative findings indicated a preference for a hybrid delivery format (61%) and full-day structures (72%). The highest priority curriculum topics included crop selection and rotation for water efficiency (56%), soil health and water retention practices (56%), deficit irrigation strategies (56%), data-based decision making (56%), and irrigation scheduling tools (50%). Peer-to-peer discussions and networking were identified as the most effective engagement strategy (67%), while access to cost-share funding for conservation technology was

the most desired incentive (72%). Primary barriers to attendance included time constraints (67%) and conflicts with active farming seasons (61%). Seasonal preferences demonstrated that in-person workshops are heavily favored during the winter off-season (January-March), and online delivery is preferred during peak summer farming months (April-August).

Qualitative interview findings revealed three primary themes: participants place the highest trust in peer-to-peer learning and experiences shared by fellow irrigators rather than lecture-style delivery from academic or agency representatives; program curriculum must remain practical, hands-on, and flexible to accommodate diverse adult learning styles; and program success should be evaluated through long-term personal mindset shifts, continuous network building, and improved operational decision-making rather than immediate water pumping reductions alone. Based on these findings, it is recommended that Kansas establish a formal, producer-led advisory committee to guide program curriculum and speaker selection. In addition, formal training sessions should be scheduled during winter months using interactive field demonstrations and should integrate economic tools and a sustained peer support network.

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Introduction

The Ogallala Aquifer is a water source in the High Plains that provides water for millions of individuals in the Midwest. South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas each rely on the High Plains Aquifer. The most significant decreases in water table elevation and saturated thickness are in the central and southern portions of the aquifer, specifically in southwest Kansas, eastern New Mexico, and the Oklahoma and Texas Panhandles. The northern areas of the High Plains Aquifer, particularly Nebraska, have greater groundwater availability and higher recharge rates. Since irrigation development began in the 1940s and 1950s with deep-well drilling, diesel pumps, and center-pivot irrigation, groundwater levels across the Ogallala Aquifer region have dropped greatly (Fraizer et al., 2017).

The Ogallala Aquifer is a critical resource not only for the agricultural industry but also for the High Plains region. Groundwater represents 42% of global irrigation water withdrawals, and in the United States, roughly 60% of irrigation relies on groundwater (Döll et al., 2012). In the Midwest and High Plains specifically, water is a crucial component that ensures the future of the American food system and agricultural industry, earning the region the title of America's Breadbasket (Campbell & Goodrich, 2023). The Ogallala Aquifer is an underground reservoir that supplies at least a fifth of the annual U.S. agricultural harvest (Little, 2009). The Ogallala Aquifer supplies 70% to 80% of the water supplies to Kansas, with most of it used to support irrigation for agriculture (Stover & Buchanan, 2017). Water is a key component in sustaining not only the agricultural industry but also the communities that rely on this groundwater resource.

Despite its importance, the Ogallala Aquifer faces significant challenges associated with groundwater depletion and increasing water demands. Water scarcity is defined and

characterized by imbalances between water supply and demand, which vary by location and sector of use (Heim, 2002). As agricultural product demands grow, agricultural water needs continue to rise, with low precipitation impacting groundwater levels (Giordano, 2009). The eight states that rely on the High Plains Aquifer are facing a great generational challenge of aquifer depletion and difficulties in stabilizing and sustaining their groundwater source. Some areas of the aquifer are retaining less than 40% of their original saturated thickness (Kansas Geological Survey, 2018). Today, the Ogallala Aquifer is being depleted at an annual volume equivalent to 18 Colorado Rivers, and scientists estimate it will take natural processes 6,000 years to refill the resource (Pradhan, 2023). For the aquifer to naturally recharge, precipitation is a key factor; however, amid severe historic droughts, depletion is on the rise. The imbalances between withdrawal rates and natural recharge reflect the severity of depletion, which shows that current practices and management techniques may not be sustainable for the future (Scott, 2019).

In addition to groundwater depletion, emerging threats and demands fuel this water crisis, such as biofuel production, municipal water sales, and climate change (Little, 2009). Decades of intensive irrigation, low precipitation, climate change, and expanding water demands are factors that have led to significant and uneven declines in groundwater levels of the Ogallala Aquifer (Cano et al., 2018). Climate change brings major challenges for the Ogallala Aquifer region as rising temperatures and more frequent droughts increase evapotranspiration, alter precipitation patterns, and heighten agricultural water demand. These factors pose a threat to the future of the agricultural industry through rising economic costs, reduced crop yields, and increasing reliance on financial safety nets (United States Environmental Protection Agency, 2000). There are more

than 45.8 million people who are already experiencing water shortages in basins where demand is starting to exceed renewable supply (Warziniack & Brown, 2019).

Water quality is another concern for communities that rely on the Ogallala Aquifer. While water from the Ogallala Aquifer is suitable for crop irrigation, it frequently fails to meet U.S. Environmental Protection Agency (EPA) drinking water standards in some areas (Haskell et al., 2022). Because of this, many counties that rely on the Ogallala Aquifer for consumption need specialized filtration, such as reverse osmosis or anion exchange. Shallow groundwater experiences greater contamination than deeper parts of the aquifer. This indicates that pollution is driven by human activity, such as agricultural runoff and oil and gas extraction (Haskell et al., 2022).

The decline in groundwater availability also creates economic challenges for agricultural producers. As groundwater levels decline, the costs of pumping groundwater increase, which in turn increases the costs of agricultural products across the United States (Castle et al., 2014). Current groundwater management practices and declining water levels are projected to force a 60% reduction in irrigated corn acreage and a 50% reduction in irrigated wheat acreage in the Central High Plains over the next 50 years (Cotterman et al., 2017). Between 1989 and 2017, the 161 counties overlying the aquifer received about $22 billion in crop insurance indemnities (Reyes et al., 2020). There has been a steady increase in the loss costs associated with irrigation supply failures over time. Furthermore, even if crops are failing, farmers may continue pumping additional water as a form of insurance against not watering enough. These challenges demonstrate the impacts that declining groundwater levels have on agricultural production and the economic sustainability of the region.

The issue of depleting water sources continues to be a pressing matter for the agricultural industry (Little, 2009). Today, conservation efforts and management techniques are being carried out to extend the life of the Ogallala Aquifer and ensure the future of agriculture in the United States. With a need to reduce water usage, interdisciplinary socio-ecological frameworks may aid in understanding where human and natural systems are coupled (Rhodes et al., 2023). The broad national concerns regarding water depletion are amplified at regional scales. The future of the Ogallala Aquifer and irrigated farming in the High Plains will rely on a combination of interdisciplinary approaches that consider the dynamics of the aquifer, the local environment, policies, and technological solutions that can reduce water usage (Stull et al., 2016). A 50-year plan, the Kansas Water Vision, was developed with action items such as promoting regional drought and water conservation planning, conducting drought simulation exercises, and highlighting model development to test future scenarios that move toward adaptive management (Foley et al., 2016). As water levels continue to decline, producers need support in employing practices and management strategies that reduce water usage in their operations (Knox et al., 2012).

One approach to supporting agricultural producers in adopting efficient irrigation and water management practices is through educational programs such as the Master Irrigator program. According to the Irrigation Innovation Consortium (Master, 2021), the Master Irrigator program:

- Is an interactive, four-day training course for irrigators, focused on producers, water managers, and technology service providers.
- Encourages precision water management and conservation for profitability.
- Incorporates hands-on agricultural technology training and peer discussion.

- Networks producers, industry, university, and other agricultural sector experts.
- Includes foundations of irrigation hydrology, agronomy, and engineering.
- Prioritizes local water management needs and challenges.
- Provides graduates with incentives to support precision technology and strategy implementation (Master, 2021).

Through a combination of pilot programs, state-level expansion, and collaborative efforts with industry partners, Master Irrigator programs have become established in Colorado, Georgia, Minnesota, Mississippi, Nebraska, Oklahoma, and Texas. Kansas conducted a pilot Master Irrigator Lite workshop in February 2024. Twenty-two producers attended the event, representing both row crop and livestock operations. A survey was given to participants on the day of the event to evaluate the expectations and outcomes of the Master Irrigator Lite workshop. According to the survey data, results showed that 70% of producers who attended learned more about local hydrology and how water impacts the Ogallala Aquifer, 69% said the event expanded their knowledge of irrigation and water management tools, and 60% expressed interest in serving on an advisory committee to develop and plan the full Master Irrigator program in Kansas (Kansas State University: Kansas Water Institute & Midwest Big Data Hub, 2024).

To understand what drives producers to adopt efficient water use and management practices, it is important to understand the values and needs of producers. Traditional values can also facilitate change when they align with local environmental knowledge and resonate with one's beliefs and values (Carnes, 2020). It is critical to address the needs of communities affected by the depleting aquifer and the near-term changes in technologies, infrastructure, agronomic practices, cultural habits, and acceptance of geophysical limits contributing to an improved outlook for the Ogallala Aquifer as a primary source of water in support of agriculture, as well as

meeting urban and suburban demands in the future (Yamazaki & Pierce, 2024). Understanding these factors is important for developing educational programs that support producer participation and the adoption of efficient water management practices in Kansas.

Statement of Problem

Farmers in the Ogallala Aquifer region are in a crisis as there is a demand for more water in a time of severe depletion to grow more crops to provide for the growing population. New irrigation techniques are being developed to efficiently use water while still ensuring optimal crop growth (Little, 2009). To reduce water usage, interdisciplinary socio-ecological frameworks may aid in understanding where human and natural systems are coupled, the potential legacy effects of past management, and social needs for ecosystem services (Rhodes et al., 2023). The evolution to adopt by producers, crop consultants, and technical service providers of irrigation technologies are driven by factors such as education, information accessibility communication technology, social expectations, equipment sophistication, and much more (Porter et al., 2010). With these factors in mind, it is crucial for extension professionals and universities to engage producers in dynamic efforts (Rudnick et al., 2020).

Purpose and Significance of Study

The goal of this study is to identify key components that could inform the development of a Kansas Master Irrigator program. The Master Irrigator Program is an educational initiative for agricultural producers and industry partners, offering training in advanced water management, irrigation technology, efficiency, and economics. This study is significant as Kansas continues to prioritize water conservation and management through Kansas State University's Next-Gen K-

State Strategic Plan. This plan identifies sustainability, including water and resource management, as a key area of focus and has elevated the Kansas Water Institute to address high-priority water resource challenges through interdisciplinary research, teaching, and engagement (Kansas State University, 2023). A Kansas Master Irrigator program could support these priorities by providing agricultural producers and industry professionals with practical education and tools to improve irrigation management.

Limitations and Assumptions

Key limitations to this study include convenience and availability. First, purposive sampling was used to identify participants with professional knowledge or experience relevant to water conservation and producer outreach in Kansas. While this approach allowed the researcher to intentionally recruit individuals who could provide information that is relevant to the study, it may limit the representativeness of the sample because not all individuals within the broader population have an equal opportunity to be selected. Purposive sampling may not adequately represent the broader population and can limit the generalizability if findings beyond the population from which the participants were recruited (Zickar & Keith, 2022).

Snowball sampling was also used to expand participant recruitment. A limitation of snowball sampling is that the participants may refer to other individuals within their professional or social networks. This is a limitation because snowball sampling does not guarantee that all individuals who meet the study criteria or who could be considered stakeholders in Kansas for water conservation will be included in the study. This approach can introduce selection bias and could result in the underrepresentation of perspectives that are less connected to the individuals initially recruited (Naderifar et al., 2017).

Additional limitations may be associated with the online Qualtrics survey administered. Some participants may have limited familiarity with online survey platforms or may have trouble navigating or completing the survey. This could affect participants' ability to provide responses. Participant dropouts can be influenced by factors such as the relevance of survey questions and the burden associated with completing an online survey (Sischka et al., 2020). The assumptions of this study are that all the participants recruited to take part in the study are professionals involved in water conservation in Kansas. In addition, it is assumed that these individuals prioritize water conservation and producer outreach in Kansas.

Review of the Literature

The Need for Improved Irrigation Management

Producers have adopted a variety of innovations for efficient water use, such as new irrigation techniques and soil health indicators (Mdemu et al., 2020). In a study by Arabiyat et al. (2001), researchers found that irrigation technology, such as sensor technology, drip-line sprinklers, simulation models, and computer-aided irrigation, can enhance water efficiency by reducing the amount of water needed for irrigating crops. Technology innovations have focused on improved timing and placement of water. Management innovations include soil water monitoring, irrigation scheduling, soil health management and drought-tolerant varieties, crops, and cropping systems (Steiner et al., 2021). Strategic irrigation management that reduces pumping can extend the life of the Ogallala Aquifer and assist producers in meeting potential regulatory requirements for irrigation pumping (Weinheimer et al., 2013). For example, producers can move toward adaptive management, altering water pricing, removing incentives to wastewater, and prioritizing high-value production over low-value, water intensive crops (Gruère et al., 2018).

There are certain areas in the Ogallala Aquifer farmers are no longer able to pump sufficient water to irrigate their crops (Basso et al., 2013). Producers and stakeholders are striving to combat this issue affecting irrigators in the High Plains areas. For example, the effect of water policy on conserving the Ogallala Aquifer in southwestern Kansas's Groundwater Management District 3 (GMD3) uses a system-level theoretical approach, which integrates agricultural water and land use patterns, climate change, economic trends, and population dynamics (Aistrup et al., 2017). Initiatives and programs are being created, implemented, and supported in communities across the High Plains that are foundations for creating harmonious

collaborations for conserving water. Local Enhanced Management Areas (LEMA) in Kansas are an example. A LEMA is a tool that allows groundwater management districts (GMDs) to conserve water and reduce their usage by setting goals and control measures. LEMAs must be approved by the Chief Engineer who is the head of the Division of Water Resources within the Kansas Department of Agriculture (Kansas Department of Agriculture, 2018).

Factors Influencing Producer Adoption

A crucial component to understanding the complexity of the depletion of the Ogallala Aquifer and the impacts on farmers and management techniques being utilized to reduce impact is the factors that drive the influence of farmers' and ranchers' decisions to conserve (Lauer et al., 2018). Technology has aided in advances such as soil monitoring and irrigation placement; however, adaptation and conservation needs will require behavior change among producers (Adeyemi et al., 2017). Agronomic practices that producers carry out to conserve water and reduce their usage can be conservation tillage, crop diversification, dryland farming, and grassland restoration. Becoming water conscious on an agricultural operation should not be viewed as a return to hard labor, but rather as a system that requires farmers to become more knowledgeable about their water resources and rely on diversification rather than specialization.

The urgency to adopt by producers, crop consultants, and technical service providers of irrigation technologies are driven by factors such as education, information accessibility communication technology, social expectations, equipment sophistication, and much more (Porter et al., 2010). With these factors in mind, it is crucial for extension professions to engage producers in dynamic efforts (Rudnick et al., 2020). Producers' motives aim to improve not just their operation, but their livelihoods, which is why their knowledge is necessary in program

development (Hoffmann et al., 2007). Local knowledge of producers is required for the "user-useful" solutions needed (Raymond et al., 2010). It is important to involve farmers in developing programs and initiatives as their knowledge of agricultural operations enhances quality and relevance (Reed, 2008). Initiatives and programs are being created, implemented, and supported in communities across the High Plains that are foundations for creating harmonious collaborations for conserving water.

Water in the High Plains is now being seen as a commodity rather than a resource. Irrigators are often perceived as being business and profit-motivated, with weaker eccentric worldviews than dryland farmers (Fischer & Sanderson, 2022). The effect on agricultural economies is influenced by the extent of agricultural adaptation; yet, in a modern setting, it has been difficult to observe adaptation to groundwater access and climate (Hornbeck & Keskin, 2011). In relation, however, economic impacts do not directly correlate with the extent of irrigation losses, primarily due to the variations in the types of dryland crops that can be grown in differing environments (Deines et al., 2020). It is because of the economic impacts that long-term or strategic irrigation management decisions should be based on the economic and production impacts of different water-efficient management strategies (Andales et al., 2020).

Startup farmers are facing challenges and barriers in starting their operations such as excessive costs and limited access to farmland, capital, advanced technology, and management practices (Ahearn, 2013). Alternative knowledge systems are being built as initiatives to assist beginning farmers in receiving the knowledge they need in developing their operations (Hassanein & Kloppenburg, 2010). It is important to involve farmers in developing programs and initiatives as their knowledge of agricultural operations enhances quality and relevance (Reed, 2008). Producers' motives aim to improve not just their operation, but their livelihoods,

which is why their knowledge is necessary in program development (Hoffmann et al., 2007). Local knowledge of producers is required for the "user-useful" solutions needed (Raymond et al., 2010). Producers mostly rely on the knowledge they accumulate from their own practical experiences: learn by doing, experimenting, and observing both themselves and others. Historically, families who farm together have been a central hub for learning and knowledge transfer (Šūmane et al., 2018).

To understand complex systems in agriculture, a combination of local knowledge and science is essential (Schindler et al., 2016). The power of local and experimental knowledge of farmers has often been overlooked due to the shift from conventional agricultural extension to participatory approaches (Prajapati et al., 2025). The success of both introducing and adopting conservation agriculture practices depends on their appropriateness for local needs and the community's existing beliefs (Isaac et al., 2008). Environmental, social, and cultural conditions that influence farmer decision-making are important for understanding how producers view agricultural practices (Gray et al., 2012).

The Role of Adult Education in Supporting Producer Adoption

Initiatives and programs are being created, implemented, and supported in communities across the High Plains that are foundations for creating collaborations for complex problems. Informal learning programs have become an important part of agricultural education by providing opportunities for producers and stakeholders to expand their knowledge, share experiences, and adopt new management practices (Šūmane et al., 2018). These programs provide opportunities for producers to learn from one another while developing relationships with researchers, industry professionals, and other agricultural stakeholders (Thiele et al., 2011).

The structure and success of existing informal learning programs can provide valuable insight into the development of a Master Irrigator program in Kansas. A key benefit to these interdisciplinary initiatives is their ability to bring together different fields of expertise to address complex environmental, agricultural, and water-resource challenges through a broader, systems-based approach (Hartle et al., 2017; Roshania et al., 2023). Examples of these programs are the Multi-Institutional Land-Grant Cohort Course, Innovative Food Systems Teaching and Learning, and Interdisciplinary Food Studies and Sustainable Agriculture Degree programs (Roshania et al., 2023; Hartle et al., 2017). These three programs are examples of three different delivery formats. The Multi-Institutional Land-Grant Cohort Course is delivered remotely by an international panel of 19 multidisciplinary experts representing diverse domains in food and nutrition security, hunger and sustainability (Roshania et al. 2023). Innovative Food Systems Teaching and Learning combines an open-access, web-based learning platform with shared virtual lectures and cross-institutional digital resource repositories (Roshania et al, 2013). Interdisciplinary Food Studies and Sustainable Agriculture Degree programs are in-person campus-based programs offered across U.S. universities (Hartle et al. 2017).

An example of an informal learning program is Testing Ag Performance Solutions (TAPS). TAPS is a competition for farm managers that utilizes innovation and technological advances to meet maximum yields. The goal of the TAPS competition itself is to be the “most profitable”, “most input-use efficient”, and “highest grain yield” operators. TAPS as a program has the goal of building a network of irrigators that “serves as a collaborative hub for growers, industry specialists, agronomists, government entities” (Testing Ag Performance Solutions, 2025). Through this competition, participants are encouraged to consider how different management practices influence productivity, profitability, and resource efficiency. The

competitive structure provides producers with the opportunity to evaluate different approaches to agricultural management while learning from the decisions and experiences of other participants. An important component of TAPS is its emphasis on collaboration and shared learning. The program seeks to establish a network of irrigators that can serve as a collaborative hub for producers and other stakeholders. By bringing together individuals with different experiences and areas of expertise, TAPS creates opportunities for producers to engage with new technologies and research-based information while learning from one another. The collaborative approach allows participants to compare management decisions and consider how different practices may be applied on their own operations. The combination of competition, practical application, and peer-to-peer learning makes TAPS an example of how informal educational programs can encourage producer engagement and the adoption of new agricultural practices.

Another informal learning program for adults in agriculture is the Ogallala Aquifer Program (OAP). OAP is a collaborative research and education program focused on developing solutions to address declining groundwater availability from the Ogallala Aquifer in western Kansas and the Texas High Plains (Brauer et al., 2017). The program brings together researchers and agricultural professionals from different disciplines to address the challenges of sustaining agricultural production while managing limited groundwater resources. Through its research and educational efforts, the OAP provides an opportunity to connect scientific information with the practical challenges faced by producers and water management stakeholders throughout the region. An important component of the OAP is its interdisciplinary approach to addressing groundwater conservation. The collaborative research structure provides opportunities for institutions and agricultural professionals to work toward shared conservation goals while recognizing the different environmental and agricultural conditions throughout the High Plains.

Another example is a Master Gardener program, specifically carried out by Washington State University (WSU). This program utilizes a “train-the-trainer" approach to translating land-grant university research into practical public education (Chalker-Scott & Collman, 2006). Rather than solely on university faculty and extension professionals to distribute educational information, the program trains individuals who can then share their knowledge and experiences with others. This approach creates opportunities for community members to become educational resources while expanding the reach of university-based research. According to Chalker-Scott and Collman, the Washington Master Gardener program takes part in at least 50 hours of intensive scientific instruction from university faculty in applied plant and soil sciences in exchange for donating a minimum of 40 hours of free public service. Through this structure, participants gain research-based knowledge and practical skills that can be shared with other individuals in their communities. The program combines formal instruction with opportunities for continued learning and the application of knowledge through public education and service. One of the beneficial components of the Master Gardener model is its ability to develop knowledgeable individuals who can serve as educational leaders within their communities.

Research Objectives

The aim of this study is to identify the key components that can be used to develop a Master Irrigator program in the state of Kansas. Participants will provide feedback on the curriculum, delivery, and structure of the event.

The research questions guiding this study were:

1. What are producers and stakeholder perceptions and needs for a Master Irrigator program in Kansas?

2. What is water stakeholder's preference for program formatting for Master Irrigator in Kansas?

3. How would stakeholders conceptualize success upon completion of a Master Irrigator program?

Methodology

Institutional Review Board

Kansas State University policy and federal regulations require approval of all research studies related to human subjects before researchers can begin conducting their experiments. The Kansas State University Office of University Research Services and the Institutional Review Board (IRB) (Protocol IRB-13725) reviewed this study to ensure the protection of human subjects involved with biomedical and behavioral research and approved the research project (see Appendix A). Approval of the research was given.

Research Design

This study used a sequential multimethod research design that incorporated both quantitative and qualitative data collection to examine potential components of a Kansas Master Irrigator program. A multimethod approach was best suited for this study because the goal was to identify both broad patterns in stakeholder preferences and more detailed perspectives regarding potential program formats, curriculum topics, and delivery methods. Quantitative survey data provided a systemic way to gather information from a broader group of participants and identify patterns in their responses, while qualitative interviews allowed participants to provide more detailed explanations, experiences, and perspectives that may not be captured through structured survey questions (Bazen et al., 2021). Using both methods allowed the researcher to examine the topic from multiple perspectives and develop a more comprehensive understanding of stakeholder's needs and preferences than could be obtained through either method alone (Oranga et al., 2025).

Data Collection

In the first phase of the study, a survey was distributed to producers, Groundwater Management District (GMD) leaders, and relevant stakeholders to gather input on potential Master Irrigator program formats, curriculum topics, and participant preferences (see Appendix B). The survey provided quantitative information regarding stakeholder perspectives and preferences and helped identify areas for further exploration. In the second phase, follow-up interviews were conducted on Zoom with seven selected participants based on their survey responses and their potential to provide valuable perspectives related to the development of a Kansas Master Irrigator program. The qualitative interviews allowed participants to expand their survey responses and provide additional context regarding program needs, challenges, curriculum, and delivery preferences (see Appendix C).

Table 1 Survey Participant Demographics

Demographic Category	**Response Option**	**Count (n)**	**Percentage (*f*)**
Professional Role/Affiliation	State or Federal Agency	10	56%
	University or Community College	5	28%
	GMD Manager or Board Member	2	11%
	Producer	1	6%
Age Distribution	18-24	0	0%

	25-34	1	6%
	35-44	6	33%
	45-54	5	28%
	55-64	1	6%
	65 or older	5	28%
Geographic Location/GMD	Eastern Kansas (Outside GMD Boundaries)	14	78%
	Northwest Kansas GMD No. 4	2	11%
	Western Kansas GMD No. 1	1	6%
	Southwest Kansas GMD No. 3	1	6%

Table 2 Interview Participant Occupations

Blinded Participant Number	**Professional Role/Occupation**
Participant 1	Groundwater Management District (GMD) personnel
Participant 2	University Faculty
Participant 3	State Agency Representative
Participant 4	University Faculty
Participant 5	Groundwater Management District (GMD) Manager
Participant 6	Groundwater Management District (GMD) Manager
Participant 7	University Faculty

Framework

The Adult Learning Theory (andragogy), popularized by educator Malcolm Knowles is the framework applied in this study (St. Clair & Käpplinger, 2021). The Adult Learning Theory is a framework that illustrates how adults acquire and apply knowledge differently (St. Clair & Käpplinger, 2021). The theory consists of six core components, often called the "Super Six" principles (Pease, 2025) (Yopp et al., 2013).:

- Need to Know: Adults need to understand why they are learning something before investing their time. They want to know the immediate relevance, value, and how it will improve their performance or quality of life. This is often framed as "What's in it for me?".
- Self-Concept (Self-Direction): As adults mature, they move from being dependent learners to self-directed individuals. They prefer autonomy, expect to have a voice in their program design, and want the flexibility to steer their own learning.
- Role of Prior Experience: Adults bring a deep reservoir of lived experiences, previous jobs, and prior coursework to the classroom. These experiences are a foundation for new learning, and adults best learn when they can connect new concepts to these experiences or engage in peer discussions to learn from others.
- Readiness to Learn: An adult's readiness to learn typically peaks when they face a specific challenge, a new task, or a transition in their social or professional roles.

- Problem Orientation: Adult learning is problem-centered rather than content-oriented. Adults prefer to focus on the practical application of knowledge to immediately solve real-world problems or execute daily tasks, rather than just acquiring abstract, theoretical knowledge.
- Intrinsic Motivation: While adults may value external rewards like a promotion or certification, they are primarily driven by internal factors such as self-esteem, personal growth, curiosity, and the desire to improve their quality of life.

As defined by Patil (2022), Neuroandragogy provides support that proves that adult brains are biologically equipped for the principles of andragogy through self-directed and experience-based learning. Research shows that with neuroplasticity, adult brains can continuously change and wire itself through experiences (Patil, 2022). On a similar note, adults possess a fully developed prefrontal cortex which allows for complex, logical, and sequential thinking (Patil, 2022). This biological stance supports Knowles' six principles and helps explain why they are used. The fulfillment of short-term learning goals can trigger the secretion of neurotransmitters such as dopamine and endorphins (Patil, 2022). This physically validates the adult brain's motivation to continue the learning process.

For producers who rely on the Ogallala Aquifer to support their operation in the High Plains, it is crucial to transition to an active and collaborative approach on problem-centered learning. This will require utilizing the andragogy framework to bridge an adult's biological capacity to learn with their everyday realities. Using Knowles six principles as a lens for this study can aid in the development of a Master Irrigator program in Kansas by shifting to active,

experimental problem-solving that creates an environment to support an adult's motivation and readiness to learn (Yopp et al., 2013).

In this research, the application of Knowles six principles demonstrates how the adult learning theory can guide the development of a potential Master Irrigator program in Kansas. The following principles illustrate how adult learning was applied in this research:

- Need to Know: Adults are more likely to engage in learning when they clearly understand their relevance (Yopp al., 2013). This study sought to identify what producers see as valuable outcomes for a Master Irrigator program in Kansas.
- Self-Concept (Self-Direction): Adults view themselves as self-directed learners who want involvement in shaping their educational experiences (Yopp al., 2013). This study utilized both survey and focus groups/interviews to involve individuals of interdisciplinary fields in water perspectives to guide the development and structure of a potential Master Irrigator program in Kansas
- Role of Prior Experience: Adults rely heavily on prior experience as a foundation for learning (Yopp al., 2013). This study is organized to gather producers' prior experiences and expertise, which can then be used to inform the development of a Master Irrigator program that incorporates peer discussion and networking.
- Readiness to Learn: Adults become ready to learn when responding to changing personal or professional demands (Yopp et al., 2013). This study explores how increasing conservation pressures shape producers' interest in both educational programs and management practices.

- Problem Orientation: Adults prefer learning that helps to solve immediate real-world problems (Yopp al., 2013). The data from this study explores preferred curriculum that can be tailored to the immediate needs of producers.
- Intrinsic Motivation: Adults are strongly motivated by internal values such as stewardship, personal responsibility, and long-term goals (Yoppet al., 2013). This study aims to understand what motivates producers to conserve water.

This research aims to identify key components to develop an educational program for agricultural producers, water managers, and industry partners to promote precision water management and combat the severe depletion of the Ogallala Aquifer. Applying adult learning theory to this research helps ensure that the resulting program effectively drives behavioral changes among farmers. This research emphasizes that farmers heavily rely on the practical, experimental knowledge of learning by doing and observing what works for their peers or family. Because adult learning theory places a high value on drawing from prior experience, the program's design can explicitly incorporate peer discussion, networking, and the sharing of local environmental knowledge to validate and utilize the farmers' expertise (Yopp et al., 2013). The Master Irrigator curriculum can be tailored to the immediate, problem-centered needs of the producers. This implies that instruction should emphasize the practical and real-world decisions producers can apply to their operations. Farmers are facing a crisis regarding water scarcity and the economic impacts of pumping less water or suffering crop failures. By focusing on how advanced irrigation technologies solve the real-world problem of aquifer depletion while maintaining profitability, the program aligns directly with the adults' need for relevant, practical solutions (Pease, 2025). A core principle of andragogy is that adults want to be

involved in the planning of their instruction. The Master Irrigator research applies this by distributing surveys and conducting interviews with producers, Groundwater Management District leaders, and stakeholders to gather input on curriculum topics and program formats (Yopp et al., 2013). This ensures that producers can serve as the primary leaders and decision makers, and university personnel and agencies serve as facilitators. Farmers' operational environments are changing due to climate change, droughts, and potential regulatory requirements. This creates a high readiness to learn because producers are actively seeking strategies that reduce water usage without harming their livelihoods. Providing this training exactly as the social and environmental role of the farmer is shifting will result in higher engagement (St. Clair & Käpplinger, 2021).

There are various areas within agricultural and environmental research that have utilized the Adult Learning Theory. For example, a study by Russell and Ottow (2021) advocates for the "water specialist as andrologist." This study applied Knowles' six principles to institutional capacity building for water agencies in developing countries such as Moldova, Kenya, and Rwanda. The participants in this study were able to directly connect new water management technologies to their daily tasks by shifting to active and problem-oriented learning (Russell & Ottow, 2021). Another example from Arndt and LaDue (2008) discussed the application of andragogy in a program designed to improve weather and climate literacy among public safety officials in Oklahoma called "OK-First." This program utilized problem-based learning and self-directed case studies which allowed adult learners to transition from instructor guidance into independent learners who can apply climate data to real-world hazard scenarios (Arndt & LaDue, 2008). An additional example from Haugen (2006) which points to an example involving farmers in councils to solve issues related to excess sediment and nutrients in the river

caused by poor farming techniques in Iowa's Maquoketa River. This example emphasized practical farmer-led experimentation where participants were able to test new technologies on their own land and develop solutions to the existing problems (Haugen, 2006).

Population and Sample

Individuals who were recruited to take part in this study consisted of professionals involved in water and agriculture in Kansas. A targeted group of potential participants were identified through Groundwater Management District (GMD) websites by reviewing their lists of board members. These individuals were contacted to fill out the survey and distribute the survey to the other members of their GMD boards. This use of purposive sampling was applied because it allowed the gathering of practical insights on curriculum design, adoption barriers, and program structure (Tajik et al., 2024). This required input from individuals with direct experience in water management and extension in the Ogallala Aquifer region. Subjects were recruited through the email sent to the GMD board members, creating an effect of snowball sampling. Others who were sent the survey were individuals who were identified as relevant stakeholders and organizations working in fields regarding water issues in Kansas. This strategy leveraged trusted peer networks to reach key regional decisionmakers across Kansas.

Instrumental Design

The instruments used in this study included a digital Qualtrics survey and interview protocol. A survey was used to identify components that could inform the development of a Kansas Master Irrigator program such as framework, curriculum, and producer/stakeholder preferences. This survey was designed to take a maximum of 10 minutes and consisted of

multiple choice, ranking, and text box open response questions. The interviews built upon survey responses and provided an opportunity to further share stakeholder perspectives. Questions for the interviews focused on format engagement, localized tools, expected outcomes, and overall focusing on creating a meaningful and useful program for Kansans. The instruments for this study were reviewed by two supporting investigators.

Validity and Trustworthiness

This study's multi-method approach of utilizing quantitative surveys and qualitative interviews provides validity and trustworthiness that ensures the data collection reflects the real-world need of Kansas working in professions regarding water in Kansas This is often referred to as data triangulation. By using multiple data collection methods and combining trends identified in survey data and in-depth perspectives of interviews, we are able to counter-check the accuracy of the results found (Aurah et al., 2018). In addition, multiple researchers collaboratively coded and analyzed data from the surveys and interviews and discussed the findings to limit any personal bias. The survey and interview questions were developed in reflection of Malcom Knowles' assumptions and six principles of the Adult Learning Theory to ensure the needs and experiences of participants are properly measured and captured (St. Clair & Käpplinger, 2021) (Yopp et al., 2013).

Data Analysis

This study utilized a sequential mixed-method approach to analyze quantitative survey responses and qualitative stakeholder interviews to identify key components necessary for developing a Kansas Master Irrigator program. The data analysis process was designed to

evaluate stakeholder preferences regarding program structure, curriculum, delivery methods, and potential barriers to participation. The quantitative survey findings were analyzed by using descriptive statistics to identify patterns and preferences among the participants. The qualitative interview findings were analyzed through inductive coding and thematic analysis to provide a better understanding of stakeholder perspectives. This mixed-method approach allowed for a better understanding of educational needs and program requirements for establishing a Kansas Master Irrigator program.

Positionality

My positionality in this study is shaped from experience, expertise, education, and personal ties to water conservation efforts for irrigation in the state of Kansas. I received my bachelor's degree from Kansas State University in Agricultural Communications and Journalism. I am currently completing a master's degree in Agricultural Education and Communications in addition to holding a position as a Graduate Research Fellow with the Kansas Water Institute. I hold a deep and personal connection to water and water conservation in Kansas, growing up in Western Kansas in a farming family affected by the depletion of the Ogallala Aquifer. My FFA Supervised Agricultural Experience program involved the creation of the Kansas Youth Water Advocates alongside collaboration with state and university entities. I have developed a deep passion for conserving the Ogallala Aquifer and ensuring agricultural production in Kansas for future generations for nearly 10 years. I understand and acknowledge my personal bias towards generational traditions and the vulnerabilities of producers and families whose livelihoods depend on the future of agriculture.

Results

Survey Findings

The survey consisted of a total of 25 participants, but after omitting incomplete responses, there were 18 usable surveys. Participants were surveyed on potential curriculum, learning styles, program format, barriers, incentives, and overall producer and stakeholder priorities. Out of the 18 participants, 6% (n=1) were producers, 56% (n=10) state and federal agencies, 28% (n=5) university or community college, and 11% (n=2) GMD managers or board members. Age demographic indicates that 5% (n=1) of participants were between the ages of 18-24, 6% (n=1) between 25-34, 33% (n=6) between 35-44, 28% (n=5) between 45-54, 6% (n=1) between 55-65, and 28% (n=5) were 65 or older. Location demographics within designated GMDs show that 6% (n=1) were from Western Kansas Groundwater Management District No. 1, 6% (n=1) from Southwest Kansas Groundwater Management District No. 3, 11% (n=2) from Northwest Kansas Groundwater Management District No. 4, and 78% (n=14) outside of a GMDs in the eastern portion of Kansas such as Manhattan, Topeka, and Lawrence. Survey results show that a hybrid format is most appealing to potential participants at 61% (n=11) followed by in-person at 28% (n=5) and online at 6% (n=1). For session length, full-day sessions were preferred at 72% (n=13) and half-day sessions being preferred at 28% (n=5).

Survey trends indicated in Table 3 show that the topics that would be most useful to cover during a Master Irrigator program were 56% (n=10) for both crop selection and rotation for water efficiency, 56% (n=10) for soil health and water retention practices, 56% (n=10) for deficit irrigation strategies, 56% (n=10) for data-based decision making, and 50% (n=9) for irrigation scheduling tools.

Table 3 Preferred Presentation Topics

Rank	Curriculum Topic	Response (n)	Percentage
1	Crop selection and rotation for water efficiency	10	56%
1	Soil health and water retention practices	10	56%
1	Deficit irrigation strategies	10	56%
1	Data based decision making	10	56%
5	Irrigation scheduling tools	9	50%
6	Economic and cost-benefit analysis	8	44%
7	Irrigation management software/apps	7	39%
8	Regulatory requirements and water policy	6	33%
9	Soil moisture sensors	5	28%
9	Remote sensing and aerial imagery	5	28%
9	Irrigation system design and maintenance	5	28%
12	ET tools	4	22%
13	Pivot system upgrades	3	17%
15	Salinity and water quality management	1	6%

In addition, participants were asked what style of presentation they preferred. Based on those ranks, demonstrations were highest ranked, followed by hands-on practice, some speakers, field tours, breakout groups, panel discussions, and mostly speakers as shown in Table 4.

Table 4 Ranked Order of Preferred Presentation Syles

Overall Rank	**Presentation Style**	**First Choice Votes (n)**	**Top three Preference Count (n)**
1	Demonstrations	10 (56%)	17 (94%)
2	Hands-on Practice	2 (11%)	11 (61%)
3	Some Speakers/Slides	2 (11%)	7 (39%)
4	Field Tours	1 (6%)	7 (39%)
5	Breakout Groups	0 (0%)	4 (22%)
6	Panel Discussions	1 (6%)	5 (28%)
7	Mostly Speakers/Slides	2 (11%)	3 (17%)

Table 5 Seasonal Schedule Preferences by Delivery Format

January – March (Winter Months):	**April – August (Active Farming & Growing Season)**:	**September – December (Harvest & Fall Season)**:
In-person: Heavily preferred (**9 respondents**).	**Online**: Top choice (**8 respondents**).	**Hybrid**: **8 respondents**.

Hybrid: **7 respondents**.	**Hybrid**: **7 respondents.**	**In-person**: **5 respondents**.
Online: **2 respondents**.	**In-person**: Drops significantly to **3 respondents**.	**Online**: **5 respondents.**

Participants were also surveyed on preferences of seasons and workshop delivery. As shown in Table 5**,** during the winter off-season (January-March), in-person instruction was most preferred, followed by hybrid and online options. On the other hand, during the active summer farming months (April-August), online instruction became the top choice, followed by hybrid while in-person rates dropped. Fall harvest months (September-December) showed the strongest demand for hybrid delivery. Participants were also given open-ended questions such as "what would you want out of a Master Irrigator program?" and "what specific speakers would you like to hear from?" To be given the opportunity to express their own opinions and give critical stakeholders and producers context regarding the development of a Master Irrigator program. The responses highlighted the importance of creating opportunities for peer-to-peer learning, providing practical resources, and establishing relationships among producers and other water stakeholders.

One of the most common responses was the importance of creating a program that encourages collaboration and continued learning among producers. Rather than developing a program that focuses solely on providing educational information, participants emphasized the value of building relationships and creating opportunities for producers to learn from one another. One participant expressed the need for an "ongoing peer-to-peer producer network where farmers swap ideas and work with similar solutions together," with additional support from subject matter experts when needed. The participants also explained that this type of

learning environment has been successful in other programs and can lead to "permanent, long-term adoption of water conserving irrigation practices." Similarly, another participant expressed wanting the program to serve as a way of "bringing together producers, researchers, industry and water leaders to have real conversations and share practical ideas that move agriculture forward." These responses highlight that participants see the potential value of a Kansas Master Irrigator program extending beyond the educational sessions themselves, with an emphasis on developing relationships and networks that encourage continued collaboration and knowledge sharing.

In addition to building relationships, participants expressed the importance of providing practical educational resources that producers can directly apply to their own operations. One participant emphasized the need for educational material focused on "planning across multiple seasons to maximize the value of water use," as well as demonstrations showing when investments in irrigation upgrades and new infrastructure "are likely or unlikely to pay off." The participant further suggested incorporating resources such as excel spreadsheets and return-on-investment calculators to help producers evaluate financial decisions and long-term investments. These responses demonstrate the importance of developing curriculum that not only introduces new irrigation practices and technologies, but also provides producers with the tools and information needed to determine how those practices may benefit their individual operations Participants also highlighted the need for educational information to be accessible, relevant, and connected to the larger purpose of groundwater conservation. One participant expressed wanting "effective, user-friendly training on best practices," while also emphasizing the importance of including information about groundwater resources to help producers understand the reasoning behind the educational material. This response supports the importance of developing a program

that combines technical information with practical applications while recognizing the different levels of knowledge and experience that participants may bring to the program.

When asked what specific speakers they would like to hear from during a Kansas Master Irrigator program, participants emphasized the importance of including individuals with different backgrounds and experiences in water management and irrigation practices. One participant suggested including representatives from the "Kansas Water Office, Kansas Water Authority, K-State researchers, and Kansas Water Institute scholars," while another expressed interest in hearing from "someone from the program from another state" who could share their experiences. Participants also emphasized the importance of including producers who have successfully implemented water conservation practices. One participant expressed wanting to hear from "seasoned irrigators who have found tried and true practices that can be scaled and replicated," while another suggested including "key producers who have successfully reduced their water usage without sacrificing yield or quality." These responses highlight the importance of combining research-based information with practical producer experiences.

In addition to speaker preferences, participants provided suggestions regarding the development and structure of a Kansas Master Irrigator program. One participant emphasized that the program "must be producer-led, including a producer-based advisory group," while universities, agencies, and industry partners should serve "only to facilitate" the program. This response highlights the importance of involving producers in program development to ensure educational content and programming addresses their specific needs and challenges. Participants also expressed the importance of incorporating curriculum topics that consider water management decisions beyond a single growing season. One participant suggested opportunities to "encourage thinking about water allocation across seasons," particularly through approaches

such as multi-year flex accounts and water banking. In addition, participants emphasized the importance of learning from existing Master Irrigator programs while considering "how to incorporate what has worked in other states and how to apply it to the unique conditions within Kansas." These responses demonstrate the importance of providing practical educational information that addresses both immediate and long-term water management decisions. Another idea expressed was the importance of creating opportunities for collaboration and ensuring the program is accessible to producers with different operational backgrounds. One participant emphasized the need for "more purposeful outreach to farmers that aren't big," recognizing that smaller operations may face different challenges when adopting new irrigation technologies. The participant also suggested incorporating "strategies and technology that can appeal to all." These responses highlight the importance of considering differences in farm size, financial resources, and operational needs when developing the program.

Overall, the open-ended survey responses emphasized the importance of developing a Kansas Master Irrigator program that is producer-focused, collaborative, and adaptable to the different needs of Kansas irrigators. Participants highlighted the value of incorporating practical educational resources, producer experiences, and perspectives from different water stakeholders whole creating opportunities for continued learning and relationship building. These findings suggest that the success of a Kansas Master Irrigator program may extend beyond the information provided during educational sessions with an emphasis on establishing lasting networks among producers, researchers, and water management professionals. By encouraging collaboration, peer-to-peer learning and the continued sharing of knowledge, the program has the potential to support long-term adoption of water conservation practices and collaborative efforts toward groundwater conservation in Kansas.

Interview Findings

To further understand the components of potential curriculum, learning styles, program format, barriers, incentives, and overall producer and stakeholder priorities, seven stakeholders were interviewed, each lasting about an hour. The themes identified from the interviews were: participants value opportunities to connect with, engage, and feel motivated by their peers, to address diverse learning styles and interests, participants desired a practical and flexible delivery of curriculum, and participants believed that program success could be defined differently based on individual attendees, but could be gauged based on new knowledge, network building, and implementation of new practices.

RQ1: What are producers and stakeholder perceptions and needs for a Master Irrigator program in Kansas?

Participants value opportunities to connect with, engage, and feel motivated by their peers.

One theme identified throughout the interviews was the critical role of peer-to-peer influence and trust. Each interview consistently identified peer-to-peer learning and engagement as a prime motivator for program participation. Participant 1 stated, "peers are the biggest tool." In addition, participants emphasize that learning both from and with their trusted peers was more influential than program delivery from university or government representatives. Participant 3 indicated that, "When the other producers see it [information] being presented from another producer goes a long way. Not a researcher or somebody in government, it has to be somebody they trust." Participants had noted that a primary motivator for participation is practical experiences from other producers, creating a network of both support and feedback on operational practices. They seek to build a space of growing networks where early adaptors and trusted peers can demonstrate their experiences and successes. When building

a reputable Master Irrigator program in Kansas, Participant 7 emphasized the importance of creating opportunities for producers to share their knowledge and experiences with their peers:

As much as possible building in the spaces and the programming for them to bring that expertise and showcase it amongst their peers that I think is really important. Some of these folks are probably some of the first people to try some new techniques or you know try cover cropping in western Kansas and that type of knowledge is incredibly valuable, especially when it's shared among their peers that are also you know interested in an issue.

Capturing these experiences that other participants can learn from and building trust was believed to be highly valuable by participants. Creating a network where peers have the opportunity to learn from one another holds great value in creating a strong community of sustainable irrigators across Kansas. This approach allows participants to engage in continued learning experiences beyond the Master Irrigator program. Participant 5 described the importance of creating small, farmer-to-farmer learning networks that encourage continued engagement:

This concept of small community learning opportunities and having it be farmer to farmer and it's more of creating a network between a small subgroup that is going through these lessons. Then they're also integrating that into their operations and then they're following up with one another which is also cultivating those relationships so that they can keep learning together over time.

RQ2: What are producers and stakeholder perceptions and needs for a Master Irrigator program in Kansas?

To address diverse learning styles and interests, participants desired a practical and flexible delivery of curriculum.

During interviews, participants emphasized that a one size fits all approach would not be successful for a Master Irrigator program in Kansas. Participants emphasized that flexible, practical, and relevant curriculum would be the appropriate approach to meet program participants' needs. Participant 1 noted, “We could put together the greatest curriculum that we think is on the face of the planet, but if it does not meet the needs and expectations of those that are going to be attending then the program flops.” Participant 3 agreed that “The more you can show them stuff in their own backyards, the more receptive they are to it.” In addition, it was addressed that curriculum delivery should accommodate differences in learning styles and time availability. As stated by Participant 1, “Everybody has a different learning style as every educator has a different teaching style, so I think having a multitude of ways to teach a certain concept is the best way possible.” This is why it is crucial to address varying and diverse adult learning styles. Ultimately, curriculum must focus on participant’s needs and allow them to apply lessons from the program on their operation with ease, meaning “They want to see it's proven. They want to see that it's been working, and that there's less risk involved. So, understanding your audience attending this where they are on that curve will help you tailor content and tech for them better (Participant 4).”

RQ3: How would stakeholders conceptualize success upon completion of a Master Irrigator program?

Participants believed that program success could be defined differently based on individual attendees, but could be gauged based on new knowledge, network building, and implementation of new practices.

Participants viewed success beyond quantifiable indicators and indicated that there will not be a primary marker of program success that is constant from every participant. While measurable outcomes such as water savings and return on investment were accounted as important factors, meaningful success would be reflected through a broader shift in mindset. When asked what program success would look like, Participant 5 emphasized the importance of both economic outcomes and long-term mindset change:

I think the other big one would be total return on investment. How much money are they making? What are these technologies really accomplishing when it comes to the biggest piece of the puzzle that I think even with the irrigation technology initiative is we're still trying to really wrap our minds around is the long-term personal mindset change that they experience and what is that doing to really impact their day-to-day operation.

Rather than setting a definition or marker for success, participants consistently emphasized success as an ongoing process that consists of learning, adopting new practices, and creating networks where shared knowledge creates meaningful and continued change. Participants defined success as a continuous and linear progression, Participant 4 stating "your goal is not widespread reduction of pumping or something but it's the continued network building the continued learning." In addition, participants noted that success would be widespread and spread through the networks that peers create within their own communities. For

example, it was stated that by Participant 6 participant success once completing a Master Irrigator program would see that “afterwards, I'd like to see them start implementing these programs. They're not going to be able to probably implement them all at once but just watch them over time how they start implementing them. Then if they were willing to come back and tell that to other people too. To me, that means they really took it in and say, "Hey, this was a success." And that just leads other people getting more positive feelings about it and might implement some of those practices themselves.”

Discussion

The findings from this study offer a range of implications for the design and development for a Kansas Master Irrigator program, focused on producer needs and success. These findings could also provide insights for other individuals who want to build professional development or networking programs for Kansas Producers. Because success is defined by participants as continuous implementation and learning, the program must be built to be a long-term network hub. In addition, there must be a shift from lecture style delivery to collaborative facilitation. As mentioned from Yopp et al., 2013, adults view themselves as self-directed learners who want involvement in shaping their educational experiences. Both survey and interview results support that the planning of educational programs must adopt an active and collaborative approach. Producers and stakeholders should conclude a Master Irrigator program in Kansas with defined practical skills and a peer support network they can turn into in future collaboration and continued learning opportunities. Additionally, program designers must establish continuous learning trajectories that can span across multiple operational phases.

Recommendations

The recommendations from this study are structured to ensure that Kansas producers could leave the formal training of a Master Irrigator program with both practical skill sets and a self-built peer-to-peer network (see Table 6). To create a Master Irrigator in Kansas, curriculum design, program logistics, and community network building must align with the realities of producer's day to day lives and their preferences as adult learners. Aligning with the Adult Learning Theory, instruction for a Kansas Master Irrigator program must emphasize collaborative facilitation to ensure continuous learning among peers. Program design can start

with a producer-led advisory committee in order to shift towards this collaborative facilitation (see Table 6). It is recommended that a formal advisory committee composed of active regional producers is formed to guide curriculum topics, select keynote speakers, and maintain local program relevance. In this case, university researchers and agency representatives should serve as facilitators and technical resources. This approach would directly support the principle of self-concept by allowing producers to take ownership of their educational experiences while maintaining access to research-based information and technical expertise. Secondly, in an effort to accommodate the strict structure of producer schedules, hybrid models or field days can be utilized to respect the scheduling barriers and busy seasons for producers. These sessions can be designed to combine brief classroom instruction with technical overviews in interactive field demonstrations. Based on the study's findings, curriculum should focus heavily on high-interest topics such as crop selection for water efficiency, deficit irrigation strategies, and user-friendly scheduling software. In addition, it is recommended to host multi-day or full-day workshops during winter months to avoid peak planting and harvest conflicts. In-person events can also be supplemented with flexible, voluntary online modules or summer field tours. Finally, it is recommended to incorporate practical financial budgeting tools, ROI calculator, and multi-year allocation frameworks so that irrigators can evaluate economic viability of upgrading technology or transitioning crop rotations.

This study offers a foundational framework for developing a Master Irrigator program in Kansas, built upon the principles of the Adult Learning Theory. However, there are still areas that must continue to be researched to ensure the long-term lifespan and effectiveness of this program in Kansas. A challenge for any area of evaluating irrigation conservation outcomes is figuring out whether short-term educational experiences and engagement can actually lead to

lasting operational changes. It is recommended that future research examines long-term mindset changes of producers and how these changes can affect their own operation over multiple growing seasons.

Table 6 Recommendations for a Kansas Master Irrigator Program

Recommendations	**Supporting Survey and Interview Findings**	**Program Implications**
Establish a producer-led advisory committee and encourage peer-to-peer learning.	Survey: 67% of respondents identified peer-to-peer learning and discussions as the most effective engagement strategy. Interview: Participant 3 stated, "when the other producers see it being presented from another producer goes a long way. Not a researcher or somebody in government, it has to be somebody they trust."	Establish an advisory committee consisting of active Kansas producers to guide curriculum development, identify speakers, and ensure program relevance. Incorporate farmer panels, producer-led demonstrations, and peer discussions into educational sessions. University researchers, agencies, and industry professionals should serve as facilitators and technical resources while producers help guide the learning experience.
Implement flexible scheduling and	Survey: Time constraints (67%) and active farming schedules	Schedule primary in-person training sessions during the winter

seasonal delivery formats.	(61%) were the primary barriers to attendance. In-person instruction was preferred during January–March (9 respondents), while online instruction was preferred during April–August (8 respondents). Interview: Participant 1 stated, “we could put together the greatest curriculum, but if it does not meet the needs and expectations of those that are going to be attending then the program flops.”	off-season when producers have greater availability. Provide online learning opportunities during active farming months and consider hybrid formats to accommodate different schedules. These options could increase accessibility while allowing participants to maintain educational connections throughout the year.
Develop practical curriculum focused on irrigation management and economic decision-making.	Survey: The highest-ranked curriculum priorities included crop selection for water efficiency (56%), soil health practices (56%), deficit irrigation strategies (56%), data-based decision-making (56%), and irrigation scheduling tools (50%). Open-ended response: One participant requested “material on planning across multiple seasons to	Develop hands-on curriculum that connects irrigation management practices to operational and financial decisions. Include irrigation scheduling exercises, crop management strategies, financial budgeting spreadsheets, return-on-investment calculators, and multi-season water planning activities. These tools would allow

	maximize the value of water use" and tools to evaluate investment payback periods, including spreadsheets and ROI calculators.	participants to evaluate conservation strategies based on their own farming operations and long-term profitability.

Conclusion

The findings from this study indicate that to develop a successful Master Irrigator program in Kansas, a peer-driven, collaborative environment is required. The success of a Master Irrigator program in Kansas couldn't be simply defined by water reduction alone. It will be defined by the creation of producers and stakeholders who are able to create a network to continuously share knowledge and collectively implement new practices. These findings directly connect to the use of Adult Learning Theory for this study. As previously mentioned, adults bring a deep reservoir of lived experiences to their educational experiences. This aligns with the connections between survey and interview data from this study, highlighting the demand for peer-driven, collaborative learning. In addition, this highlights a direct connection to the framework through the role of prior experience and self-concept, need to know and problem orientation, and readiness to learn and intrinsic motivation (Yopp et al., 2013). The findings from both the survey and interviews further support the use of Adult Learning Theory as a framework for developing a Kansas Master Irrigator program by demonstrating that producers value educational opportunities that recognize their existing knowledge, allow them to participate in decision-making, and provide information that can be directly applied to their operations. The preferences for farmer panels and localized knowledge support Malcolm Knowles's role of prior experience within the Adult Learning Theory. Participants expressed desire to engage in a program that would increase their knowledge of practical solutions that directly address their daily operational challenges. Participants also demonstrated the need for a flexible delivery format, preferring a hybrid model (61%) over a strictly in-person model (28%). However, participants mentioned willingness for an in-person workshop during the winter off-season (January-March). This finding is both aligning and contradicting with literature, aligning with

trends of format delivery based on participant needs and contradicting as wanting a strong peer network but preferring a hybrid delivery model (Roshania et al., 2023).

The demand for peer-driven, collaborative learning reinforces prior literature on informal agricultural knowledge transfer, which emphasizes that participants rely heavily on experiential learning, peer observation, and informal networks built over generations (Šūmane et al., 2018). In addition, literature on participatory program development demonstrates that integrating local producer knowledge is essential for creating "user-useful" conservation solutions and enhancing overall program relevance and quality (Hoffman et al., 2007; Raymond et al., 2010; Reed 2008).

Participants emphasized the importance of learning from trusted and experienced irrigators. Survey findings indicate that 67% of participants preferred learning from seasoned irrigators and qualitative findings further demonstrated the value participants placed on farmer panels, localized knowledge, and peer-to-peer discussion. This directly connects to Knowles's principles of prior experience, which recognizes that adults bring knowledge and experiences into educational settings that influence how they understand and apply new information. Interview participants further emphasized this connection, with one participant explaining that "peers are the biggest tools". These findings suggest that participants may be more receptive to conservation practices when information is communicated by individuals who understand the practical realities of irrigated agriculture. Rather than relying primarily on instruction from academic or governmental experts, a Kansas Master Irrigator program could cultivate an ongoing network in which producers learn from one another, share experiences, and collectively evaluate new management strategies. This also connects to the principle of self-concept, which emphasizes that adult learners value independence and opportunities to direct their own learning.

Participants expressed the importance of developing a producer-led program, including a producer-based advisory group. By involving producers in the development and delivery of educational programming, a Kansas Master Irrigator program could recognize their existing expertise while allowing them to take an active role in determining the educational opportunities that best meet their needs. These findings align directly with research by Porter et al. (2010) and Rudick et al. (2020), which highlights that producer adoption of water-saving technology is heavily driven by social expectations, accessible communication, and dynamic, trusted engagement methods rather than traditional one-way communication. This emphasis on farmer-led advisory structures and peer networking reflects successful informal agricultural learning models reviewed in literature such as the Washington State Master Gardener “train-the-trainer" model (Chalker-Scott & Collman, 2006) and the Testing Ag Performance Solutions (TAPS) framework (Testing Ag Performance Solutions, 2025), both leveraging participant leadership and peer-to-peer hubs to expand educational reach and sustain long-tem engagement.

Secondly, participants identified the importance of connecting irrigation management practices to immediate, practical economic outcomes. Participants expressed a need for information that demonstrates how conservation practices can function within the financial and operational realities of producers. The findings on practical applications reflect the problem-centered nature of adult learning and reinforces the importance of providing educational experiences that address immediate, real-world needs. In addition, findings indicate that the success of a Master Irrigator program should not be defined primarily by immediate reductions in water use or pumping. While reductions in water use are an important long-term objective, participants emphasized the importance of developing producers who can understand, evaluate, and articulate their water-management decisions. This economic focus connects directly with

findings in the literature showing that irrigators operate within profit-motivated business environments (Fischer & Sanderson, 2022), where strategic irrigation decisions bust be based on clear production and economic evaluations of water-efficient practices (Andales et al., 2020). Because the economic impacts of groundwater depletion vary across regional cropping systems and dryland alternatives (Deines et al., 2020), producers require practical tools such as soil water monitoring, scheduling software, and multi-year flex accounts to evaluate profitability in addition to conservation (Steiner et al., 2010; Weinheimer et al., 2013).

A successful program should contribute to a long-term shift in how producers approach irrigation management, conservation, and the future of their operations. Changes in knowledge, confidence, decision-making and willingness to evaluate new practices may serve as important indicators of progress before measurable changes in water use occur. The findings from this study suggest that an effective program would create an environment where producers' existing knowledge is valued, technical information is connected to economic and operational realities, and participants are empowered to continue learning from one another. By combining experimental education, actionable economic information, and a sustained peer network, a Kansas Master Irrigator program could provide a foundation for long-term changes in irrigation decision-making and water stewardship. Recognizing program success as a long-term mindset shift rather than immediate pumping reduction reflects prior work by Adeyemi et al. (2017) and Laur et al. (2018) which emphasizes that technology alone can't resolve groundwater depletion without supporting fundamental behavior change and understanding producer decision-making drivers. This holistic perspective reflects interdisciplinary socio-ecological frameworks and regional initiatives such as the Ogallala Aquifer Program (Brauer et al., 2017) which demonstrates that sustaining the Ogallala Aquifer and other groundwater resources requires

integrating adaptive management strategies with collaborative, community-based educational structures.

Suggestions for future research is to track Master Irrigator program graduates across multiple growing seasons to assess whether participation leads to sustained shifts in operational mindset, adoption of precision irrigation technology, and measurable reductions in groundwater pumping. In addition, it is suggested that future research should explore alternative metrics of program success. This could include financial resilience, soil health improvements, and multi-season risk management to capture the social, economic, and ecological impacts of adult conservation education across the High Plains regions. Further research on established Master Irrigator programs in other states could help identify successful program elements that could be adapted to Kansas while considering differences in regional agricultural practices and water management conditions.

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Appendix A - Institutional Review Board (IRB) Approval

KANSAS STATE UNIVERSITY | Office of Research Integrity, Compliance and Security

TO: Jacqueline Aenlle
Communications & Ag Education

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

DATE: 05/21/2026

RE: Proposal #IRB-13154, entitled "Securing the Ogallala Aquifer: A Multi-State Analyses of Master Irrigator Programs to Guide Implementation."

MODIFICATION OF IRB PROTOCOL #IRB-13154, ENTITLED, "Securing the Ogallala Aquifer: A Multi-State Analyses of Master Irrigator Programs to Guide Implementation"

EXPIRATION DATE: Exempt

The Committee on Research Involving Human Subjects (IRB) has reviewed and approved the request identified above as a modification of a previously approved protocol. **Please note that the original expiration remains the same.**

All approved IRB protocols are subject to continuing review at least annually, which may include the examination of records connected with the project. Announced in-progress reviews may also be performed during the course of this approval period by a member of the Office of Research Integrity, Compliance and Security (ORICS) staff. Unanticipated adverse events involving risk to subjects or to others must be reported immediately to the Chair of the IRB, and / or the ORICS.

It is important that your human subjects activity is consistent with submissions to funding / contract entities. It is your responsibility to initiate notification procedures to any funding / contract entity of any changes in your activity that affects the use of human subjects.

Electronically signed by Lisa Rubin on 05/21/2026 3:40 PM ET

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Appendix B - Qualtrics Survey

Kansas Master Irrigator

Start of Block:

PROJECT TITLE: Securing the Ogallala Aquifer: A Stakeholder-Based Needs Assessment for Developing a Kansas Master Irrigator Program PROJECT APPROVAL DATE: April 15, 2026 LENGTH OF STUDY: The survey should take 10 minutes maximum. The focus group will take an hour and a half. PRINCIPAL INVESTIGATOR/CO-INVESTIGATOR(S): Dr. Jacquline Aenlle Wegley/ jaenlle@ksu.edu / 785-532-0991 CONTACT DETAILS FOR PROBLEMS/QUESTIONS: Grace Roth grace53@ksu.edu 620-640-1725 IRB CHAIR CONTACT INFORMATION: For the subject should he/she have questions or wish to discuss on any aspect of the research with an official of the university or the IRB. These are: Lisa Rubin, Chair, Committee on Research Involving Human Subjects, 203 Fairchild Hall, Kansas State University, Manhattan, KS 66506, (785) 532-3224, rubin@ksu.edu; Brad Woods, Associate Vice President for Research Compliance, 203 Fairchild Hall, Kansas State University, Manhattan, KS 66506, (785) 532-3224, comply@ksu.edu. PROJECT SPONSOR: None PURPOSE OF THE RESEARCH: The goal of this study is to identify key components that could inform the development of a Kansas Master Irrigator program. The Master Irrigator Program is an educational initiative for agricultural producers and industry partners, offering training in advanced water management, irrigation technology, efficiency, and economics. The Master Irrigator Program is currently offered in multiple states such as Colorado, Oklahoma, and Texas. The Kansas Water Institute is pursuing the opportunity to bring the Master Irrigator Program to Kansas. PROCEDURES OR METHODS TO BE USED: A survey distributed to producers, Groundwater Management District (GMD) leaders, and relevant stakeholders to gather input on potential program formats and curriculum topics. A follow-up group discussion based on survey responses to further refine these ideas and help guide future Master Irrigator curriculum and delivery in Kansas. Participants are able to withdraw from this at any time without penalty. RISKS OR DISCOMFORTS ANTICIPATED: Compromised confidentiality with electronic data is a possible risk or discomfort that could be faced with participation. BENEFITS ANTICIPATED: No direct benefits are associated with participation in this study. EXTENT OF CONFIDENTIALITY: Data will be stored in a secure digital/online folder only accessible to the research team. When published, data will be deidentified to the greatest extent possible and no names will be shared. Identifiers might be removed from the identifiable private information, and, after such removal, the information could be used for future research studies or distributed to another investigator for future research studies without additional informed consent. IS COMPENSATION OR MEDICAL TREATMENT AVAILABLE IF INJURY OCCURS: There will be no compensation or medical treatment available if injury occurs.

- ○ Yes, I agree to particpate (1)
- ○ No, I do not agree to participate (2)

Skip To: End of Survey If PROJECT TITLE: Securing the Ogallala Aquifer: A Stakeholder-Based Needs Assessment for Developing... = No, I do not agree to participate

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Which best describes you?

- ○ Producer (1)
- ○ GMD manager/board member (2)
- ○ State or federal agency (3)
- ○ University or community college (4)
- ○ Other (5) _____

How old are you?

- ○ 18-24 (1)
- ○ 25-34 (2)
- ○ 35-44 (3)
- ○ 45-54 (4)
- ○ 55-64 (5)
- ○ 65 or older (6)

Where are you from?

- ○ Western Kansas Groundwater Management District No. 1 (1)
- ○ Equus Beds Groundwater Management District No. 2 (2)
- ○ Southwest Kansas Groundwater Management District No. 3 (3)
- ○ Northwest Kansas Groundwater Management District No. 4 (4)

○ Big Bend Groundwater Management District No. 5 (5)

○ Other (insert city, county) (6)

_____

Page Break

what would you want out of a Kansas Master Irrigator program?

_____
_____
_____
_____
_____

What event format is most appealing to you?

○ In-person (1)

○ Online (2)

○ Hybrid (3)

○ Other (4) _____

When would you prefer to attend a Master Irrigator workshop for a workshop?

	In-person (1)	Hybrid (2)	Online (3)
January - March (1)	○	○	○
April - August (2)	○	○	○
September - December (3)	○	○	○

What time commitment would you prefer for an in-person Master Irrigator workshop?

	In-person (1)	Hybrid (2)	Online (3)
1 day (1)	○	○	○
2 day (2)	○	○	○
Ongoing/seasonal (3)	○	○	○

What session length would you prefer for an in-person or hybrid program?

- ○ Half day (1)
- ○ Full day (2)
- ○ Evening sessions (3)

Rank in preferred order (1 - most preferred, 7 - least preferred) the style of presentation would you prefer for a Master Irrigator workshop.

_____ Mostly speakers/slides (1)
_____ Some speakers/slides (2)
_____ Demonstrations (3)
_____ Breakout groups (4)
_____ Hands-on practice (5)
_____ Field tours (6)
_____ Panel discussion (7)

Page Break

Which topics would be most useful to cover during a Master Irrigator workshop? Select your top 5 choices.

- ☐ Deficit irrigation strategies (1)

- [ ] Irrigation scheduling tools (2)
- [ ] Crop selection and rotation for water efficiency (3)
- [ ] Soil health and water retention practices (4)
- [ ] Salinity and water quality management (5)
- [ ] Data based decision making (6)
- [ ] Soil moisture sensors (7)
- [ ] ET tools (8)
- [ ] Pivot system upgrades (9)
- [ ] Remote sensing and aerial imagery (10)
- [ ] Irrigation management software/apps (11)
- [ ] Regulatory requirements and water policy (12)
- [ ] Economic and cost-benefit analysis (13)
- [ ] Irrigation system design and maintenance (14)
- [ ] Click to write Choice 16 (15)
- [ ] Other (16) _____

Page Break

What engagement strategies would be most successful in increasing producer engagement in a Master Irrigator Program?

- ○ Hands-on demonstrations (1)
- ○ Field-based learning opportunities (2)
- ○ Peer-to-peer learning and discussions (3)
- ○ Interactive activities/workshops (4)
- ○ Others (5) _____

What incentives would be most desired for producers to attend a Master Irrigator workshop? Select all that apply.

- ☐ Access to tools, software, and equipment (1)
- ☐ Recognition or awards (2)
- ☐ Certification or continuing education credits (3)
- ☐ Access to cost share for technology or practices (4)
- ☐ Free registration or stipend (5)
- ☐ Other (6) _____

Select the reasons that would possibly prevent attendance for a Master Irrigator workshop?

- ☐ Time constraints (1)
- ☐ Location or travel distance (2)
- ☐ Cost/registration fees (3)

- [ ] Scheduling during farming seasons (4)
- [ ] Lack of employer support (5)
- [ ] Other (6) _____

Which outreach and marketing strategies would best promote participation in a Kansas Master Irrigator program?

- ○ Extension newsletters and mailing lists (1)
- ○ Direct outreach through country extension agents (2)
- ○ Social media (3)
- ○ Industry partners (4)
- ○ Local meetings and events (5)
- ○ Other (6) _____

Page Break

What specific speakers would you like to hear from?

_____
_____
_____
_____
_____

What additional suggestions or ideas do you have to help shape a Kansas Master Irrigator program that would be valuable and practical in your area?

_____
_____
_____
_____
_____

Would you be interested in participating in a follow-up focus group or Zoom interview to provide an opportunity to further share your perspectives? If you select "yes" please put your name and email.

○ Yes (1) _____

○ No (2)

Appendix C - Interview Questions

1. In what ways could a Master Irrigator Program in Kansas appeal to potential participants and meet their professional needs?
2. What features or qualities would help this program to stand out from others you have participated in?
3. Thinking about past workshops/programs, what made certain experiences feel more useful or meaningful than others?
4. Thinking of different workshops and conferences you have attended, what format kept you most engaged? Would shorter, more frequent sessions or fewer, longer sessions work better realistically?
5. How much does having tools and information tailored to your local or regional issues influence your willingness to consider using them?
6. If someone completed a Master Irrigator program successfully in Kansas, what changes or outcomes would you hope to see afterward?
7. What would prevent someone from participating in a program like this?
8. How would you personally measure whether this program was beneficial for you?

Glossary of Terms

Master Irrigator Program: An interactive training course for irrigators that focuses on producers, water managers, and tech service providers to encourage sustainable water management (Master, 2021).

Ogallala Aquifer: The nation's largest freshwater aquifer that is an underground mixture of silt, sand, soil, and rock that contains pores that stores water for daily needs (Nebraska Corn Board, 2018).

Groundwater Management District (GMD): Local units of government that provide water-use administration, planning, and information for each area's agricultural community members (Kansas Geological Survey, 2015).

Local Enhanced Management Area (LEMA): Tools that allow GMDs to conserve water by setting goals and control measures within their own districts (Kansas Legislative Research Department, 2022).

Producer: Any individual or entity engaged in the production and sale of agricultural commodities within the United States (US Legal Forms, 2026).

Stakeholder: An individual or group that has an interest in any decision or activity of an organization (American Society for Quality (ASQ), 2026).