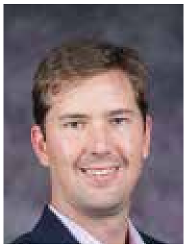
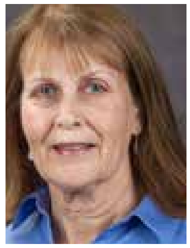
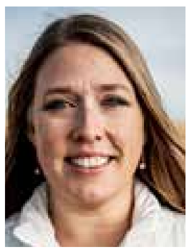
Water Management and Information Gaps in the High Plains Aquifer







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Acknowledgment

The authors acknowledge the assistance and feedback of Pat Janssen and Groundwater Management District 5. Funding for this project was provided by a Natural Resources Conservation Service Conservation Innovation grant.

Abstract

Water is a critical input to agricultural production in arid regions. Understanding irrigator perspectives and determining their information and technical needs are critical to increasing water conservation while maintaining profitable yields. This paper summarizes survey data for 140 irrigators operating in the High Plains Aquifer portion of southcentral Kansas. We document adoption of different farm management practices, key challenges facing irrigators, information gaps, and qualitative information obtained from open-ended questions. Survey response patterns are discussed in the context of local water use conflicts and water governance.

INTRODUCTION

Groundwater is fundamental to crop production in arid geographies such as the Great Plains region of the United States. Approximately 60% of all irrigated agricultural land in the United States is irrigated from groundwater (Siebert et al., 2010). The High Plains Aquifer (HPA) in Kansas provides water for approximately 2.6 million acres of irrigated land annually (Kansas Department of Agriculture, 2017). Using the relative difference between irrigated and non-irrigated land values, Sampson, et al. (2023) estimate that agricultural land values in Kansas are $3.8 billion greater today due to access to irrigation water from the HPA. However, decades of pumping that exceed the rate of aquifer recharge has led to predictions that future irrigated crop production over some areas of the HPA will not be possible without changes to groundwater management (Haacker et al., 2016).

This paper summarizes information on irrigation and water management practices obtained from survey responses of 140 irrigators located in southcentral

Kansas (Figure 1). We document different elements of irrigation technology adoption and outcomes, conservation practice adoption and outcomes, key challenges facing irrigators, and current information gaps perceived as impeding irrigation management and agricultural production. Additionally, we document qualitative data collected through open-ended survey questions aimed at improving current and future irrigation programs.

BACKGROUND

Irrigation in Kansas is governed by prior appropriation rights first established by the Water Appropriation Act of 1945. Under this act, any producer seeking to use groundwater for irrigated production must first file a water use application with the Division of Water Resources (DWR). If the application is approved, the water-using entity is granted a water right that places limitations on the well location, where the water may be applied (i.e., the place of use), the annual volume of water that may be pumped, the number of acres that may be irrigated, and the priority date (i.e., seniority ranking).

The Kansas legislature authorized the Groundwater Management District Act in 1972, which led to the formation of five Groundwater Management Districts (GMDs). These districts have the power to set local water governance across the district's irrigators subject to approval of the DWR. GMD 5 is in southcentral Kansas, spans eight counties, and is the context of our mail survey (Figure 1). Total annual water use and irrigated acreage for GMD 5 averages around 500,000 acre-ft and 450,000 acres, respectively. GMD 5 is the second largest GMD in Kansas in terms of total annual water use and irrigated acreage.

Kansas requires annual water use reporting for all irrigators. The irrigation and cropping data are made publicly available through the Water Information Management and Analysis System (WIMAS) of the DWR. We summarize this data for GMD 5 below. One challenge to interpreting the WIMAS data is that two or more water rights may spatially overlap in the location of the well or the place of use (Earnhart and Hendricks, 2023). Due to this potential overlap, we choose to aggregate water use data up to the level of a "water right group," which is defined by the smallest legal combination of well location and place of use such that no two water right groups overlap. Each water right group thus provides information to a common farming operation.

Panel A of Table 1 summarizes water use and cropping data for all 3,358 active water right groups located in GMD 5 for the years 2000-2019. On average, a single water right group uses about 143 acre-ft of water per year and irrigates 137 total acres with an average water application depth of 12.5 inches. Corn and soybean are the two most commonly irrigated cash crops. The average number of irrigated corn and soybean acres is 67 and 26, respectively. Cropping practices in southcentral Kansas commonly involve a rotation, which explains why the average crop-specific acreage is lower than the average total irrigated acreage.[1]

There are 1,148 registered holders of agricultural water rights in GMD 5. We refer to these entities as water use correspondents because they are responsible for filing annual water use reports with the DWR. Taken together, the total number of water right groups in GMD 5 with the total number of water use correspondents in GMD 5 suggests that approximately three water right groups are registered to each water use correspondent, on average (i.e., 3,358/1,148). Using this information together with panel A of Table 1 implies that each correspondent in GMD 5 operates approximately 402 irrigated acres per year and uses approximately 432 acre-ft of water per year. By comparison, the average number of acres irrigated from groundwater and the total amount of groundwater used per farm in the U.S. in 2018 was approximately 323 acres and 371 acre-ft, respectively (United States Department of Agriculture, 2019).

Our study region, GMD 5, has two notable water conflicts that are likely to influence irrigator perceptions of water use challenges. In 2013, the U.S. Fish and Wildlife Service (USFWS) filed a water use impairment against nearby irrigators holding junior water rights. The USFWS holds a senior surface water right to Rattlesnake Creek, which is used to flood wetland habitat in Quivira National Wildlife Refuge. USFWS argues that junior irrigators in GMD 5 are reducing streamflow in Rattlesnake Creek via hydrologic connections to the aquifer and thus affecting USFWS's ability to pump their water allocation into the wetland. The Chief Engineer of the DWR concluded that an impairment existed. Several years of negotiation between irrigators and USFWS ensued. Dissatisfied with proposed water management plans that emerged from negotiations, the USFWS in 2023 requested secure water in the amount of 14,632 acre-ft per year. The issue is still in dispute, and there is warranted concern about a resolution requiring water curtailments for nearby junior water rights holders, as has occurred elsewhere in Kansas.

The Walnut Creek Intensive Groundwater Use Control Area (IGUCA) was established in the northwestern region of GMD 5 in 1992 because of conflict between senior surface water rights to Walnut Creek streamflow and junior groundwater irrigators. Walnut Creek supplies water to Cheyenne Bottoms Wildlife Area. Under the IGUCA, groundwater irrigators were forced to curtail their annual water use to support long-term sustainable use of the aquifer. Water rights are divided by priority dates before and after October 1, 1965. Water rights with a priority date prior to October 1, 1965, had water allocations curtailed to 12-14 inches/acre, or about the net irrigation requirements for corn in the region. Water rights with a priority date after October 1, 1965, were required to curtail their usage an additional 60% (about 5-6 inches/acre). Irrigators with post October 1, 1965 priority dates responded to IGUCA water curtailments by reducing the number of acres they irrigate by an average of 26% (Earnhart and Hendricks, 2023).

METHODS

Names and mailing addresses were obtained from DWR water use reports for all 1,148 water rights holders in GMD 5 who were the recipients of our mail survey. A pre-survey postcard notifying recipients of the survey and its purpose was mailed on January 24, 2023, followed by the full survey on January 31, 2023, which included business reply envelopes. The survey contained 18 questions on irrigation practices, outcomes, information gaps, concerns over future irrigation viability, and space to provide qualitative feedback for the implementation of future irrigation programs. All aspects of the survey were reviewed and approved by the Kansas State University Institutional Review Board prior to data collection. Survey responses were anonymized and hand-entered into Qualtrics survey software for aggregation and then downloaded into a spreadsheet for analysis

RESULTS

Four surveys were returned as blank, and a total of 140 surveys were returned at least partially completed, for a response rate of 12%.[1] The remainder of this paper details the information provided in the mail survey. We organize the survey results into sections, starting with factors influencing irrigator decisions to adopt a new technology or conservation practice.

Demographics

A wide range of ages were represented in the survey responses (Figure 2). The youngest and oldest age ranges represented were 30-39 years and above 80 years, respectively. Approximately half of the sample indicated an age range of either 50-69 or 60-69 years. Approximately 10% of the sample indicated an age younger than 50 years, and approximately 40% of the sample indicated an age range of 70 years or older. By comparison, the 2017 USDA Agricultural Census indicated that 34% of US farm producers were 65 years or older while 36% of all Kansas producers were 65 years or older (United States Department of Agriculture, 2019).

Adoption of New Technologies/ Practices

We summarize in Panel B of Table 1 the frequency of different irrigation technologies currently being used by the survey respondents. Nearly 90% of respondents use crop consultants and nearly two-thirds use remote pivot monitoring. Approximately one-third of respondents use soil moisture probes, and less than one-third use aerial imagery or other forms of remote sensing technology, variable frequency drives, variable rate irrigation speed control, or rain sensors.

We included in the survey a series of questions related to the various motivations leading an irrigator to adopt new technologies/practices or barriers to the adoption of technologies/practices. We asked irrigators to identify the three most important considerations when choosing to make changes to their irrigation or cropping system (Panel A, Table 2). The three most frequently chosen considerations were the potential for increased income generation (78%), need for greater irrigation efficiency (69%), and availability of farm labor (34%). Sampson and Perry (2019) documented the importance of peer networks in the diffusion of irrigation technologies in Kansas. Consistent with this research, we observed that positive or negative experiences of peers was chosen by 29% of respondents.

When asked to identify the three most important barriers to implementing a new irrigation technology or practice, the most frequently chosen was the cost associated with the new technology or necessary equipment upgrade (83%) (Panel B, Table 2). The second most frequently indicated barrier was the need to maintain historical water use to protect against potential future allocation reductions (39%). As previously discussed, curtailing water allocations as a proportion of historical water use (as opposed to the maximum permitted amount) is one method the DWR uses to manage water conflict. Curtailing based on historic use is viewed by some respondents as unjustly punitive toward irrigators who have been voluntarily conserving by using amounts below the permitted maximum. The third most frequently indicated barrier was lack of available financial information on return-on-investment (32%). Approximately one-quarter of respondents indicated a lack of user-friendly cost-share programs or, on leased land, where landowners are unwilling to invest in the new technology/practice. Nearly half the farmland in Kansas is leased (Bigelow et al., 2016), and landlords typically own the irrigation equipment (Tsoodle and Li, 2022).

We dedicated a few questions to conservation practices, the results of which we document in Tables 3 and 4. Over three-quarters of respondents currently practice no-till or reduced-till farming (Panel A, Table 3), and more than half of respondents currently practice cover cropping, with approximately one-third practicing conservation crop rotations or livestock integration. Numerous respondents noted in comments that they have been practicing no-till and cover cropping for well over five years, which is consistent with previous surveys of Kansas producers, indicating widespread implementation of no-till and cover crops. Using a survey of 237 producers across Kansas, Canales et al. (2024) found that 62% had some prior adoption of continuous no-till and 34% had some prior adoption of cover crops. Using a survey of 429 landowners in central and western Kansas, Gardner (2022) found that approximately 80% had some prior adoption of no-till and 30% had some prior adoption of cover crops.

For respondents who had implemented a conservation practice within the past five years, we asked them to identify the environmental outcomes that have been observed post-implementation (Panel B, Table 3). The most frequently indicated outcome was reduced soil erosion (64%), followed by improved water utilization (51%). Over one-third of respondents indicated higher crop yields, improved soil water holding capacity, and improved soil moisture during field preparation or planting.

Respondents who are currently implementing a conservation practice were also asked to indicate their top three reasons for implementing the practice (Table 4). There were four reasons that were indicated at high frequency: to improve production efficiency (56%), to improve soil health or to reduce soil erosion (54%), to increase profitability (53%), and to reduce input costs (52%)[3]. Other reasons that were frequently indicated were in response to weather patterns or risks (29%), to reduce labor costs (27%), and to increase long-run sustainability (26%). Only 2% of respondents indicated implementing a conservation practice as part of a carbon sequestration contract. While the number of carbon credit programs has grown in recent years (Wongpiyabovorn et al., 2023), our results indicate that carbon contracts are not widely utilized in Kansas, nor do they serve as important motivation for implementing new conservation practices. Moreover, producers must typically implement a new conservation practice to qualify for carbon credit programs—a requirement known as additionality (Wongpiyabovorn et al., 2023). If already implemented on the farm, no-till or cover cropping would not count as a qualifying practice in generating carbon credits. Given that no-till and cover cropping already has widespread implementation in Kansas, the scope for participating in carbon credit programs may be limited.

Concerns and Challenges for Irrigation in the Future

We included two questions in the survey to collect information on the key concerns and challenges facing irrigators. We asked irrigators to identify their top three concerns regarding the future of collective irrigation within GMD 5 (Panel A, Table 5). The concern indicated with most frequency by far was regulatory uncertainty, including concerns about reduced water allocations. Again, two prominent water conflicts have occurred in GMD 5 between senior surface water rights and junior groundwater rights. Our findings provide evidence that regulatory uncertainty is almost unanimously viewed by irrigators as one of the most salient concerns for the future of irrigation. The second most frequently indicated concern was insufficient pumping capacities or lack of water in the aquifer (54%). Pumping capacity is defined as the upper limit on the volumetric rate of water withdrawal and is correlated with saturated thickness of the aquifer (i.e., stocks of water). Declining saturated thickness generally correlates with decreases in pumping capacity (Foster et al., 2015). One respondent provided a note that his single irrigation well had declined in pumping capacity from 2,000 gallons per minute when it was first drilled in 1969 to less than 700 gallons per minute currently. Over one-quarter of respondents indicated lack of farm labor or low water quality as one of the top three concerns regarding the future of irrigation. Water quality in GMD 5 is deteriorated by intrusions of brackish water from oil well drilling or from saline surface waters such as the Arkansas River (Whittemore, 2000). Additionally, rapid groundwater withdrawals can trigger upward movement of saline water that is present in the underlying hydrogeologic formation (Ma et al., 1997). Our result is consistent with Gardner et al. (2021), which found that over 20% of sampled irrigators in southcentral and southwest Kansas reported either "moderate" or "major" impacts of low groundwater quality on their crop yields.

Irrigators were also asked to indicate the top three challenges personally facing them. Whereas the previous question was designed to gather information on factors presenting collective challenge to irrigation within GMD 5, this question was designed to gather information on challenges specific to each respondent. Over 70% of respondents indicated that increased drought was a challenge to irrigated production (Panel B, Table 5). Over half of respondents also indicated uncertainty about future water allocations, suggesting that irrigators view regulatory uncertainty as a regional problem that is likely to present future difficulties, even though it might not directly threaten the individual respondent. Over half of respondents indicated power costs associated with operating their pump plants as a challenge to irrigation[4]. Roughly one-third of respondents indicated an aging irrigation system or limited water allocations. Salinity or other water quality problems was indicated by 15% of irrigators.

Information Provision and Information Gaps

Our survey concluded with a series of questions designed to collect information on key information gaps currently impacting irrigators and the ways in which researchers, university extension, and government agencies might better provide services deemed useful to irrigators.

We included an open-ended question of what irrigators wished that researchers, university extension, GMD managers, and state and federal government agency staff would consider when planning irrigation outreach and programs. Respondents were provided one and one-half pages of writing space to provide their feedback, and we received written feedback from 66 respondents. We organize the responses into major themes to summarize the information along with some salient quotes.

Approximately one-third of the responses touched on the value of flexibility when water use curtailments are implemented in response to water use conflict. For instance, a flexible curtailment might involve a five-year ceiling on water use with carryover between years such that more water could be used in dry years and less water could be used in wet years. This type of flexibility is built into current and proposed Local Enhanced Management Areas (LEMAs) in GMDs 1 and 4. Seven responses focused on compliance burdens associated with state or local water governance. Six responses detailed how agencies need to do a better job of understanding "on the ground" consequences of water governance. Another six responses argued that controls on woody encroachment should be part of the solution to water management. Plant species such as eastern red cedar are expanding beyond their historic range in Kansas and can reduce available water and disrupt grassland ecosystem function (Zou et al., 2018). Another five responses were critical of the use of end guns, which are large sprinklers set at the end of a center pivot and are used to reach portions of the field not directly accessible by the pivot, such as field corners. However, end guns are viewed as inefficient because they do not apply water to a uniform depth and require greater pressure to operate. A bill introduced into the Kansas legislature in 2018 would have allowed the DWR to regulate the use of end guns, but the bill did not pass through committee. End gun removal and regulation is currently authorized through the formation of IGUCAs and LEMAs.

Below we include three salient quotes from the survey:

> *"The implementation of more rules and regulations increases the workload and becomes worrisome if you have government agencies slapping fines or penalties for what they consider negligence. This is not always the case, sometimes it is too many rules that confuse the farmer when he is the busiest."*

> *"Flexibility should be the first consideration in any of the plans going forward. We will have to have clear goals or benchmarks to work towards, however, how we get there can look several different ways. Making sure each operation knows the goal, and is given the flexibility to reach it, will allow the most positive outcome."*

> *"I believe it should be a very high priority for those who make these decisions to avoid putting a high economic burden on irrigators. Rather than simply reducing allocations, I would propose 'rewarding' irrigators for efficiency and other conservation practices. We farmers are very good at improvising effective solutions. Set us a target of some sort and let us try to hit it."*

We next discuss three questions focused on key information gaps impacting irrigators. We asked irrigators to indicate the three pieces of information most needed to improve irrigation management (Panel A, Table 6). Just under one-half of respondents indicated information on the benefits of conservation practices, such as reduced tillage or cover crops, information on determining whether upgrades to pumping plant and irrigation systems were needed to maximize efficiency, or information on the selection and use of remote sensors to aid in irrigation decisions. Approximately one-third of respondents indicated that interpretation of existing agency program availability/eligibility or information on the selection and use of irrigation scheduling software would be helpful.

For livestock producers, we asked respondents to indicate their top three pieces of information that would improve livestock production on irrigated ground (Panel B, Table 6). Over one-third of respondents indicated comparison of livestock to crop production returns, managing livestock impact on soil conditions such as compaction, or selecting forage varieties. Approximately one-quarter of respondents indicated "other" or managing grazing considerations, such as duration and timing. Somewhat surprisingly, less than one-fifth of respondents indicated information on finding cost-share programs or the selection of water sources.

We also asked how crop consultants might improve their water application recommendations (Table 7). Over half of respondents indicated crop consultants could improve recommendations by reducing reliance on maximum water application to achieve yield goals. Within the Walnut Creek IGUCA in GMD 5, some water allocations were curtailed to 5-6 inches/acre, which is generally not adequate to meet net irrigation requirement of corn. Thus, information on how to achieve profitable yields with limited water is of value to irrigators.

Just under half of respondents indicated considerations for times when their permitted annual water allocation is spent before the end of the irrigation season (i.e., end-of-water). Over one-third of respondents indicated improving consultant skills through ongoing agronomic or irrigation training and by including the contribution of rainfall to estimated crop water needs. However, it should be noted that there were numerous written comments accompanying this question indicating that the respondent's crop consultant was already performing adequately with respect to each factor listed.

Lastly, we asked respondents to indicate their top five sources of reliable information for irrigation decisions and crop management (Table 8). It is not surprising that agronomists and crop consultants were the sources of reliable information indicated with the most frequency (78%). There is a financial relationship between crop consultant and producer, so it makes intuitive sense that the producer would value information delivered by the consultant. The second most frequently indicated source of information was the respondent's own experience or education (57%). Over one-third of respondents indicated peer producers, local irrigation organizations, or GMD 5. Less than one-quarter of respondents indicated university extension or Natural Resource Conservation Service as reliable sources of information. Industry trade groups such as the Kansas Corn Growers Association and state agencies such as the Kansas Department of Agriculture were selected by fewer than 10% of respondents.

SUMMARY AND CONCLUSIONS

This paper summarizes survey data for 140 irrigators in a water-stressed region of southcentral Kansas. Two local water use conflicts between senior surface rights and junior groundwater rights contextualize the regulatory challenges encountered by irrigators. One region of the study area (Walnut Creek IGUCA) implemented annual water use cutbacks that were differentiated by water right seniority. Water rights granted after October 1, 1965, had their annual allocations cut to 5-6 inches/acre within the IGUCA. Elsewhere in the study area, irrigators and the USFWS are engaged in a water dispute that has yet to be resolved.

Survey respondents near unanimously viewed regulatory uncertainty, including the risk of reduced allocations, as a top concern confronting the future of irrigation in the region. Drought, energy costs associated with operating pumping plants, and reduced pumping capacities were also highly cited as irrigation challenges and concerns. Crop consultants, the producer's own past experiences, and peer producers ranked the highest in terms of reliable provision of information. Equipment dealers, trade groups, and state agencies (including the DWR) ranked the lowest in terms of reliability. Respondent data on sources of reliable information coupled with written comments provided in the survey are indicative of general skepticism of state government dissemination of groundwater information.

It is almost certain that changes to groundwater management will be necessary to prolong the useful life of the aquifer (Haacker et al., 2016). Respondent feedback highlights that irrigators most value flexibility and incentive-based approaches to achieving water conservation. Policies designed to curtail water allocations based on a proportion of historic use are generally viewed as punitive toward irrigators who have actively applied water conservation practices. This type of policy can have unintended consequences as irrigators are forced to use their entire allocation or suffer reductions in their allocated water, discouraging conservation.

Lastly, it is worth noting some caveats to the survey information. First, a portion of the survey area is experiencing an unresolved water right conflict. Information provided by irrigators involved in this conflict may not be entirely representative of irrigators in other parts of Kansas or other plains states where water use conflicts are less of an issue. Secondly, we did not collect any demographic information apart from age. Thus, we cannot speak specifically to the representativeness of the survey sample with respect to certain demographic characteristics.

FOOTNOTES

1. The WIMAS data do not indicate crops grown as a single crop versus a second crop. However, irrigated double cropping in Kansas is limited (Kansas Department of Agriculture, 2017).
2. The survey response rate is similar to other mail surveys targeted to Kansas irrigators (Gardner et al., 2021; Perez-Quesada and Hendricks, 2021).
3. Separate options for profitability and input costs were included to account for the possibility that a conservation practice might jointly affect costs and revenue.
4. Irrigation pumping stations in Kansas are powered by natural gas, diesel, or electricity (Sampson and Perry, 2019). We did not include a question specific to the respondent's energy source.

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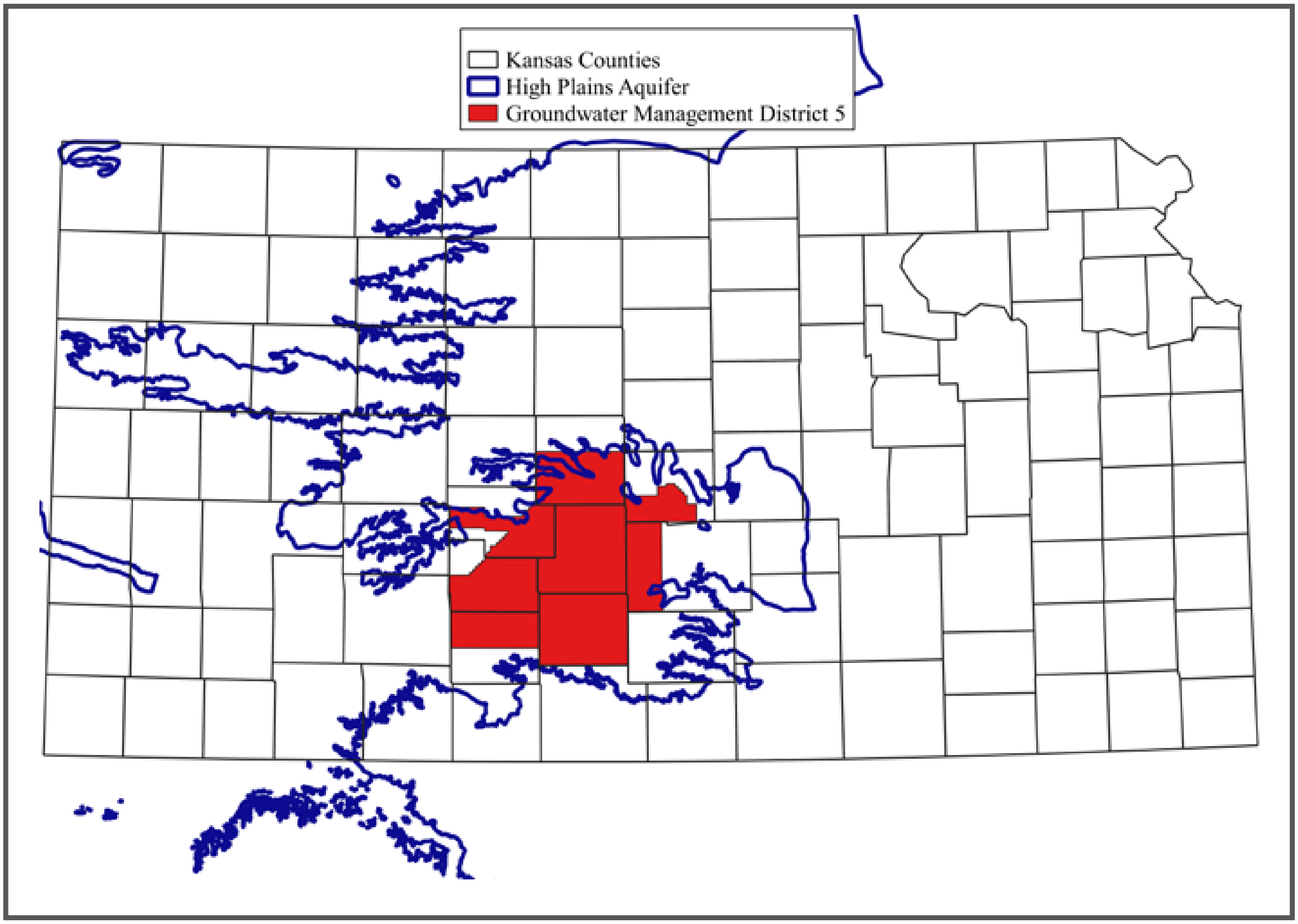

Figure 1. Location of GMD 5 in Kansas, the region covered by the mail survey

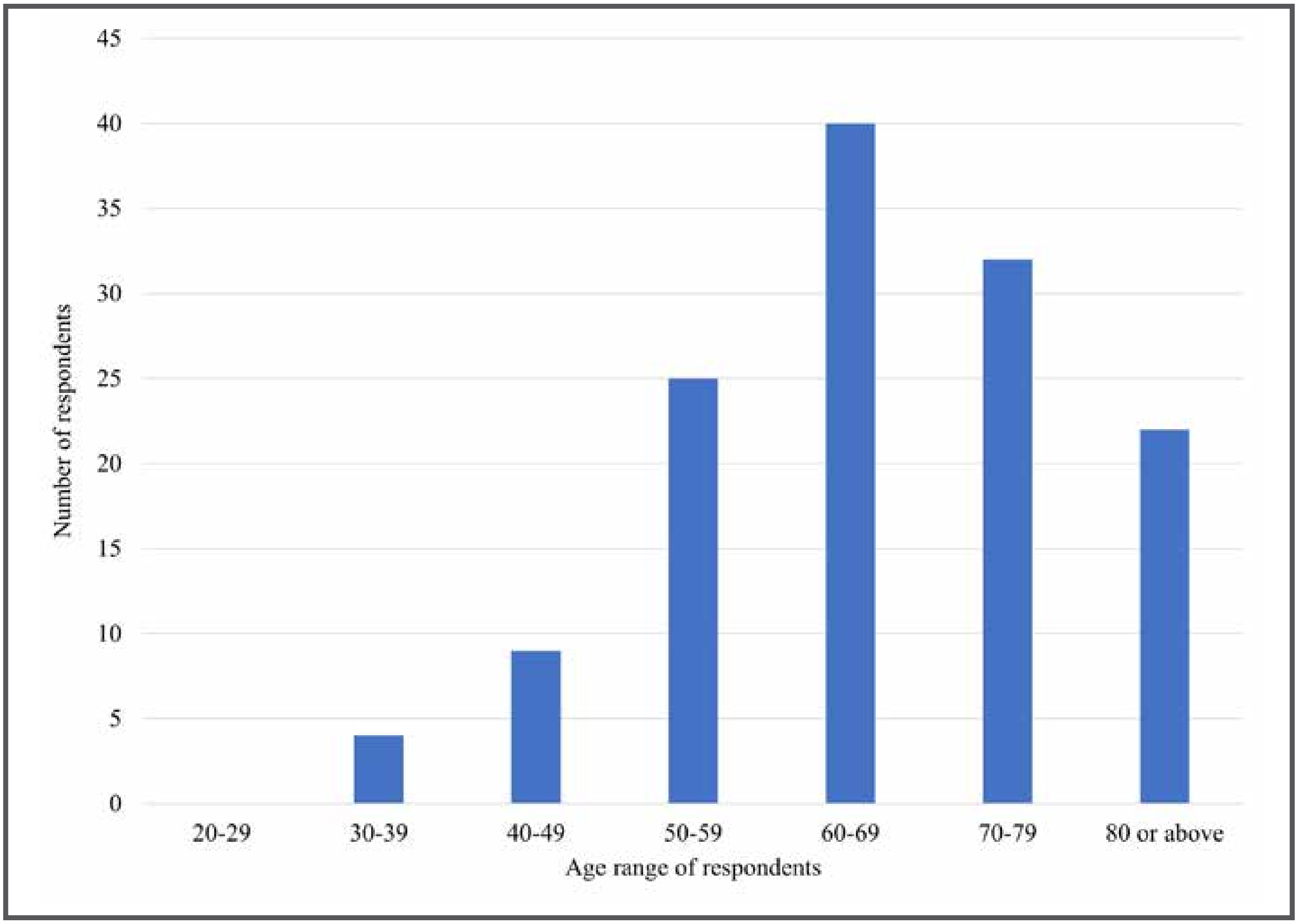

Figure 2. Distribution of age range for survey respondents (source: original data collection from survey of 140 irrigators in GMD 5)

Table 1. Water Use Characteristics for GMD 5 (Panel A) and Technology Use of Survey Respondents (Panel B)

Panel A: GMD 5 water use	n	Mean (Std. D)
Total water use (acre-ft)	65,198	147.3 (83.32)
Total irrigated acreage	65,198	137.28 (64.50)
Corn irrigated acreage	65,198	66.98 (71.63)
Soybean irrigated acreage	65,198	26.19 (51.76)
Panel B: Survey respondent technology use	**n**	**%**
Crop consultants	116	87.2%
Remote pivot monitoring	84	63.2%
Soil moisture probes	46	34.6%
Aerial imagery or other remote monitoring	37	27.8%
Variable frequency (Hz) drives	34	25.6%
Variable rate irrigation-speed control	24	18.0%
Rain sensors	18	13.5%
Other	15	11.3%
Irrigation scheduling software (e.g., KanSched, CropFlex, etc.)	14	10.5%

(Source: WIMAS (Panel A) and original data collection from survey of 140 irrigators in GMD 5 (Panel B))

Note: Panel A is averaged over all water right groups in GMD 5 for 2000-2019.

Table 2. Most Important Considerations When Adopting New Irrigation/Cropping System (Panel A) and Top Barriers to New Technology Adoption (Panel B)

Panel A: Most important considerations when adopting new irrigation/cropping system	n	%
Potential for increased income generation	102	77.9%
Need for greater irrigation efficiency	90	68.7%
Availability of farm labor	45	34.4%
Positive or negative experiences of peers	38	29.0%
Availability of new farm management information	27	20.6%
Agreements with farm management team (i.e., siblings, landlords, etc.)	24	18.3%
Availability of farm equipment	22	16.8%
Other	13	9.9%
Panel B: Top barriers to adoption	**n**	**%**
Cost of new technologies or equipment upgrades	108	83.1%
Maintaining historical water use to protect against future allocation reductions	51	39.2%
Lack of financial information on return-on-investment	42	32.3%
Lack of user-friendly cost-share programs or crop insurance requirements	36	27.7%
Landowners unwilling to invest in new technologies	31	23.8%
Lack of available training or information on new technologies/practices	24	18.5%
Previous negative experiences by yourself or peers	19	14.6%
Other	14	10.8%
Lack of engagement/information from crop consultants	12	9.2%
Generational disputes over new practices	8	6.2%

(Source: original data collection from survey of 140 irrigators in GMD 5)

Table 3. Conservation Practice Implementation and Outcomes		
Panel A: Conservation practices implemented in past 5 years	**n**	**%**
No-till or reduced-till	98	77.2%
Cover crops	68	53.5%
Conservation crop rotations	48	37.8%
Livestock integration	43	33.9%
Other	21	16.5%
Panel B: Conservation practice outcomes	**n**	**%**
Reduced soil erosion	79	64.2%
Improved water utilization	63	51.2%
Higher crop yields	53	43.1%
Improved soil water holding capacity	51	41.5%
Improved soil moisture during field prep or planting	51	41.5%
Higher water infiltration rates	46	37.4%
None	7	5.7%
Other	4	3.3%

(Source: original data collection from survey of 140 irrigators in GMD 5)

Table 4. Top Reasons for Implementing Conservation Practices		
	n	**%**
Improve production efficiency	69	55.6%
Improve soil health or reduce soil erosion	67	54.0%
Increase profitability	66	53.2%
Reduce input costs	65	52.4%
Response to weather patterns or weather-related production risks	36	29.0%
Reduce labor costs	33	26.6%
Increase long-run sustainability	32	25.8%
Increase nutrient efficiency	27	21.8%
Other	7	5.6%
As part of carbon sequestration contract	3	2.4%

(Source: original data collection from survey of 140 irrigators in GMD 5)

Table 5. Top Concerns and Challenges to Irrigation		
Panel A: Top concerns for future of irrigation in GMD 5	**n**	**%**
Regulatory uncertainty, including concerns about reduced allocations	125	93.3%
Insufficient pumping capacities or lack of water in the aquifer	72	53.7%
Lack of farm labor	37	27.6%
Low water quality	35	26.1%
Lack of technical support/expertise	32	23.9%
Other	20	14.9%
Panel B: Top irrigation challenges facing the respondent	**n**	**%**
Reduced rainfall, increased drought	95	70.9%
Uncertainty about future water allocations	77	57.5%
Power costs	68	50.7%
Aging irrigation system (including pump and well)	45	33.6%
Limited water allocations	42	31.3%
Salinity or other water quality problems	20	14.9%
Limited farm labor availability	18	13.4%
Data burdens and excessive data reporting requirements	15	11.2%
Succession planning	8	6.0%
Other	7	5.2%
Limited farm equipment availability	5	3.7%
Lack of cell service for monitoring and pivot operation	2	1.5%

(Source: original data collection from survey of 140 irrigators in GMD 5)

Table 6. Most Useful Information for Improved Irrigation Management (Panel A) and Livestock Production on Irrigated Ground (Panel B)

Panel A: Information most helpful to improved irrigation management	n	%
Benefits of reduced tillage, cover crops, and other soil conservation practices	61	49.2%
Evaluation of pumping plant and irrigation system to determine if upgrades are needed for maximum efficiency	58	46.8%
Selection and use of remote sensors to aid in irrigation decisions	57	46.0%
Interpretation of existing agency program availability and eligibility	46	37.1%
Selection and use of irrigation scheduling software and applying recommendations	39	31.5%
Utilization of data from pivot monitors to track performance and operation	27	21.8%
Other	15	12.1%
How/where to obtain employee training on any/all of the above topics	11	8.9%
Panel B: Information most useful to livestock production	**n**	**%**
Comparison of livestock to crop production returns	40	38.5%
Managing livestock impact on soil (compaction, manure, etc.)	39	37.5%
Selecting forage varieties	36	34.6%
Other	28	26.9%
Managing grazing (duration, timing, species, etc.)	26	25.0%
Finding or participating in water banking programs	22	21.2%
Managing forage production (water application, timing, amounts)	20	19.2%
Finding cost-share programs for establishment of perennial grasses	16	15.4%
Selecting water sources for livestock	13	12.5%
Managing livestock performance (animal care, etc.)	5	4.8%

(Source: original data collection from survey of 140 irrigators in GMD 5)

Table 7. Factors that Would Improve Crop Consultant Recommendations

	n	%
Reduce reliance on maximum water applications to achieve yield	66	54.1%
Include consideration of end-of-water allocations for the field	56	45.9%
Update and improve consultant skills through ongoing agronomic and irrigation training	52	42.6%
Include contribution of rainfall to estimated crop water needs	42	34.4%
Increased awareness of opportunities for water carryover between seasons	36	29.5%
Update and adjust soil moisture and water recommendations on more frequent basis	31	25.4%
Other	16	13.1%

(Source: original data collection from survey of 140 irrigators in GMD 5)

Table 8. Most Reliable Sources of Information	n	%
Agronomists or crop consultants	101	77.7%
Your own previous experience or education	74	56.9%
Peer producers in your area	58	44.6%
Local and regional irrigation organizations (e.g., WaterPACK)	55	42.3%
GMD #5	54	41.5%
Extension	30	23.1%
Farm publications	30	23.1%
NRCS	25	19.2%
Equipment dealers and other ag businesses (including their websites)	20	15.4%
Ag industry trade groups	10	7.7%
State agencies	10	7.7%
Other	7	5.4%

(Source: original data collection from survey of 140 irrigators in GMD 5)