FARM SIZE, IRRIGATION PRACTICES, AND CONSERVATION PROGRAM PARTICIPATION IN THE COLORADO BASIN STATES

by

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STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at the University of Arizona.

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Abstract

This study uses data from a special tabulation of the USDA Farm and Ranch Irrigation Survey to examine the relationship between farm size and adoption of a variety of water management practices across seven Colorado Basin states. Parametric (Cochran-Armitage trend test) and non-parametric (Goodman-Kruskal gamma) methods were used to estimate associations between farm size and adoption of water management practices, use of water management information, and participation in conservation programs. Farms where divided into five categories: small farms, medium farms, large farms and very large farms, based on their gross sales. In all seven states, very large farms relied on a greater number of different information sources for water management than small farms. The relationship between farm size and information source use was not always monotonic, however. Small farms were more likely to rely more on their neighbors and irrigation district staff for water management information. Large and very large farms relied on a more diverse set of information sources and relied more on privately provide sources, such as consultants. In very few cases was a public or private information source used by more than half of any group of farmers. There is no “one-stop shopping” for irrigation management information. Smaller farms were more likely to not have investigated ways to improve water or energy conservation practices in the previous five years. Farmers cited economic factors as the most important largest constraints on adoption of conservation investments. Larger farms were more likely to participate in

government (federal, state, or local) other conservation programs. These farms, though, account for the greatest share of water use. Many smaller farms do not have control over the timing of their irrigation applications, but rather depend on irrigation districts to supply water "in turn." Extension messaging to improve irrigation timing may be more effective if they target irrigation district staff that control irrigation scheduling.

Chapter One: Introduction

1.1 Background of water in Colorado River Basin

In the seven Colorado Basin states, Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming, agriculture accounts for 81% of fresh water withdrawals. Of agricultural withdrawals 97% was for irrigation with the remaining 3% going to water livestock and for aquaculture (USGS 2010). So irrigation accounts for 79% of total fresh water withdrawals in the region. This is a decline from irrigation's share (84%) in 2000 (USGS 2000). In contrast, the residential and commercial water-use in the seven Colorado Basin states only accounted for 16% of total fresh water.

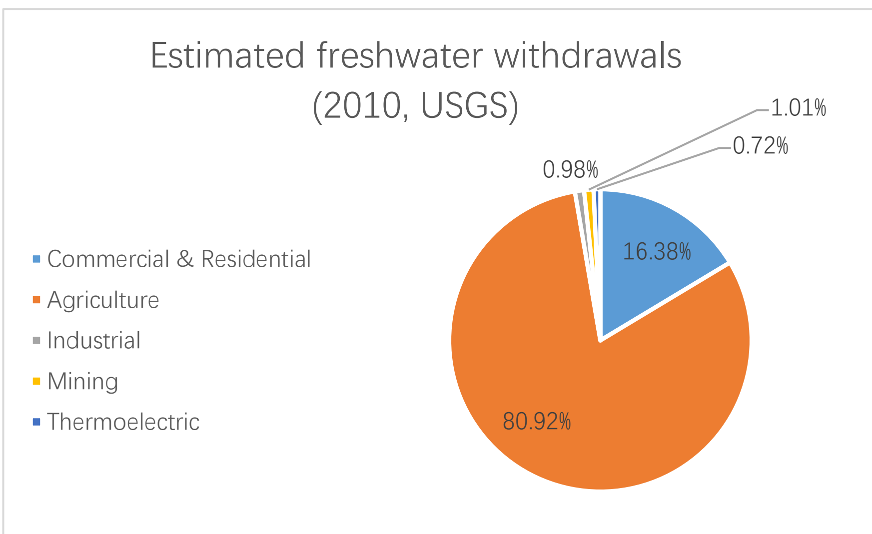


Figure 1. Freshwater withdrawals by water use category across the seven Colorado Basin states

Because irrigation accounts for such a large share of water use, relatively small reductions in irrigation water use (in percentage terms) could play a larger role in regional water conservation than conservation by other sectors. For example, from the Figure 1, we can see that 10% reduction in agricultural water use would conserve as much water as a 50% reduction in residential and commercial water-use.

Prolonged drought and increasing urban water demands have raised concerns that there will be a water availability crisis in the Colorado River Basin. Conservation of the agricultural water use, especially irrigation water use, is seen as more necessary than before. The *Colorado River Basin Water Supply and Demand Study* (USBR, 2012) published by the U.S. Department of the Interior, Bureau of Reclamation, claimed that there would be severe imbalances between future water demands and supplies. The report suggested there is a need for additional management actions to reduce irrigation water use to prevent future demands from surpassing available water supplies. Without the irrigator participation of conservation programs and the adoption of efficient managements and technologies, the traditional irrigation management and equipment can exacerbate scarcity, lower the quality of resource, and damage the river basin resilience by loss of flexibility and redundancy. (Scott, 2014). Improving irrigation efficiency is a pivotal part of strategies to adapt to climate change (Mendelsohn and Dinar, 2003), while also offering the possibility of increasing, farm profits (Abd El-Wahed, 2012).

This study relies on data from the United States Department of Agriculture (USDA)'s 2008 and 1998 Farm and Ranch Irrigation Surveys (FRIS). The study relies on special tabulations of the FRIS reported by USDA's Economic Research Service (ERS). These special tabulations report on a variety of water management practices by state and farm size category. The original FRIS data are only reported publicly by state-level aggregates. The ERS tabulation reports state for 17 western states, but this study focuses only on the seven Colorado Basing States. This thesis updates and extends the study by Frisvold and Deva (2011), which relied on ERS special tabulation data just for Arizona and New Mexico in 1998. That study examined relationships between farm scale of operation and several water management practices. The data for the 2008 FRIS are now available. I test the same hypotheses as in Frisvold and Deva (2011), but for the seven Basin states in both 1998 and 2008. I examine the relationship between the farm size and (i) source and use of water management information; (ii) barriers to improve irrigation systems for water or energy conservation; (iii) participation in government conservation programs across the seven Basin States. In addition, we can see (iv) whether there are any changes in Arizona and New Mexico between 1998 and 2008.

1.2 Value of irrigation information: a simple model

The value of irrigation information is the increase in farm returns from using information minus the costs of acquiring information and processing that information to make it useable. Kislev and Shchori-Bachrach (1973) analyzed the relationship between a firm's productivity and the adoption of new technology. They argued that the production function associated with the new technology incorporates an efficiency factor which was positively related to the level of knowledge. Feder and Slade (1984) established a new model, which has the similar approach as Kislev and Shchori-Bachrach, but applied to the agriculture. Frisvold and Deva (2011) presented a simple model to analyze the value of information to irrigators. The model is similar in approach to that of

Feder and Slade, which states that knowledge can affect the farmers' decision of adoption. The value of information to an individual irrigator, V, is

$$V = \{\pi[x(s), z(s)] - \pi_0(x_0, z_0)\}A - c(s, k, A)$$

where

A = acreage;

X_0 = variable inputs chosen when information is not used;

Z_0 = parameters characterizing irrigation management technologies or practices chosen when information is not used;

$\Pi_0(X_0, Z_0)$ = per-acre profits when information is not used;

S = the number of information sources used; this could also represent the amount of information used from a given source;

X(s) = variable inputs chosen given use of information, s;

Z(s) = technologies or practices chosen given use of information, s;

$\Pi[X(s), Z(s)]$ = per-acre profits given information use;

C = the cost of processing information, s;

K = an index of human capital or technical capacity; and

C_i = first derivative of information cost function with respect to i = s, k or A.

The difference between income from using the information minus the costs from processing the information to make it useful is the value of information. (Frisvold and Deva, 2011)

Per-acre profits, Π, are the difference between per-acre revenues, R and per-acre costs, C. The value of information is

$$V = \{R[x(s), z(s)] - R[x(s), z(s)]\}A - \{R(x_0, z_0) - C(x_0, z_0)\}A - c(s, k, A)$$
$$= \{R[x(s), z(s)] - R[x(s), z(s)]\}A - \{R(x_0, z_0) - C(x_0, z_0)\}A - c(s, k, A)$$

The value information can be written in terms of a percent increase in revenue per acre, $\Delta_R(s)$, a percentage reduction in costs per acre, $\Delta_C(s)$, or both. The value of information is

$$V = \{R[x_0, z_0][1 + \Delta \mathrm{R(s)}] - C[x_0, z_0][1 + \Delta \mathrm{C(s)}\}A - c(s, k, A)$$

where

$$\frac{\partial V^2}{\partial s \partial R} > 0;\ \frac{\partial V^2}{\partial s \partial A} > 0;\ \frac{\partial V^2}{\partial s \partial RA} > 0$$

The term $\mathrm{R}_0\mathrm{A} = R[x_0, z_0]A$ shows total farm revenues, before any information is used. The percentage increase in revenues from information ΔR(s) use will increase irrigator revenues by a greater absolute amount if R_oA is bigger. This means that farms with more acreage, A, or farms growing higher value crops, greater Ro, will get a higher absolute payoff from using information. If $C_A = 0$, this means the cost of processing information is independent of scale. This means that making use of information to manage irrigation on 200 acres costs the same as using it to manage irrigation on 50 acres. If the benefits to using information increase with farm scale, but the costs do not increase with farm scale, then large farm will greater incentives to use information. If $C_s > 0$, the cost of processing information will increase the number of sources used. (Frisvold and Deva, 2011)

1.3 Data and Hypotheses:

The above model suggests farm scale (in terms of acres or potential sales) may affect information use for irrigation management. The same testable hypotheses about irrigator information use from Frisvold and Deva (2011):

H1. The probability that an irrigator relies on any given source of information increases with farm scale

H2. Both small and large farms will rely on low-cost sources of information (such as extension or neighbors). Reliance on the high-cost sources of information (such as private consultants) will increase with farm size.

H3. Larger irrigators will rely on more information sources in total.

H4. Use of management-intensive methods to schedule irrigation will increase with farm size. These are methods that require more understanding of scientific methods or other technical knowledge

Four farm sizes and a yes-no answer gives us a 4 X 2 contingency table. The farm sizes were at first been considered as the ordinal variable. It was easy to understand, because the more sales mean a higher or better ag-business status. When we process yes-no part of the data, we transfer "Yes" to 1, and "No" to 0. For example, if farmers mark the box of "Rely on Private irrigation specialists for guidance in reducing irrigation cost or to conserve water used for irrigation". Have the private specialists is a better status than without them. ERS break the farmers' response into four farm sizes, which are the following:

Small farms: Sales less than $100,000;

Medium Farms: Sales between $100,000 and $249,999;

Large Farms: Sales between $250,000 and $499,999;

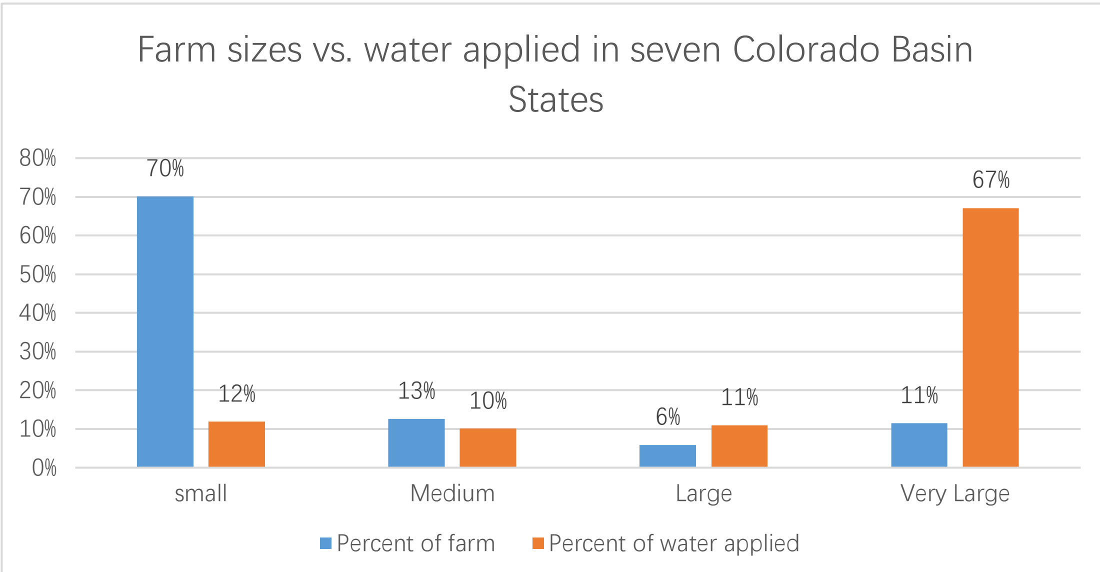
Very Large Farms: Sales more than $500,000.

Table I. Basic statistics of the farms (2008 data only)

	Small		Medium		Large		Very Large		Total	
	Percent of farms	**Percent of water**	**Percent of farms**	**Percent of water**	**Percent of farms**	**Percent of water**	**Percent of farms**	**Percent of water**	**Percent of farms**	**Percent of water**
AZ	68.6	4.9	9.1	4	5.6	6.7	16.7	84.4	100	100
CA	61.5	5.4	16	6.4	6.5	9.1	16	79.1	100	100
CO	75.3	22.1	10.4	17.3	6.8	18.7	7.5	41.9	100	100
NV	69.6	15.3	12.1	14.7	8.6	18.1	9.8	51.9	100	100
NM	88.5	19.6	5	9.1	2.6	11.6	4	59.7	100	100
UT	86.1	37.2	6.8	23.9	3.6	11.5	3.6	27.4	100	100
WY	67.8	29.5	15.8	23.6	8.5	15.8	8	31.1	100	100
	Farms	**Water applied**	**Number of farms**	**Water applied**	**Number of farms**	**Water applied**	**Number of farms**	**Water applied**	**Number of farms**	**Water applied**
AZ	1,891	223	252	180	154	304	459	3,826	2,756	4,533
CA	24,787	1,179	6,443	1,402	2,602	1,985	6,466	17,313	40,298	21,879
CO	8,647	976	1,197	762	775	825	859	1,847	11,478	4,410
NV	1,166	215	202	206	144	254	164	729	1,676	1,404
NM	6,944	357	393	166	201	211	310	1,086	7,848	1,819
UT	8,594	872	674	559	355	269	358	642	9,981	2,342
WY	3,020	845	704	675	377	453	356	892	4,457	2,866
Total	55,049	4,668	9,865	3,949	4,608	4,300	8,972	26,335	78,494	39,252

*unit of water applied = 1,000 acre feet.

In all seven states, 70% of the farms account for small, and only use 12% of the water. 11% of the farms account for very large, but use 67% of the fresh water. Arizona and California are following the “80-20 rule”, which leads to the same result. In Utah, very large farms account only for 3.6% and only 27.4% water applied to their farms. The largest water user group in Utah is the small irrigators, which account for 86% of farm use and 37% of water. California, as the largest agricultural state in the U.S., used 56% of water used in the seven states.



Source: USDA, NASS FRIS

Figure II. Relationship Between the farm sizes and water applied

CHAPTER TWO: Literature Review

The literature on irrigation efficiency has focused on the consequences of improving irrigation efficiency, how to improve it and the possible approach of improving it. Information adoption literature is more concerned with models and theoretical arguments to explain how people adopt technologies and use information.

The importance of irrigated agriculture in adapting to global warming was examined by Mendelsohn and Dinar (2003). They argued that there were ample opportunities to adapt to global warming by irrigation. Scott (2014) illustrated the consequences of improving irrigation efficiency, and the outcome of not doing that. Low efficiency can impair the quality of water and river basin resilience. High efficiency can solve many water issues, such as water pollution and water scarcity.

Kislev and Shchori-Bachrach (1973) built a model and analyzed the economic theory of the process of innovation cycles. In the adoption part, they illustrated how knowledge affected the adopters and the change in their profit. They argued profits from the new product of the first adopters can be regarded as rent to innovativeness, which is a payment for skill. The higher rent the first adopters pay, the more profit will be received from the new product.

Feder and Slade (1984) adopted the adoption model from Kislev and Shchori-Bachrach (1973) to the agricultural field into a more specific model. They introduced knowledge was a factor that can reduce uncertainty. The impact of knowledge could be varied by the amount of land and the other input (water, fertilizer, etc.). Processed information can influence input use production costs, and profits. More knowledge allows a farmer to process information at a lower price. They argued the larger farmers with a larger scale of farming would adopt earlier than other farmers, and they would access more sources of information.

Survey data from Leib et al. (2002) was consistent with Feder and Slade's hypotheses. Washington state farmers' adoption of scientific irrigation scheduling methods was positively and significantly associated with farm size. Skaggs and Samani (2005) found that small farmers were less likely to make irrigation capital and infrastructure improvements. This was due to their limited financial resource, easement disputes, and lack of urgency or interest.

Michelsen et al. (1999) pointed out that many western irrigation districts use fixed charges independent of the quantity of water used. When water costs are low and not a function of water use, then incentives to adopt conservation practices or participate in conservation programs will be weak.

In a case study in Queensland, Australia about why landholders choose to participate or withdraw from conservation programs, Comerford (2014) highlighted agricultural production, property size and level of financial support. These were all positively associated with participation rates. He also argued that the government is a major influence on participation. This might be a reason why participation rates vary across U.S. states (discussed below).

Frisvold and Deva (2012) used the FRIS data from Arizona and New Mexico and illustrated it was possible to use public available FRIS data to test economic hypotheses. They found the significant relationships between the farm sizes and the adoption of irrigation information. This study encourages me to use a larger and newer data set to get a new result matches the new irrigator's behaviors.

Literature has so far established many consequences of improving irrigation efficiency and the relationships between farm size and information adoption etc. Knowledge has a positive impact on the farmers to adopt the new technologies and equipment and reduces the uncertainty of farming. The models of adoption of irrigation information give us a clue of irrigator's behavior. The case study and the results of the surveys provided basic hypotheses. All the literature offers valuable insights into irrigator behavior. Study of irrigator's behavior from Arizona and New Mexico opened a new path of analyzing the demand for water management information. This paper is the same attempt as Frisvold and Deva to understand the irrigator's behavior.

CHAPTER THREE: Methods

To test the association between of the contingency tables, we need to use the Goodman-Kruskal Gamma (γ) coefficient, since the chi-squared test will almost always lead the null hypothesis to be rejected when the dataset is large (Frisvold and Deva, 2011). To measure the association between two ordinal variables, we normally use the γ coefficient. It has a value interval from -1 to 1. Positive one means the association is positive, and the data pairs are monotonically increasing. Zero means the data pairs was no association, says the data are independent, or says there is not monotonically increasing or decreasing relationship. Before we calculate γ, there are two terms which are needed for calculating γ. Two bivariate observations, (X_1, Y_1) and (X_2, Y_2), are called concordant whenever the product $(X_1- X_2)(Y_1-Y_2)$ is positive, that is, if X_1 is greater or less than X_2, then Y_1 will be same greater or less than Y_2. This pair is called a *concordant*, usually represented by C. Another term called *discordant* when the same product has different sign, usually marked as D. The gamma coefficient, $\gamma = \frac{C-D}{C+D}$, is very easy to calculate. The reason that the gamma test avoids the disadvantage of Chi-square is the Goodman-Kruskal Gamma "shirked" the sample size during the calculation. The formula of test statistic $Z = \frac{3\gamma\sqrt{n(r-1)(c-1)}}{2\sqrt{(r+1)(c+1)}}$, which contains n inside of square root. This makes the result more trustable when the sample size is large.

Cochran-Armitage trend test gives results close to the Wald or likelihood-ratio test of null hypothesis of slope equal to zero in the logistic regression. It also works well when we do not have many observations. (Agresti, 2010) As an alternative to the Goodman-Kruskal Gamma under the small sample size, Cochran-Armitage trend test is a stricter trend test. Cochran-Armitage expects a monotonic effect of X on Y. They used a linear probability model,

$$\pi_i = \alpha + \beta x_i$$

fitted by ordinary least squares. The null hypothesis of independence is H_0: $\beta = 0$, if there is no linear relationship between x, which is the farm sizes in our data, and the probability of saying 'yes'. The test has a normally distributed z-test statistic. Both Goodman-Kruskal Gamma coefficient and Cochran-Armitage trend test are having z-test statistics as the critical vales, so it will be easier for us to compare the test results and make decisions. The significance level=5% for |z|=1.96; 1% for |z|=2.576; 0.1% for |z|=3.291. The data for this study has many observations, so it will be easier to reject null hypothesis. Therefore, to check whether a result is significant or not, I used the significance level at 0.1%, which means the result will only be significant when the z-values of gamma or Cochran-Armitage are greater than 3.291.

Before we see the result, from the formula of two methods, we should know that if the sample size is small we may rely on the Cochran-Armitage more, and on Goodman-Kruskal Gamma if it is large. In addition, if the data has more non-linear changes, more attention must be paid to the results from gamma tests.

CHAPTER FOUR: Results

4.1 Farm size and sources of irrigation information

The same question was asked in the FRIS of 1998 and 2008, "What sources of information does this operation rely on for guidance in reducing irrigation costs or to conserve water used for irrigation? Mark (X) all that apply." The respondents could choose as many as they thought applied. The list of choices was (USDA, NASS 2009):

1. Extension agents or university specialists.
2. Private irrigation specialists or crop consultants hired by owner or operator.
3. Irrigation equipment dealers
4. Local irrigation district employees or others hired by the water supplier
5. Government specialists from the Natural Resources Conservation Service, local conservation district, Bureau of Reclamation, or other federal and state agencies.
6. Media reports or information in the press.
7. Neighboring farmers.
8. Electronic information services (Internet, DTN, Internet links to private or public data source, etc.).
9. other"

Table II. (1) (AZ&CA) Source of Irrigation Information (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Extension Agents or University Specialists	Government Specialists from USDA	Irrigation Equipment Dealers	Local Irrigation District Employees	Private Irrigation Specialists or Consultants	Media Report Press	Neighboring Farmers	Electronic Information Services	Row sum
ARIZONA	2,756	2,756	2,756	2,756	2,756	2,756	2,756	2,756	
Small	19.67%	20.73%	8.46%	22.10%	13.17%	6.45%	42.31%	12.06%	153.68%
Medium	15.48%	11.51%	8.73%	24.21%	2.78%	7.54%	11.90%		93.25%
Large	31.82%	25.32%	14.94%	35.71%	18.18%	1.95%	22.73%	7.79%	167.53%
Very Large	33.77%	38.78%	11.11%	10.24%	20.48%	8.28%	20.26%	6.75%	161.87%
Gamma	0.2411	0.2455	0.1364	-0.1358	0.1257	0.0478	-0.4735	-0.2805	
Gamma Z value	8.491	8.646	4.804	-4.782	4.427	1.683	-16.675	-9.878	
Cochran Z value	6.7602	7.5708	2.3462	-3.9163	3.8235	0.7401	-10.2471	-3.4567	
CALIFORNIA	40,298	40,298	40,298	40,298	40,298	40,298	40,298	40,298	
Small	16.86%	2.84%	6.52%	20.57%	19.04%	15.22%	32.57%	3.24%	134.77%
Medium	38.60%	19.80%	29.63%	8.54%	54.32%	23.86%	35.22%	21.40%	245.82%
Large	19.18%	7.88%	6.50%	7.72%	16.06%	6.53%	17.79%	9.65%	111.34%
Very Large	44.01%	13.38%	28.04%	14.54%	42.68%	17.58%	32.54%	17.26%	218.91%
Gamma	0.4234	0.5129	0.5157	-0.2847	0.4011	0.0643	-0.0347	0.5451	
Gamma Z value	57.016	69.069	69.446	-38.339	54.013	8.659	-4.673	73.405	
Cochran Z value	44.1288	32.2751	44.3363	-17.229	37.6592	2.2818	-4.1505	38.9511	

Table II. (2) (CO&NV) Source of Irrigation Information (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Extension Agents or University Specialists	Government Specialists from USDA	Irrigation Equipment Dealers	Local Irrigation District Employees	Private Irrigation Specialists or Consultants	Media Report Press	Neighboring Farmers	Electronic Information Services	Row sum
COLORADO	11,478	11,478	11,478	11,478	11,478	11,478	11,478	11,478	
Small	28.84%	22.23%	13.91%	20.59%	8.34%	4.08%	37.99%	8.77%	155.68%
Medium	35.84%	24.81%	13.20%	8.69%	21.97%	8.19%	20.30%	17.46%	162.99%
Large	30.71%	27.61%	30.58%	6.97%	36.13%	10.97%	33.29%	14.19%	194.45%
Very Large	31.66%	23.52%	36.44%	13.74%	56.93%	19.09%	21.89%	22.12%	229.22%
Gamma	0.0836	0.072	0.356	-0.3722	0.6976	0.5057	-0.2801	0.355	
Gamma Z value	6.008	5.175	25.585	-26.750	50.136	36.344	-20.130	25.513	
Cochran Z value	2.8734	2.6454	18.7969	-10.340	41.9934	18.6059	-11.1861	13.4251	
NEVADA	1,676	1,676	1,676	1,676	1,676	1,676	1,676	1,676	
Small	20.50%	8.83%	4.12%	20.84%	5.92%	4.89%	47.86%	2.92%	128.30%
Medium	20.79%	29.70%	16.34%	9.41%	9.90%	0.99%	27.23%	5.45%	142.08%
Large	27.08%	27.08%	29.17%	11.81%	20.14%	13.89%	34.03%	11.81%	188.19%
Very Large	32.32%	25.00%	35.98%	7.93%	18.29%	12.20%	32.32%	18.29%	195.12%
Gamma	0.1664	0.4881	0.7103	-0.3919	0.4463	0.3094	-0.2984	0.5853	
Gamma Z value	4.570	13.405	19.507	-10.763	12.257	8.497	-8.195	16.074	
Cochran Z value	3.547	8.223	14.698	-5.089	6.992	1.198	-5.277	8.69	

Table II. (3) (NM&UT) Source of Irrigation Information (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Extension Agents or University Specialists	Government Specialists from USDA	Irrigation Equipment Dealers	Local Irrigation District Employees	Private Irrigation Specialists or Consultants	Media Report Press	Neighboring Farmers	Electronic Information Services	Row sum
NEW MEXICO	7,848	7,848	7,848	7,848	7,848	7,848	7,848	7,848	
Small	24.76%	20.45%	3.11%	3.89%	1.87%	4.48%	25.23%	1.47%	100.96%
Medium	22.39%	38.93%	13.74%	10.43%	19.59%	8.65%	23.41%	17.81%	173.54%
Large	36.32%	42.79%	29.35%	8.46%	27.36%	12.94%	28.86%	9.95%	218.41%
Very Large	23.23%	24.52%	30.32%	9.68%	36.13%	8.39%	23.55%	10.32%	178.39%
Gamma	0.0274	0.3254	0.7774	0.428	0.8672	0.3631	-0.0139	0.759	
Gamma Z value	1.628	19.338	46.199	25.435	51.535	21.578	-0.826	45.105	
Cochran Z value	0.8068	6.8864	26.6166	6.8868	34.4476	5.8297	-0.2727	15.6736	
UTAH	9,981	9,981	9,981	9,981	9,981	9,981	9,981	9,981	
Small	26.66%	12.52%	9.16%	20.57%	4.43%	6.43%	44.86%	3.47%	132.99%
Medium	29.82%	33.38%	36.05%	14.39%	13.95%	5.93%	34.12%	12.46%	196.59%
Large	51.27%	23.94%	32.68%	21.41%	13.24%	15.21%	68.73%	15.77%	256.06%
Very Large	63.13%	51.12%	46.65%	12.85%	21.51%	8.94%	27.09%	11.17%	252.79%
Gamma	0.371	0.5651	0.6829	-0.1525	0.5717	0.1856	-0.0692	0.5688	
Gamma Z value	24.864	37.872	45.767	-10.220	38.314	12.439	-4.638	38.120	
Cochran Z value	16.9706	22.3202	28.1333	-3.734	16.654	4.443	-2.375	13.5293	

Table II. (4) (WY) Source of Irrigation Information (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Extension Agents or University Specialists	Government Specialists from USDA	Irrigation Equipment Dealers	Local Irrigation District Employees	Private Irrigation Specialists or Consultants	Media Report Press	Neighboring Farmers	Electronic Information Services	Row sum
WYOMING	4,457	4,457	4,457	4,457	4,457	4,457	4,457	4,457	
Small	16.36%	22.48%	9.30%	15.96%	9.67%	4.34%	28.64%	1.69%	121.16%
Medium	31.11%	28.27%	23.30%	12.50%	6.25%	8.66%	23.15%	3.84%	143.18%
Large	32.36%	19.63%	26.53%	15.92%	7.16%	12.73%	46.95%	6.10%	174.80%
Very Large	39.61%	33.71%	34.55%	27.81%	17.13%	7.30%	16.85%	33.15%	213.76%
Gamma	0.3936	0.1169	0.5026	0.0836	0.0258	0.3263	-0.0138	0.5023	
Gamma Z value	17.627	5.235	22.509	3.744	1.155	14.613	-0.618	22.495	
Cochran Z value	12.751	3.686	15.730	3.934	2.198	5.634	0.701	15.475	

Table III. 95% Confidence Intervals of Gamma coefficient table for source of information

		AZ	CA	CO	NV	NM	UT	WY
Extension Agents or University Specialists	95% Lower	0.16	0.41	0.04	0.06	-0.05	0.32	0.34
	Gamma Value	0.24	0.42	0.08	0.17	0.03	0.37	0.39
	95% Upper	0.32	0.44	0.12	0.27	0.10	0.42	0.45
Government Specialists from USDA	95% Lower	0.17	0.49	0.03	0.41	0.26	0.53	0.05
	Gamma Value	0.25	0.51	0.07	0.49	0.33	0.57	0.12
	95% Upper	0.32	0.53	0.12	0.57	0.39	0.60	0.18
Irrigation Equipment Dealers	95% Lower	0.02	0.50	0.31	0.65	0.74	0.65	0.45
	Gamma Value	0.14	0.52	0.36	0.71	0.78	0.68	0.50
	95% Upper	0.25	0.53	0.40	0.77	0.81	0.71	0.55
Local Irrigation District Employees	95% Lower	-0.22	-0.31	-0.43	-0.52	0.33	-0.22	0.01
	Gamma Value	-0.14	-0.28	-0.37	-0.39	0.43	-0.15	0.08
	95% Upper	-0.05	-0.26	-0.32	-0.26	0.52	-0.08	0.16
Private Irrigation Specialists or Consultants	95% Lower	0.02	0.39	0.67	0.34	0.85	0.52	-0.07
	Gamma Value	0.13	0.40	0.70	0.45	0.87	0.57	0.03
	95% Upper	0.23	0.42	0.72	0.56	0.89	0.62	0.13
Media Report Press	95% Lower	-0.10	0.04	0.46	0.14	0.26	0.09	0.24
	Gamma Value	0.05	0.06	0.51	0.31	0.36	0.19	0.33
	95% Upper	0.19	0.09	0.55	0.48	0.46	0.28	0.41
Neighboring Farmers	95% Lower	-0.54	-0.05	-0.32	-0.39	-0.09	-0.12	-0.08
	Gamma Value	-0.47	-0.03	-0.28	-0.30	-0.01	-0.07	-0.01
	95% Upper	-0.40	-0.02	-0.24	-0.21	0.06	-0.01	0.05
Electronic Information Services	95% Lower	-0.43	0.53	0.31	0.47	0.72	0.51	0.42
	Gamma Value	-0.28	0.55	0.36	0.59	0.76	0.57	0.50
	95% Upper	-0.13	0.56	0.40	0.70	0.80	0.63	0.58

Table IV. Primary source of information for different farm size

	AZ	CA	CO	NV	NM	UT	WY
Small	Neighbors	Neighbors	Neighbors	Neighbors	Neighbors	Neighbors	Neighbors
Medium	District	Private	Extension	USDA	USDA	Dealer	Extension
Large	District	Extension	Private	Neighbors	USDA	Extension	Neighbors
Very Large	USDA	Extension	Private	Dealers	Private	Extension	Extension

Getting information from neighbors and from irrigation district staff has a negative association with the farm sizes among all seven states. The very large farms in different states relied relatively more on the extension service and private consultants.

USDA / government specialists are also an important information source for the farms. In seven states, there is a positively significant relationship between farm size and reliance on this information source. The data shows that this source has relatively lower adoption rate than getting information from extensions.

Reliance on private consultants is the major information source for the medium farm in California, large and very large farms in Colorado, and very large farm in New Mexico. There are strong positive associations between this information source and farm size in New Mexico and Colorado. In the very large farm at Colorado and medium farm at California, the reliance on private consultants is the primary information source, and Wyoming has a relatively low adoption rate of this information source. Wyoming appears as a state always has a difference in their adoption of information.

Getting information from government specialists or the private consultants are independent. From the model introduced by Frisvold and Deva (2011), we know the benefits will increase with scale. No matter the cost of information, the large-scale farms are always having more incentive, which is higher return from processing information, than the small farms. So, we may can expect the measurement of association gamma (γ) to be greater when the cost is higher. The above result did not show a case that higher cost information has higher gamma value among all seven states, but the maximum gamma coefficient of private consultant is much greater than the coefficients of the low-cost information sources.

Except for New Mexico and Wyoming, there is a negative association between farm size and reliance on irrigation district employees. Getting information from irrigation district employees may be related to the how the farmers get water (water delivered in turn or have the water right), but I cannot know the reason from this dataset. In most state except Colorado and Wyoming, the gamma coefficient of this source is higher than the gamma coefficient of extensions.

For all the small farm's owners, no matter where they come from, getting information from the neighbors is the main source of information, which has the highest adoption rate of all the sources of information. If the information sources are paid or have higher time cost, the adoption of those sources for small farms will be relatively lower than the other farms. The small farms are less likely to get irrigation information than the large farms.

Many common patterns appeared among most of the Colorado Basin states. The trend of choices of government specialists, irrigation equipment dealers and extension agents are all significant and have the same positive directions. For government specialists and irrigation equipment dealers, I found the trend that the proportion of access that information from specialists increase with the farm size are all significant. This result is consistent with our first hypothesis (H1), consulting the government specialists has a potential cost, therefore, the farmers would like to evaluate the cost and expected return increase, they would only go consult the USDA specialist when they think the net return of consulting them is positive. Reliance on Extension agents/ University Specialists is positively associated with the farm size and has a relative higher adoption rate than the other sources. The test results for getting information from Extension are significant for most states, except New Mexico. In California and Utah, this method is adopted by the large and very large farms as their primary information source.

Information acquired from irrigation equipment dealers is positively associated with the farm size. The gamma coefficients are greater than 0.7 at Nevada and New Mexico, which means a strong positive association. Getting information from the equipment dealers as a precursor to buying irrigation equipment. Buying irrigation equipment and getting irrigation information are two behaviors that reasonable have positive correlation, and it reasonable to assume that farmers would not get any information from the equipment dealer unless they visit the dealers or purchase at the stores. I will also discuss this in the later chapter about the priority of investigating the improvement for farmers. While the association is strong, the average adoption rate is relative low, especially for the small farms. An exception is in Colorado with an adoption rate of 13%; adoption rates for the other states are all less than 10%.

Use of media reports, which has an easier access and lower cost, is also giving an insignificant result and varying less. Utah has highest total number of information sources accessed among all seven Basin states.

Another important result, is the use of electronic information services, which is significantly increasing with farm size. An exception is, Arizona, but it might because of the missing data in that state’s sample Maumbe (2012) pointed out that the use of information technologies, which is getting more and more affordable, brought more opportunities and greater return to the farmers.

Hypothesis H2 suggested that if the cost of the information is relatively low, then both large and small farms will rely on such information source. The gamma test results of “Extension agents”, “USDA specialists” and “District employees” not are consistent with the hypothesis.

On the left side of the result table, the row sum of the percentage of accessing information shows a clear trend that the larger the farm size the more sources of information will be accessed. The numbers are also consistent with the third hypothesis H3.

For Arizona and New Mexico, the results are consistent with the Frisvold and Deva's study (2011) of those two states, there is no single information source was used by half of irrigators. In addition, the small farms in Arizona adopt irrigation information from private specialists increased from 0 to 13%. The share of g very large farms at New Mexico getting information from private specialists increased from 28% to 36%. The level of accessing the directly-provided and low-cost information maintained or even decreased within this ten-year period. Public entities may need to "advertise" themselves more and consider how to deliver the message to the farmers.

4.2 Operations for scheduling water use

Farmers were asked in the 2008 FRIS (USDA, NASS 2009) "How did this operation decide when to schedule water use in 2008? Mark(X) all that apply" with the choices below:

1. Condition of crop (observation)

2. Feel of the soil.

3. Use of soil moisture-sensing devices such as moisture blocks or tensiometers.

4. Use of plant moisture-sensing devices such as pressure (chamber) bombs or infrared (IR) thermometer.

5. Use of irrigation scheduling service, including commercial and government.

6. Report on daily crop-water evapo-transpiration (ET) use (Internet, newspapers, radio, TV, fax,

and email).

7. Water delivered by irrigation organization in turn (no choice by water user).

8. Personal calendar schedule.

9. Computer simulation models (not from a commercial service).

10. When neighbors began to irrigate.

11. Other.

Table V. (1) (AZ&CA) Method to determine time to apply irrigation water (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Condition of Crop by observation	Feel of the Soil	Soil-Moisture Sensing Devices	Commercial - Scheduling Services	Media Reports on Crop Water Needs	Water delivered in turn	Calendar Schedule	Computer Simulation Models	Neighbor Practices	Water-Management -intensive and Water-Conserving Means
Arizona	2,756	2,756	**865**	2,756	**865**	2,756	2,756	2,756	2,756	2,756
Small	58.22%	29.24%	0.00%	3.70%	0.00%	24.59%	45.58%	0.00%	0.16%	3.70%
Medium	63.10%	22.22%	2.78%	2.78%	1.59%	2.38%	37.70%	0.00%	0.00%	3.97%
Large	75.97%	46.75%	12.34%	5.84%	4.55%	6.49%	51.30%	0.00%	1.95%	18.18%
Very Large	93.68%	47.06%	9.15%	5.23%	9.37%	9.15%	29.19%	0.87%	1.74%	13.07%
Gamma	0.5355	0.2454	0.2725	0.1244	0.5676	-0.5807	-0.2028	-0.081	0.7268	0.495
Gamma Z value	18.858	8.642	5.376	4.381	11.198	-20.450	-7.142	-2.853	25.595	17.418
Cochran Z value	14.411	7.6987	2.7055	1.6676	4.191	-9.1156	-5.6124	-1.0851	4.7019	8.8652
California	40,298	40,298	40,298	40,298	40,298	40,298	40,298	40,298	40,298	40,298
Small	56.26%	37.08%	8.56%	11.32%	6.07%	12.86%	37.54%	2.20%	10.14%	17.49%
Medium	84.90%	65.78%	22.69%	3.99%	32.62%	5.12%	33.46%	0.00%	1.41%	30.48%
Large	50.08%	23.41%	37.20%	0.08%	27.71%	4.88%	9.38%	0.00%	4.11%	40.62%
Very Large	86.53%	55.35%	27.98%	13.61%	18.40%	10.53%	29.72%	4.28%	0.85%	39.82%
Gamma	0.4452	0.2558	0.4998	-0.1284	0.4841	-0.2246	-0.196	0.0708	-0.7085	0.3996
Gamma Z value	59.952	34.447	67.305	-17.291	65.190	-30.245	-26.394	9.534	-95.409	53.811
Cochran Z value	42.6352	23.362	47.5919	-2.0563	-6.8443	-10.081	-19.512	0.4544	-29.059	0.4544

Table V. (2) (CO&NV) Method to determine time to apply irrigation water (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Condition of Crop by observation	Feel of the Soil	Soil-Moisture Sensing Devices	Commercial - Scheduling Services	Media Reports on Crop Water Needs	Water delivered in turn	Calendar Schedule	Computer Simulation Models	Neighbor Practices	Water-Management -intensive and Water-Conserving Means
Colorado	11,478	11,478	**2831**	11,478	11,478	11,478	11,478	11,478	11,478	11,478
Small	70.79%	38.46%	0.00%	9.23%	3.63%	27.51%	26.03%	0.00%	15.28%	9.24%
Medium	88.30%	28.91%	3.09%	7.94%	5.85%	23.89%	25.40%	0.00%	6.18%	10.19%
Large	79.10%	38.97%	15.87%	14.19%	14.45%	27.35%	29.03%	0.00%	7.35%	26.32%
Very Large	84.75%	50.87%	17.00%	26.19%	37.49%	16.18%	17.00%	4.89%	2.56%	37.83%
Gamma	0.3533	0.0284	0.4932	0.2973	0.6971	-0.1331	-0.066	0.4189	-0.5025	0.4189
Gamma Z value	25.391	2.041	17.604	21.367	50.100	-9.566	-4.743	30.106	-36.114	30.106
Cochran Z value	12.0544	4.5206	10.4401	13.9115	35.0093	-6.3199	-3.8773	10.868	-13.137	42.6038
Nevada	1,676	1,676	**510**	1,676	1,676	1,676	1,676	1,676	1,676	1,676
Small	59.35%	29.93%	0.00%	1.03%	1.29%	33.88%	22.38%	1.03%	17.07%	2.23%
Medium	79.21%	40.10%	1.49%	3.47%	2.97%	3.47%	28.22%	0.00%	5.94%	4.95%
Large	75.00%	41.67%	4.17%	2.78%	1.39%	6.94%	26.39%	0.00%	2.78%	6.94%
Very Large	77.44%	43.90%	4.27%	8.54%	2.44%	17.68%	24.39%	0.61%	6.10%	11.59%
Gamma	0.3584	0.2273	0.3208	0.6049	0.2367	-0.5977	0.0869	0.3104	-0.5496	0.5226
Gamma Z value	9.843	6.242	4.860	16.612	6.500	-16.414	2.387	8.524	-15.094	14.352
Cochran Z value	6.1403	4.5347	1.5629	5.8673	1.1981	-8.0035	1.2052	.6137	-5.8586	6.1835

Table V. (3) (NM&UT) Method to determine time to apply irrigation water (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Condition of Crop by observation	Feel of the Soil	Soil-Moisture Sensing Devices	Commercial - Scheduling Services	Media Reports on Crop Water Needs	Water delivered in turn	Calendar Schedule	Computer Simulation Models	Neighbor Practices	Water-Management -intensive and Water-Conserving Means
New Mexico	7,848	7,848	7,848	7,848	**7455**	7,848	7,848	7,848	7,848	**7848**
Small	70.35%	35.12%	1.84%	4.55%	0.03%	25.23%	39.06%	0.09%	9.27%	5.56%
Medium	80.41%	31.30%	6.36%	1.78%	0.00%	13.23%	27.23%	0.00%	5.09%	8.14%
Large	73.63%	56.22%	2.99%	6.97%	3.98%	5.97%	38.81%	0.00%	3.98%	9.95%
Very Large	82.58%	50.65%	15.16%	10.00%	5.81%	2.26%	19.03%	4.84%	0.97%	25.48%
Gamma	0.2377	0.179	0.6502	0.1419	0.9647	-0.5963	-0.2631	-0.6004	-0.4837	0.4839
Gamma Z value	14.126	10.637	38.640	8.433	55.876	-35.436	-15.635	-35.680	-28.745	28.757
Cochran Z value	5.4543	6.8474	13.8209	3.7102	18.3419	-11.973	-7.2062	-7.1212	-6.1378	13.1114
Utah	9,981	9,981	9,981	9,981	9,981	9,981	9,981	9,981	9,981	9,981
Small	58.98%	20.25%	2.01%	8.40%	1.71%	34.34%	18.44%	1.61%	3.98%	8.81%
Medium	73.44%	27.15%	3.26%	8.01%	3.86%	34.87%	29.97%	0.00%	7.57%	11.13%
Large	82.54%	38.03%	5.35%	8.73%	0.28%	38.59%	20.28%	0.00%	19.44%	14.08%
Very Large	88.83%	37.71%	5.03%	18.44%	3.91%	25.42%	22.91%	0.28%	3.07%	20.39%
Gamma	0.4608	0.3059	0.3546	0.1522	0.2505	-0.0258	0.1891	0.4312	0.4002	0.2644
Gamma Z value	30.882	20.501	23.765	10.200	16.788	-1.729	12.673	28.898	26.821	17.720
Cochran Z value	15.4274	11.187	5.4987	5.106	2.5402	-1.8046	4.1964	7.8219	7.2356	7.8663

Table V. (4) (WY) Method to determine time to apply irrigation water (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Condition of Crop by observation	Feel of the Soil	Soil-Moisture Sensing Devices	Commercial-Scheduling Services	Media Reports on Crop Water Needs	Water delivered in turn	Calendar Schedule	Computer Simulation Models	Neighbor Practices	Water-Management -intensive and Water-Conserving Means
Wyoming	4,457	4,457	3753	4,457	4,457	4,457	4,457	4,457	4,457	4,457
Small	67.52%	27.55%	0.43%	9.14%	1.66%	22.45%	19.64%	0.00%	13.38%	9.64%
Medium	78.98%	43.47%	0.00%	1.14%	1.99%	11.51%	22.02%	0.00%	11.22%	1.14%
Large	78.51%	28.65%	1.86%	0.53%	4.51%	9.02%	25.99%	0.00%	9.81%	2.39%
Very Large	70.79%	50.00%	4.49%	6.46%	6.46%	16.85%	24.44%	0.00%	6.46%	10.96%
Gamma	0.1862	0.2582	0.7322	-0.5432	0.398	-0.3046	0.1105		-0.1811	-0.3432
Gamma Z value	8.339	11.563	30.090	-24.327	17.824	-13.641	4.949		-8.110	-15.370
Cochran Z value	4.2635	8.4583	7.3834	-5.8704	6.0928	-6.2194	3.2408		-4.153	-3.1728

Table VI. 95% Confidence Intervals of Gamma Coefficients table for responses of Method to determine time to apply irrigation water

		AZ	CA	CO	NV	NM	UT	WY
Condition of Crop by Observation	95% Lower	0.47	0.43	0.31	0.26	0.16	0.41	0.12
	Gamma Value	0.54	0.45	0.35	0.36	0.24	0.46	0.19
	95% Upper	0.60	0.46	0.40	0.45	0.32	0.51	0.25
Feel of the Soil	95% Lower	0.17	0.24	-0.01	0.14	0.11	0.25	0.20
	Gamma Value	0.25	0.26	0.03	0.23	0.18	0.31	0.26
	95% Upper	0.32	0.27	0.07	0.32	0.24	0.36	0.31
Soil-Moisture Sensing Devices	95% Lower	0.08	0.48	0.42	-0.02	0.57	0.23	0.60
	Gamma Value	0.27	0.50	0.49	0.32	0.65	0.35	0.73
	95% Upper	0.46	0.52	0.56	0.66	0.73	0.48	0.86
Commercial-Scheduling Services	95% Lower	-0.05	-0.16	0.24	0.44	0.00	0.07	-0.67
	Gamma Value	0.12	-0.13	0.30	0.60	0.14	0.15	-0.54
	95% Upper	0.30	-0.09	0.35	0.77	0.29	0.24	-0.42
Media Reports on Crop water Needs	95% Lower	0.87	0.47	0.66	-0.06	0.94	0.10	0.26
	Gamma Value	0.92	0.48	0.70	0.24	0.96	0.25	0.40
	95% Upper	0.96	0.50	0.73	0.53	0.99	0.40	0.54
Water Delivered in Turn	95% Lower	-0.67	-0.26	-0.18	-0.70	-0.67	-0.08	-0.38
	Gamma Value	-0.58	-0.22	-0.13	-0.60	-0.60	-0.03	-0.30
	95% Upper	-0.49	-0.19	-0.09	-0.50	-0.52	0.03	-0.23
Calendar Schedule	95% Lower	-0.27	-0.21	-0.11	-0.02	-0.33	0.13	0.05
	Gamma Value	-0.20	-0.20	-0.07	0.09	-0.26	0.19	0.11
	95% Upper	-0.13	-0.18	-0.02	0.19	-0.19	0.25	0.18
Neighbor Practices	95% Lower	0.56	-0.74	-0.56	-0.69	-0.62	0.32	-0.27
	Gamma Value	0.75	-0.71	-0.50	-0.55	-0.48	0.40	-0.18
	95% Upper	0.94	-0.68	-0.44	-0.41	-0.35	0.48	-0.09
Water-Management-Intensive and Water-Conserving Means	95% Lower	0.40	0.38	0.46	0.38	0.41	0.19	-0.47
	Gamma Value	0.49	0.40	0.49	0.52	0.48	0.26	-0.34
	95% Upper	0.59	0.42	0.53	0.67	0.56	0.34	-0.22

Similarly to the Leib et al. (2002) study of adoption and adaptation of scientific irrigation scheduling, observation and feel of the soil are the dominant methods to schedule irrigation. The gamma coefficient and Cochran-Armitage test both show a positively significant association between the farm size and the percentage of farms using observation of the condition of the crop. The feel of the soil practice is somewhat ambiguous. It could mean to use a more sophisticated technique to check the soil or simply means the farmer puts his hand in the soil. USDA did not clarify that in the survey. Intuitively, the adoption rate of irrigation scheduling methods will be positively associated with the farm size if the cost of this methods is relative higher; if the method is free or low-cost, then using such method should be no difference between the different farm size. However, observing the crops and feel of soil, which are having no cost, show a positive trend of adopting as farm size increases. The gamma coefficients for observation are higher than the coefficients for the feel of the soil in all states except for Wyoming, and the smaller standard deviation lead a shorter confidence interval for the most states on those two methods. In the results, I expected to see the gamma coefficients for the high-cost methods were higher than the gamma coefficients for the free or low-cost methods. Those two methods are important and different, but I cannot see more details beyond this from the data. And the confidence intervals were not affected by the cost of the method.

The next major methods used by farmers were the “Calendar schedule” and “Water delivered in turn by the irrigation organization.” The gamma coefficients of water delivered in turn to all the states are negative. The gamma coefficients of Calendar Schedule are positive for Wyoming, Utah, Nevada and negative for Arizona, California, Colorado and New Mexico. The confidence interval for Nevada include the zero, which means the relationship is insignificant. Calendar Schedule should be based on the location history and farming habits. The geographical location might be the reason that Nevada, Utah, and Wyoming have common signs.

The adoption rates of commercial-scheduling services, soil-moisture sensing devices and media reports on crop water needs are relatively low in each farm size and most states. Although, the adoption rate of those three methods maintain a relatively low level in most of the basin states, California is doing more to adopt soil-moisture sensing devices and using media reports on crop water needs. Normally, those three methods are normally positively associated with the farm size. Gamma coefficients of commercial scheduling service in California and Wyoming are negative. This is consistent with the finding of Ali (2012), a positive association between farm size and use of mass media information. And at the era of the new media, using the information from the new media is showing more advantages than people thought. A large volume of the information was posted on the USDA’s Facebook and Twitter. Elise and Hodde claim that agriculture is a modern enterprise and farming is not watering the crops only. Communication and adoption of new media is a “requirement” for farms. (Eise, Hodde 2016)

One important finding is the adoption rate of the looking at the neighbors is positively associated with the farm size in Arizona and Utah. In the other five states, the associations are negative, and the adoption rate of this method for the small farm are around 15%. In Arizona, less than 1% of small farm’s owner determine their irrigation timing by looking at their neighbors. The gamma value for Arizona has a confidence interval from 0.56 to 0.94, which shows a strong positive association. In Utah, around 20% of the large farm owners determine the irrigation schedule by looking at their neighbors. The confidence interval of gamma value at Utah has a smaller range than Arizona, which is from 0.32 to 0.48. The small farms not only get more information from their neighbor, and determine irrigation timing by neighbor's practices. Small farm reliance on their neighbor more than the other sizes farms.

We turn now to, H4, which says the use of management-intensive methods to schedule irrigation will increase with farm size. The association between farm size and use of the most water-management-intensive and water-conserving means to decide when to apply water are mainly significant and positive, except Arizona is insignificant, and Wyoming is negative. Use of management-intensive methods are higher-cost methods. Wyoming again has a negative association between using this method and the farm size. California has the highest adoption rate of the management-intensive method in Colorado Bains states for each sales class. Compare this with the data from 10 years ago, and the adoption rate of the management-intensive method was positively associated with farm size, but now it is insignificant. This is because the use of management-intensive methods decreased among very large farms, and increased in the small farms.

Consistent with the Frisvold and Deva's study (2011) of Arizona and New Mexico farms, the associations between farm size and having water delivered in turn are negative for all state. Across all seven basin states, 26% of small farms responded that water was delivered in turn, which means scheduling irrigation may not base on the condition of the crop. Since the smaller farm receive the water in turn from their irrigation districts and rely on the irrigation district employee for information, government or the agents of the local agricultural department could train the irrigation district staffs for water management information.

4.3 Barriers to implementing improvements in the irrigation system

The 2008 FRIS survey (USDA, NASS 2009) asked farmers, “what are barriers to implementing improvements that might reduce energy and/or conserve water in this operation’s irrigation system? Mark (X) all that apply”. The choices listed here:

1. Investigating improvements is not a priority at this time.
2. Risk of reduced yield or poorer quality crop yields from not meeting water needs.
3. Physical field/crop conditions limit system improvements.
4. Improvements will reduce costs, but not enough to cover installation costs.
5. Cannot finance improvements.
6. Landlord will not share cost of improvements.
7. Uncertainty about future availability of water.
8. Will not be farming this operation long enough to justify new improvements.
9. Other.

Table VII. (1) (AZ&CA) Barriers to adopting irrigation improvements (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Risk of Reduced yield	Physical Field/Crop Conditions	Installation Costs Greater Than Benefits	Lack of Financial Ability	Lack of Landlord cost-Sharing Participation	Uncertainty About Future Water	Will Not Be Farming in the Future	Other Reason
Arizona	1912	1912	1912	1912	1912	1912	1912	1912
Small	22.83%	10.37%	4.18%	53.46%	0.32%	24.20%	16.40%	17.85%
Medium	0.00%	11.11%	9.94%	36.26%	6.43%	10.53%	36.26%	40.94%
Large	4.23%	9.15%	6.34%	10.56%	4.93%	2.82%	15.49%	14.08%
Very Large	6.76%	8.45%	9.86%	24.23%	10.14%	4.51%	18.87%	5.35%
Gamma	-0.66	-0.07	0.33	-0.52	0.78	-0.66	0.12	-0.16
Gamma Z value	-19.4298	-1.9770	9.7560	-15.1385	22.9058	-19.3125	3.5433	-4.7284
Cochran Z value	-8.5629	-1.0758	4.0749	-11.9156	9.7042	-9.8047	1.2208	-4.8671
California	30480	40298	40298	40298	40298	40298	40298	40298
Small	28.52%	34.34%	30.02%	23.05%	0.31%	22.27%	16.53%	5.35%
Medium	16.82%	26.64%	10.73%	8.22%	0.37%	3.88%	1.41%	9.32%
Large	24.38%	19.98%	18.53%	12.09%	1.20%	8.24%	9.04%	12.54%
Very Large	8.88%	6.49%	14.20%	11.09%	5.87%	12.01%	8.91%	9.64%
Gamma	-0.38	-0.36	-0.31	-0.31	0.83	-0.35	-0.34	0.32
Gamma Z value	-44.5389	-48.3035	-41.2741	-41.1664	112.0799	-47.3070	-45.7988	42.5400
Cochran Z value	-29.9269	-33.5118	-20.0887	-17.6281	31.4462	-17.1812	-13.7411	17.4412

Table VII. (2) (CO&NV) Barriers to adopting irrigation improvements (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Risk of Reduced yield	Physical Field/Crop Conditions	Installation Costs Greater Than Benefits	Lack of Financial Ability	Lack of Landlord cost-Sharing Participation	Uncertainty About Future Water	Will Not Be Farming in the Future	Other Reason
Colorado	8894	8894	8894	8894	8894	8894	8894	8894
Small	3.27%	3.96%	19.78%	27.80%	2.91%	10.30%	12.99%	21.75%
Medium	4.97%	18.98%	20.25%	14.52%	15.54%	11.72%	17.83%	15.41%
Large	4.07%	9.70%	13.93%	18.47%	12.21%	19.72%	11.42%	7.51%
Very Large	8.23%	5.18%	27.90%	16.92%	3.81%	8.23%	0.00%	5.64%
Gamma	0.27	0.41	0.04	-0.29	0.47	0.11	-0.18	-0.43
Gamma Z value	17.3026	25.6407	2.4925	-18.5552	29.9301	7.1235	-11.1597	-27.2161
Cochran Z value	5.9172	7.0385	2.3136	-8.8539	8.7985	2.4002	-7.47	-12.9404
Nevada	1517	1517	1517	1517	1517	1517	1517	1517
Small	0.47%	0.66%	18.17%	19.59%	2.82%	22.32%	2.73%	15.73%
Medium	6.42%	8.02%	11.76%	19.79%	0.53%	13.37%	2.14%	4.28%
Large	6.72%	10.08%	11.76%	11.76%	1.68%	13.45%	4.20%	4.20%
Very Large	15.44%	12.75%	6.71%	14.09%	1.34%	12.75%	1.34%	6.04%
Gamma	0.80	0.75	-0.31	-0.13	-0.39	-0.28	-0.06	-0.53
Gamma Z value	20.9203	19.6009	-8.2171	-3.472	-10.247	-7.3104	-1.6930	-13.7796
Cochran Z value	10.2288	9.2067	-4.063	-2.1909	-1.5668	-3.6875	-0.4818	-4.971

Table VII. (3) (NM&UT) Barriers to adopting irrigation improvements (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Risk of Reduced yield	Physical Field/Crop Conditions	Installation Costs Greater Than Benefits	Lack of Financial Ability	Lack of Landlord cost-Sharing Participation	Uncertainty About Future Water	Will Not Be Farming in the Future	Other Reason
New Mexico	4986	4986	4986	4986	4986	4986	4986	4986
Small	4.02%	12.33%	27.29%	46.55%	0.05%	37.40%	18.87%	1.79%
Medium	20.95%	1.35%	11.15%	15.88%	10.81%	27.03%	8.78%	8.78%
Large	5.59%	15.64%	12.29%	13.41%	4.47%	16.76%	4.47%	10.06%
Very Large	8.85%	3.85%	4.62%	6.54%	2.69%	5.77%	1.54%	12.69%
Gamma	0.49	-0.37	-0.57	-0.72	0.85	-0.49	-0.62	0.68
Gamma Z value	23.1675	-17.7439	-26.9617	-34.0858	40.1204	-23.2480	-29.2827	32.3427
Cochran Z value	6.1142	-4.2318	-10.2723	-16.7906	10.2662	-11.9683	-9.244	12.512
Utah	7509	7509	7509	7509	7509	7509	7509	7509
Small	9.20%	13.20%	17.56%	39.64%	5.00%	15.40%	13.46%	11.73%
Medium	10.91%	9.33%	22.22%	18.85%	0.79%	12.90%	18.85%	0.00%
Large	10.95%	14.49%	20.85%	24.03%	13.07%	2.83%	15.90%	0.71%
Very Large	7.19%	5.00%	5.31%	13.13%	7.19%	5.63%	0.00%	2.81%
Gamma	0.03	-0.19	-0.04	-0.47	0.10	-0.34	-0.06	-0.75
Gamma Z value	1.6392	-10.8121	-2.2844	-27.4023	5.8711	-19.9559	-3.6679	-43.3821
Cochran Z value	0.1476	-3.8012	-3.081	-12.6795	3.1128	-7.0733	-4.0098	-6.8017

Table VII. (4) (WY) Barriers to adopting irrigation improvements (values next to the state are sample size, next to farm sizes are percentage yes responses)

	Risk of Reduced yield	Physical Field/Crop Conditions	Installation Costs Greater Than Benefits	Lack of Financial Ability	Lack of Landlord cost-Sharing Participation	Uncertainty About Future Water	Will Not Be Farming in the Future	Other Reason
Wyoming	3215	3215	3215	3215	3215	3215	3215	3215
Small	18.24%	15.57%	37.04%	39.19%	2.82%	37.45%	7.53%	1.54%
Medium	3.28%	19.22%	22.81%	7.03%	2.19%	16.88%	8.75%	3.44%
Large	1.20%	5.69%	6.59%	43.71%	3.29%	31.14%	3.59%	0.00%
Very Large	6.57%	10.38%	13.49%	10.38%	0.69%	6.23%	4.15%	3.11%
Gamma	-0.66	-0.12	-0.48	-0.39	-0.14	-0.41	-0.13	0.33
Gamma Z value	-25.2142	-4.6632	-18.3717	-14.9444	-5.3592	-15.6176	-4.9447	12.4073
Cochran Z value	-10.0366	-3.5884	-12.7496	-9.3413	-1.5337	-10.9808	-2.6317	2.758

Table VIII. 95% confidence intervals of Gamma Coefficients table for responses of Barriers to implementing irrigation improvements

		AZ	CA	CO	NV	NM	UT	WY
Risk of Reduced Yield	95% Lower	-0.74	-0.40	0.18	0.72	0.41	-0.07	-0.75
	Gamma Value	-0.62	-0.38	0.27	0.80	0.49	0.03	-0.66
	95% Upper	-0.50	-0.36	0.37	0.88	0.57	0.13	-0.57
Physical Field/Crop Conditions	95% Lower	-0.21	-0.38	0.35	0.67	-0.51	-0.29	-0.21
	Gamma Value	-0.07	-0.36	0.41	0.75	-0.37	-0.19	-0.12
	95% Upper	0.07	-0.34	0.46	0.83	-0.24	-0.09	-0.04
Installation Costs Greater than Benefits	95% Lower	0.20	-0.33	-0.02	-0.46	-0.66	-0.12	-0.54
	Gamma Value	0.33	-0.31	0.04	-0.31	-0.57	-0.04	-0.48
	95% Upper	0.47	-0.28	0.10	-0.17	-0.48	0.04	-0.42
Lack of Financial Ability	95% Lower	-0.59	-0.33	-0.35	-0.26	-0.77	-0.53	-0.46
	Gamma Value	-0.52	-0.31	-0.29	-0.13	-0.72	-0.47	-0.39
	95% Upper	-0.45	-0.28	-0.24	0.00	-0.67	-0.41	-0.33
Lack of Landlord Cost-Sharing Participation	95% Lower	0.70	0.80	0.42	-0.78	0.82	-0.03	-0.34
	Gamma Value	0.78	0.83	0.47	-0.39	0.85	0.10	-0.14
	95% Upper	0.86	0.87	0.53	0.00	0.88	0.23	0.06
Uncertainty About Future Water	95% Lower	-0.75	-0.38	0.05	-0.41	-0.56	-0.44	-0.47
	Gamma Value	-0.66	-0.35	0.11	-0.28	-0.49	-0.34	-0.41
	95% Upper	-0.56	-0.32	0.18	-0.15	-0.42	-0.25	-0.35
Will Not Be Farming in the Future	95% Lower	0.02	-0.38	-0.01	-0.38	-0.72	0.06	-0.25
	Gamma Value	0.12	-0.34	0.06	-0.06	-0.62	0.16	-0.13
	95% Upper	0.22	-0.31	0.14	0.25	-0.52	0.25	-0.01
Other Reason	95% Lower	-0.26	0.29	-0.49	-0.69	0.61	-0.88	0.14
	Gamma Value	-0.16	0.32	-0.43	-0.53	0.68	-0.75	0.33
	95% Upper	-0.06	0.35	-0.37	-0.37	0.75	-0.61	0.52

Table IX. Major barriers to implementing irrigation improvements

	Small	Medium	Large	Very Large
Arizona	Financial	Financial/ Will Not Be Farming	Will Not Be Farming	Financial
California	Physical	Physical	Risk of Yield	Installation
Colorado	Financial	Installation	Uncertainty	Installation
Nevada	Uncertainty	Financial	Uncertainty	Risk of Yield
New Mexico	Financial	Uncertainty	Uncertainty	Risk of Yield
Utah	Financial	Installation	Financial	Financial
Wyoming	Financial	Physical	Financial	Installation

Kislev and Shchori-Bachrach (1973) claimed that people with more knowledge of about a new technology would be early adopters. This means the farm size could be associated with using of new technology. Feder and Slade (1984) said the acquiring information was considered as a cost for the farmer, and the effect of this information would have a different return by different farm size. The cost varies by farmers' knowledge, and it would be lower if the farmers have more knowledge. The return increases with the land the farmers own. Those two variables are the key factors that will affect the decision of adoption. The consistent finding from Kislev and Shchori-Bachrach (1973) and Feder and Slade (1984) is information acquisition increases farm productivity. If we consider the farm size as the representative of the knowledge and the land that farmers have.

The association between adopting the new technology or investing the improvements and the farm size would be positive.

For this section, we have to reconsider the methods for measuring the strength of the association between farm size and different yes-no responses. ,. The reason is simple; if a farmer has no willingness or need to invest in improvements, they may not report any barriers to making investments. The figure below shows that, a significant proportion of small and medium farms did not investigate improvements. In general, larger farms tend to be more likely to investigate improvements. That said, there are several differences in the relationship between farm size and investigating improvements across states.

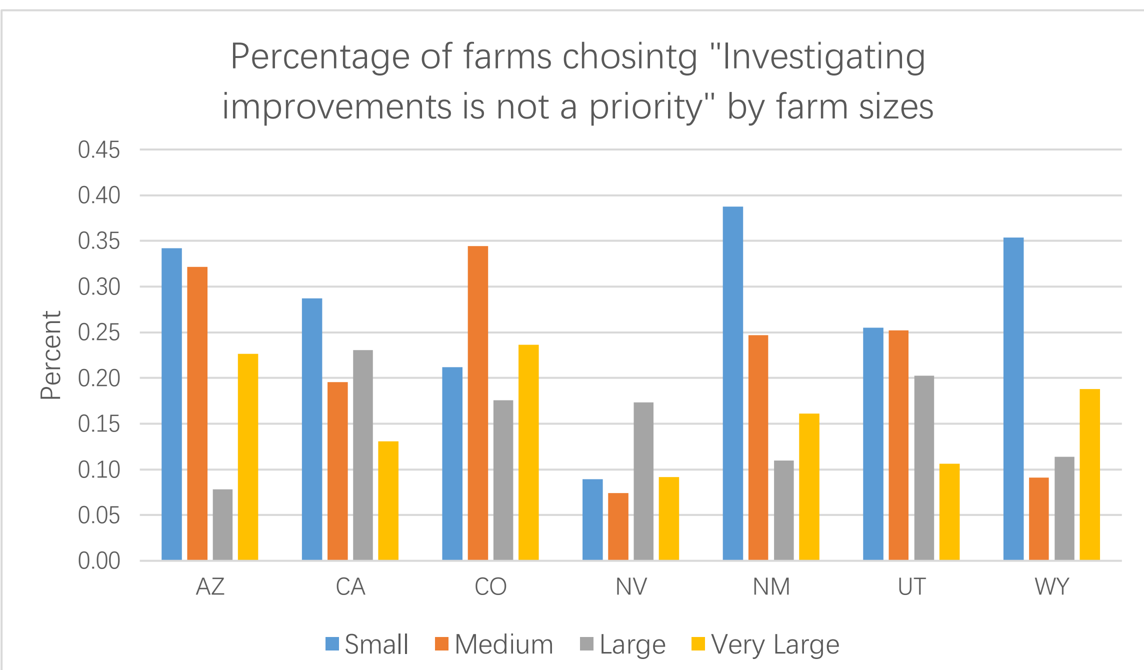


Figure III. Farm size class shares of total responses “Investigating improvement is not a priority”

So, we need to count the farmers who consider investigating the improvements as a priority as the total sample size for the rest of the tests. The table III shows farms experiencing adoption barriers as a share of farms are investigating improvements.

In most cases, there is a negative association between farm size and adoption barriers. Response option “risk of reduced yield or poorer quality yield from not meeting water needs” did not show a common reaction from all seven states. The results from most states, except Utah, have the significant associations, but not a common sign.

For lack of financial ability, there is a significant negative association between the farm size and the rate of farms that have a lack of financial ability. There are two conditions to be a large farm, either growing the high-return crops or with having a large farm in terms of acreage. Both conditions are positively associated with profit, which means higher financial ability. The primary barriers to adopting irrigation improvements for small farms in the five out of seven states is the financial reason. In California, the farmers seem to have more troubles from the physical conditions than the average. In Nevada, the small farm owners are facing more uncertainty from water, and lack of financial ability is still a primary barrier to making improvements for one-fifth of the small farmers who think investigating improvement is a priority. Go back to the response “getting information from irrigation equipment dealer” in the first section of this chapter, around 10% of the small farm owners use this information source, but 30% of very large farm owners getting information from dealers. Getting information from irrigation equipment dealer should be positively associated with the financial ability. Those responses evidenced each other and show small farms are facing more problems and uncertainty.

About the response option "will not be farming the farm in the near future" (FRIS 2009), the significant test results are also consistent with the negative association. The gamma coefficient in Arizona is not significant, but a relatively large number of farmers will not be farming in the near future. The data from USDA Census of Agriculture shows that the small irrigated land owner and water users have a negative net income on average.

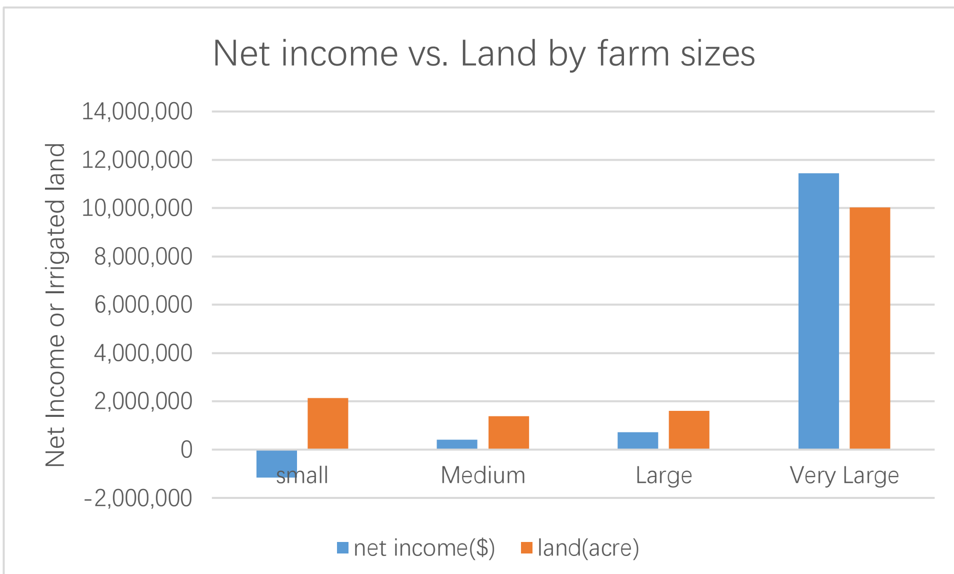


Figure IV. Relationship between net income and farm sizes

The negative or low-income farms have smaller financial ability compare to the large farms. The large farms have more financial stability than the small farms, so they are less likely to leave the market and more likely to invest. About 20% of small and medium farm operators will not be farming in the near future, and this group of the farmers is facing more water and financial issues.

The association between farm size and the barrier "installation costs greater than benefits" is mainly negative. Of small farms in Wyoming, 37% cannot get net benefits from the installation of improvements for the barrier “lack of landlord participation”, the tests show a common result. The association between farm sales class and lack of landlord participation is strongly positive. Gamma coefficients are around 0.8 for Arizona, California and New Mexico. However, if we look at the percentage of farms which have the barrier of lack of landlord participation, we see no state, and the sales class has the response more than 15%.

The association between the farm size and having uncertainty about future water is negative. In Colorado, the gamma coefficient is insignificant and small and very large farms have a low rate of uncertainty about future water supplies. None of the very large farms has uncertainty about future water as the primary barrier. This result tells that the very large farms, which are the major water users, do not have many issues or barriers to making improvements.

4.4 Participation in water conservation cost-share programs

Water conservation cost share programs help farmers buy technology or gain financial ability to improve the irrigation efficiency and have higher incomes. The 2008 FRIS data contains many missing values but we can still have some useful findings from the data available.

The 2008 FRIS survey asked farmers to mark all the conservation programs that they currently participate in, or have participated in the past five years. The program could be a government payment program or technical assistance program for irrigation and/or drainage improvements. Payment programs may include cost-share or incentive payments or only technical assistance for system design or on-farm management. The information was found from the following sources ”

(USDA, NASS 2009): USDA – Environmental quality incentive program (EQIP)

1. Other USDA conservation payment programs (CSP, CRP, WRP, FWP, GRP, etc).
2. USDA-NRCS conservation technical assistance program.
3. Non-USDA federal programs – include EPA, Bureau of Reclamation, or other programs
4. State programs (including CREP), local water management programs, or supply district programs.
5. Other

Table X. (1) (AZ & CA) Participation in water conservation cost share program (values next to the state are sample size, next to farm sizes are percentage yes responses)

	USDA EQIP Financial Assistance	Other USDA Conservation Programs	State / Local Water Management	Other Programs	Any Federal Program	Any Program Source	USDA-NRCS Technical Assistance
Arizona	2,756	2,756	**865**	**2350**	2,756	2,756	2,756
small	9.31%	0.00%	0.00%	0.63%	12.85%	13.48%	4.55%
medium	14.29%	5.95%	4.76%	0.00%	17.46%	22.22%	4.37%
large	28.57%	11.04%	5.19%	0.00%	34.42%	34.42%	12.99%
very large	40.74%	8.06%	1.31%	1.74%	50.11%	52.29%	12.42%
Gamma	0.60	0.07	-0.44	0.47	0.60	0.60	0.39
Gamma Z value	21.225	2.430	-8.622	15.304	20.975	21.271	13.815
Cochran Z value	16.8671	0.7876	-2.7831	2.3188	17.9869	18.3364	6.7974
California	40,298	40,298	**9068**	**31253**	40,298	40,298	**15511**
small	3.98%	0.22%	0.00%	0.22%	3.98%	4.20%	0.00%
medium	5.88%	0.82%	0.00%	0.00%	9.58%	9.58%	4.52%
large	4.38%	6.65%	2.08%	0.00%	13.11%	15.18%	2.38%
very large	16.01%	4.19%	2.00%	0.84%	20.91%	22.38%	5.49%
Gamma	0.45	0.74	-0.02	0.59	0.56	0.57	0.09
Gamma Z value	60.625	99.906	-1.284	69.755	75.034	76.287	7.494
Cochran Z value	32.462	29.9906	-0.2459	7.5327	45.4412	47.941	2.6546

Table X. (2) (CO&NV) Participation in water conservation cost share program (values next to the state are sample size, next to farm sizes are percentage yes responses)

	USDA EQIP Financial Assistance	Other USDA Conservation Programs	State / Local Water Management	Other Programs	Any Federal Program	Any Program Source	USDA-NRCS Technical Assistance
Colorado	11,478	11,478	11,478	**10703**	11,478	11,478	11,478
small	4.14%	9.15%	0.22%	0.05%	14.99%	15.21%	4.85%
medium	21.39%	14.45%	1.92%	2.26%	34.34%	37.84%	4.85%
large	27.61%	15.48%	2.45%	0.00%	44.00%	45.29%	16.77%
very large	37.83%	26.66%	1.86%	0.81%	52.85%	53.67%	7.33%
Gamma	0.73	0.37	0.68	0.81	0.58	0.59	0.29
Gamma Z value	52.651	26.512	48.863	56.443	41.554	42.640	21.151
Cochran Z value	38.2517	15.7777	9.1826	6.6741	32.0683	32.8652	8.5608
Nevada	1,676	**510**		**308**	1,676	1,676	1,676
small	10.38%	0.00%	0.00%	0.00%	15.09%	15.09%	7.46%
medium	20.79%	11.39%	0.00%	0.00%	35.15%	35.15%	16.34%
large	30.56%	2.78%	0.00%	1.39%	43.06%	44.44%	16.67%
very large	23.17%	9.76%	0.00%	6.71%	29.27%	34.76%	4.88%
Gamma	0.41	-0.11		0.67	0.43	0.47	0.19
Gamma Z value	11.177	-1.622	0.000	7.916	11.751	12.880	5.347
Cochran Z value	6.9397	-0.7169		2.3162	7.7394	9.1026	1.3548

Table X. (3) (NM& UT) Participation in water conservation cost share program (values next to the state are sample size, next to farm sizes are percentage yes responses)

	USDA EQIP Financial Assistance	Other USDA Conservation Programs	State / Local Water Management	Other Programs	Any Federal Program	Any Program Source	USDA-NRCS Technical Assistance
New Mexico	7,848	7,848	**511**	**511**	7,848	7,848	7,848
small	6.58%	5.75%	0.00%	0.00%	12.89%	12.89%	0.76%
medium	20.61%	9.67%	0.00%	0.00%	33.84%	33.84%	18.58%
large	20.40%	5.97%	1.00%	12.94%	26.37%	39.30%	6.97%
very large	36.45%	13.55%	0.65%	0.97%	42.90%	43.87%	6.13%
Gamma	0.65	0.29	-0.22	-0.88	0.55	0.60	0.80
Gamma Z value	38.354	17.371	-3.260	-13.293	32.822	35.436	47.732
Cochran Z value	20.5441	5.505	-0.4384	-5.7118	17.0884	19.4158	14.5408
Utah	9,981	9,981	9,981	9,981	9,981	9,981	9,981
small	1.68%	2.33%	0.31%	1.22%	7.87%	9.30%	3.60%
medium	17.36%	16.47%	0.74%	9.79%	38.28%	41.25%	15.43%
large	14.65%	17.75%	3.94%	1.69%	34.93%	35.49%	10.14%
very large	39.94%	12.01%	2.79%	9.22%	50.00%	56.42%	30.45%
Gamma	0.85	0.71	0.71	0.67	0.74	0.73	0.68
Gamma Z value	56.945	47.583	47.751	45.110	49.647	49.212	45.385
Cochran Z value	37.5197	19.1737	9.5988	12.7189	32.6486	33.096	23.185

Table X. (4) (WY) Participation in water conservation cost share program (values next to the state are sample size, next to farm sizes are percentage yes responses)

	USDA EQIP Financial Assistance	Other USDA Conservation Programs	State / Local Water Management	Other Programs	Any Federal Program	Any Program Source	USDA-NRCS Technical Assistance
Wyoming	4,457	4,457	**3753**	**4080**	4,457	4,457	4,457
small	11.92%	4.87%	0.17%	1.16%	24.47%	25.23%	7.75%
medium	27.41%	18.32%	0.00%	3.98%	38.07%	42.05%	15.91%
large	20.95%	18.30%	1.06%	0.00%	36.60%	37.14%	10.08%
very large	22.75%	7.58%	0.56%	0.28%	26.97%	27.25%	5.34%
Gamma	0.33	0.43	0.58	0.31	0.19	0.21	0.14
Gamma Z value	14.922	19.253	23.716	13.253	8.608	9.208	6.288
Cochran Z value	8.2071	7.8569	2.5893	0.4603	4.5475	4.6429	0.917

Table XI. Confidence Intervals of Gamma Coefficients table for responses of water conservation program participation

		AZ	CA	CO	NV	NM	UT
USDA EQIP Financial Assistance	95% Lower	0.55	0.42	0.71	0.31	0.60	0.83
	Gamma Value	0.60	0.45	0.73	0.41	0.65	0.85
	955 Upper	0.66	0.48	0.76	0.50	0.69	0.87
State/ Local Water Management Program	95% Lower	-0.68	-0.18	0.60		-1.15	0.61
	Gamma Value	-0.44	-0.02	0.68		-0.22	0.71
	955 Upper	-0.20	0.14	0.76		0.72	0.82
Other Programs	95% Lower	0.12	0.46	0.76	0.25	-1.02	0.61
	Gamma Value	0.47	0.59	0.81	0.67	-0.88	0.67
	955 Upper	0.82	0.71	0.87	1.09	-0.74	0.73
Financial Assistance From Any Federal Program	95% Lower	0.54	0.54	0.55	0.35	0.50	0.71
	Gamma Value	0.60	0.56	0.58	0.43	0.55	0.74
	955 Upper	0.65	0.58	0.61	0.51	0.60	0.77
Financial Assistance From Any Program	95% Lower	0.55	0.55	0.57	0.39	0.55	0.71
	Gamma Value	0.60	0.57	0.59	0.47	0.60	0.73
	955 Upper	0.66	0.59	0.62	0.55	0.64	0.76
USDA-NRCS Technical Assistance	95% Lower	0.28	0.02	0.23	0.07	0.77	0.64
	Gamma Value	0.39	0.09	0.29	0.19	0.80	0.68
	955 Upper	0.50	0.16	0.36	0.32	0.84	0.72
Other USDA Conservation Program	95% Lower	-0.13	0.71	0.32	-0.40	0.19	0.67
	Gamma Value	0.07	0.74	0.37	-0.11	0.29	0.71
	955 Upper	0.27	0.77	0.41	0.18	0.40	0.75

The overall participation rate in water conservation program varied by the state. The participation rate in Wyoming is 29%, which is the highest among all seven states. The participation rate in California is 8%, which is the lowest in all seven states. Twenty-five percent of the small farms in Wyoming participate in a water conservation program, which is the highest participation rate of small farms across the states examined. In Arizona, Colorado, and Utah, the participation rates of the very large farms exceed 50%. While the overall participation rate is not very high, large farms are doing well.

The Environmental Quality Incentives Program (EQIP) provides technical and financial assistance to the farmers to implement conservation practices. From table X, the association between farm size and participation of EQIP is strong positively significant. From this data, I cannot evaluate the work done by EQIP managers. This requires the study of the supply side information of EQIP or the other water conservation programs.

For the state and local programs, the participation rate is low in all seven states. This might be because of the limited number of the state or local programs. USDA-NRCS Conservation Technical Assistance Program is pure technical assistance program; it does not include any financial or cost-share assistance, therefore, will be considered relatively expensive. This program could be considered as the information adoption (go back to the hypothesis H1). As we regard this program as an information source, the test result is consistent with the hypothesis. The adoption rate of this program increases with farm size significantly. In New Mexico, a gamma of 0.8 shows a strong positive association between the farm size and participation in the program. In California, the gamma is 0.09, which means the association is weak. The overall participation rates of all the programs are very low; the weak association might because of it. In Nevada, gamma is 0.19, and the z value is 5.3, which is weak but significant. The Cochran-Armitage test statistic shows the relationship is insignificant. The very large farms in Nevada have a lower adoption rate than all other sales classes farms. Medium and large size farms have much higher adoption rate than the small farms.

Large farms use much more water than small farms (Figure I). Large farms in Arizona, Colorado, and Utah have the adoption rate over 50% in any of the sources of the programs; this means less than 50% of the water applied to agriculture are currently in the conservation programs. The rest of four states examined have much lower adoption rates, especially in California, with a participation rate of the conservation program is only 21%. California, which is the state using almost half of the Colorado Basin fresh water, has only one-fifth of the water in the conservation program.

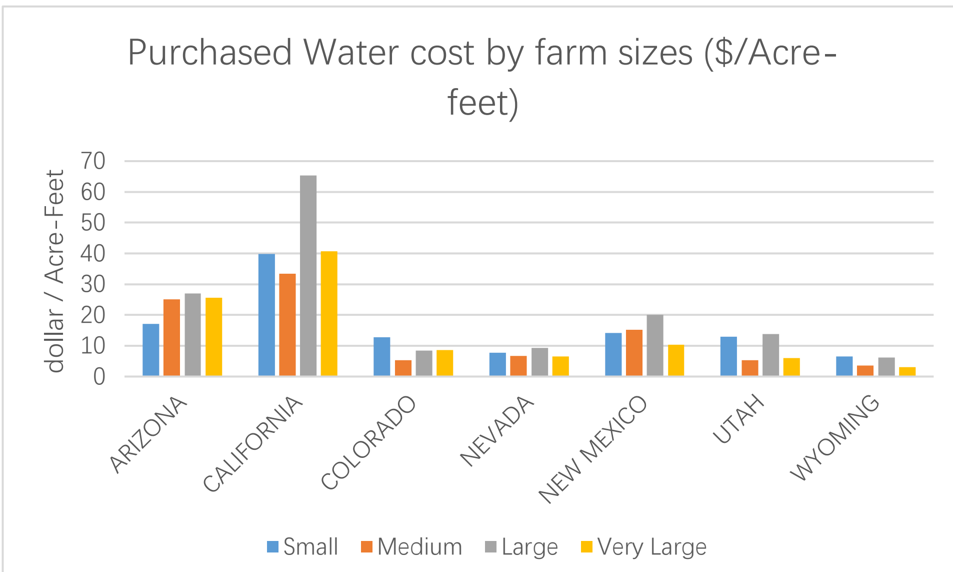


Figure V. Purchased water cost by farm sales class

Even the association between the farm size and the participation of the water conservation programs is positively significant, but the overall participation may still far from the adoption ceiling. Only a little more than 20% of the very large farms in California participated the programs. Farm service agencies may need to think how to encourage farmers to participate. Schaible (2004) claimed targeting those farms that account for more water use could improve the conservation efficiency. Figure IV is the purchased water cost by farm sizes. From the figure, very large farms have lower purchased water prices. Overall, very large farms are the major water users with over 80% of the water available used by them. If their water costs are cheap, they will have less incentive to join water conservation programs and will not have incentives to adopt management-intensive methods or efficient irrigation equipment.

CHAPTER FIVE: Conclusion

This study extended the previous study from Frisvold and Deva (2011). The same economic framework was used to examine irrigator's demand for information and water conservation programs to develop and test hypotheses concerning scale of the farm operation and water management practices. The same methods, Goodman-Kruskal gamma coefficient and the Cochran-Armitage trend test, were used again to test four hypotheses on the different and larger dataset. Use of these statistical methods gives the criteria rank correlation of ordinal data. The previous study from Frisvold and Deva illustrated these two methods were very powerful of testing the hypotheses; it gave us a chance to open a new field of the information of the irrigators' behaviors by formal hypothesis tests instead of simply describing the data.

This study tests of all seven basin states did not support all the hypotheses of Frisvold and Deva's earlier study. Consistent with the first hypothesis, large farm owners were more likely to access any given source of irrigation information than the small farm owners. Different from the previous research, the test results show a positive association between farm size and use of low-cost sources of information. Smaller farms were much more likely to rely on neighbors and irrigation district staff for information.

Use of the most management intensive methods to schedule irrigation and participation in water and energy conservation programs also increased with farm size. However, the overall participation rate in conservation programs was low, even among large farms. Schaible (2004) claimed that targeting the large farms or the major water users could increase the efficiency of the cost-share programs.

The data revealed many important facts. About a quarter of the small farms do not control their irrigation scheduling directly but have water delivered "in turn" by irrigation districts. To improve irrigation timing on small farms, it may make more sense to focus extension information to irrigation district staff

The second implication of this study is that different farm sales classes have different information needs and incentives for investment in water conservation programs. Public programs may thus be more effective if they tailored program delivery to the specific needs of different farm sizes. The adoption rate for the large farms, which are the major water users, is still very low.

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