Influence of Peer Networks on the Use of Surface Water Systems

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Abstract

Agriculture in the Arkansas Delta region is dependent upon the accessibility of irrigation water. The most common irrigation water source is groundwater. This practice has led to the depletion of groundwater which is having a damaging influence on the natural resources of the state and the productions costs of agriculture in the region. The adoption of reservoirs and tail-water recovery systems are being promoted as a way of minimizing groundwater depletion and promoting surface water irrigation. Despite the long term benefits of surface water use, many producers are reluctant to adopt the water saving practices. To better understand the barriers of adoption, this project uses the responses from producers who took part in the Arkansas Irrigation Survey in 2016. The responses from this survey are used to find which factors are correlated with the adoption of water storage facilities. The research finds that peer networks are positively correlated with the adoption of surface water irrigation. Producers who know someone who has already adopted surface water irrigation practices, are more likely to have adopted. The results of this research can be used to help extension agencies promote surface water irrigation.

Keywords: *Irrigation, Groundwater conservation, Reservoir, Surface water delivery, Tail-water recovery*

JEL Classifications: Q15, Q24, Q25

Introduction

Agriculture is the largest industry in Arkansas generating close to $16billion to the state's economy each year (Arkansas Farm Bureau, 2017). Irrigated crops such as rice and soybean are key contributors to the large agricultural sector with Arkansas being the number 1 producer for rice and 10th largest producer for soybean in the United States. The success of producing these crops has been possible due to the availability of groundwater in the Arkansas Delta region of the state. Like all natural resources, the groundwater availability in the Delta is finite, and with the growing success of irrigation agriculture in recent decades brings issues with the overconsumption of groundwater. This overconsumption has led to greater difficulty in accessing groundwater as aquifer volumes decrease; leading to future challenges for irrigated agriculture in Arkansas (Hignight , Wailes , Popp, & Smartt, 2005).

Irrigated agriculture in Arkansas accounts for over 8% of all irrigated acres in the United States, making it the third largest irrigating state behind Nebraska and California. Of all water extracted in Arkansas, irrigated agriculture accounts for 80% (United Stated Deprtment of Agriculture , 2012). These figures identify irrigation agriculture as the main source of groundwater depletion, resulting in the industry being a focal point in finding ways to reduce the groundwater depletion and encourage natural recharge.

The use of reservoirs and tail-water recovery systems are advocated as a way of conserving water in irrigation agriculture. Figure 1 uses a diagram to show how the water storage system works to preserve groundwater. It can be seen in figure 1 that water stored in wetter seasons is preserved using tail-water recovery and reservoirs for use in months where there is a higher demand for irrigation water. The incoming flow comes from rainfall, surface water from irrigation and from groundwater stocks. This storage of water in previous months ensure that there is adequate irrigation water available in the months of high demand and limits the irrigation water being pumped from the ground.

The adoption of reservoirs and tail-water recovery systems also have economic benefits for producers; pumping costs to access the groundwater are reduced as water can be accessed from the storage system. Despite these benefits some farmers are reluctant to adopt reservoirs or tail-water recovery systems, this is due to the up-front cost of implementing the water management methods, or the lack of knowledge and interest into alternative methods of irrigation.

In a bid to encourage producers to adopt surface water irrigation the Arkansas Natural Resource Commission off the Tax Credit Program. This program offers producers a tax credit of up to 50% of the project cost to install a storage reservoir. Despite this incentive, there has been little stimulus to encourage producers to adopt the water saving methods.

The aim of this paper is to get a greater understanding of how the peer networking of farmers influences the adoption of both reservoirs and tail-water recovery systems. The research tests a variety of different factors from the Arkansas Irrigation Survey of 2016. By identifying factors that have the greatest correlation adoption could be beneficial to agricultural extension services in the state when trying to encourage producers to adopt the water saving methods in the future. The paper will outline how the data used was collected, what method was used to determine the most influential factors, results of these methods, identification of tests to determine the reliability of these results, discussion of the results, how research could be improved in the future and concluding remarks.

Literature Review

The reasons for conducting this research is help better understand the increasing issue of groundwater scarcity in the Arkansas Delta region. Despite the issue not being as prevalent as other drought stricken states such as California, water scarcity from the increasing groundwater pumping could harm future agricultural production in our study area. To prevent these future issues producers must adopt water saving technologies, in our case we focus on reservoirs and tail-water recovery systems. It is often difficult to understand what factors influence the adoption of these kinds of technologies, especially when the problem is currently not key issue for many producers. Much of the literature behind adoption of irrigation technology is in response to drought conditions, an example of this is the research conducted by (Schuck, Frasier, Webb, Ellingson , & Umberger , 2005). The research looks to determine the responses from producers after the 2002 Colorado drought, and finds that there are in fact lower adoption rate responses than expected from producers. The findings suggest that producers look for short term, low cost fixes to address irrigation shortages. These results highlight the issues that policy makers and interest groups who looks to preserve both economic and environmental assets in agricultural production face when trying to encourage the adoption of irrigation saving technologies. Our will look to build on this literature by including a variety of factors that could influence the adoption of water saving technologies.

One of these factors includes the influences of peer networks on the adoption of surface water systems. We draw from the work conducted by (Genius , Koundouri, Nauges, & Tzouvelekas, 2013) who looked to better understand the influences of both extension agencies and social networks on the promotion of agricultural technology adoption. They find that the both extension agencies and social networks help increase the levels of technology adoption. To build on this the paper also finds that the presence of extension agencies and social networks can act as complements to each other and increase the diffusion of adoption agricultural technologies. The research for these findings were conducted in Crete, Greece. Our paper looks to yield similar understanding about the impacts of peer interviews in the Arkansas Delta region. We believe that peer networks can increase the rate of adoption of surface water technologies much to the benefit of extension agents.

Developing on the literature behind the influence of peer networks, (Ramirez, 2013) finds that the trust between farmers in a social network, has a positive influence on the adoption of water saving technology. The paper also concludes that government-led information sessions through clubs and organizations can also have a positive influence on the adoption of water saving technologies. Our paper looks to expand on this literature, by looking at the influences of knowing others with reservoirs or tail-water recovery systems. We will also look understand the impacts of being part of a conservation group has on the adoption of water saving technologies.

Data

The data used in this paper is extracted from the Arkansas Irrigation Survey Questionnaire which was conducted in 2015 by the Mississippi State University Survey Research Laboratory. A total of 228 producers conducted the survey and were asked 199 questions during a phone call interview. The survey targeted producers living in the Arkansas Delta region. The questions cover a variety of topics which looked to gain a better understanding of peer network relationships, farm ownership, crops grown, irrigation techniques and preferences, groundwater concerns, willingness to pay for irrigation, farm income and farmer education. The data will be used to figure out the reasons behind the current adoption of reservoirs and tail-water recovery. Responses such as peer networks, farm income, education, conservation preferences and groundwater concerns will be used to find relationships between influential factors and adoption. The collected data is cross-sectional which includes both qualitative and quantitative data, where the qualitative data is binominal, nominal and ordinal and the quantitative data is discrete. A full list of variables groups and variables names can be seen in Table 1 and the meaning behind each variable can be seen in Table 2.

To gain a better insight of the current adoption of on farm water storage, we show the number of producers who use a reservoir per crop in figure 2. The graph shows that for all crops the majority of producers do not use on-farm water storage. It can also be seen that the majority of producers who do use on-farm storage reservoirs, use them for soybean, rice and corn. This could be because these crops are the most irrigation intensive crops.

In figure 3 we observe the current adoption of tail-water recovery systems by crop. It can be seen in figure 3 that both rice and corn growers are more likely to use tail-water recovery systems, with rice growers having the highest rate of adoption. This data would also suggest that there has been a higher rate of adoption of tail-water recovery systems than reservoirs on the landscape.

Methods

To find which factors are correlated with the adoption of surface water technology, a multinomial logit regression (MNL) will be conducted. Before getting to that stage the first stage of the process is to clean the data from the Arkansas Irrigation Survey. This will mean changing the qualitative data into quantitative data through the use of dummy variables. As this research looks to use a regression model, a selection of dependent variables which would potentially have an impact on the reservoir and tail-water recovery were selected which are shown in table 4 of the data section. The research will then use a MNL model and the estimation method will be to maximize the likelihood of each independent variable having an impact on the dependent variables. This will allow for a better understanding of what variables are influencing producer's choice when it comes to adopting reservoirs or tail-water recovery. For the MNL model there will be four dependent variables which are assigned a whole value between 0 and 3. The dependent variables will include; producers that have neither a reservoir nor a tail-water recovery system (0), producers that have a tail-water recovery system only (1), producers that have a reservoir only (2) and producers that have both a tail-water recovery system and a reservoir (3). These dependent variables are ordered in a way that having both a reservoir and tail-water recovery system is the most preferable option, followed by having a reservoir only, then having a tail-water recovery system only and neither a reservoir or tail-water recovery system being the least preferable option.

This multinomial model is described below where *m* represents the alternative choice options and *y* is the dependent variable which takes the value of *j* if the j^{th} alternative is taken, $j = 1,\ldots$m. We can define the probability that alternative *j* is chosen as:

$$p_j = \Pr[\, y = j],\ \ j = 1,\ldots,\text{m}. \qquad (1.1)$$

Where *p* and Pr is the probability. This introduces *m* binary variables for each observation *y*,

$$yj = \begin{cases} 1 \text{ if } y = j, \\ 0 \text{ if } y \neq j, \end{cases} \qquad (1.2)$$

We can see that *yj* is equal to one if alternative *j* is the observed outcome and the remaining y_k are equal to zero, meaning that for each observation of *y*, one of $y_1, y_2, \ldots, y_\text{m}$ will be nonzero.

For the likelihood function we use a sample of *N* independent observations as:

$$L_N = \prod_{i=1}^{N} \prod_{j=1}^{M} p_{ij}^{yij} \ \ ,$$

where i represents the i^{th} of N individuals and j represents the j^{th} of m alternatives. The log-likelihood function is therefore:

$$\Lambda = InL_N = \sum_{i=1}^{N} \sum_{j=1}^{m} y_{ij} \; In\, p_{ij,} \tag{1.3}$$

As our regressors do not vary over alternatives, we use MNL model,

$$p_{ij} = \frac{e^{x'_{ij}\beta_j}}{\sum_{l=1}^{m} e^{x'_{ij}\beta_j}}, \qquad j = 1, \dots, m \tag{1.4}$$

Because $\sum_{j=1}^{m} pij = 1$, a constraint is needed to ensure the model identification and the usual restriction of $\beta_1 = 0$.

The coefficients in our model will be represented in terms of relative risk. For the MNL model we draw a comparison from the base category, which is also known at the alternative which is normalized to have a coefficient of zero. This is explained in (1.4) where it is implied that the probability of observing alternative j given that either alternative j or alternative k is observed is

$$\Pr[y = j \mid j \text{ or } k \text{ or } r \text{ or } s] = \frac{p_j}{p_j + p_k + p_r + p_s}$$

$$= \frac{e^{x'\beta_j}}{e^{x'\beta_j} + e^{x'\beta_k} + e^{x'\beta_r} + e^{x'\beta_s}} \tag{1.5}$$

$$= \frac{e^{x'(\beta_j - \beta_k)}}{1 + e^{x'(\beta_j - \beta_k)} + e^{x'(\beta_j - \beta_r)}}$$

which represents a logit model with the coefficient ($\beta_j - \beta_k$). We then simplify to reach a second equality. Supposing that normalization is attributed to base alternative s, meaning $\beta_s = 0$. Then

$$\Pr[y_i = j \mid \; y_i = j \; or \; k \; or \; r \; or \; s = \frac{e^{x_{ij}'\beta_j}}{1 + e^{x_{ij}'\beta_j} + e^{x_{ik}'\beta_k} + e^{x_{ir}'\beta_r}} \tag{1.6}$$

β_j can carry the same interpretation as logit model coefficient binary choice alternatives *j* and 1. Likewise, it can be interpreted using relative risk of choosing alternative *j* rather than alternative s, this is shown as

$$\frac{\Pr[y_i=j]}{\Pr[y_i=s]} = e^{x_{ij}'\beta_j} \quad (1.7)$$

meaning e^{β_j} explains the proportionate change in relative risk when x_{ir} changes by one unit. We will output our results of the model using the relative risk values.

The linear regression formula is shown as;

$$y_i = \beta_0 + x_i'\beta_1 + c_i'\beta_2 + \beta_3 z_i' + \beta_3 w_i' + \beta_3 p_i' + u_i \text{ where } i = 1,\dots, n. \quad (1.8)$$

The parameter β_0 is the intercept of the model, $\beta_1 x_i$' is a vector of independent variables which are associated with conservation. Variables which show producer socioeconomics are held in the vector $\beta_2 c_i$'. Variables which represent farm practices are held in the vector $\beta_3 z_i$'. Variable which represent aquifer are held in vector $\beta_3 w_i$. Vector $\beta_3 p_i$' hold variables for the methods of payments for storage technology and surge irrigation. There term is shown as u_i which includes all other possible variables that is not represented in the model.

Results

The results are presented by variable group, table 3 shows the results for conservation variables, table 4 shows the results for socioeconomic variables, in table 5 the results for farm practice results are listed, aquifer change results are presented in table 6 and irrigation finance results can be seen in table 7. Results are recorded using relative risk ratios (RRR), which are recorded for each level of adoption; tail-water recovery only, reservoir only and both tail-water recover and reservoir adoption. The RRR value gives the proportionate change on odds of surface water investment, when an independent variable increases by one unit. For example, suppose the coefficient for education is 0.43, this means that one more additional unit of education lowers the odds of choosing that investment to less than one half.

It can be seen in table 3 that being part of the EQIP program is significant at the 10% level with a RRR of 0.14 when adopting a reservoir only. Knowing someone with a tail-water recovery system is significant at the 1% level with a RRR of 18.6 when adopting TWR only and significant at the 5% level with an RRR of 7.5 for the adoption of both reservoirs and tail-water recovery systems. Being part of a conservation group is significant at the 10% level when adopting only tail-water recovery systems with an RRR of 0.34.

Table 4 shows that having 2 years of college education is significant at the 5% level with an RRR of 10.41 when adopting tail-water recovery only. Having 4 year college experience is significant at the 1% level, with an RRR of 0.17 when adopting both tail-water recovery and reservoirs. If producers have advanced college degrees the RRR for adopting only a reservoir is <0.00, and 0.01 for adopting both a reservoir and tail-water recovery, both are significant at the 1% level. Faming experience has a 0.89 RRR for adopting reservoir only, which is significant at the 10% level.

The results for table 5 show that irrigated corn acres have an RRR of 1.002 for the adoption of tail-water recovery only and is significant at the 10% level, an RRR of 1.003 for reservoir adoption only and the adoption of both which are significant at the 1% and 5% levels respectively. Irrigated soybean acres are significant at the 10% level with an RRR of 0.999 for tail-water recovery adoption only and significant at the 1% level for the adoption of both with the same RRR. Irrigated rice acres have an RRR of 1.001 for the adoption of tail-water recovery only and both reservoir and tail-water recovery, each have a significance level of 1%. Use of cover crops is significant at the 10% level with an RRR of 0.24 for the adoption of tail-water recovery only, it is also has an RRR of 0.12 for the adoption of a reservoir only which is significant at 5%. The use of flowmeters has an RRR of 4.69 and significant at the 5% level for the adoption of tail-water recovery only. It is also 1% significant for the adoption of both, with an RRR of 11.38. Using soils sensors are significant at the 10% level when adopting both, the RRR is 8.66.

Table 6 shows that a depth fall in the aquifer has an RRR of <0.00 for the adoption of reservoirs only, which is significant at the 1% level. The RRR for adopting both is 3.85 and significant at the 10% level. A rise in the depth rise in the aquifer has an RRR of 0.26 for the adoption of tail-water recovery only and is significant at 10%

It can be seen in table 7 that the financing method of using cash to pay for the water storage facilities, paying cash for surge irrigation and using federal funding for surge irrigation is significant at the 1% level with an RRR of 413, 11.8 and 48.26 respectively, while using federal methods of finance for water storage facilities is significant at the 10% level with an RRR of 67.03 for the adoption of tail-water recovery only. For the adoption of reservoirs only, federal funding for is significant at the 1% level with an RRR of 129.94, both cash and federal funding are also significant at the 1% level and both have an RRR of <0.00. Using a loan to finance storage water facilities is significant at the 5% level with an RRR of 0.02, for the adoption of reservoirs only. Two variables are significant at the 10% level for the adoption of both reservoirs and tail-water recovery systems, these include; cash with an RRR of 112.87 and federal funding with an RRR of 86.86.

Discussion and Conclusions

It can be seen from the results in table 3 that there is a peer network influence in the adoption of tail-water recovery systems. Knowing someone with a tail-water recovery system increases the odds of adopting both forms of water storage by 7.5. There are multiple reasons why this might be the case, including that adopters have spoken highly of the surface water system and recommended it to their peers. This highlights that farmers trust their fellow peers when thinking about adopting new technologies. These claims are aligned with findings from previous literature where (Ramirez, 2013) identified that farmers get the majority of their information from their peers, thus making the relationship between farmers key for increasing adoption rates. Our results are also aligned with the findings from the (Genius , Koundouri, Nauges, & Tzouvelekas, 2013) paper which finds that social networks have a positive influence on the adoption of agricultural technology. One other key influence on adoption drawn from this literature is the participation of producers in like-minded organizations. It can be seen from the results that for the participation in conservation groups, there is only one significant outcome, which suggests a decrease in likelihood for the adoption of tail-water recovery when being part of a conservation group. These results would suggest that being part of a conservation network has no real significant positive impact on the adoption of surface water facilities.

Despite two years of college being significant in the adoption of tail-water recovery systems, our results show that as education levels increase the likelihood of adopting both surface water facilities decrease. This again goes against the findings of previous literature, such as (Anderson, Wilson, & Thompson, 1999), who find that education has a positive influence on the adoption of other agricultural technology. We believe our findings are negative due to the high proportion of respondents with advanced education, compared to the number of people who have adopted surface water facilities. It could be that education no longer plays a major role in adoption decisions, or it could be a limitation of our relatively small sample size. We also offer the possible explanation that producers who have advanced education are investing in alternative water conservation practices. This could be more advanced technologies such as computerized hole selection and polypipe planner, which also yield significant water savings.

There are slight odds increases when the acres of both irrigated corn and rice increase. We assume that this increase is due to rice being an irrigation intensive rice. The more rice acres a producer has, the more water they are going to use which would make them more inclined to invest in water saving technologies to reduce water pumping costs in their production. Another positive variable is use of flow meters when adopting both reservoir and tail-water recovery systems. Flow meters are also considered to be a water conservation technology, it makes sense that people who are conscious of their water use would adopt both water storage facilities and flow meter technology as they are invested in water conservation.

Our results don't give concrete evidence for the adoption of water saving technologies compared to producer's beliefs in the changes of groundwater depths. There is a high RRR for the adoption of both reservoirs and tail-water recovery when depths fall, however this is only significant at the 10% level. We would expect to see that producers who believe their depths are falling, would be more likely to have adopted. Due to the nature of the question asked it is difficult to get a deep understanding the meaning of the response. We believe that adoption of water storage should be because of the falling groundwater depths. However, the respondents who have adopted could be more inclined to respond that their depths to groundwater have increased, therefore we should expect to see positive RRR for producers who have adopted both reservoirs and tail-water recovery and who also see their groundwater depths rising.

The payment methods for the adoption of the water storage facilities gives some interesting results. There is a high RRR to show that producers mainly use cash to purchase their tail-water recovery systems only. For the adoption of reservoir adoption producers are more inclined to use federal funding options. These differences between tail-water recovery and reservoir adoption could be due to the difference in upfront costs of the two systems. It may be that tail-water recovery systems are much cheaper than reservoirs and therefore producers are more likely to use their profits for tail-water recovery systems, and use the help from the government for the more expensive reservoir option. For the adoption of both reservoir and tail-water recovery we see that cash and federal funding have positive RRR coefficients, but with less significance. This could be due to when adoption both technologies, producers are using cash for the tail-water recovery systems, and federal funding for the reservoir technology.

Our results give some key insights into the role of peer networks when adopting water conserving storage water facilities. There is evidence that knowing someone with a tail-water recovery system makes other more likely to adopt, creating a positive feedback scenario for future adoption trends. We also find that producers who use flowmeters are more likely to use both water storage facilities. This is due to producers being invested conservation agriculture meaning they are more likely to use water efficient systems. Despite these positive insights are results give rather counterintuitive results such as the negative correlation between high levels of education and adoption. Although we present the potential scenarios where producers with higher education could be investing in other technologies, or it could be that the majority of our respondents have a high level of education leading to no real correlation in adoption.

Our progression has thus far given us valuable results in understanding the adoption of water storage technologies. As a next step we will look to address counterintuitive results, by looking deeper into the data we have and performing rigorous statistical analysis of our responses. The high RRR coefficients will also not go unnoticed, and we will look to find the source of the large, unrealistic values that are presented for many of our results. As our research evolves we will take our current findings and use our data to better understand the variables that encourage the adoption of water storage facilities, and the relationships between producers when influencing adoption.

Tables and Figures

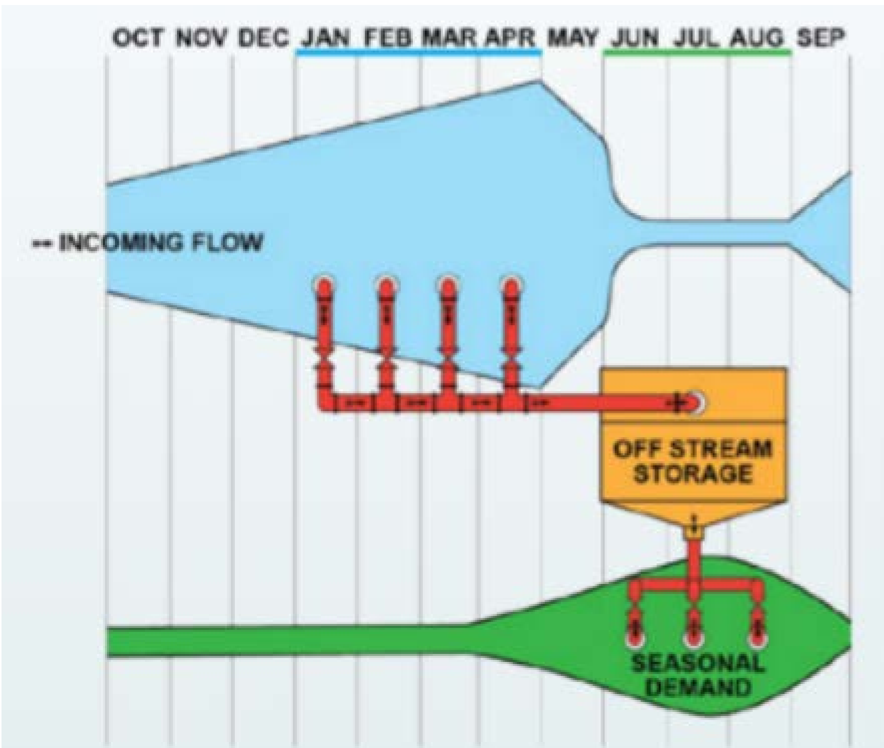

Figure 1: Diagram representing the storage of water using reservoirs and tail-water recovery systems

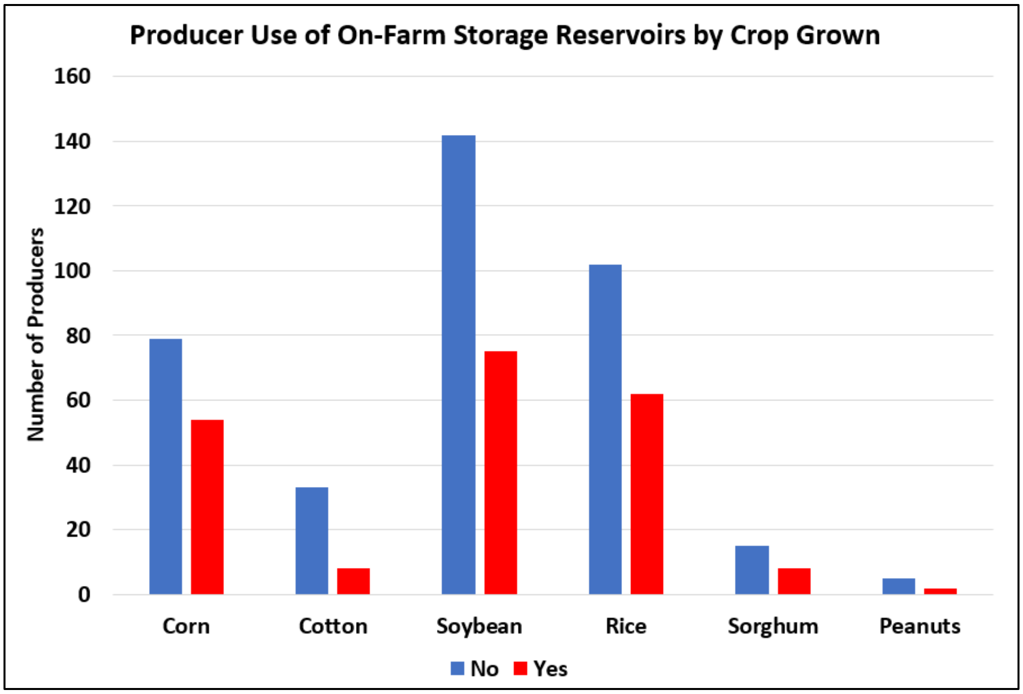

Figure 2: Producer use of on-farm storage reservoirs by crop grown

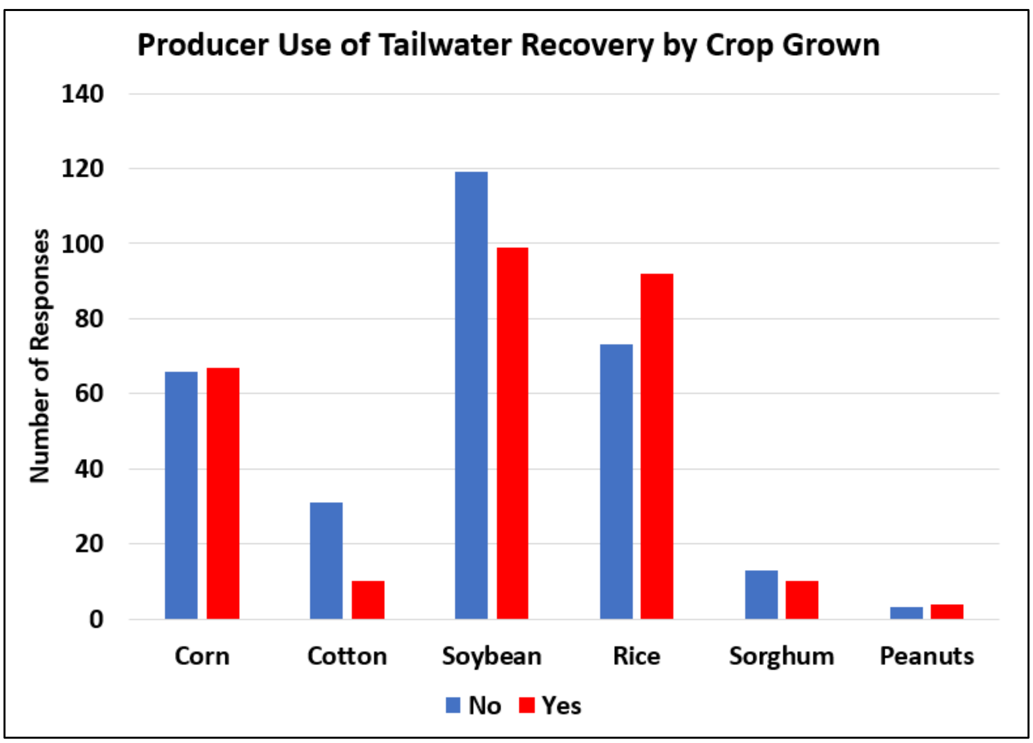

Figure 3: Producer use of tail-water recovery by crop grown

Table 1: Variable groups and names

Variable Group	Variable Names
Conservation network	Eqip, K_Twr, K_Res, Cgroup
Socioeconomics	2Col, 4Col, AdvEdu, IncM, IncH, FrmExper
Farm practices	IrrCornAcres, IrrSoyAcres, IrrRiceAcres, CoverCrop, FlowMeter, SoilSensor
Aquifer change	DepthFall, DepthRise
Irrigation finance	CashResTWR, LoanResTWR, FedResTWR, CashSurge, FedSurge

Table 2: Variable Descriptions

Variable Name	Description
Eqip	Respondents were asked if they have ever been involved in the EQIP which is a program which offers financial incentive to adopt conservation practices
K_Twr	Respondents were asked if they know of any family members, friends or neighbors who have used a tail-water recovery system
K_Res	Respondents were asked if they knew any family members, friends or neighbors who use a reservoir
Cgroup	Respondents who have been part of a conservation group
2Col	Respondents who have attained 2 years of college as their highest level of education
4Col	Respondents who have attained 4 years of college as their highest level of education
AdvEdu	Respondents who have attained above a 4 year college degree as their highest level of education
IncM	Respondents who have a 2014 household income between $75,000 and $200,000
IncH	Respondents who have a 2014 household income above $200,000
FrmExper	The total years the respondent has been a farmer
IrrCornAcres	The total acres of irrigated corn the farmer has on their land
IrrSoyAcres	The total acres of irrigated soybean the farmer has on their land
IrrRiceAcres	The total acres of irrigated rice the farmer has on their land
CoverCrop	Respondents who use cover crops
FlowMeter	Respondents who use flowmeters
SoilSensor	Respondents who use soil sensors
DepthFall	Respondents who believe groundwater depths have fallen on their site over the past 5 years
DepthRise	Respondents who believe groundwater depths have increased on their site over the past 5 years
CashResTWR	Respondents who used cash to implement either a reservoir or a tail-water recovery system

LoanResTWR	Respondents who took out a loan to implement either a reservoir or a tail-water recovery system
CashSurge	Respondents who used cash to implement either surge irrigation system
FedSurge	Respondents who used federal support to implement either surge irrigation system

Table 3: Conservation network results

Conservation Network			
Independent Variable	**TWR**	**RES**	**BOTH**
Eqip	0.47	0.14*	2.14
K_Twr	18.60***	0.07*	7.50**
K_Res	0.31	794.56	3.53
Cgroup	0.34*	0.45	2.19
N	228	228	228

Table 4: Socioeconomic Results

Socioeconomics			
Independent Variable	**TWR**	**RES**	**BOTH**
2Col	10.41**	1.28	0.93
4Col	1.50	0.10	0.17***
AdvCol	0.47	0.00***	0.01***
IncM	3.54	0.42	1.41
IncH	6.30	21.38	1.37
Frm_Exper	0.96	0.89*	0.98
N	228	228	228

Table 5: Farm Practice Results

Farm Practices			
Independent Variable	**TWR**	**RES**	**BOTH**

IrrCornAcres	1.002*	1.003***	1.003**
IrrSoyAcres	0.999*	1.000	0.999***
IrrRiceAcres	1.001***	0.998	1.001***
CoverCrop	0.24*	0.12**	1.17
FlowMeter	4.69**	0.74	11.38***
SoilSensor	6.38	0.04	8.66*
N	228	228	228

Table 6: Aquifer Change Results

Aquifer Change			
Independent Variable	**TWR**	**RES**	**BOTH**
DepthFall	0.45	0.00***	3.85*
DepthRise	0.26*	3.04	0.71
N	228	228	228

Table 7: Irrigation Finance Results

Irrigation Finance			
Independent Variable	**TWR**	**RES**	**BOTH**
CashResTWR	413.00***	4.67	112.87*
LoanResTWR	7.87	0.02**	0.58
FedResTWR	67.03*	129.94***	86.86*
CashSurge	11.80***	0.00***	2.12
FedSurge	48.26***	0.00***	1.60
N	228	228	228

References

Anderson, D. P., Wilson, P. N., & Thompson, G. D. (1999). The Adoption and Diffusion of Level Fields and Basins. *Journal of Agricultural and Resource Economics* , 186-203.

Arkansas Farm Bureau. (2017, March). *Arkansas Agriculture* . Retrieved from ARFB: http://www.arfb.com/pages/arkansas-agriculture/

Genius , M., Koundouri, P., Nauges, C., & Tzouvelekas, V. (2013). INFORMATION TRANSMISSION IN IRRIGATION TECHNOLOGY ADOPTION AND DIFFUSION:SOCIAL LEARNING,EXTENSION SERVICES, AND SPATIAL EFFECT. *American Journal of Agricultural Economics* , 328-344.

Hignight , J., Wailes , E. J., Popp, J., & Smartt, J. (2005). Investing in On-Farm Reservoirs Under Alternative Land Tenure Arrangement . *AAES*, 413-419.

Ramirez, A. (2013). The Influence of Social Networks on Agricultural Technology Adoption . *Procedia-Social and Behavioral Sciences* , 101-116.

Schuck, E. E., Frasier, W. M., Webb, R. S., Ellingson , L. J., & Umberger , W. J. (2005). Adoption of More Technically Efficient Irrigation Systems as a Drought Response. *Water Resources Development* , 651-662.

United Stated Deprtment of Agriculture . (2012, September). *Publications* . Retrieved from ERS: https://www.ers.usda.gov/webdocs/publications/eib99/30956_eib99.pdf?v=41744