12-2016

Willingness to Pay for Irrigation Water under Scarcity Conditions

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Willingness to Pay for Irrigation Water under Scarcity Conditions

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Agriculture Economics

by

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December 2016
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Abstract

Reliance of Arkansas agricultural producers on groundwater for irrigation has led to depletion of the Mississippi River Valley alluvial aquifer. Without intervention, consequences include insufficient groundwater to meet irrigation demand as well as drawdown of the deeper Sparta Aquifer, upon which communities in eastern Arkansas rely for non-agricultural use. Among proposed solutions to combat groundwater decline is the construction of off-farm surface water infrastructure to meet the irrigation needs of producers. Despite the importance of irrigated agriculture to Arkansas, there is little know about the economic value of irrigation water to producers. Thus, we implement a double-bounded dichotomous choice contingent valuation survey to estimate producer willingness to pay (WTP) for irrigation water from irrigation districts when access to groundwater is restricted. While WTP clearly varies between water-scarce and water-abundant areas of the Delta, we find that, on average, producers are WTP $32.87 per acre-foot of irrigation water. Nonetheless, high levels of uncertainty among producers regarding the extent of groundwater shortage in the region persist, highlighting the need for continued, targeted education efforts by extension professionals.

Acknowledgements

Many people deserve my thanks for their help and guidance during my Master's study and research. I would like to thank my advisor and thesis chair, Dr. Huang, for her patience and support, which has made my success as a student possible. To my University of Arkansas and Ghent University co-promoters, Dr. Kovacs and Dr. Speelman, thank you both for your time and energy. To my remaining thesis committee members, Dr. Dixon, Dr. Popp and Dr. Nayga, all of whom have taken time out of their days help me along the way, thank you. I would also like to express my appreciation to those who have made my study in the Atlantis program possible: Dr. Ahrendsen, Dr. Rainey and Ms. Alicia. Your assistance has been invaluable.

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Introduction

Groundwater depletion is a globally important issue, which threatens the security of nearly half of the world's drinking water and 43% the world's irrigation water (van der Gun 2012). Since aquifers are both a common pool resource and a resource with a finite stock, groundwater is frequently overused by those who share the resource as well as by those in the present at the expense of the future. Specifically, overuse of groundwater results from systems of management that fail to incorporate the full value of water (i.e. use and nonuse values) into allocation schemes. To create policy which positively impacts the long-term sustainability of groundwater, the full value of the resource must be understood.

As a common pool resource, groundwater aquifers are non-excludable but rivalrous, and because individual users often fail to account for the impact of their groundwater use on others, the consequence is overuse of groundwater resources. Further, current users do not always consider the impact of overuse in the current period on future generations, and thus, the scarcity rent of groundwater may be ignored and again the result is overuse. In addition to limiting the availability of groundwater resources for current and future generations, overuse may also impact the quality of ecological and environmental services (e.g. maintenance of riparian habitat and prevention of land subsidence, respectively; Canter et al. 1997).

While several studies have examined the impact of water scarcity on the market value of water, few have analyzed the non-market benefits of water to agricultural users. Mesa-Jurado et al. (2012) used the contingent valuation method (CVM) to show that the WTP of farmers in the Guadalquivir River Basin in southern Spain increased under conditions of water scarcity when farmers perceived the impact of guaranteed water supply to positively influence their own welfare. Toshisuke and Hiroshi (2008) evaluated the economic value of irrigation water to urban and non-urban users in Japan and found that rural users who rely on water resources for household use and to maintain agricultural income have a higher WTP for water than urban users. Storm, Heckelei and Heidecke (2011) model demand for irrigation water in the Moroccan Drâa Valley using CVM. They found that producers' true WTP exceeds current water prices in the region, but they also note that only small increases in cost would be politically tenable, and because demand for irrigation water is relatively inelastic, such price increases would do little to prevent aquifer drawdown.

Irrigated agriculture is critical to the economy of Arkansas. Even given the existence of a large collection of US based water resources literature outside of Arkansas, few state-specific economic analyses are available to support the design of policies which help irrigated agriculture adapt to decreasing groundwater supply and climate change. Most irrigation studies, specifically those analyzing the value of irrigation water, have been restricted to other regions of the United States and foreign countries. Nonetheless, in recent years the interest in non-market valuation of irrigation water resources has grown. Because misallocation of groundwater has consequences for individual producers and society and because agricultural producers may care about the viability of agricultural production in the future, producers' willingness to pay (WTP) for irrigation water from surface sources may be greater than what they currently pay for groundwater. Therefore, we use a double-bounded CVM to determine an agricultural household's WTP for off-farm surface water in response to decreased reliability of on-farm groundwater resources. Knowledge of a respondent's WTP in a stated preference framework is useful to policymakers considering infrastructure projects to bring surface water to farming communities and to identify whether the total WTP for surface water is greater than the extraction costs producers currently pay to pump groundwater. To date, no known studies address Arkansas farmers' WTP for irrigation water under scarcity conditions.

The rest of the paper is organized as follows. The second section of this paper describes the study area. The third section outlines econometric methodology. Fourth, we present our survey methodology and response rates, and describe variables used in the analyses. The fifth section provides data analysis and discussion. In the final section, we present conclusion from the study.

Study Area

The Arkansas Delta is in eastern Arkansas. The area is underlain by the Mississippi River alluvial aquifer (MRVAA), which extends approximately 250 miles from north to south and 75 to 150 miles from west to east (Czarnecki, Hays and McKee 2002). Crowley's Ridge in the north divides the Delta into two distinct regions; the area to the east of Crowley's Ridge is characterized by relative water abundance while the area to the west of Crowley's Ridge is characterized by relative water scarcity. While rivers, streams and marshes—facilitated by shallow clay caps throughout the region—are common, the entirety of the Delta region faces increased depth-to-groundwater, largely as a result of withdrawals for agricultural irrigation (Engler, Bayley and Sniegocki 1963; Reba et al. 2013).

The climate of the study region is humid and subtropical, with an average high temperature of approximately 72°F and an average low temperature of approximately 50.25°F (Table 1). During summer months, temperatures regularly reach 100°F and in winter months temperatures often fall below 32°F. On average, the region experiences total annual rainfall of 50 inches; however, months with the greatest quantities of rainfall (October through May) occur outside of the growing season. As such, there is usually insufficient rainfall within the study region during the growing season to sustain agricultural production, causing producers to rely heavily on groundwater to meet irrigation needs.

The overdraft of groundwater in Arkansas from irrigation-intensive agricultural production has led to increased depth-to-groundwater and projections of long-run shortage of water from the Mississippi River Valley alluvial aquifer (ANRC 2015a). To combat projected scarcity, the state of Arkansas and the Arkansas Natural Resources Commission (ANRC) have proposed the adoption of more efficient irrigation technology and greater reliance on the state's surface water resources (ANRC 2015).

Irrigated agricultural production in the Arkansas Delta is of key importance to the state's economy. The value of production of rice, soybean, corn and cotton totaled $2.6 billion in 2013, which was 2.4% of Arkansas' gross domestic product (English, Popp and Miller 2015). Arkansas ranks first among states in terms of rice production, accounting for 49.96% of total U.S. production (USDA ERS 2016). In 2013, the average return to land and management for rice was $403.13/acre, outpacing the per acre returns of corn by $84.42 (Flanders 2014). Since the 1960s, Thailand, Vietnam, the United States and Pakistan have accounted for 60 to 70% of total global rice exports (Mohanty 2013). Arkansas, with rice exports valued at $859 million in 2011, contributes large quantities of rice to the export market and plays an important role in the global rice economy (Richardson and Outlaw 2010; English, Popp and Miller 2013; ARF 2015).

Like rice, soybean production is critical to the agricultural economy of Arkansas and the United States. Soybeans are important to the maintenance of productivity through crop rotation, and on average contributes $205.67/acre to the state economy (Flanders 2014). While Arkansas soybean production is less important to national production than is rice, continued drought throughout many of the top soybean producing states and Arkansas' ability, to date, to outperform national averages under drought conditions, increases the importance of Arkansas soybean production to the U.S. economy. Because the United States is the world's top soybean producer, drought induced decreases in domestic production may impact world soybean prices.

Commercial rice production in Arkansas began in the early 1900s, marking the onset and rapid growth of groundwater-sourced irrigation in the Delta (Engler et al. 1963). By the early 1920s irrigation water was being withdrawn at rates greater than the natural rate of recharge (Gates 2005). Since the 1920s, irrigated acres in Arkansas have increased steadily. In 2007, Arkansas accounted for 7.9% of all cropland under irrigation in the United States, making the state the fourth largest user of irrigation water in the country (Schaible and Aillery 2012). In 2013, Arkansas farmers irrigated about 93% of rice, soybean, corn and cotton (Table 2a), more than 4.8 million acres in total (NASS 2014). In 2008 and 2003, approximately 87% (Table 2b) and 81% (Table 2c) of these crops were irrigated, respectively (NASS 2004; NASS 2009).

In total, nearly 86% of irrigation water in Arkansas in 2013 was sourced from groundwater; and currently, about 60% of the state's water supply comes from groundwater in the MRVAA alone (Table 3; Schrader 2008; NASS 2014). Within Arkansas, the purchase of off-farm water is relatively rare. Agricultural irrigation is responsible for 96% of all withdrawals from the MRVAA (ANRC 2012). While groundwater use in Arkansas has increased 380% since 1965, the basic issue surrounding depletion of the MRVAA—withdrawals above the estimated sustainable yield—remains unchanged (ANRC 2012). In 2009, 5,687 million gallons per day (190% of the sustainable yield) were withdrawn from the MRVAA, which has limited recharge capacity due to a shallow confining layer (Schrader 2008; ANRC 2012; Schaible and Aillery 2012). The continuous and unsustainable pumping has put the MRVAA in danger. Many counties in eastern Arkansas have been designated as critical groundwater areas due to continued decline in groundwater levels (Figure 1; Arkansas Soil and Water Conservation Commission 2003). Irrigation water that used to be readily accessible to producers is now markedly diminished. For example, pumping in Arkansas County decreased between 2000 and 2008 because producers were unable to pump sufficient water from the alluvial aquifer (Czarnecki and Schrader 2013). Despite reports of loss of access to irrigation water, only 294 farms in Arkansas reported utilization of off-farm water in 2012 (NASS 2014). The distribution of prices paid for water by these produces was bimodal; 79 producers reported paying more than $60 per acre-foot and 28 reported paying between $1 and $8 per acre-foot, while no producers reported paying in the ranges of $10-$19, $20-$29 or $30-$59 per acre-foot.

Despite widespread drought throughout much of Arkansas in the United States in 2012, Arkansas soybean farmers harvested record yields (Hightower 2012). Continued depletion of the MRVAA, largely as the result of increased irrigation to insure against potential drought induced losses, as in 2012, poses a threat to the continued success of water intensive crops in Arkansas (Kovacs et al. 2015). An annual gap in groundwater as large as 7 million acre-feet is projected for 2050 and most of the expected shortfall is attributed to agriculture (ANRC 2015a). Three watersheds in Arkansas are expected to experience a water shortage including both groundwater and excess surface water by 2050. The literature review conducted by the Arkansas Governor's Commission on Global Warming (2008) indicates that the state should anticipate increased incidence of severe weather events, flooding and drought in the coming decades. Reducing the reliance on groundwater resources in the MRVAA is the step needed to avoid disastrous consequences of aquifer depletion (ANRC 2015a). Further, in focus groups conducted by the authors in November 2014 with stakeholders from eastern Arkansas, the decline in groundwater supply was ranked among the top concerns Arkansas farmers.

The critical initiatives identified in the 2014 Arkansas Water Plan Update highlight adopting conservation measures that can improve on-farm application efficiency as well as infrastructure-based solutions that convert more irrigated acres currently supplied by groundwater to surface water in eastern Arkansas (ANRC 2015a). Surface water in Arkansas is relatively abundant and is allocated to farmers based on riparian water rights[1]. The Arkansas Natural Resources Commission (2015) estimates that average annual excess surface water available for interbasin transfer and non-riparian use is 7,605,800 acre feet.

The Grand Prairie Area Demonstration Project and the Bayou Metro Project[2] are both important features of the Arkansas Water Plan, which are designed to supplement agricultural groundwater with surface water in the hopes of reducing overuse of the Grand Prairie Critical Groundwater Area and preventing decline of the deeper Sparta Aquifer, which is a critical source of drinking water for the region (ANRC 2015a). In total, ANRC (2015) estimates that the construction of needed infrastructure to shift groundwater irrigation to surface water irrigation in the nine major river basins of eastern Arkansas will cost between $3.4 and $7.7 billion. Financing these projects has grown increasingly difficult as the a result of decreases in the availability of federal grants, cost-share and loans (ANRC 2015a). As such, understanding the nature of water use and quantifying the full value of irrigation water to agricultural producers in the Delta will be critical for continued funding and long-run success of irrigation district projects, as well as the long-run viability of agricultural production in Arkansas.

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[1]In Arkansas, when land touches a surface water resource (a lake, stream, river or other waterway), land owners have the right to divert water without permit if doing so does not unreasonably harm another use. Arkansas law also provides a mechanism for non-riparian owners to divert surface water with approval from the ANRC as long as the use is reasonable, beneficial and will not adversely impact the environment (ANRC 2015a).

[2]These projects are expected to supply irrigation water to 15% of regions with expected groundwater gaps (ANRC 2015a).

Econometric Model

The model constructed relies on the double-bounded dichotomous choice (DBDC) CVM, which is a simple extension of the single-bound dichotomous choice (SBDC) model. In a single-bound model, survey respondents are asked to state ("yes" or "no") if they would be willing to pay a single bid amount for a good or service. For each respondent, the probability of responding "yes" to a given bid amount is defined by

(1) $$P_i^Y(b^k) = \Pr\{b^k \leq \max WTP\}$$

where b^k is the offered bid amount, and the probability of a "no" response is $1 - P_i^Y(b^k)$ (Hanemann, Loomis and Kanninen 1991). Following Hanemann (1989) and Koss and Khawaja (2001), we restrict WTP to positive values and define the expected value of willingness to pay as

(2) $$E(WTP) = \int_0^\infty [1 - G(b)]\mathrm{d}b$$

where $G(b)$ is the cumulative probability density function (CDF) and the probability that the offered bid is greater than the respondent's true willingness to pay. By defining the CDF as a logistic function, the probability that respondent's WTP is greater than the offered bid amount is written as

(3) $$G(\alpha + \beta b^k) = \frac{1}{1+e^{-\left(\alpha+\beta b^k+\sum \delta_j z_j\right)}} = \pi^Y$$

where π^Y is the probability of a yes response, β is the bid coefficient, and δ_j is the coefficient vector corresponding to the vector of j control variables, Z.

In contrast to the SBDC model, the DBDC model requires each respondent to answer "yes" or "no" to two sequential bids. If a respondent answered "yes" to the initial question, a corresponding higher bid value was proposed, while respondents who answered "no" to the initial question were asked a corresponding lower bid value. Thus, each respondent falls into one of four categories, yes/yes (YY), yes/no (YN), no/yes (NY), or no/no (NN). We denote the probability of each response sequence as π^{YY}, π^{YN}, π^{NY} and π^{NN}, such that

(4) $\pi^{YY}\left(b_i^I, b_i^U\right) = \Pr\{b_i^I \leq \max WTP \text{ and } b_i^U \leq \max WTP\}$

(5) $\pi^{YN}\left(b_i^I, b_i^U\right) = \Pr\{b_i^I \leq \max WTP \text{ and } b_i^U \geq \max WTP\}$

(6) $\pi^{NY}(b_i^I, b_i^L) = \Pr\{b_i^I \geq \max WTP \text{ and } b_i^L \leq \max WTP\}$

(7) $\pi^{NN}(b_i^I, b_i^L) = \Pr\{b_i^I \geq \max WTP \text{ and } b_i^L \geq \max WTP\}$

where the b_i^I, b_i^U, and b_i^Lcorrespond to the initial, upper, and lower bid values, respectively, and *i* is the respondent index. In contrast to the single-bound dichotomous choice model, which results in only one minimum or maximum value for each respondent's WTP, the DBDC methodology allows for the construction of a bounded interval (Eqs. 5 and 6), or minimum or maximum bound (Eqs. 4 and 7), of each respondent's WTP, and improves the asymptotic efficiency of parameter estimates. Relying on (3), equations 4-7 are written as

(8) $\pi^{YY} = \frac{1}{1+e^{-\left(\alpha+\beta b_i^U+\sum \delta_j Z_j\right)}}$

(9) $\pi^{YN} = \frac{1}{1+e^{-\left(\alpha+\beta b_i^I+\sum \delta_j Z_j\right)}} - \frac{1}{1+e^{-\left(\alpha+\beta b_i^U+\sum \delta_j Z_j\right)}}$

(10) $\pi^{NY} = \frac{1}{1+e^{-\left(\alpha+\beta b_i^L+\sum \delta_j Z_j\right)}} - \frac{1}{1+e^{-\left(\alpha+\beta b_i^I+\sum \delta_j Z_j\right)}}$

(11) $\pi^{NN} = 1 - \frac{1}{1+e^{-\left(\alpha+\beta b_i^L+\sum \delta_j Z_j\right)}}$

The double-bounded log-likelihood function, L^{DB}, if define as

(12) $L^{DB} = \sum_i y_i^{YY} \log \pi_i^{YY} + \sum_i y_i^{YN} \log \pi_i^{YN} + \sum_i y_i^{NY} \log \pi_i^{NY} + \sum_i y_i^{NN} \log \pi_i^{NN}$

where y_i^{xx} is the discrete binary choice variable (1 = in *xx*, 0 if not) of the i^{th} respondent (Hanemann et al. 1991; Koss and Khawaja 2001). As shown in Koss and Khawaja (2001), coefficients estimated by (12) can be used for direct estimation of WTP, such that

(13) $$WTP = \frac{\ln\left(1+e^{\left(\alpha+\sum \delta_{ij} z_{ij}\right)}\right)}{-\beta}$$

Data

Survey data were collected via telephone interview administered by the Mississippi State University Survey Research Laboratory. Potential survey respondents included all commercial crop growers identified by Dun & Bradstreet records for the State of Arkansas. Table 4 shows that, of 3,712 attempted contacts, 842 (22.68%) resulted in calls to disabled numbers and 1,321 (45.58%) led to no answer, busy signal or voicemail (Table 4). In total, 665 contacts were reached and eligible to complete the survey; 247 contacts declined to participate and 199 completed the survey in its entirety, while 171 contacts discontinued the survey. Depending on how response rate is calculated, the response rate for this survey varies from 6.87% to 32.25%.

Prior to presentation of contingent valuation questions, each respondent was asked to state their preferred method for addressing irrigation water shortage if there was no longer sufficient groundwater to meet irrigation needs and it was not possible to deepen wells to access more water. Out of 169 respondents, 34 (20%) indicated that they would engage in deficit irrigation and 92 (54.4%) indicated that they would construct a tailwater recovery and reservoir system. Only 15 (8.9%) indicated that they would prefer to purchase irrigation water from an irrigation district. Each respondent was next asked a pair of dichotomous choice contingent valuation questions. The first provided an initial WTP value randomly selected from a set of possible start values ranging from $10-$60 (Table 5). Thus, each subject responded to an initial question, constructed as follows:

> Would you be willing to pay **$___** per acre-foot of water to purchase water from an irrigation district?

When a respondent answered “yes” (“no”), this question was repeated at a higher (lower) value. The range of WTP values proposed and units of pricing (dollars per acre foot) were determined by examining average energy costs for groundwater withdrawals as well as the payment schedules for irrigation districts throughout the United States, but primarily in California, Oregon and Washington (Weinberg 1997; Burt 2007; Wichelns 2010; Christian-Smith and Kaphiem 2011; Board of Directors 2013). A pilot survey was then conducted and confirmed the appropriateness of the selected range.

Out of 199 responses, 6 respondents refused to answer both WTP questions and were excluded from analysis (Table 6). Twenty-eight respondents answered “no” to a third, follow up WTP question with a nominal bid amount of ($0.5 per acre-foot). Only those respondents who registered a protest response to the nominal bid were excluded from analysis (24 respondents). In total, 30 responses were excluded from initial analyses. Of the remaining 169 respondents, 53 registered “don’t know” responses to one or more of the proposed bid levels and one refused to answer the second bid level[3]. Because these responses may indicate a lack of certainty rather than unwillingness to pay, separate specifications were estimated with these responses coded as “no” at both bid levels as well as “yes” at the initial bid level and “no” at the second bid level, and “yes” at both bid levels. However, we found that exclusion of “don’t know” responses resulted in more robust estimates and 54 additional respondents were excluded from analysis. In total, 114 respondents were retained for final analysis (see Table 7 for responses at each bid level).

In addition to contingent valuation questions, the survey instrument (Appendix 3) collected information regarding several control variables, including years of farming experience,

[3]This response was initially coded as “no” and later removed from the dataset.

education, gross income, percent of income from farming, irrigated crop mix, awareness of groundwater shortage, participation in the Conservation Reserve Program, awareness of an Arkansas state tax credit for investment in irrigation technology, and county of residence (Table 8). Experience farming ranged from one to 60 years; on average, respondents reported 30.91 years of experience (Table 9). The average reported gross income of the sample fell between $100,000 and $150,000, while the percent of gross income from farming was, on average, 81.7%. The highest education attained by producers in our sample varied widely. Twenty-six respondents' highest educational attainment was high school or less, 16 had attended college but not graduated, 8 reported earning an associate's degree, and 64 reported earning a bachelor's degree or higher. County of residence was used to construct a dummy variable denoting Crowley's Ridge, where 1 indicates that Crowley's ridge passes through or falls to the west of the respondent's county of residence. Out of 114 respondents, 39 indicated that they reside in a county east of Crowley's Ridge (Table 10).

Several variables were constructed to gauge a respondent's general awareness of water issues in the Delta. First, to determine awareness of options for conversion to surface water irrigation, respondents were asked to state whether they knew of a $9,000 state tax credit for construction of reservoirs or tailwater recovery systems (1=is aware and 0=not). In total 55 respondents indicated awareness of the state tax credit program. Respondents were also asked if they have ever participated in the Conservation Reserve Program, where 1=has participated in the CRP and 0=has not. Fifty-six respondents indicated that they have participated in the CRP. Finally, producers were asked to rate the severity of groundwater shortage on their farm and in the state (Figure 2). Very few respondents indicated that they believe there is a groundwater shortage problem on their farm (only respondents from Prairie county had an average rating greater than or equal to two for on-farm shortage). Surprisingly, however, respondents were generally very aware of state-level groundwater shortage. The average ranking of groundwater shortage severity in the state was 2.66, and 68 respondents (59.6%) ranked the severity of shortage as three or greater.

Four variables were constructed for acreage of main crops produced in the Delta, each of which was paired with a second variable for the percent of each irrigated crop produced relative to total irrigated acres[4]. Figure 3 shows that irrigated acres of each crop varied widely. Thirteen producers reported irrigated cotton production, while the average production is 95.18 acres, eight respondents (61.54%) reported production greater than 500 acres. The percent of irrigated cotton produced was relatively small, with producers reporting that about 3% of all irrigated crops were cotton. While irrigated rice and soybean production, 712.24 and 1,255.82 acres respectively, are far greater than cotton production, they are also highly right-skewed, with maximum acreage of 6,000 acres reported for both crops. On average, 53.9% of producers' irrigated acreage was planted in soybean, while only 27.5% was planted in rice. Producers planted 13.9% of irrigated acreage in corn, about 257.6 acres, on average.

The data collected by enumerators were recorded using Qualtrics Survey Software. Statistical analyses were conducted using Stata Data Analysis and Statistical Software and maps were created with MapViewer.

Results and Discussion

Goodness-of-fit of double-bounded models is best measured by the sequential classification procedure outline by Kanninen and Khawaja (1995). The steps of sequential classification result in two values, initial correctly classified cases (ICCC) and fully, correctly

[4]Percent of irrigated corn was omitted from the MLE estimations due to a multicollinearity issue.

classified cases (FCCC),[5] the latter of which is used to test the goodness-of-fit of the model. While no standard for a "good" model exists, the maximum chance criterion—the percentage of correctly classified cases that would be achieved if all responses were allocated to the group with the highest number of cases—is used as a benchmark to determine the relative predictive power of the model (Kanninen and Khawaja 1995). For the primary specification estimated in Table 11, the computed value of FCCC is 52.63% (60 cases), which exceeds the benchmark established by the maximum chance criterion, 33.33% (38 "No, No"). As such, the model specified above correctly classifies more respondents than if all responses were grouped within the most frequent case. Our primary specification also outperforms alternative specifications, which had 50% and 47.37% FCCC. Alternative specifications return parameters of the same sign and magnitude as the primary specification, indicating that our results are robust[6].

Although the estimated coefficient of an independent variable does not directly measure the marginal effect of that variable on WTP, the sign of the estimated coefficient does indicate the direction of the effect[7]. The coefficient of the bid variable is negative and significant at the 1% level, indicating that respondents are more likely to say no to a large bid. This result is consistent with theoretical expectations. The coefficient for the binary variable that indicates a producer is located east of Crowley's Ridge is also negative and statistically significant at the 5% level. This is probably because groundwater resources are more abundant in areas east of Crowley's Ridge and so producers are likely to exhibit lower WTP than those in the western portion of the Delta.

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[5] Classification Procedure in Appendix 3.

[6] Additionally, random effects Probit regression analysis (omitted) was used to check for anchoring and shift effects, but neither were present.

[7] From equation (13), we can show that sign(∂WTP/∂Z_j) = sign($\partial[\alpha + \sum \delta_{ij} Z_{ij}]/\partial Z_j$).

Coefficients of variables that measure awareness of conservation and water shortage issues are statistically significant. As expected, the coefficient of respondent's rating of groundwater shortage in the state is positive and statistically significant at the 5% level, indicating greater willingness to pay for irrigation water when groundwater resources are perceived as scarce. Respondents who indicated awareness of Arkansas' tax credit program for construction of on-farm surface water infrastructure display a greater willingness to pay. These results highlight the importance of increasing extension efforts to raise awareness of growing and long-term groundwater scarcity in the Delta as well as providing information that explains financial or technical assistance available to farmers who wish to transition to surface water irrigation.

A somewhat unexpected result is that Arkansas producers' WTP for irrigation water from irrigation districts decreases if they have participated in or are currently enrolled in the CRP. Previous studies have shown that producers who participate in conservation programs, such as the CRP, have better access to conservation information and make production decisions based on the impact of their choices in future periods (Lubbell et al. 2013). One possible explanation for this finding is that farmers see the transfer of land out of crop production as a more viable financial decision when groundwater supply decreases.

The estimated coefficient of years of farming experience and the squared term are statistically significant at 1% and 5%, respectively. In contrast to findings from previous studies that age is strictly negatively correlated with WTP for irrigation water, we find that WTP for water from irrigation districts increases with years of farming experience until approximately 38 years of experience, after which, WTP decreases with years of farming experience (Figure 4; Mesa-Jurado et al. 2012). The nonlinear relationship exhibited here may be the result of mixed influences of three factors. First, for both very young (inexperienced) and very old (experienced) producers, exit may be a more preferred option than continued farming with purchased off-farm water when groundwater is scarce. For young farmers, each additional year of experience increases their dependence on farming, and thus decreases their ease of exit. This explanation may contribute to the positive relationship between years of farming and WTP observed among farmers with fewer than 28 years of farming experience. Older producers, or in the sample data, those with more than 38 years of experience, are more likely to start to plan for retirement. In this case, years of farming may lead to a decrease in WTP since each additional year moves a producer closer to the age of retirement (and ease of exit increases).

Second, younger producers tend to be more concerned with the future availability of productive resources and maintaining the long-term viability of their farming operation than older producers (Mesa-Jurado et al. 2012). Since age and years of farming experience are highly correlated, this will lead to a negative relationship between years of farming experience and WTP. Third, producers who have farmed in the Delta for many decades are accustomed to "free" water, where the cost of water is only the cost of energy needed to pump groundwater from the aquifer. As such, a sense of entitlement towards water resources makes the purchase of irrigation water unpalatable and causes WTP to decline with years of farming experience.

Results on social-economic variables are mixed. The coefficient of highest education attained is not statistically significant. Among the sample producers, 64% have some college or associate degrees or have college education. Another 24% have completed high school education or have GED certificates. So, most sample producers either have college (or equivalent) degree or high school (or equivalent) education. Our finding indicates that sample producers with college education do have seem to have higher WTP than those with only high school education.

The estimated coefficient of gross income and its squared term are statistically significant at 10% and 5% respectively, but with opposite signs. WTP increases with gross income until approximately $100,000 per year, after which WTP decreases with income (Figure 5). This change may indicate that farmers are willing to incur some level of income loss by engaging in deficit irrigation or that they can incur higher pumping costs that result from groundwater decline. Or more likely, that producers with higher gross income prefer to invest in on-farm surface water infrastructure which requires higher upfront capital investment rather than paying smaller, recurring fees to access irrigation water. The estimated coefficient of the percent of income from farming is not statistically significant. This could be because there is very little variation in this variable in the sample data.

The coefficients of corn acres, soybean acres, and percent of soybean are not statistically significant. Likely reflecting that these crops require less water to produce or, as is the case with soybean, that they can be produced as unirrigated crops. Thus, WTP for irrigation water is not significantly impacted when these crops are produced. In contrast, the coefficients of cotton acreage as well as for percent of irrigated acreage in cotton, are both statistically significant at the 5% level, but with opposite signs. As expected, as total acreage of cotton increases, WTP decreases, reflecting producers' desire to minimize total cost of irrigation. However, as percent of irrigated cotton acreage relative to total irrigated acreage increases, WTP also increases. One reason that this coefficient is significant for cotton but no other crops may be that differences in yield given reduced irrigation for cotton, which is highly sensitive to changes irrigation, are well understood by cotton producers.   Between 1997 and 2013, the average yield for non-irrigated cotton was 223.5 pounds less than that of irrigated cotton, amounting to revenue loss of about $150 per acre (NASS 2004; NASS 2009; NASS 2014). As such, economic theory would dictate that producers whose earnings are highly dependent on cotton should be WTP up to the average loss in revenue per acre to maintain cotton yield.

Interestingly, while the coefficient of rice acres is statistically significant at the 1% level and negative, the coefficient of percent rice is not statistically significant. Thus, WTP decreases as acres under rice increases. Despite the importance of irrigation to rice production, higher dependency of producer income on the production of rice does not translate to higher WTP. Many factors may explain this relationship. For instance, because rice is always irrigated in Arkansas, producers may not fully understand how decreased access to irrigation water will impact their total earnings. Or it may be that, because the need for irrigation water when rice is produced is so large, the relative importance of the crop to a producer's bottom line has no impact on the negative relationship between rice acres and WTP. Last, the coefficient on percent rice may not be statistically significant because there is high substitutability between rice and other crops, such as soybean. As a result, a large percent of rice production relative to total irrigated acreage may not equate to high dependency of producer income on rice. When access to irrigation water becomes unfavorable for rice production, then, producers may prefer to switch non-irrigated soybean or grain, rather than to spend large amounts of money to maintain rice production.

Estimation of Willingness to Pay

Willingness to pay is estimated for each observation using Equation 13. The average WTP of producers in the Arkansas Delta WTP $32.87 per acre-foot (Table 12). The 95% confidence interval is $27.07 to $38.68. There are few estimates of WTP for irrigation water from previous studies against which we can compare our results. However, the estimated values of WTPs are consistent with prices charged by irrigation districts in other regions of the United

States as well as with prices currently paid by producers in Arkansas who purchase surface water from off-farm sources (Weinberg 1997; Burt 2007; Wichelns 2010; Christian-Smith and Kaphiem 2011; NASS 2014; Board of Directors 2013). One important finding is that the estimated WTP for surface water is likely to be greater than the energy cost producers are currently paying to pump groundwater from the Aquifer. The 95% confidence interval lies within the bounds of the computed minimum and maximum values of pumping cost for Lonoke county, the county in Arkansas where average depth-to-water is greatest (Table 13). In addition, the estimated values of WTP are greater than pumping costs in relatively more groundwater-rich areas of Arkansas. In fact, even when WTP is calculated only for respondents who reside to the east of Crowley's Ridge, where the average depth-to-ground water is as low as 16 feet and pumping costs rarely exceed $9 per acre-foot, average estimated WTP is $23.32 with a 95% confidence interval ranging from $14.54 to $32.11, ceteris paribus (Table 14). Thus, even in areas of the state where groundwater is most abundant, producers' WTP for surface water exceeds the energy cost paid to pump it from the aquifer.

A similar pattern is observed among producers who said that they believe there is no groundwater shortage in the state. On average, estimated WTP of these producers is $24.30 per acre-foot, while the lower bound of the confidence interval, $15.98, is nearly double the maximum cost of pumping paid by producers in Mississippi county. In contrast, the estimated WTP of producers who view groundwater shortage in the state as severe is, on average, $41 per acre-foot for off-farm irrigation water.

Table 15 shows how WTP changes, ceteris paribus, given alternate crop mixes at different farm sizes. Notably, at low acreages, introduction of small quantities of cotton acres has a large impact on total WTP. For instance, WTP of a farmer with only 300 irrigated acres can increase as much as $51 per acre-foot (from about $36 to $87) when they switch from producing only rice (100 acres) and soybean (200 acres) to all four crops, with only 25 acres (8.3%) of cotton. The disproportionate influence of cotton production on WTP holds until acreage grows large. For instance, for producers with more than 6,000 irrigated acres, no cropping combination could be found which results in a WTP that is statistically different from zero. As expected, when cotton production is assumed to be zero, WTP for varied cropping decisions decreases as acreage increases.[8]

Conclusion

Depth-to-groundwater in the MRVAA has consistently increased since the early 20th century. Long-term projections indicate that only 40% of groundwater demand may be met by 2050 (ANRC 2015a). Critical initiatives to slow and reverse groundwater decline in the Delta include the adoption of more efficient irrigation technology and the construction of infrastructure to increase the use of surface water resources that are relatively abundant in the state. The objective of this study is to estimate producers' WTP for irrigation water from irrigation districts.

The study generates an estimated WTP of $32.87/acre-foot and the confidence interval is $27.07/acre-foot to $32.87/acre-foot. Importantly, these estimated values are greater than the cost of pumping groundwater producers are currently paying. Our study also identifies a set of factors that influence producers' WTP. While producers in this study are aware of growing state-level groundwater scarcity, few producers believe that scarcity is a problem that directly impacts their farm operations. Nonetheless, higher awareness seems to predict increases in

[8] Relative to equal proportions of crops at different acreages. In other words, if WTP is calculated at 50% rice and 50% soybean at 1,000 acres, WTP decreases at 2,000 acres when the proportion of rice and soybean is held constant. WTP may in fact increase if the proportion of each crop also changes or if corn acreage increases.

producers' WTP for irrigation water. This finding highlights the importance of continued outreach by the Extension Service to increase awareness of water problems in Arkansas. In contrast, for producers at higher income levels, WTP for off-farm irrigation water decreases. In this case, directing education toward the potential benefits from reservoirs and tailwater recovery systems may result in greater water conservation. In total, 14 variables are statistically significant. The bid value, awareness of state tax credit, if county of residence east of Crowley's Ridge, participation in the CRP, perception of groundwater shortage, years farming and its squared term, gross income and its squared term, cotton acres, percent of cotton acres and rice acres all have statistically significant impacts on WTP.

The conclusion that participation in the CRP decreases WTP could have important policy implications. While large water savings could be achieved by increasing producers' awareness of the CRP, such practices may also decrease the level of producers' WTP for water from irrigation districts. If the downward influence of such programs on the WTPs is large enough irrigation districts cannot set the price of surface water to a level that allows districts to recover the cost of delivering water, then the financial viability of such projects may be hampered. Similar conflicts may also arise between conservation programs that focus on improving irrigation efficiency and programs that focus on conversion to surface water. Both types of programs would positively impact the health of the Aquifer by reducing groundwater use or moving producers towards surface water resources. However, the effectiveness or viability of one program may negatively influence the demand for off-farm water, and thus the existence of infrastructure projects. Policymakers and extension personnel need to take such unintended consequences into account when promoting these programs. For example, conservation programs that focus on improving irrigation efficiency may be more fruitful in areas where conversion to surface water is not an option (e.g., due to lack of infrastructure).

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Tables

Table 1. Average climatic conditions in the study region from 1981 to 2010

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	12M	12MT
Average high in °F:	48.3	53.3	62.7	72.3	81.0	88.3	91.0	90.7	84.3	74.0	61.7	51.0	71.6	--
Average low in °F:	29.3	32.7	41.0	49.7	59.0	67.3	70.7	69.0	61.3	50.0	41.0	32.0	50.3	--
Av. precipitation (in.)	3.91	4.16	4.60	4.91	5.14	3.35	3.44	2.73	2.87	4.58	4.88	5.09	4.14	49.67

Table 2a. Total acres, total irrigated acres, and total non-irrigated acres for major crops produced in Arkansas in 2013 (NASS 2014)

	Irrigated Acres Harvested	**Non-Irrigated Acres Harvested**	**Total Acres Harvested**
Rice	1,294,506 (100%)	--	1,294,506
Corn for grain or seed	698,974 (98.42%)	11,215 (1.58%)	710,189
Cotton	246,842 (92.75%)	19,303 (7.25%)	266,145
Soybeans for beans	2,592,619 (88.67%)	331,167 (11.33%)	2,923,786
Total	4,832,941 (93.04%)	361,685 (6.96%)	5,194,626

Table 2b. Total acres, total irrigated acres, and total non-irrigated acres from major crops produced in Arkansas in 2008 (NASS 2009)

	Irrigated Acres Harvested	**Non-Irrigated Acres Harvested**	**Total Acres Harvested**
Rice	1,303,574 (100%)	--	1,303,574
Corn for grain or seed	381,321 (94.34%)	22,857 (5.66%)	404,178
Cotton	519,707 (89.81%)	58,953 (10.19%)	578,660
Soybeans for beans	2,167,646 (78.82%)	582,321 (21.18%)	2,749,967
Total	4,372,248 (86.81%)	664,131 (13.19%)	5,036,379

Table 2c. Total acres, total irrigated acres, and total non-irrigated acres from major crops produced in Arkansas in 2003 (NASS 2004)

	Irrigated Acres Harvested	**Non-Irrigated Acres Harvested**	**Total Acres Harvested**
Rice	1,322,891 (100%)	--	1,322,891
Corn for grain or seed	192,564 (77.81%)	54,915 (22.19%)	247,479
Cotton	633,598 (83.32%)	126,851 (16.68%)	760,449
Soybeans for beans	1,686,946 (70.93%)	691,455 (29.07%)	2,378,401
Total	3,835,999 (81.46%)	873,221 (18.54%)	4,709,220

Table 3. Irrigated acreage by source for 2013, 2008, and 2003

Year	Source	Farms	Acres irrigated (%)	Acre-feet applied
2013	Groundwater from wells	3,709	4,493,900 (85.53)	5,495,085
	On-farm surface water	1,314	701,343 (13.35)	895,347
	Off-farm water	245	59,218 (1.12)	63,759
2008	Groundwater from wells	3,646	3,909,914 (79.25)	6,864,792
	On-farm surface water	1,471	985,911 (19.98)	1,720,577
	Off-farm water	231	37,897 (0.77)	46,412
2003	Groundwater from wells	3,912	3,421,365 (86.44)	3,520,455
	On-farm surface water	1,808	509,914 (12.88)	699,967
	Off-farm water	58	26,793 (0.68)	45,885

Data provided by the National Agricultural Statistics Service (NASS 2004; NASS 2009; NASS 2014).

Table 4. Survey Response Rates

Category	**Count**	**%**
Attempted contacts	3,712	100.0
Disabled numbers	842	22.68
Net sample size	2,898	78.07
No answer, busy signal or voicemail after repeated calls	1,321	45.58
Sample contacted	1,577	54.42
Total eligible of respondents contacted	665	42.17
Refusals by contact	247	8.523
Refusals by someone other than contact	8	0.276
Ineligible: illness, language barrier or non-farmer	912	31.47
Already completed survey under different listing	5	0.173
Discontinued survey	171	5.901
Accepted and interviewed	199	6.867
Response rate of those contacted and eligible		0.323
Response rate of those contacted		0.126
Response rate of net sample		0.069

Table 5. DBDC bid levels and question sequence

	Initial Bid	**Upper Bid**	**Lower Bid**
Bid Set 1	$10/acre-foot	$15/acre-foot	$5/acre-foot
Bid Set 2	$20/acre-foot	$30/acre-foot	$10/acre-foot
Bid Set 3	$30/acre-foot	$45/acre-foot	$15/acre-foot
Bid Set 4	$40/acre-foot	$60/acre-foot	$20/acre-foot
Bid Set 5	$50/acre-foot	$75/acre-foot	$25/acre-foot
Bid Set 6	$60/acre-foot	$90/acre-foot	$30/acre-foot
Question 1	Would you be willing to pay **Initial Bid** per acre-foot of water to purchase water from an irrigation district?		
Question 2a	(If yes to Question 1) Would you be willing to pay **Upper Bid** per-acre foot of water to purchase water from an irrigation district?		
Question 2b	(If no to Question 1) Would you be willing to pay **Lower Bid** per-acre foot of water to purchase water from an irrigation district?		

Table 6. Number of respondents who refused, responded don’t know, or answered no to follow up bid level of $0.5

Category	Respondents	(%)
Refused both bid levels	6	0.03
Refused one bid level	1	0.01
Don't know to both bid levels	29	0.15
Don't know to one bid level	25	0.13
No to $.5/acre-foot	28	0.14
Don't know to $.5/acre-foot	3	0.02
All refusal, don't know, or protest	92	0.46
No refusal, don't know, or protest	107	0.54
Total	199	1.00
Less deleted respondents	85	0.15
Total respondents kept	114	0.85

Table 7. Number of Yes and No responses at each bid level

	Bid	**Yes**	**(%)**	**No**	**(%)**	**Total Responses**
	$5	2	0.33	4	0.67	6
Bid Set 1	*$10*	14	0.70	6	0.30	20
	$15	10	0.71	4	0.29	14
	$10	5	0.63	3	0.38	8
Bid Set 2	*$20*	5	0.38	8	0.62	13
	$30	4	0.80	1	0.20	5
	$15	5	0.56	4	0.44	9
Bid Set 3	*$30*	9	0.50	9	0.50	18
	$45	5	0.56	4	0.44	9
	$20	7	0.44	9	0.56	16
Bid Set 4	*$40*	9	0.36	16	0.64	25
	$60	6	0.67	3	0.33	9
	$25	5	0.38	8	0.62	13
Bid Set 5	*$50*	5	0.28	13	0.72	18
	$75	2	0.40	3	0.60	5
	$30	3	0.23	10	0.77	13
Bid Set 6	*$60*	7	0.35	13	0.65	20
	$90	1	0.14	6	0.86	7

Table 8. Independent variable definitions

Variable	Description
Conservation, CRP	Binary variable where 1=has participated in the Conservation Reserve Program, 0=not
East of Crowley's Ridge	Binary variable where 1=lives in a county to the east (in part or fully) of Crowley's Ridge, 0=not
Gross Income [a]	Gross income range in 2014, treated as continuous, where 0=don't know or refused; 1=less than \$10,000; 2=\$10,000 to \$15,000; 3=\$15,000 to \$20,000; 4=\$20,000 to \$25,000; 5=\$25,000 to \$35,000; 6=\$35,000 to \$50,000; 7=\$50,000 to \$75,000; 8=\$75,000 to \$100,000; 9=\$100,000 to \$150,000; 10=\$1500,000 to \$200,000; 11=\$200,000 to \$250,000; 12=\$250,000 to \$300,000; and 13=greater than \$300,000
Gross Income Squared	The square of gross income.
Percent Farm Income	Percent of gross income from farming.
Groundwater Shortage (State)	Respondent rating of the severity of water shortage, from 0=no shortage to 5=severe shortage, in the state
Highest Education	The highest level of education completed, where Highest education level achieved: 1=no formal education, 2=less than high school, 3=completed high school or GED, 4=some college or vocational program, 5= completed Associate degree, 6=completed Bachelor degree, 7=completed Master degree, 8=beyond Master
Awareness of State Tax Credit	Binary variable where 1=is aware of state tax credit program, 0=not
Years Farming	Total years of farming experience.
Years Farming Squared	The square of total years of farming experience.
Corn Acres	Irrigated acres of corn produced in 2015.
Percent Corn	Percent irrigated corn production of total irrigated acres
Cotton Acres	Irrigated acres of cotton produced in 2015.
Percent Cotton	Percent irrigated cotton production of total irrigated acres.
Rice Acres	Irrigated acres of rice produced in 2015.
Percent Rice	Percent irrigated rice production of total irrigated acres.
Soybean Acres	Irrigated acres of soybean produced in 2015.
Percent Soybean	Percent irrigated soybean production of total irrigated acres.

a. Fourteen respondents refused to provide income information. These respondents were assigned an income value equal to the mean of the sample (8.61).

Table 9. Summary statistics of sample

Variable	Mean	St. Dev.	Min	Max
Gross Income	8.61	2.21	1	13
Percent Farm Income	0.8169	0.2623	0	1
Groundwater Shortage (State)	2.66	1.96	0	5
Highest Education	5.07	1.52	1	8
Years Farming	30.91	14.41	1	60
Corn Acres	257.63	404.56	0	1,800
Percent Corn	0.1385	0.2118	0	1
Cotton Acres	95.18	399.88	0	2,000
Percent Cotton	0.0296	0.1139	0	0.77
Rice Acres	712.24	967.98	0	6,000
Percent Rice	0.2751	0.2642	0	1
Soybean Acres	1,255.8	1,132.9	0	6,000
Percent Soybean	0.5393	0.2737	0	1

Table 10. Frequency statistics for dummy variables

Variable	Yes (%)	No (%)
Conservation, CRP	56 (49.12)	58 (50.88)
East of Crowley’s Ridge	39 (34.21)	75 (65.79)
Awareness of State Tax Credit	55 (48.25)	59 (51.75)

Table 11. Maximum Likelihood Estimation results

	Primary Specification		*Alternate Specification 1*		*Alternate Specification 2*	
	Coefficient	**S. Error**	**Coefficient**	**S. Error**	**Coefficient**	**S. Error**
Intercept	-7.4364**	3.3638	-6.6513**	3.0963	-7.4690**	3.1295
Bid	-0.0660***	0.0082	-0.0633***	0.0079	-0.0646***	0.0080
Awareness of State Tax credit	1.2097***	0.4358	1.1262***	0.4259	1.1845***	0.4304
Crowley's Ridge	-1.1412**	0.4673	-1.0889**	0.4527	-1.0525**	0.4546
Conservation, CRP	-1.2380***	0.4495	-1.0616**	0.4310	-1.2035***	0.4468
Groundwater shortage	0.2518**	0.1109	0.2211**	0.1066	0.2559**	0.1098
Years farming	0.2063***	0.0696	0.2018***	0.0673	0.2039***	0.0686
Years farming^2	-0.0027**	0.0011	-0.0028***	0.0010	-0.0027**	0.0011
Gross income	1.2160*	0.6342	1.2261*	0.6518	1.2768**	0.6422
Gross income^2	-0.0678**	0.0334	-0.0649*	0.0342	-0.0681**	0.0337
Percent Farm Income	-0.5124	0.8338	--	--	--	--
Highest Education	0.1676	0.1449	--	--	--	--
Corn Acres [b]	-0.00004	0.0007	--	--	--	--
Cotton Acres	-0.0148**	0.0060	-0.0119**	0.0056	-0.0139**	0.0058
Percent Cotton	51.2548**	21.949	40.0830*	20.693	47.8286**	21.515
Soybean Acres	0.0004	0.0003	0.0003	0.0002	0.0005*	0.0003
Percent Soybean	0.2313	1.2893	--	--	--	--
Rice Acres	-0.0010***	0.0004	-0.0007***	0.0003	-0.0011***	0.0004
Percent Rice	1.5944	1.3627	--	--	1.6799	1.1227
Observations	114		114		114	
Wald Chi^2	31.50		29.02		29.63	
P > Chi^2	0.0174		0.0039		0.0053	
Log Likelihood	-127.18		-129.54		-128.41	
ICCC	71.05%[a]		70.18%[a]		71.05%[a]	
FCCC	52.63%[a]		50.00%[a]		47.37%[a]	

***significant at 1%, **significant at 5%, and * significant at 10%

a. Indicates percent correctly classified responses by model is greater than the most frequently observed response.

b. Percent corn omitted because of problem with multicollinearity.

Table 12. Baseline WTP estimates

	WTP	s.e.	P > z	2.5%	95%
Primary Specification	32.87	2.9611	0.000	27.0691	38.6762
Alternate Specification 1	32.63	3.0135	0.000	26.7243	38.5370
Alternate Specification 2	32.68	2.9758	0.000	26.8450	38.5100

Table 13. Average pumping cost per acre-foot of water in the Delta, Lonoke County (highest average depth-to-groundwater in Arkansas), and Mississippi county (lowest average depth-to-groundwater in Arkansas)

Region	**Av. Depth (ft.)**	**Low Diesel Cost ($2.43)**	**High Diesel Cost ($3.77)**
Delta	40.49	$14.08	$22.17
Lonoke County	83.35	$28.95	$45.62
Mississippi County	16.22	$5.66	$8.90

Table 14. Estimated WTP at alternate variable values

	WTP	[95% Confidence	Interval]
Mean WTP	*$32.87*	*27.07*	*38.68*
West of Crowley's Ridge	$38.21	30.83	45.60
East of Crowley's Ridge	$23.32	14.54	32.11
Does/has participated in CRP	$24.78	17.24	32.32
Does not/has not participated in CRP	$41.27	32.67	49.88
Groundwater shortage rating = 0	$24.30	15.98	32.63
Groundwater shortage rating = 1	$27.42	20.61	34.23
Groundwater shortage rating = 2	$30.67	24.84	36.51
Groundwater shortage rating = 3	$34.03	28.01	40.06
Groundwater shortage rating = 5	$41.01	31.24	50.79
Highest education [a] = 2	$26.20	14.28	38.13
Highest education [a] = 8	$39.62	26.31	52.94
Percent income from farming [a] = 0.2	$37.18	21.88	52.49
Percent income from farming [a] = 1	$31.62	24.75	38.50
Not Aware of State Tax Credit	$25.35	17.78	32.92
Aware of State Tax Credit	$41.53	33.07	49.98

[a]The coefficient is not statistically significant.

Table 15. Estimated WTP under different crop mixes

Total acres	Corn[a]	%[b]	Cotton	%	Rice	%[a]	Soybean[a]	%[a]	WTP	2.50%	97.50%
300	0	0.000	0	0.000	100	0.333	200	0.667	$35.60	26.06	45.14
300	0	0.000	0	0.000	300	1.000	0	0.000	$44.19	21.81	66.56
300	100	0.333	25	0.083	75	0.250	100	0.333	$87.07	0.60	133.53
800	200	0.250	0	0.000	300	0.375	300	0.375	$33.23	0.99	41.46
800	100	0.125	0	0.000	300	0.375	400	0.500	$34.27	0.84	41.71
800	400	0.500	75	0.094	0	0.000	125	0.156	$81.23	0.93	130.53
1,000	0	0.000	0	0.000	500	0.500	500	0.500	$34.81	0.17	43.45
1,000	300	0.300	50	0.050	250	0.250	400	0.400	$57.81	0.25	80.37
1,000	100	0.100	100	0.100	500	0.500	300	0.300	$86.31	0.16	132.45
2,000	500	0.250	100	0.050	400	0.200	1000	0.500	$47.56	32.22	62.91
2,000	0	0.000	500	0.250	1000	0.500	500	0.250	$106.19	32.37	180.01
2,000	500	0.250	0	0.000	1000	0.500	500	0.250	$26.91	16.96	36.85
6,000	2,500	0.417	500	0.083	2,000	0.333	1,000	0.167	$0.92[c]	-2.84	4.69
6,000	2,000	0.200	0	0.000	2,000	0.333	2,000	0.333	$18.76[c]	-6.75	44.28

[a]Coefficient is not statistically significant.
[b] Coefficient omitted from MLE due to multicollinearity; listed percent is implied but not specified in WTP estimation.
[c]Estimated WTP is not statistically different from zero.

Figures

Figure 1. Extent of critical groundwater areas and groundwater study regions in Arkansas

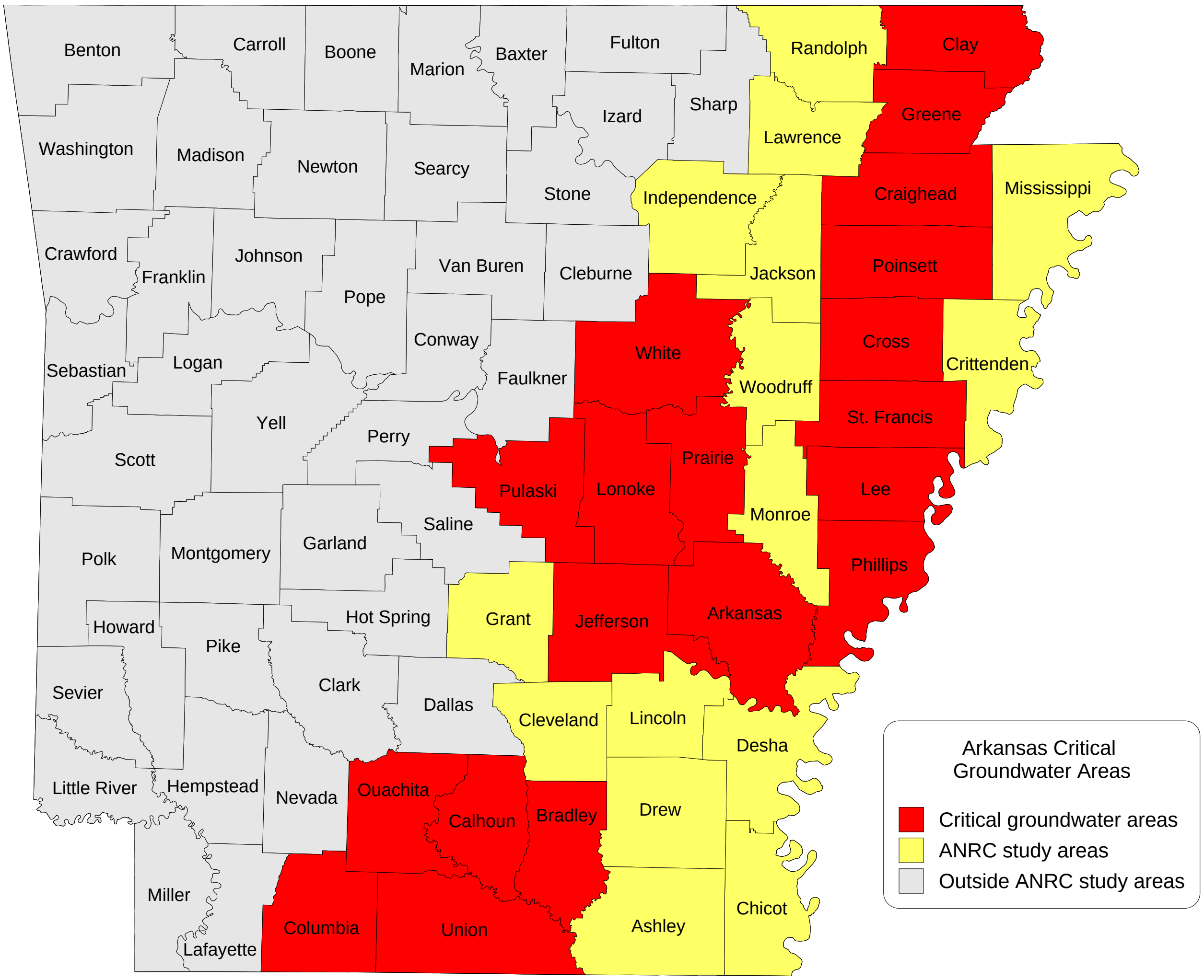


Figure 2. County averages of respondent belief of water shortage on their farm (left) and in Arkansas (right).

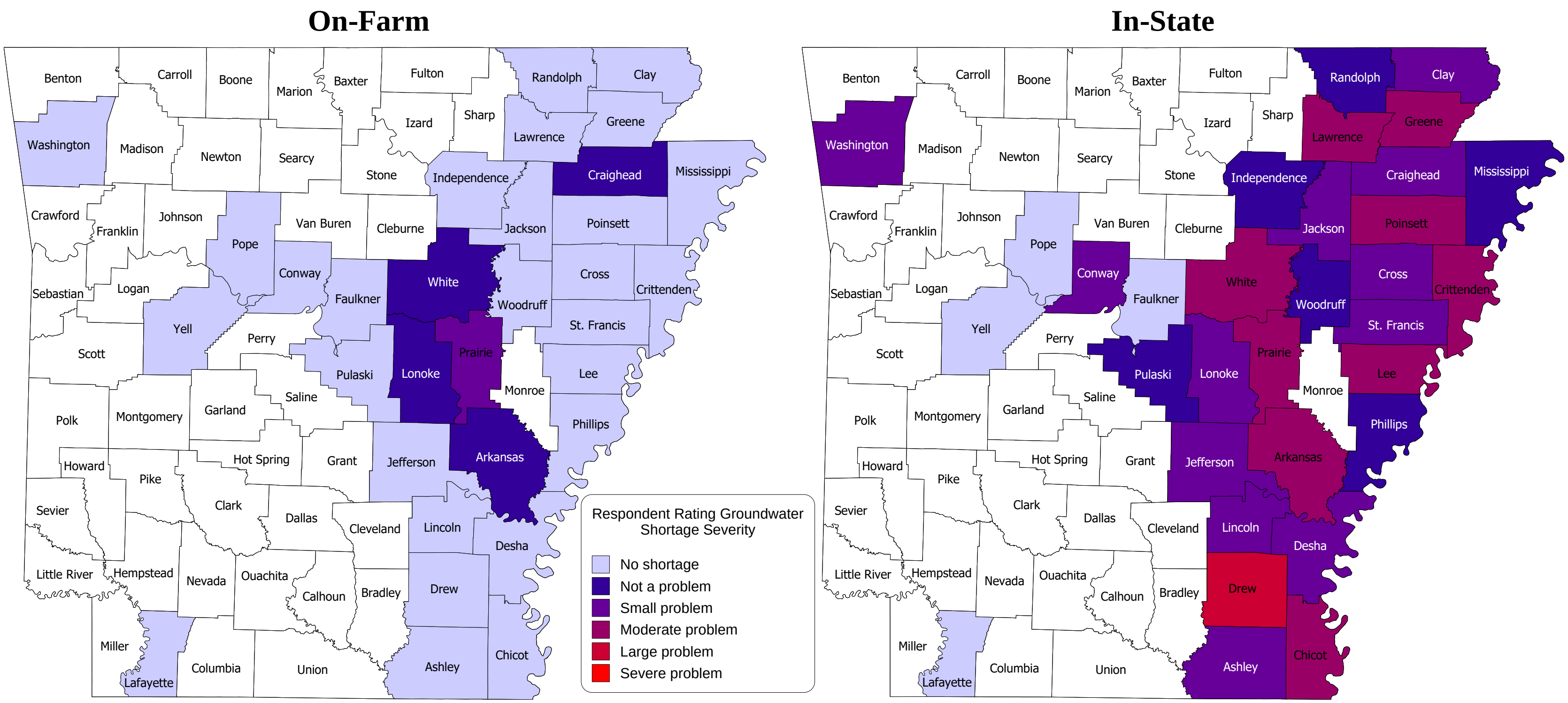


Figure 3. Box and whisker plot of irrigated acreage of main crops

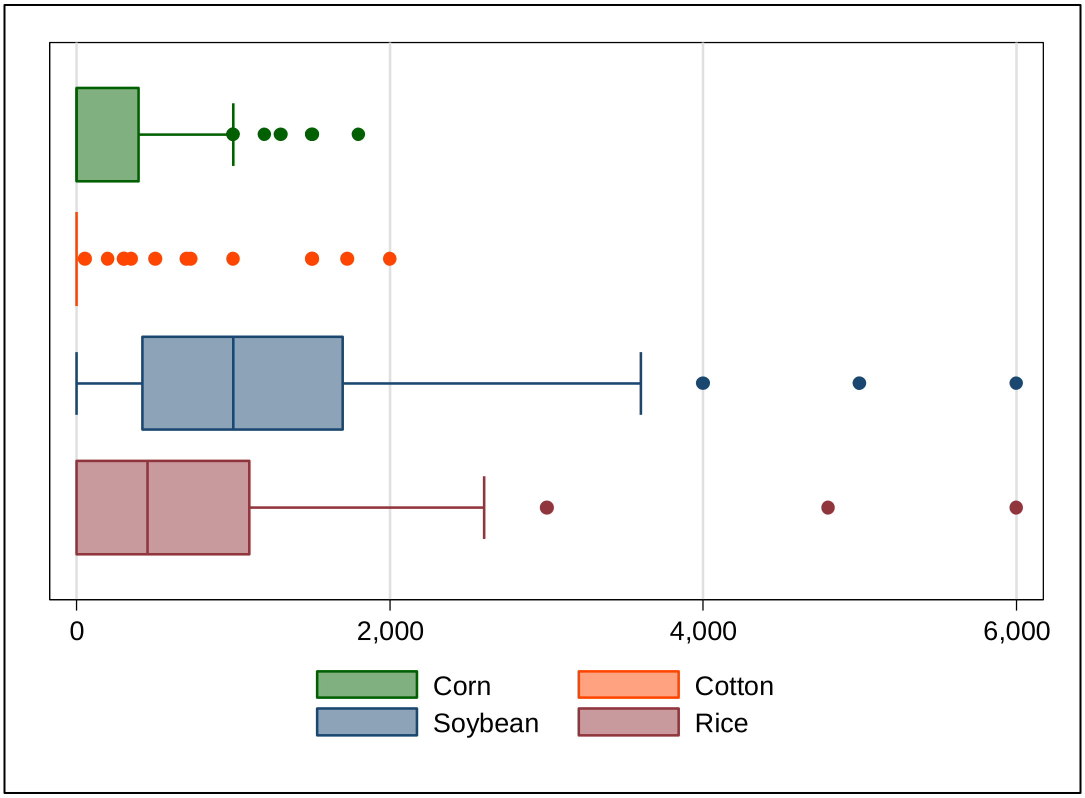


Figure 4. Net effect of years farming experience on WTP

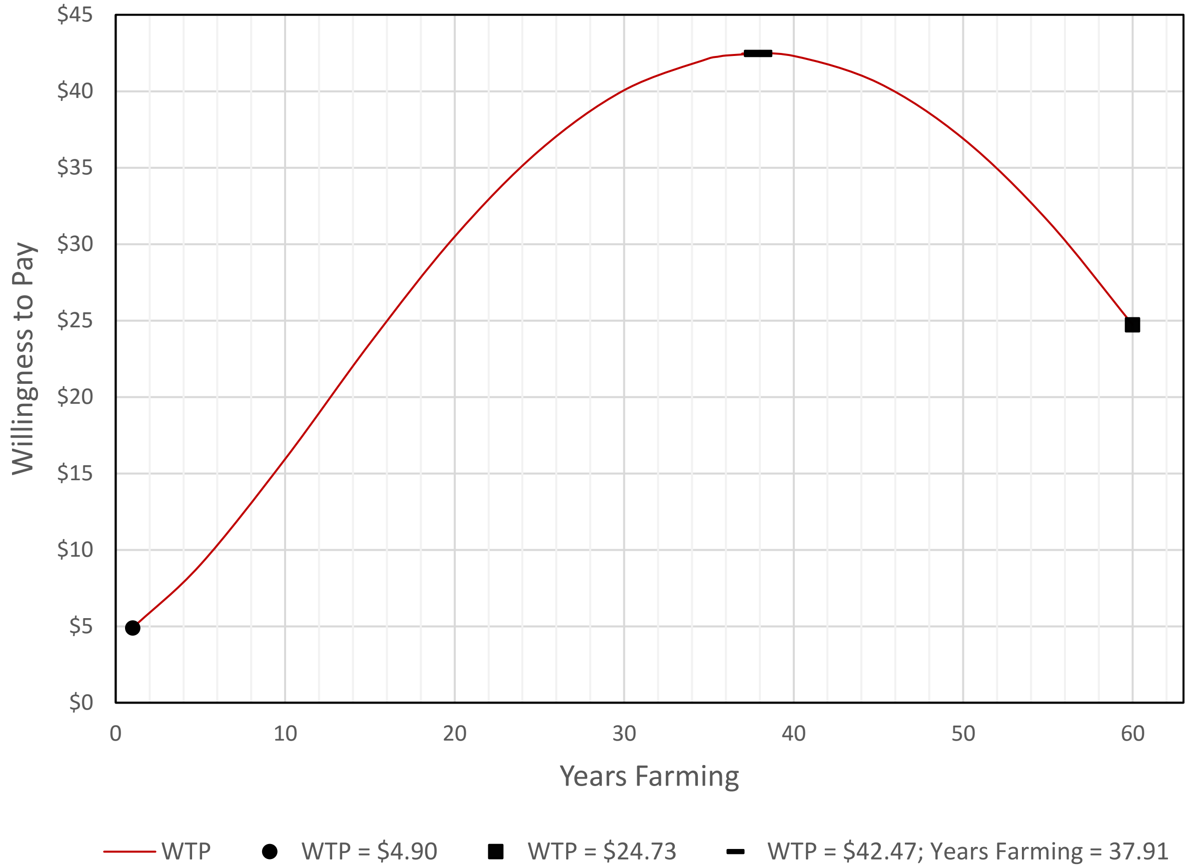
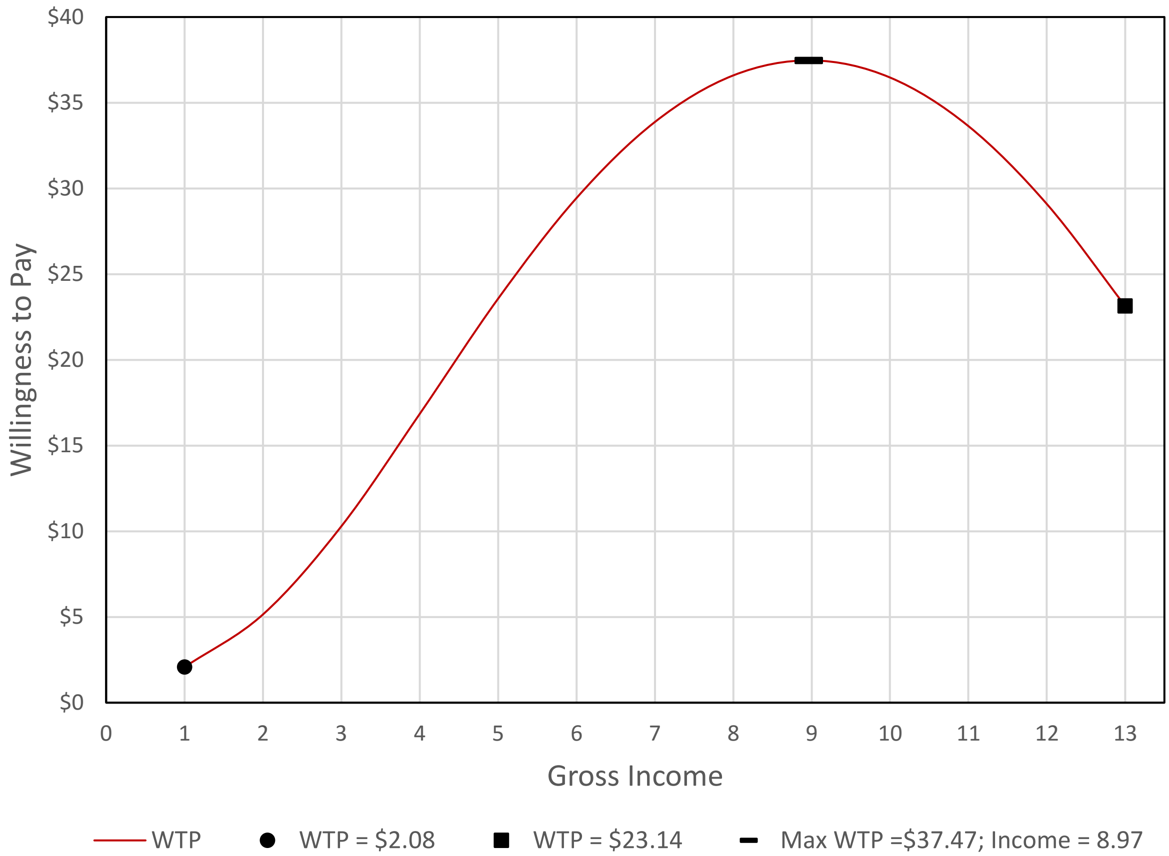


Figure 5. Net effect of gross income on WTP



Appendix 1. Goodness-of-Fit Sequential Classification Procedure developed by Kanninen and Khawaja (1995)

Step 1. Estimate the single-bound probability of obtaining a yes or no response for each case using the estimated coefficients of the specified model

(A) $$\pi^Y = \frac{1}{1+e^{-\left(\alpha+\beta b^I+\sum \delta_{ij} z_{ij}\right)}}$$

Step 2. Sort the number of initially, correctly classified cases (P>.5 indicates yes and P<.5 indicates no) from the incorrectly classified cases. In following the following steps, only initially, correctly classified cases are retained to calculate FCCC.

Step 3. Estimate the joint probability for remaining respondents using Eqs. 8-11.

Step 4. Estimate the conditional probabilities for remaining respondents. For respondents who were correctly classified as yes in steps 1 and 2 only use equations B and C; for respondents who were correctly classified as no in steps 1 and 2 only use equations D and E.

(B) $$P_i^{Y_2/Y_1} = \frac{P_i^{YY}}{P_i^{Y}}$$

(C) $$P_i^{N_2/Y_1} = \frac{P_i^{YN}}{P_i^{Y}}$$

(D) $$P_i^{Y_2/N_1} = \frac{P_i^{NY}}{P_i^{N}}$$

(E) $$P_i^{N_2/Y_1} = \frac{P_i^{NN}}{P_i^{N}}$$

Step 5. For respondents ICCC yes respondents, classify based on the higher valued conditional probability of B and C (if B is greater YY, if C is greater YN). For respondents ICCC no respondents, classify based on the higher valued conditional probability of D and E (if D is greater NY, if E is greater NN). Count the total number of fully, correctly classified cases

(F) $$FCCC = \frac{n}{N}$$

Appendix 2: Survey Instrument

Q8 Would you consider yourself a...
□ Land owner only
□ Operator only
□ Land owner and operator
□ Prefer not to respond

Q9 Unfortunately, we are only able to complete surveys with operators. Thank you for your time. Goodbye.

Q10 Do you produce any of the following crops under irrigation? [Check all that apply]
□ Corn
□ Cotton
□ Soybeans
□ Rice
□ Peanuts
□ Grain, Sorghum
□ Other ____________________
□ None of these
□ Refused

Q11 Do you have any additional acres, either fallowed or not accounted for by the crops we've discussed?
□ Yes
□ No
□ Don't Know
□ Refused

Q14 What state do you live in?
□ Mississippi
□ Arkansas
□ Louisiana
□ Missouri
□ Refused

Q16 What county do you live in? (Arkansas)

Q19 Thinking about the water source you use for your irrigated acres, what percentage of this water comes from:
groundwater?
surface water?

Q20 For the wells used on this operation, how has the depth-to-water changed over the last five years? Note that a depth-to water increase means water levels are dropping.
□ Depth-to-water did not change

☐ Depth-to-water increased
☐ Depth-to-water decreased
☐ Don't Know
☐ Refused

Q21 In your opinion, do you have a groundwater shortage problem:

	Yes	No	Don't Know	Refused
On your farm?	☐	☐	☐	☐
In your state?	☐	☐	☐	☐

Q22 On a scale of 1 to 5, with 1 meaning 'no problem' and 5 meaning 'severe problem,' how would you rate the groundwater shortage problem on your farm?
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ Don't Know
☐ Refused

Q23 On a scale of 1 to 5, with 1 meaning 'not concerned' and 5 meaning 'very concerned,' how concerned are you that a water shortage may occur in your state in the next 10 years?
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ Don't Know
☐ Refused

Q24 Do you have a tailwater recovery system?
☐ Yes
☐ No
☐ Prefer not to answer

Q25 How many irrigated acres use tailwater recovery?

Q26 When did you start using a tailwater recovery system?
[Year] [Month]

Q27 How many storage reservoirs do you have?

Q28 Next, I'll ask you to tell me the size and depth of each of these reservoirs.

Q29 What is the size of Reservoir (1, 2,…,n) in acres?

Q30 What is the depth of Reservoir (1, 2,…,n) in feet?

Q31 When did you start using a storage reservoir?
[Year] [Month]

Q32 What is the primary reason you started using a tailwater recovery system or storage reservoirs?
☐ Groundwater was no longer sufficient
☐ Financial assistance was available
☐ Landlord converted, it was not my decision
☐ Desired to reduce irrigation costs
☐ Desired to reduce risk of regulation or water shortage
☐ Other ____________________
☐ None of these
☐ Don't Know
☐ Refused

Q33 How was money raised for the tailwater recovery systems or storage reservoirs? [Check all that apply]
☐ Paid cash
☐ Bank loan
☐ Federal program cost share such as NRCS
☐ State tax credit program
☐ Other ____________________
☐ None of these
☐ Don't Know
☐ Refused

Q34 Have you ever used flood irrigation for row crop corn, cotton, and/or soybeans?
☐ Yes
☐ No
☐ Don't Know
☐ Refused

Q35 Of your total irrigated acres, how many acres alternate between flood and furrow irrigation? Such as levee rice and row watered soybeans.

Q36 Please tell me how many of your total irrigated acres were exclusively flood irrigated in 2015, and did not alternate between flood and furrow. Such as levee fields that rotate between soybeans and corn.

Q37 Please tell me how many of your total irrigated acres were continuously furrow irrigated in 2015, such as fields that are furrow irrigated both for soybeans and cotton in rotation. This excludes acres that alternated between flood and furrow irrigation.

Q38 Have you ever used border irrigation for corn, cotton, and/or soybeans?
□ Yes
□ No
□ Don't Know
□ Refused

Q39 Please tell me how many of your total irrigated acres used border irrigation in 2015?For Don't Know, enter -1For Refused, enter -2

Q40 Have you ever used microirrigation for corn, cotton, and/or soybeans?
□ Yes
□ No
□ Don't Know
□ Refused

Q41 Please tell me how many of your total irrigated acres used microirrigation in 2015?For Don't Know, enter -1For Refused, enter -2

Q42 Is your microirrigation system above ground or subsurface?
□ Above ground
□ Subsurface
□ Don't Know
□ Refused

Q43 Do you use computerized hole selection?
□ Yes
□ No
□ Don't Know
□ Refused

Q44 How many of your total irrigated acres used computerized hole selection in 2015? (i.e.PHAUCET or Pipe Planner)

Q45 When did you start using computerized hole selection?
[Year] [Month]

Q46 What is the primary reason you started using computerized hole selection? Was it because...
□ Profit allowed for new investment in technology
□ Experienced water shortage on farm, needed to increase capacity
□ Heard about this technology from a neighbor
□ Learned about this technology at an Extension meeting
□ Learned about this technology from an industry meeting
□ I wanted to reduce input costs
□ I tried it on my farm and saw the benefit
□ Other ____________________
□ Don't Know

□ Refused

Q47 What is the primary reason you are not using computerized hole selection (e.g. PHAUCET or Pipe Planner)?
□ Was not aware of technology
□ Don’t know how to use it
□ Takes too much time to implement
□ Groundwater is adequate
□ Surface water is adequate
□ Rental agreement does not allow for irrigation investment
□ Crop prices too low
□ Fuel, labor, and equipment costs too high
□ It doesn’t work on my farm
□ Would like to use the system, but unsure how to get started
□ Other ____________________
□ Don't Know
□ Refused

Q48 Have you ever used surge irrigation?
□ Yes
□ No
□ Don't Know
□ Refused

Q49 How many of your total irrigated acres use surge irrigation? For Don't Know, enter -1For Refused, enter -2

Q50 When did you start using surge irrigation?
[Year] [Month]

Q51 What is the primary reason you started using surge irrigation? Was it because...
□ Profit allowed for new investment in technology
□ Experienced water shortage on farm, needed to increase capacity
□ Heard about this technology from a neighbor
□ Learned about this technology at an Extension meeting
□ Learned about this technology from an industry meeting
□ I wanted to reduce input costs
□ I tried it on my farm and saw the benefit
□ Other ____________________
□ Don't Know
□ Refused

Q52 How did you raise money for surge irrigation? [Check all that apply]
□ Reinvestment of farm profits
□ Bank loan
□ Federal program cost share

☐ Other ____________________
☐ Don't Know
☐ Refused

Q53 What are the reasons you are not using surge irrigation?
☐ Was not aware of technology
☐ Don’t know how to use it
☐ Takes too much time to implement
☐ Groundwater is adequate
☐ Surface water is adequate
☐ Rental agreement does not allow for irrigation investment
☐ Crop prices too low
☐ Fuel, labor, and equipment costs too high
☐ It doesn't work on my farm
☐ Would like to use the system, but unsure how to get started
☐ Other ____________________
☐ Don't Know
☐ Refused

Q54 How many of your TOTAL IRRIGATED acres have been leveled through each of the following means?
Zero grade
Precision Grade / Constant Slope
Warped surface, optisurface (sloped in two directions to minimize earthwork costs)
Not leveled

Q55 Do your furrow irrigation fields use...?

	Yes	No	Don't Know	Refused	Does not have furrow irrigated fields
End blocking	☐	☐	☐	☐	☐
Cutback irrigation	☐	☐	☐	☐	☐
Deep tillage	☐	☐	☐	☐	☐

Q56 How many of your total irrigated acres used end blocking in 2015?

Q57 How many of your total irrigated acres used Cutback irrigation in 2015?

Q58 How many of your total irrigated acres used deep tillage in 2015?

Q59 Thinking about your acres that are currently using furrow irrigation, at any point in the past, were you using pivot irrigation for those acres?
☐ Yes
☐ No
☐ Does not have furrow irrigated fields

□ Don't Know
□ Refused

Q60 When did you start to convert from pivot irrigation to furrow irrigation?
[Year] [Month]

Q61 On how many of your total acres have you replaced pivot irrigation with furrow irrigation?

Q62 Have you ever used center pivot irrigation for row crops?
□ Yes
□ No
□ Don't Know
□ Refused

Q63 Have you ever used portable center pivot irrigation for row crops?
□ Yes
□ No
□ Don't Know
□ Refused

Q64 How many of your acres used center pivot irrigation in 2015?

Q65 How many of your acres used portable center pivot irrigation in 2015?

Q66 When did you start using center pivot irrigation?
[Year] [Month]

Q67 How often, in years, are sprinkler packages replaced on all center pivot machines in service? (Note: This means how many years between replacements. Eg: Every ## years.)

Q68 Do you use any of the following on your center pivots? [Check all that apply]
□ Drop nozzles
□ End guns
□ Rotators
□ Variable rate irrigation
□ Corner Unit
□ None of these
□ Don't Know
□ Refused

Q69 Are you considering converting any of your pivot irrigated acres to furrow irrigated in the future?
□ Yes
□ No
□ Prefer not to answer

Q70 How many of your pivot irrigated acres are you considering converting to furrow irrigated?

Q71 How many irrigation pumps are on your farms?

Q72 Do you have a timer on your pumps?
□ Yes
□ No
□ Prefer not to answer

Q73 How many pumps have a timer?

Q74 Do you own any flow meters?
□ Yes
□ No
□ Prefer not to answer

Q75 How many of these flow meters are mounted permanently?

Q76 How many portable flow meters do you own?

Q77 What energy sources do you use on your farm for your pumps? [Check all that apply]
□ Electric
□ Diesel
□ Propane
□ Natural gas
□ Dual fuel
□ Some Other Energy Source ____________________
□ Don't Know
□ Refused

Q78 How many pumps use electric power?

Q79 How many pumps use diesel power?

Q80 How many pumps use propane power?

Q81 How many pumps use natural gas power?

Q82 How many pumps use dual fuel power?

Q83 How many pumps use ${q://QID37/ChoiceTextEntryValue/6} power?

Q84 Which of the following methods do you use to schedule irrigation on your farm? [Check all that apply]
□ Visual crop stress
□ Computerized scheduler (like the Arkansas Irrigation Scheduler)

- Woodruff charts
- Routine scheduling
- Probe or feel method
- ET or Atmometer
- Canopy temperature
- Watch what neighbor / other local farmer does
- Soil moisture sensors
- None of these
- Don't Know
- Prefer Not to Answer

Q85 When did you start using soil moisture sensors?
[Year] [Month]

Q86 On how many of your total irrigated acres are you using soil moisture sensors to schedule irrigation?

Q87 What type or brand of soil moisture sensor do you use?

Q88 When did you start using ET or Atmometers?
[Year] [Month]

Q89 On how many of your total irrigated acres are you using ET or Atmometers to schedule irrigation?

Q90 When did you start using Computerized Scheduling?
[Year] [Month]

Q91 On how many of your total irrigated acres are you using Computerized Scheduling?

Q92 When did you start using Woodruff Charts?
[Year] [Month]

Q93 On how many of your total irrigated acres are you using Woodruff Charts?

Q94 I am going to read a list of soil amendments and treatments. Please tell me how many of your acres, if any, are treated with each.
Gypsum
PAM
Deep Tillage

Q95 When you till, do you till more or less than twelve inches?
- Less than 12"
- 12" or more
- Don't Know
- Prefer not to answer

Q96 Do you use a low (no-till ripper) or high disturbance (parabolic) soil treatment?
- Low
- High
- Other ____________________
- Don't Know
- Prefer not to answer

Q97 Do you use any cover crops?
- Yes
- No
- Don't Know
- Prefer not to answer

Q98 What species of cover crops do you use? Please tell me how many acres each crop covers.

Q99 Of your average annual rice acreage, how many acres of rice use each of the following irrigation systems on your farm?
Precision grade
Contour levee
Zero grade
Row-water
Pivot

Q100 How many of your total irrigated acres that are contour levee fields use Multiple Inlet Rice Irrigation?

Q101 How many of your total irrigated acres that are precision grade fields use Multiple Inlet Rice Irrigation?

Q102 How many of your total irrigated acres that are zero grade are continuous rice?

Q106 What is primary the reason you are not using precision leveling?
- Was not aware of precision leveling
- Don't know how to use it
- Takes too much time to implement
- Groundwater is adequate
- Surface water is adequate
- Rental agreement does not allow for irrigation investment
- Crop prices too low
- Fuel, labor, and equipment costs too high
- Would like to use the system, but unsure how to get started
- It doesn't work on my farm
- Other ____________________
- Don't Know
- Refused

Q107 When did you start using zero grade?
[Year] [Month]

Q108 How was money raised for zero grade? [Check all that apply]
□ Paid cash
□ Bank loan
□ Federal program cost share such as NRCS
□ State tax credit program
□ Other ____________________
□ None of these
□ Don't Know
□ Refused

Q109 In what year did you start using multiple-inlet rice irrigation?

Q346 In what month in STATED YEAR did you start using multiple-inlet rice irrigation?

Q110 What is the primary reason you started using Multiple Inlet Rice Irrigation on your farm?
□ Profit allowed for new investment in technology
□ Experienced water shortage on farm, needed to increase capacity
□ Heard about this technology from a neighbor
□ Learned about this technology at an Extension meeting
□ Learned about this technology from an industry meeting
□ I wanted to reduce input costs
□ I tried it on my farm and saw the benefit
□ Other ____________________
□ Don't Know
□ Refused

Q111 What is the primary reason you are not using Multiple Inlet Rice Irrigation on your farm?
□ Was not aware of multiple inlet rice
□ Don't know how to use it
□ Takes too much time to implement
□ Groundwater is adequate
□ Surface water is adequate
□ Rental agreement does not allow for irrigation investment
□ Crop prices too low
□ Fuel, labor, and equipment costs too high
□ Damage to pipe during season is too much to keep repaired
□ It doesn’t work on my farm
□ Would like to use the system, but unsure how to get started
□ Other ____________________
□ Don't Know
□ Refused

Q112 Thinking about a typical year between 2011 and 2015, how many rice acres are managed under the following methods?
Continuous Flood
Alternate wetting and drying
Straight Head Drain

Q113 Which of the following rice irrigation scheduling tools are utilized on your farm? [Check all that apply]
□ Visual Determination
□ Calendar Event
□ Float Indication
□ Electronic Sensor
□ Other ____________________
□ None of these
□ Don't Know
□ Prefer not to answer

Q103 When did you start using precision leveling?
[Year] [Month]

Q104 What is the primary reason you started using precision leveling? Was it because...
□ Government assistance was available to defer the cost
□ Irrigation water was limited
□ It improves drainage on my farms
□ It makes irrigation easier
□ It improved my profitability
□ I could afford it, because it became more economical to do
□ Other ____________________
□ Don't Know
□ Refused

Q105 How did you raise money for precision leveling? [Check all that apply]
□ Reinvestment of farm profits
□ Bank loan
□ Federal program cost share
□ Other ____________________
□ Don't Know
□ Refused

Q114 For each of the following changes you've made to irrigation, by what percent did pumping time decrease (if any) as a result of the change?
Tail-water recovery
Multiple inlet irrigation for rice
Storage reservoir
Computerized hole selection (e.g. PHAUCET or Pipe Planner)
Surge irrigation

Precision leveling
Zero grade
Deep tillage
End blocking
Center pivot
Irrigation scheduling methods (computerized scheduler, soil moisture sensors, canopy temperature, ET or Atmometer

Q115 Have you participated in any of these federal, state, or local conservation programs in the last five years?

	Yes	No	Don't Know	Refused
Conservation Reserve Program	☐	☐	☐	☐
Environmental Quality Incentives Program	☐	☐	☐	☐
Regional Conservation Partnership Program	☐	☐	☐	☐
Any other conservation program	☐	☐	☐	☐

Q116 It has been proposed by government entities that groundwater levels are declining and only part of irrigation water demand will be met in the future. If groundwater levels declined to the point where you no longer had adequate water for your crops AND you cannot deepen or drill new wells to access more water, which of the following would you choose?
☐ Irrigate with reduced capacity from my wells, also called deficit irrigation, to produce as much as I can with available water.
☐ Use surface water irrigation by constructing reservoirs AND tail water recovery systems.
☐ Purchase the additional water that I need from irrigation districts (assume that this would be available to everyone in the state). A reservoir may be needed to store purchased water.
☐ Other responses (please specify) ____________________
☐ Don't Know
☐ Refused

Q117 What is the maximum reduction in profit, measured in dollars per acre per year, acceptable to you?

Q118 Would you be willing to pay <u>initial bid</u> per acre foot of water to purchase water from an irrigation district?
☐ Yes
☐ No
☐ Don't Know
☐ Refused

Q119 (If Q118 is yes) Would you be willing to pay <u>higher bid</u> per acre foot of water to purchase water from an irrigation district?
☐ Yes
☐ No
☐ Don't Know

□ Refused

Q120 (If Q118 is no) Would you be willing to pay lower bid per acre foot of water to purchase water from an irrigation district?
□ Yes
□ No
□ Don't Know
□ Refused

Q121 Would you be willing to pay 50 cents per acre foot of water to purchase water from an irrigation district?
□ Yes
□ No
□ Don't Know
□ Refused

Answer If Would you be willing to pay 50 cents per acre foot of water to purchase water from an irrigation district? No Is Selected
Q122 Why are you not willing to pay 50 cents per acre foot?
□ I will not receive adequate benefits from the irrigation water
□ I cannot afford more than 50 cents per acre foot at this time
□ It is unfair that producers should pay more for water from the irrigation district
□ Some Other ____________________
□ Don't know
□ Refused

Q123 What is maximum dollar amount per acre foot of water at or below which you would definitely buy water from an irrigation district?

Q124 What is maximum dollar amount per acre foot of water at or above which you would definitely NOT buy water from an irrigation district?

Q321 If you or other producers were to build a reservoir today, what percentage of cost share assistance should be offered by the government to help producers that would like to build reservoirs but cannot afford to?

Q322 Are you aware of the state tax credits program that allow you to claim up to $9,000 tax credits for conversions to surface water or land leveling?
□ Yes
□ No
□ Don't Know
□ Refused

Q323 Did you ever use the state tax credits program?
□ Yes
□ No

□ Don't Know
□ Refused

Q324 What did you use the tax credits on? [Choose all that apply]
□ Construction of impoundments to use available surface water
□ Conversion from ground water use to surface water use
□ Land leveling to reduce agricultural irrigation water use
□ Other ____________________
□ Don't Know
□ Refused

Q325 Thinking about a typical year between 2011 - 2015, what is the estimated total quantity of water applied per acre of irrigated rice, in acre-feet?

Q326 Thinking about a typical year between 2011 - 2015, what is the estimated total quantity of water applied per acre of irrigated soybeans, in acre-feet?

Q327 Thinking about a typical year between 2011 - 2015, what is the estimated total quantity of water applied per acre of irrigated corn, in acre-feet?

Q328 Thinking about a typical year between 2011 - 2015, what is the estimated total quantity of water applied per acre of irrigated cotton, in acre-feet?

Q329 In the past five years, on average, approximately what percent of your family income (net income from all sources) came from farming?

Q330 I'm going to read a list of practices. Please tell me if one or more of your close family members, friends or neighbor producers has used this practice in the past 10 years? [Choose all that apply.]
□ Center Pivot
□ Tail-water recovery system
□ Storage reservoir
□ Computerized hole selection (i.e. PHAUCET or Pipe Planner)
□ Surge irrigation
□ Flow meters on the wells
□ Precision leveling
□ Zero grade leveling
□ End blocking, cutback irrigation, or furrow diking
□ Irrigation scheduling methods such as computerized scheduler, Soil moisture sensors, ET, or Atometer
□ Multiple-inlet rice irrigation
□ Alternate wetting and drying for rice irrigation
□ None of these
□ Don't Know
□ Refused

Q331 Do you belong, or have you ever belonged, to a conservation organization such as Ducks Unlimited?
- Yes
- No
- Don't Know
- Refused

Q332 What conservation organization did you belong to?

Q333 Finally I have a few background questions. How many years of farming experience do you have?

Q13 Please tell me how many IRRIGATED acres you had of each of the following crops in 2015: For
______ Corn
______ Cotton
______ Soybeans
______ Rice
______ Peanuts
______ Grain, Sorghum

Q358 I added up each of the answers for those crops and it comes out to SUM irrigated acres in 2015. Was that how many total acres you irrigated in 2015?
- Yes
- No
- Don't Know
- Refused

Q359 How many total irrigated acres did you have in 2015?

Q360 Why is your total irrigated acreage less than the number we added up by crop type?

Q361 Why is your total irrigated acreage greater than the number we added up by crop type?

Q337 What yield expectation do you have on your farms for the following crops?
Corn (in bushels per acre)
Soybeans (in bushels per acre)
Rice (in bushels per acre)
Cotton (in pounds of lint per acre)

Q334 What was the last grade or year of school that you attended?
- No formal education
- Less than high school
- Completed High School or GED equivalent
- Some college or vocational program
- Completed Associate degree (2-year program)

□ Completed Bachelors degree (4-year program)
□ Completed Masters degree
□ Beyond Masters degree
□ Don't Know/Not Sure
□ Refused

Q335 Was any part of your formal education related to agriculture?
□ Yes
□ No
□ Refused

Q336 Which of the following categories best describes your 2014 household income from all sources BEFORE taxes? Would you say.:

□ Less than $10,000	□ $10,000 to $15,000	□ $15,000 to $20,000
□ $20,000 to $25,000	□ $25,000 to $35,000	□ $35,000 to $50,000
□ $50,000 to $75,000	□ $75,000 to $100,000	□ $100,000 to $150,000
□ $150,000 to $200,000	□ $200,000 to $250,000	□ $250,000 to $300,000
□ More than $300,000	□ Don't Know/Not Sure	□ Refused

Appendix 3. Stata Code

```
***Scalar Code***
summarize bidi, meanonly
scalar bidm=r(mean)
summarize gws, meanonly
scalar gwsm=r(mean)
summarize stc, meanonly
scalar stcm=r(mean)
summarize cons_crp, meanonly
scalar cons_crpm=r(mean)
summarize yf, meanonly
scalar yfm=r(mean)
summarize he, meanonly
scalar hem=r(mean)
summarize gi_ra, meanonly
scalar gi_ram=r(mean)
summarize crowleysridge, meanonly
scalar crowleysridgem=r(mean)
summarize gws2, meanonly
scalar gws2m=r(mean)
summarize yf2, meanonly
scalar yf2m=r(mean)
summarize gi_ra2, meanonly
scalar gi_ra2m=r(mean)
summarize corn, meanonly
scalar cornm=r(mean)
summarize cotton, meanonly
scalar cottonm=r(mean)
summarize soybean, meanonly
scalar soybeanm=r(mean)
summarize rice, meanonly
scalar ricem=r(mean)
summarize gws_state, meanonly
scalar gws_statem=r(mean)
summarize percentrice, meanonly
scalar percentricem=r(mean)
summarize percentcotton, meanonly
scalar percentcottonm=r(mean)
summarize percentcorn, meanonly
scalar percentcornm=r(mean)
summarize percentsoybean, meanonly
scalar percentsoybeanm=r(mean)
summarize percentfarm, meanonly
scalar percentfarmm=r(mean)

***Model Definition***
capture program drop double_cv
program double_cv
version 14.1
args lnf xb bid
qui replace `lnf' = ln(invlogit($ML_y6*`bid'+`xb')) if $ML_y1 == 1
qui replace `lnf' = ln(invlogit(-($ML_y7*`bid'+`xb'))) if $ML_y2 == 1
qui replace `lnf' = ln(invlogit(-($ML_y6*`bid'+`xb')) - invlogit(-
($ML_y5*`bid'+`xb'))) if $ML_y3 == 1
```

```
qui replace `lnf' = ln(invlogit(-($ML_y5*`bid'+`xb')) - invlogit(-
($ML_y7*`bid'+`xb'))) if $ML_y4 == 1
end

***Regression 1***
ml model lf double_cv (xb: yy nn yn ny = stc crowleysridge cons_crp gws_state
yf yf2 gi_ra gi_ra2 rice cotton pcotton soybean) (bid: bidi bidu bidl = )
ml maximize

**WTP Evaluated at the mean**
nlcom (WTP: (ln(1+
exp(_b[_cons]+_b[stc]*stcm+_b[cons_crp]*cons_crpm+_b[crowleysridge]*crowleysr
idgem+_b[gws_state]*gws_statem+_b[yf]*yfm+_b[yf2]*yf2m+_b[gi_ra]*gi_ram+_b[gi
_ra2]*gi_ra2m+_b[cotton]*cottonm+_b[pcotton]*pcottonm+_b[soybean]*soybeanm+_b
[rice]*ricem))/-[bid]_b[_cons]))

**NEWFCCC**
gen pyesnew1=1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[cons_crp]*cons_crp+_b[crowleysr
idge]*crowleysridge+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2
+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soybean+_b[rice]*rice))))

gen pnonew1=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_
b[pcotton]*pcotton+_b[soybean]*soybean+_b[rice]*rice)))))

gen pyesyesnew1=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice)))))

gen pnononew1=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_
b[pcotton]*pcotton+_b[soybean]*soybean+_b[rice]*rice)))))

gen pnoyesnew1=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[gws_state]*gws_state+_b[cons_crp]*cons_crp+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice)))))-(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[cons_crp]*cons_crp+_b[crowleysr
idge]*crowleysridge+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice)))))

gen pyesnonew1=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[gws_state]*gws_state+_b[cons_crp]*cons_crp+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice)))))-(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
```

```
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice)))))

gen pyyynew1 =pyesyesnew1/pyesnew1
gen pynynew1 =pyesnonew1/pyesnew1
gen pnynnew1 =pnoyesnew1/pnonew1
gen pnnnnew1 =pnononew1/pnonew1
gen probsumnew1=pyesyesnew1+pyesnonew1+pnoyesnew1+pnononew1

***Regression 2***
ml model lf double_cv (xb: yy nn yn ny = stc crowleysridge cons_crp gws_state
yf yf2 gi_ra gi_ra2 rice price cotton pcotton soybean) (bid: bidi bidu bidl =
)
ml maximize

**WTP Evaluated at the mean**
nlcom (WTP: (ln(1+
exp(_b[_cons]+_b[stc]*stcm+_b[crowleysridge]*crowleysridgem+_b[cons_crp]*cons
_crpm+_b[gws_state]*gws_statem+_b[yf]*yfm+_b[yf2]*yf2m+_b[gi_ra]*gi_ram+_b[gi
_ra2]*gi_ra2m+_b[cotton]*cottonm+_b[pcotton]*pcottonm+_b[soybean]*soybeanm+_b
[rice]*ricem+_b[price]*pricem))/-[bid]_b[_cons]))

**NEWFCCC**
gen pyesnew2=1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[gws_state]*gws_state+_b[cons_crp]*cons_crp+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2
+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soybean+_b[rice]*rice+_b[p
rice]*price))))

gen pnonew2=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_
b[pcotton]*pcotton+_b[soybean]*soybean+_b[rice]*rice+_b[price]*price)))))

gen pyesyesnew2=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice+_b[price]*price)))))

gen pnononew2=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_
b[pcotton]*pcotton+_b[soybean]*soybean+_b[rice]*rice+_b[price]*price)))))

gen pnoyesnew2=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice+_b[price]*price)))))-(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice+_b[price]*price)))))
```

```
gen pyesnonew2=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice+_b[price]*price)))))-(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[cotton]*cotton+_b[pcotton]*pcotton+_b[soybean]*soyb
ean+_b[rice]*rice+_b[price]*price)))))

gen pyyynew2 =pyesyesnew2/pyesnew2
gen pynynew2 =pyesnonew2/pyesnew2
gen pnynnew2 =pnoyesnew2/pnonew2
gen pnnnnew2 =pnononew2/pnonew2
gen probsumnew2=pyesyesnew2+pyesnonew2+pnoyesnew2+pnononew2

***Regression 3***
ml model lf double_cv (xb: yy nn yn ny = stc crowleysridge cons_crp gws_state
yf yf2 gi_ra gi_ra2 rice) (bid: bidi bidu bidl = )
ml maximize

**WTP Evaluated at the mean**
nlcom (WTP: (ln(1+
exp(_b[_cons]+_b[stc]*stcm+_b[crowleysridge]*crowleysridgem+_b[cons_crp]*cons
_crpm+_b[gws_state]*gws_statem+_b[yf]*yfm+_b[yf2]*yf2m+_b[gi_ra]*gi_ram+_b[gi
_ra2]*gi_ra2m +_b[rice]*ricem))/-[bid]_b[_cons]))

**NEWFCCC**
gen pyesnew3=1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))

gen pnonew3=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))

gen pyesyesnew3=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))

gen pnononew3=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))

gen pnoyesnew3=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))-(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))

gen pyesnonew3=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
```

```
i_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))-(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[rice]*rice)))))

gen pyyynew3 =pyesyesnew3/pyesnew3
gen pynynew3 =pyesnonew3/pyesnew3
gen pnynnew3 =pnoyesnew3/pnonew3
gen pnnnnew3 =pnononew3/pnonew3
gen probsumnew3 =pyesyesnew3+pyesnonew3+pnoyesnew3+pnononew3


***Regression 4***
ml model lf double_cv (xb: yy nn yn ny = stc crowleysridge cons_crp gws_state
yf yf2 gi_ra gi_ra2 percentfarm he corn cotton percentcotton soybean
percentsoybean rice percentrice) (bid: bidi bidu bidl = )
ml maximize

**WTP Evaluated at the mean**
nlcom (WTP: (ln(1+
exp(_b[_cons]+_b[stc]*stcm+_b[cons_crp]*cons_crpm+_b[crowleysridge]*crowleysr
idgem+_b[gws_state]*gws_statem+_b[yf]*yfm+_b[yf2]*yf2m+_b[gi_ra]*gi_ram+_b[gi
_ra2]*gi_ra2m+_b[corn]*cornm+_b[cotton]*cottonm+_b[percentcotton]*percentcott
onm+_b[soybean]*soybeanm+_b[percentsoybean]*percentsoybeanm+_b[rice]*ricem+_b
[percentrice]*percentricem+_b[he]*hem+_b[percentfarm]*percentfarmm))/-
[bid]_b[_cons]))

**FCCC for all Crops**
gen pyesac=1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[cons_crp]*cons_crp+_b[crowleysr
idge]*crowleysridge+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[cotton]*cotton+_b[percentcotton]*perc
entcotton+_b[soybean]*soybean+_b[percentsoybean]*percentsoybean+_b[rice]*rice
+_b[percentrice]*percentrice+_b[he]*he+_b[percentfarm]*percentfarm))))

gen pnoac=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[co
tton]*cotton+_b[percentcotton]*percentcotton+_b[soybean]*soybean+_b[percentso
ybean]*percentsoybean+_b[rice]*rice+_b[percentrice]*percentrice+_b[he]*he+_b[
percentfarm]*percentfarm)))))

gen pyesyesac=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[cotton]*cotton+_b[percentcotton]*perc
entcotton+_b[soybean]*soybean+_b[percentsoybean]*percentsoybean+_b[rice]*rice
+_b[percentrice]*percentrice+_b[he]*he+_b[percentfarm]*percentfarm)))))

gen pnonoac=1-(1/((1+exp(-(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc
+_b[crowleysridge]*crowleysridge+_b[cons_crp]*cons_crp+_b[gws_state]*gws_stat
e+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*gi_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[co
tton]*cotton+_b[percentcotton]*percentcotton+_b[soybean]*soybean+_b[percentso
ybean]*percentsoybean+_b[rice]*rice+_b[percentrice]*percentrice+_b[he]*he+_b[
percentfarm]*percentfarm)))))
```

```
gen pnoyesac=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidl+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[gws_state]*gws_state+_b[cons_crp]*cons_crp+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[cotton]*cotton+_b[percentcotton]*perc
entcotton+_b[soybean]*soybean+_b[percentsoybean]*percentsoybean+_b[rice]*rice
+_b[percentrice]*percentrice+_b[he]*he+_b[percentfarm]*percentfarm)))))-
(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[cons_crp]*cons_crp+_b[crowleysr
idge]*crowleysridge+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[cotton]*cotton+_b[percentcotton]*perc
entcotton+_b[soybean]*soybean+_b[percentsoybean]*percentsoybean+_b[rice]*rice
+_b[percentrice]*percentrice+_b[he]*he+_b[percentfarm]*percentfarm)))))

gen pyesnoac=(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidi+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[gws_state]*gws_state+_b[cons_crp]*cons_crp+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[cotton]*cotton+_b[percentcotton]*perc
entcotton+_b[soybean]*soybean+_b[percentsoybean]*percentsoybean+_b[rice]*rice
+_b[percentrice]*percentrice+_b[he]*he+_b[percentfarm]*percentfarm)))))-
(1/((1+exp(-
(_b[_cons]+[bid]_b[_cons]*bidu+_b[stc]*stc+_b[crowleysridge]*crowleysridge+_b
[cons_crp]*cons_crp+_b[gws_state]*gws_state+_b[yf]*yf+_b[yf2]*yf2+_b[gi_ra]*g
i_ra+_b[gi_ra2]*gi_ra2+_b[corn]*corn+_b[cotton]*cotton+_b[percentcotton]*perc
entcotton+_b[soybean]*soybean+_b[percentsoybean]*percentsoybean+_b[rice]*rice
+_b[percentrice]*percentrice+_b[he]*he+_b[percentfarm]*percentfarm)))))

gen pyyyac =pyesyesac/pyesac
gen pynyac =pyesnoac/pyesac
gen pnynac =pnoyesac/pnoac
gen pnnnac =pnonoac/pnoac
gen probsumac=pyesyesac+pyesnoac+pnoyesac+pnonoac
```

Appendix 4. Institutional Review Board Research Compliance Letter

UNIVERSITY OF ARKANSAS

Office of Research Compliance
Institutional Review Board

April 11, 2016

MEMORANDUM

TO:	Tyler Knapp Kent Kovacs Chris Henry Quiqiung Huang
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	16-03-659
Protocol Title:	*Willingness to Pay for Irrigation Water Under Scarcity Conditions in the Arkansas Delta*
Review Type:	☒ EXEMPT ☐ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 04/08/2016 Expiration Date: 04/07/2017

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 270 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

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