Universities Council on Water Resources
Journal of Contemporary Water Research & Education
Issue 178, Pages 60-70, August 2023

Producer Perceptions on the Value and Availability of Water for Irrigation in the Mississippi Delta

*Gurpreet Kaur[1], Nicolas E. Quintana Ashwell[2], Gurbir Singh[1], Drew Gholson[2], Martin A. Locke[3], L.J. Krutz[4], and Trey Cooke[5]

[1]*Northern Missouri Research, Extension, and Education Center, University of Missouri, Novelty, Missouri, USA*
[2]*National Center for Alluvial Aquifer Research, Mississippi State University, Stoneville, Mississippi, USA*
[3]*National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, Mississippi, USA*
[4]*Water Resources Research Institute, Mississippi State University, Mississippi State, Mississippi, USA*
[5]*Mississippi River Basin Program, The Nature Conservancy, Cleveland, Mississippi, USA*
**Corresponding Author*

Abstract: The agricultural production in the Mississippi Delta is threatened by the water level declines in the Mississippi River Valley Alluvial Aquifer (MRVAA). This study assesses the growers' perceptions of the value and availability of water for irrigation based on data collected in a survey in 2012 in the Delta region of Mississippi, USA. The total cooperation rate for this survey was 79.3%. The results showed that 97.39% (448 out of 460) of respondents believed that water is important for farming in the Delta region of the MRVAA. Fifty-two percent of the survey respondents agreed that the major cause of groundwater depletion is agricultural irrigation water use. More than 50% of the survey respondents believed there is sufficient water in the Delta region, but it is not managed properly. The value of water for irrigation ranged from $463 to $690 per ha for corn (*Zea mays* L.), $399 to $615 per ha for soybean (*Glycine max* L.), and $223 to $336 per ha for cotton (*Gossypium hirsutum* L.). The majority of the respondents considered that there is a need for regulation of water use to protect the aquifer and ensure water availability in the future.

Keywords: *water crisis, water shortage, groundwater depletion, regulations*

Agriculture is the leading industry in Mississippi. Major crops grown in Mississippi are soybean, corn, cotton, rice *(Oryza sativa L.),* sweet potatoes *(Ipomoea batatas),* peanuts *(Arachis hypogaea)*, wheat *(Triticum aestivum* L.*),* and grain sorghum (*Sorghum bicolor*). About 80% of row crop production in Mississippi occurs in the north-western portion of the state known as the Delta region. The Delta region occupies more than 1.6 million ha and is one of the most productive agricultural areas in the United States (Snipes et al. 2005; Kebede et al. 2014). The Mississippi Delta region has 220 to 260 frost-free days per year and has deep alluvial soils developed over time through deposition from seasonal flooding of the Mississippi River and its tributaries (Snipes et al. 2005). The Delta soils vary widely in texture, ranging from a coarser sandy texture to finer clayey textured soils which swell when wet and shrink when dry (locally referred to as gumbo or buckshot) (Snipes et al. 2005). The soils are low in organic matter and most of the coarse-textured soils (sandy loam, silty loam) are compacted due to heavy equipment traffic, resulting in poor water infiltration and more water runoff. Drainage and proper soil management are critical for optimum crop production in the Delta region.

The Mississippi Delta receives an annual average rainfall of about 1143 mm in the northern Delta to about 1524 mm in the southern Delta (Snipes et al. 2005). About 70% of the annual rainfall in the Mississippi Delta is received during the off-season from September to April (Snipes et al. 2005; Kebede et al. 2014), making the agricultural fields more prone to erosion losses during the winter and

Research Implications

- Water withdrawals at unsustainable rates result in declining groundwater levels in the Mississippi River Valley Alluvial Aquifer.
- Irrigation is important for agriculture in the Mississippi Delta region, but most respondents anticipate future water shortage in the central Delta region.
- Water availability for irrigation in the future might be ensured by regulations on water pumping.

early spring months. The remaining 30% of rainfall is received from May to August, resulting in brief in-season periods of drought that can negatively impact crop production and farm profitability. Therefore, the producers in the Mississippi Delta rely heavily on irrigation to achieve profitable yields due to the uncertainty of rainfall during the summer months when crops are at their peak water demand (Snipes et al. 2005; Kebede et al. 2014).

The main source of irrigation water supply in this region is the Mississippi River Valley Alluvial Aquifer (MRVAA) (Wax et al. 2008). The MRVAA covers an area of 82,879 km^2 and irrigates over 700,000 hectares of row crops in the Mississippi Delta region (Wax et al. 2008; Massey 2010). Higher volume of water pumping for irrigation than the rate of recharge has resulted in a water level decline in the MRVAA (Wax et al. 2008; Marston et al. 2015). Ongoing water-level declines in the MRVAA and the current inefficient and unsustainable crop production and irrigation management practices in the Mississippi Delta jeopardize the long-term water availability from the MRVAA for fulfilling the demand for irrigation. Therefore, there is an urgent need for the development and adoption of improved crop and water management practices to conserve water and contribute to aquifer recharge. However, the adoption of management practices depends upon farmers' perceptions and knowledge about their water issues. In Mississippi, all wells drilled with a casing diameter of six inches or greater are required by law to have a permit which is valid for five years (YMD 2013). The permitting process was started in 1985 by the Department of Environmental Quality. Beginning in 1993, all new agricultural permits in the Mississippi Delta were processed by the Yazoo Mississippi Delta Joint Water Management District. About 80% of the water use permits are in the Delta region in Mississippi.

The first step in solving a problem is to recognize that the problem exists. Therefore, it is important to assess the perceptions of producers on irrigation water availability and its value in the Mississippi Delta. The objective of this paper is to determine the value of water and the perceptions of the farmers on water-related issues in the Mississippi Delta region based on unpublished data from the 2012 Mississippi Irrigation survey (Mississippi State University's Survey Research laboratory). Documenting historic perceptions regarding the value and availability of groundwater for irrigation would facilitate an understanding of the current status and anticipate future groundwater management challenges.

Materials and Methods

A survey was conducted by the Mississippi State University's Survey Research laboratory from November to December 2012 to assess the Mississippi Delta producers' perceptions of the value and availability of irrigation water. For this survey, the target population included all the permit holders, landowners, and operators (producers) who withdraw water (surface and groundwater) for agricultural irrigation in the Yazoo-Mississippi Delta region. The Permit Database from the Office of Land and Water at the Mississippi Department of Environmental Quality was used as the survey contact list. About 1,877 individuals were identified from these records who were thought to hold permits for irrigation water withdrawals in the Yazoo-Mississippi Delta. Out of these 1,877, only 1,789 farmland owners and operators were used for the survey; the remaining 88 were excluded due to duplicate entries or missing telephone numbers. The Survey Research laboratory personnel called the valid phone numbers, and only 460 respondents completed the survey out of the total 1,789 cases. Out of 1,789 cases, 120 respondents refused to complete the survey, 14 were out of town at the time of the survey, 314 did not answer the call, 26 had communication or language problems, 68

were either deceased or were unable to talk due to personal health issues, and 606 had their telephone number disconnected. About 133 respondents no longer held a permit for agricultural irrigation wells and were therefore not included in this survey. In summary, the total cooperation rate for this survey was 79.3%. The cooperation rate was calculated as a ratio of completed surveys (460) to the sum of completed responses plus refusals which was 580 (460 completed surveys + 120 refusals).

The questionnaire for the survey was developed by a team of scientists at Mississippi State University and Delta Farmers Advocating Resource Management (Delta F.A.R.M.). Delta F.A.R.M. is an association of growers and landowners that work on the conservation, restoration, and enhancement of the environment in northwest Mississippi (https://deltafarm.org/). The questionnaire included a total of 13 questions, out of which many had sub-parts. In this article, only part of the survey questionnaire related to the value and availability of water for irrigation is included. The full questionnaire is presented in Appendix 1. The frequency of specific answers to each question was determined and presented in the results section.

Results

Out of the 460 respondents to the survey, 37.8% were landowners only, 51.5% were both landowners and operators, and about 10.7% were operators only. When asked about the crop(s) they grow, only 286 of the 460 replied either yes or no, and the remaining 174 either did not know or did not reply to the survey. The percentages of respondents planting corn, cotton, soybean, and rice were 78.7, 19.1, 59.6, and 22.4%, respectively (Figure 1). About 16.3% of respondents said they plant crops other than corn, soybean, cotton, and rice. The other crops or commodities included assorted grains and peas, catfish, vegetables, peanuts, turfgrass, fruits, wheat, sorghum, sunflower (*Helianthus annuus* L.), and millets (*Panicum miliaceum*).

Value of Water

To assess the farmers' perceptions on water status and importance for irrigation in the Delta, they were asked if it would be difficult to farm without irrigation water using a five-point Likert scale: *strongly disagree, disagree, neither disagree nor agree, agree, strongly agree*, with two additional response options, *do not know*, and *refused to answer* as mentioned in Appendix 1. Although 97.39% (448 out of 460 respondents) believed that water is important for farming, 1.5% disagreed, and 0.9% of respondents neither agreed nor disagreed.

Another survey question asked for a ranking of the following water issues in order of priority: (a) flooding, (b) aquifer depletion, (c) lack of alternative surface water supplies, (d) wasting irrigation water, and (e) lack of streamflow (Figure 2). About 366 respondents provided a valid response to this question, and of those valid responses, 52.2% believed that the depletion of groundwater aquifers was the most important water issue, whereas only 5.7% thought it was the least important issue (Figure 2). Based on the survey responses, 52% (239 respondents out of a total of 460) considered the major cause of groundwater depletion to be agricultural irrigation water use. However, 30.7% of respondents thought agricultural irrigation was not the major cause of groundwater depletion, and 17.4% of respondents were undecided, refused to answer, or did not know.

Respondents were asked about groundwater availability in the Delta region. Out of 460 respondents, only 28.5% agreed that there was not enough groundwater in the Delta to supply all irrigation water needs, whereas the majority of the respondents (48.2%) disagreed. About 8% neither disagreed nor agreed, whereas 15.9% of respondents either refused to provide a reply or did not know about the water status for irrigation needs in the Delta. At the same time, when respondents were asked about their opinion concerning whether "there is enough water in the Delta, but it is not managed properly," a slight majority, 54.6%, of the respondents agreed, whereas 27.2% disagreed.

To better understand the economic value of irrigation water, the survey also included a question on the value of irrigation water in terms of dollars per acre to produce a crop (corn, soybean, or cotton) on their farm (Figure 3). Out of 460 respondents, 204 provided a dollar value for the irrigation water to produce corn on their farm. Among those 204 respondents, 41.2% said the value of irrigation

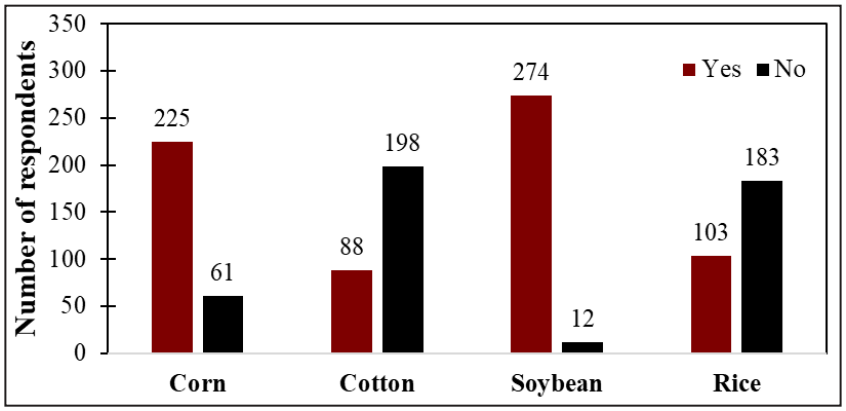

Figure 1. Number of responses to the question whether the respondents grow and irrigate crops including corn, cotton, soybean, and rice. (Valid responses: 286 out of 460 respondents.)

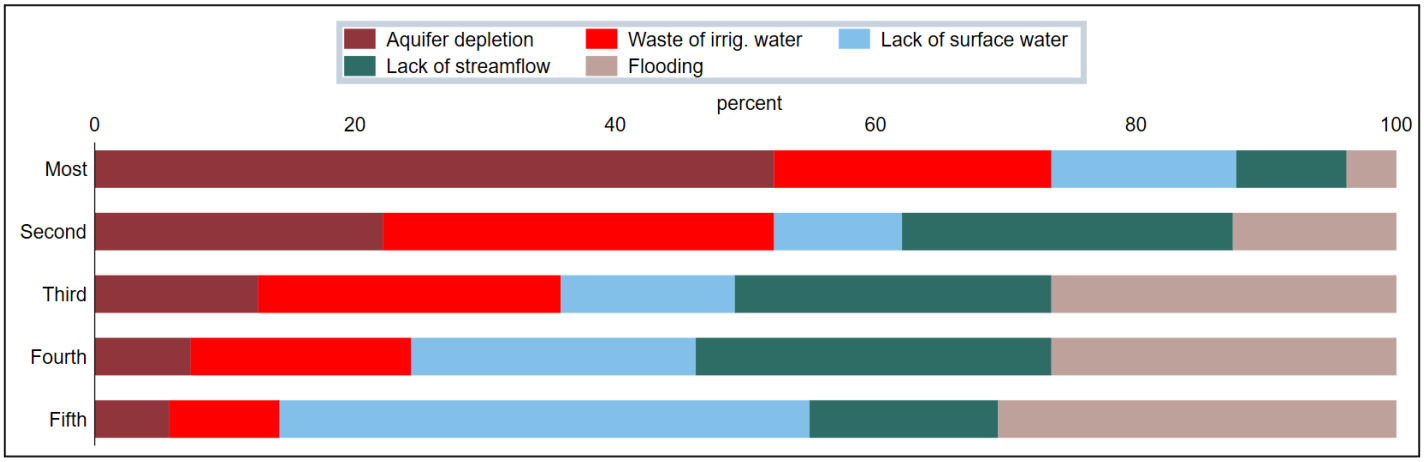

Figure 2. Percent responses to the survey question about the most important, second most important, third most important, fourth most important, and least important water-related issues in the Delta.

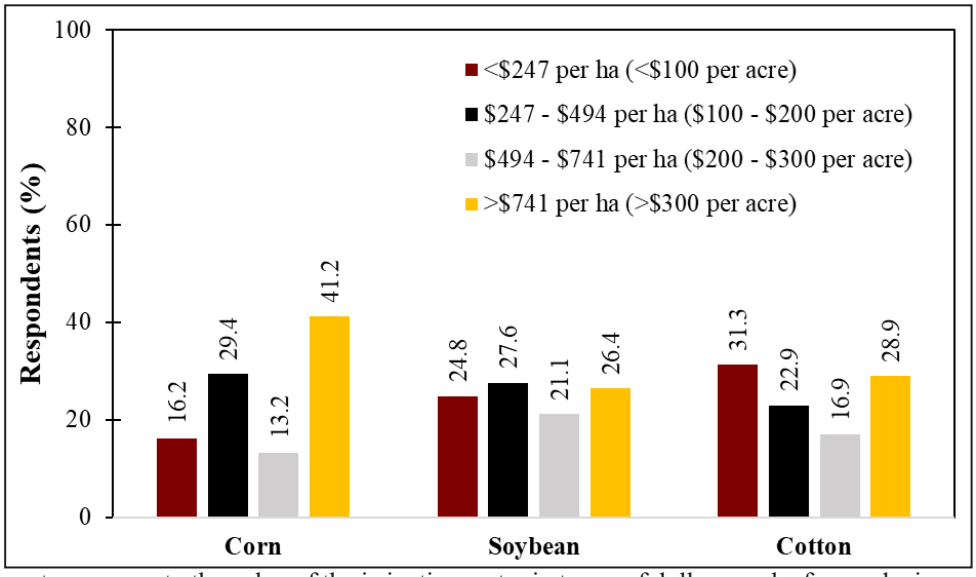

Figure 3. Percent responses to the value of the irrigation water in terms of dollars per ha for producing corn, soybean, and cotton.

water was more than $741 per ha, whereas 29.4% said the value was between $247-$494. About 13.2% of the respondents answered that the irrigation value was between $494-$741 per ha on their farm, whereas 16.2% of respondents thought it was less than $247 per ha. Similarly, for soybean, 246 respondents provided the value of irrigation water in terms of dollars. The percentages were 24.8, 27.6, 21.1, and 26.4% for less than $247 per ha, $247-$494 per ha, $494-$741 per ha, and more than $741 per ha, respectively. For cotton, 31.3% of the respondents believed that the value of irrigation water was less than $247 per ha out of the 83 total respondents who grew cotton.

Because the survey captured the valuation responses in a range of values rather than an amount, it is difficult to produce a point estimate of the value of irrigation water. Therefore, we summarized a weighted average for each crop in Table 1. The lower bound was calculated using the lowest number for each value range category, the upper bound was the highest number in each value range, and the mid-point fell between the high and low values (e.g., for the $247-$494, the three levels are $247, $371, and $494 per ha). Then, each number is multiplied by the percentage under each crop category to provide a range and mid-point of valuation estimate for each type of crop grown. The value of water in corn irrigation ranged from $463 to $690 per ha with a mid-point of $577 per ha. For soybean production, the value ranged from $399 to almost $615 per ha with a mid-point of $507 per ha. In cotton production, water for irrigation was valued at $223 to $336 per ha with a mid-point of $280 per ha. These amounts were produced directly from responses to the 2012 survey so they are assumed to reflect the values of the dollar at the end of the year 2012, which, considering the Producer Price Index, indicate the conversion factor to bring these values to current prices would be 1.15, or about 15% higher than reported in 2012. Of course, the base valuation may have changed since 2012.

Table 1. The weighted average valuation of irrigation water in dollars per ha by crop grown.

	Value of Irrigation Water ($ per ha)		
Crop	Lower Bound	Mid Point	Upper Bound
Corn	463	577	690
Soybean	399	507	615
Cotton	223	280	336

All respondents, regardless of their locations, were asked about the status of water in different regions of the Mississippi Delta (Tables 2 and 3). Among the respondents who only owned land in the Delta region, 73% believed that water was available in abundance, whereas 12.6% thought there was a water shortage (Table 2). Of the respondents who both rented and owned land in the Delta region, about 2% thought there was a water crisis. Among respondents who only rented land in the Delta region, 46.5% believed that there was abundant water available, whereas 11.1% thought there was a shortage. Overall, 24.1% of the respondents thought that there was a water shortage Delta-wide, and 3.5% responded there was a water crisis Delta-wide. About 7.2% of respondents thought there was a water crisis in the central Delta, whereas only about 2 to 2.4% of respondents thought it was true for the north and south Delta regions as well. Similarly, 29.6% of the respondents believed that there was a water shortage in the central Delta, whereas only 15 and 12.4% of respondents thought there was a water shortage in the north and south Delta, respectively. About 32.2, 46.7, and 29.8% of respondents replied that there will be a water shortage in the future in the north Delta, central Delta, and south Delta, respectively (Table 3), while 40.2% of the respondents said “yes” to anticipated Delta-wide future water shortages.

Regulations on Water

Since the MRVAA water levels are declining, the survey also included questions on the regulation of water to protect the aquifer. About 28.3% of respondents from the 460 disagreed that regulations are needed to protect the MRVAA. About 56.3% of the respondents agreed that water use regulations are needed to protect the aquifer and ensure water availability in the future. However, only 6.1% of respondents either refused to reply or said they did not know, and about 9.3% of respondents neither agreed nor disagreed about the regulations on water use. In addition, the respondents were also asked if

Table 2. Percent responses to the current water situation (water crisis, water shortage, water abundance) at different locations.

Location	Water crisis	Water shortage	Water abundance	Don't know	Refused	Does not apply
	----------	----------	----------	%	----------	----------
Land you own	2.4	12.6	73.0	4.3	1.1	6.5
Land you rent	2.0	11.1	46.5	2.8	1.1	36.5
North Delta	2.4	15.0	39.6	40.0	1.1	2.0
Central Delta	7.2	29.6	35.2	25.4	1.3	1.3
South Delta	2.0	12.4	39.8	42.4	1.1	2.4
Delta-wide	3.5	24.1	42.8	28	1.1	0.4

Table 3. Percent responses to the question: "Do you anticipate a future water shortage?"

Location	Yes	No	Don't know	Refused	Does not apply
	----------	----------	%	----------	----------
Land you own	29.3	54.1	12.0	0.4	4.1
Land you rent	23.9	39.8	8.5	0.4	27.4
North Delta	32.2	35.9	29.3	0.7	2.0
Central Delta	46.7	30.4	21.3	0.9	0.7
South Delta	29.8	36.7	30.7	0.7	2.2
Delta-wide	40.2	33.9	24.3	0.7	0.9

"self-regulation by farmers can protect the aquifer from overuse and ensure water availability in the future" and if "regulations on water use will hurt agriculture." About 83.4% of respondents believed that self-regulation by farmers can help in reducing declining water tables in the MRVAA, however, 4.5% neither agreed nor disagreed. About 9.6% of respondents disagreed that self-regulation by farmers will help with aquifer overuse. Sixty-eight percent of respondents also thought that regulation of water use will hurt agriculture in the Delta, whereas only 18.3% disagreed. About 7.4% were undecided, and 6.7% either refused to answer or answered that they did not know.

Discussion

The survey conducted by Mississippi State University found that respondents believed that water is important for farming in the Delta, and water withdrawals for irrigation are the primary reason for water-level declines in the MRVAA. In the midsouth U.S., there was a 71% increase in irrigated farmland from 1988 to 2008 (Vories and Evett 2014), and increases in irrigated areas in Mississippi and Arkansas were 92 and 71%, respectively, during this period. The irrigated land increased in the lower Mississippi River Valley at an annual average rate of 2% between 2002 and 2012 (Massey et al. 2017). About 60% of the agricultural land is irrigated, either using furrow or center pivot irrigation systems in the Mississippi Delta (Kebede et al. 2014). Water withdrawals from the MRVAA have increased since the early 1900s and about 96% of the water removal is attributed to irrigation use for agriculture (Reba et al. 2014). Seventy-five percent of the irrigated area is under furrow irrigation. The furrow irrigation

method is less efficient in terms of water savings as it results in deep percolation losses and tail-water runoff, which further elevates the water depletion issue in the Delta region. Based on our survey results, producers in the Mississippi Delta acknowledged that there is a water depletion issue in the Delta. Depletion of the aquifer groundwater is the most important water-related issue in the Delta followed by the wasting of irrigation water. The third most important water-related issue is the lack of alternative water supplies. This indicates that producers are interested in exploring and using alternative options for meeting irrigation water needs. However, a small percentage (28.5%) of the respondents acknowledged that there is not enough groundwater in the Delta. Most of the respondents believe that water is not managed properly, but there is enough water in the Delta. The survey conducted in 2012 helped in understanding the perception about value and availability of water by the farmers. The survey results indicate the need to develop and adopt better crop and water management strategies that will conserve water and increase irrigation water use efficiency. Currently, farmers have multiple technologies for better irrigation water management, such as computer-hole-selection (CHS), surge valve flow irrigation (SURGE), tailwater recovery systems, on-farm water storage, sprinkler irrigation systems, and sensor-based irrigation scheduling.The CHS technology computes the flow and pressures along the length of lay-flat polyethylene tubing and selects optimal hole sizes to improve down-row uniformity across the irrigation set regardless of furrow length (Bryant et al. 2017; Spencer et al. 2019). Sensor thresholds for irrigation scheduling for soybean (*Glycine max* L.), corn (Zea mays L.), cotton (*Gossypium hirsutum* L.), and peanuts (*Arachis hypogaea*) have been developed by the researchers at the Mississippi State University (Williams et al. 2018; Leininger et al. 2019).

Survey respondents provided an economic value of irrigation water in dollars for producing corn, soybean, and cotton. However, more respondents (41%) indicated that the value of irrigation water for corn was greater than $741 per ha ($300 per acre) than they did for cotton (28.9%) or soybean (26.4%). This is possibly due to greater water requirements for corn than for other crops. A study by Massey et al. (2017), over a period of 12-years (2002-2013), reported that the irrigation rates were greater for corn (3100 m^3 ha^{-1}), followed by soybean (2800 m^3 ha^{-1}), and cotton (1800 m^3 ha^{-1}) in the Mississippi Delta. The same study reported no change in irrigation rates for cotton over time, but increases were observed for corn and soybean irrigation rates over time by approximately 200 m^3 ha^{-1} yr^{-1}. The largest share of cotton producers (31.3%) reported that the economic value of irrigation water for cotton production is less than $247 per ha ($100 per acre). For soybean, the economic value of irrigation water varied widely with similar shares across the available category responses.

Survey responses indicated that the severity of water-related issues varied across the Delta. More respondents thought that there was a water shortage in the central Delta than believed that there was a shortage of water in the north and south Delta. Similarly, more respondents expect to see future water shortages in the central Delta than in the north and south Delta regions. This might be due to higher rice production in the counties in the central Delta region, as the water requirement of rice is greater than other crops including corn, soybean, and cotton. Massey et al. (2017) reported that the irrigation rate for rice was 9200 m^3 ha^{-1}, whereas the rates were 3100, 2800, and 1800 m^3 ha^{-1} for corn, soybean, and cotton, respectively, averaged over 12 years in the Mississippi Delta region. Smith et al. (2007) reported irrigation water use was 721 and 895 mm in rice production systems in Arkansas and Mississippi, respectively, when data was averaged over two years (2003-2004). The higher rate of alluvial aquifer decline was associated with areas of intensive aquaculture and rice production with approximately 268 mm yr^{-1} in Mississippi (Pennington 2005; Young and Sweeny 2005). These survey results indicate that farmers in the central Delta may benefit from increased emphasis on education and extension programs concerning water conservation practices and improved irrigation practices. To save water, a majority of farmers agreed that regulations are needed for water use in the Delta, however, such regulations were expected to negatively impact agriculture production in the Delta region. Regulation of irrigation water use could limit the amount of

water that farmers can pump from the MRVAA and, consequently, reduce crop yields. Cotton was the predominant crop in the Mississippi Delta with 53,000 ha in 2000; however, cotton production has been declining in recent years with only 18,000 ha of land under cotton in 2021 (USDA-NASS 2021) due to lower economic returns and introduction of irrigated corn and soybean crops. However, any regulation on irrigation water use in the future might result in reversing this trend as corn and soybean have higher water requirements than cotton. To date, no volumetric or pecuniary regulations have been imposed on groundwater users. Regulation on water use for irrigation might include restrictions on the amount of water withdrawals from wells for irrigation. Imposition of regulatory controls would encourage producers to use alternatives such as tailwater recovery systems, on-farm water storage, and surface water bodies as water sources, adopt more efficient irrigation systems, or use crop management practices that will conserve water, e.g., improve water infiltration into the soil and increase soil water holding capacity and reduce surface runoff losses.

Conclusion

The survey results presented in this article evaluated the perceptions of crop producers about irrigation water availability and its value. The majority of survey respondents in the Mississippi Delta recognized that irrigation is necessary for farming in this region. Irrigation was also considered as the main cause of water declines in the MRVAA. Water level declines might result in a water shortage for irrigation in the future if proper conservation measures are not implemented. This survey provided important information to the scientists at the Mississippi State University and the USDA which will be used to develop programs for water conservation in the Mississippi Delta for sustainable water management. However, the target population included all permit holders, landowners, and operators (producers) who withdraw water (surface and groundwater) for agricultural irrigation in the Yazoo-Mississippi Delta region. One of the limitations of this survey is that only 26% of the sample population used in the study completed the survey. Therefore, future surveys in the area should pay attention to the selection of the population sample for the survey and include more numbers of producers to get opinions about the value for water in the Delta region of Mississippi.

Acknowledgements

This publication is a contribution of the National Center for Alluvial Aquifer Research, the Mississippi Agricultural and Forestry Experiment Station, and the University of Missouri Northern Missouri Research, Extension, and Education Center. This material is based upon work that is funded jointly by the Agricultural Research Service, United States Department of Agriculture, under Cooperative Agreement number 58-6001-7-001.

Author Bio and Contact Information

Dr. Gurpreet Kaur (corresponding author) is an Assistant Professor at the University of Missouri Northern Missouri Research, Extension, and Education Center in Novelty, MO. Dr. Kaur received her Ph.D. degree in Natural Resources from the University of Missouri in 2016. Dr. Kaur can be contacted at gk478@missouri.edu or by mail at Lee Greenley Jr. Memorial Research Farm, 64399 Greenley Place, Novelty, MO 63460.

Dr. Nicolas E. Quintana Ashwell is an Assistant Professor and Natural Resource Economist at the National Center for Alluvial Aquifer Research, Mississippi State University. Dr. Quintana received his Ph.D. degree from Kansas State University. Dr. Quintana's research is focused on improving academic and stakeholder understanding of the economic factors that drive the decline of an aquifer in an area with abundant precipitation and surface water sources. Dr. Quintana can be contacted at n.quintana@msstate.edu or by mail at National Center for Alluvial Aquifer Research, 4006 Old Leland Road, Leland, MS 38756.

Dr. Gurbir Singh is an Assistant Professor at the University of Missouri Northern Missouri Research, Extension, and Education Center. Dr. Singh received his Ph.D. degree in Agricultural Sciences from Southern Illinois University in 2018 and M.S. degree in Soil, Environmental, and Atmospheric Sciences from the University of Missouri in 2013. Dr. Singh can be contacted at singhgu@missouri.edu or by mail at Lee Greenley Jr. Memorial Research Farm, 64399 Greenley Place, Novelty, MO 63460.

Dr. Drew Gholson is an Extension Irrigation Specialist at the Delta Research and Extension Center,

Mississippi State University and Coordinator for the National Center for Alluvial Aquifer Research. Dr. Gholson received his Ph.D. from Texas A&M University. Dr. Gholson can be contacted at drew.gholson@msstate.edu or by mail at Delta Research and Extension Center, 82 Stoneville Road, Stoneville, MS 38756.

Dr. Martin A. Locke is the director of the USDA-ARS National Sedimentation laboratory, Oxford, MS. Dr. Locke received his Ph.D. degree in Soil Science from Texas A&M University and M.S. degree from the University of Missouri. Dr. Locke's research is focused on assessing the impact and value of conservation management practices and their influence on environmental quality. Dr. Locke can be contacted at martin.locke@usda.gov or by mail at National Sedimentation Laboratory, 598 McElroy Drive, Oxford, MS 38655.

Dr. L.J. Krutz is the director of the Mississippi Water Resources Research Institute, Mississippi State University. Dr. Krutz received his Ph.D. from Texas A&M University. Dr. Krutz can be contacted at ljk81@msstate.edu or by mail at MS Water Resources Research Institute, 207 Ballew Hall, Mississippi State, MS 39762.

Trey Cooke works for The Nature Conservancy, Cleveland, MS. Mr. Cooke can be contacted at trey.cooke@tnc.org.

References

Bryant, C.J., L.J. Krutz, L. Falconer, J.T. Irby, C.G. Henry, H.C. Pringle III, et. al. 2017. Irrigation water management practices that reduce water requirements for Mid-South furrow-irrigated soybean. *Crop, Forage & Turfgrass Management* 3(1): 1-7.

Kebede, H., D.K. Fisher, R. Sui, and K.N. Reddy. 2014. Irrigation methods and scheduling in the Delta region of Mississippi: Current status and strategies to improve irrigation efficiency. *American Journal of Plant Sciences* 5(20): 2917.

Leininger, S.D., L.J. Krutz, J.M. Sarver, J. Gore, A. Henn, C.J. Bryant, R.L. Atwill, and G.D. Spencer. 2019. Establishing irrigation thresholds for furrow-irrigated peanuts. *Crop, Forage & Turfgrass Management* 5: 1-6.

Marston, L., M. Konar, X. Cai, and T.J. Troy. 2015. Virtual groundwater transfers from overexploited aquifers in the United States. *Proceedings of the National Academy of Sciences* 112(28): 8561-8566.

Massey, J. 2010. *Water-conserving Irrigation Systems for Furrow and Flood Irrigated Crops in the Mississippi Delta*. Final Report. Available at: https://www.wrri.msstate.edu/pdf/massey_final.pdf. Accessed July 17, 2023.

Massey, J.H., C.M. Stiles, J.W. Epting, R.S. Powers, D.B. Kelly, T.H. Bowling, et al. 2017. Long-term measurements of agronomic crop irrigation made in the Mississippi delta portion of the lower Mississippi River Valley. *Irrigation Science* 35(5): 297-313.

Pennington, D.A. 2005. *YMD Joint Water Management District Annual Report 2004*. Available at: http://www.ymd.org/annualreports.htm. Last accessed January 2021.

Reba, M., T. Teague, and E. Vories. 2014. A retrospective review of cotton irrigation on a production farm in the mid-south. *Journal of Cotton Science* 18(2): 137-144.

Smith, M.C., J.H. Massey, J. Branson, J.W. Epting, D. Pennington, P.L. Tacker, J. Thomas, E.D. Vories, and C. Wilson. 2007. Water use estimates for various rice production systems in Mississippi and Arkansas. *Irrigation Science* 25(2): 141-147.

Snipes, C., S.P. Nichols, D.H. Poston, T.W. Walker, L.P. Evans, and H.R. Robinson. 2005. Current Agricultural Practices of the Mississippi Delta. Mississippi Agriculutral & Forestry Experiment Station. Bulletin 1143. Available at: https://www.mafes.msstate.edu/publications/bulletins/b1143.pdf. Accessed July 17, 2023.

Spencer, G.D., L.J. Krutz, L.L. Falconer, W.B. Henry, C.G. Henry, E.J. Larson, H.C. Pringle III, C.J. Bryant, and R.L. Atwill. 2019. Irrigation water management technologies for furrow-irrigated corn that decrease water use and improve yield and on-farm profitability. *Crop Forage & Turfgrass Management* 5(1): 1-8.

USDA-NASS. 2021. 2019 Census of Agriculture. U.S. Department of Agriculture, National Agricultural Statistical Service, Washington, D.C.

Vories, E.D. and S.R. Evett. 2014. Irrigation challenges in the sub-humid US Mid-South. *International Journal of Water* 8(3): 259-274.

Wax, C.L., J.W. Pote, and T.L. Merrell. 2008. Climatological and cultural influences on annual groundwater decline in the Mississippi Delta shallow alluvial aquifer. In: *38th Annual Mississippi Water Resources Conference: Book of Abstracts*, April 15-16, 2008, Jackson, MS.

Williams, J., W. Henry, J. Varco, D. Reynolds, N. Buehring, L. Krutz, et al. 2018. Deficit irrigation, planting date, and hybrid selection impacts on a

Mid-South corn production system. *Crop, Forage & Turfgrass Management* 4: 1-8.

YMD. 2013. Yazoo Mississippi Delta Joint Water Management District. Annual Summary.

Young, J.R. and J.R. Sweeny. 2005. *Arkansas Ground Water and Management Report for 2004*. Available at: http://www.aswcc.arkansas.gov/Draft%20for%20'04–'05.pdf. Last accessed January 2021.

Appendix 1. Survey questions and their respective answer choices.

Question	Response
Are you a:	a) Landowner only b) Landowner & operator c) Operator only d) Other e) Don't know/not sure f) Refused
Please tell me whether you grow and irrigate each of the following crops: corn, cotton, soybeans, rice, other crops	a) Yes b) No c) Don't know/not sure d) Refused
What other crops do you grow and irrigate?	a) None b) Don't know/not sure c) Refused
Please tell me whether you strongly disagree, disagree, neither disagree nor agree, agree, or strongly agree with the following statement: • It would be difficult to farm without irrigation water	a) Strongly disagree b) Disagree c) Neither disagree nor agree d) Agree e) Strongly agree f) Don't know g) Refused
Please rank the following water issues in order of priority. Which one you would rank as the most important, second most important, third most important and so on?	• Flooding • Depletion of the groundwater aquifer • Lack of alternative surface water supplies • Wasting irrigation water • Lack of stream flow • Don't know/not sure • Refused

Appendix 1 Continued.

Question	Response
What is the value of irrigation water in terms of dollars per acre in producing following crops on your farm? Would you say? • Corn • Soybean • Cotton	a) Less than $100 per acre b) $100 to $200 per acre c) $200 to $300 per acre d) More than $300 per acre e) Don't know/Not sure f) Refused g) Doesn't apply (doesn't grow)
Next, I am going to read some statements about water conservation, for each one please tell me if you strongly disagree, disagree, neither disagree nor agree, agree, or strongly agree. • Regulations on water use are needed to protect the aquifer and ensure water will be available in the future • Self-regulation by farmers can protect the aquifer from overuse and ensure water will be available in the future • There is not enough groundwater in the Delta to satisfy all the irrigation needs • Regulations on water use will hurt agriculture • There is currently sufficient water in the Delta, but we aren't managing it properly • Agricultural irrigation water use is the primary cause of the groundwater depletion	a) Strongly disagree b) Disagree c) Neither disagree nor agree d) Agree e) Strongly agree f) Don't know g) Refused
For the following locations, please tell if you would describe the current water situations as having a water crisis, water shortage, or water abundance? • The land you own • The land you rent • North Delta • Central Delta • South Delta • Delta-wide	a) Water crisis b) Water shortage c) Water abundance d) Don't know e) Refused f) Does not apply
For which of these same locations, do you anticipate a future water shortage: • The land you own • The land you rent • North Delta • Central Delta • South Delta • Delta-wide	a) Yes b) No c) Don't know d) Refused e) Does not apply