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The Price of Energy: Impact on Irrigation

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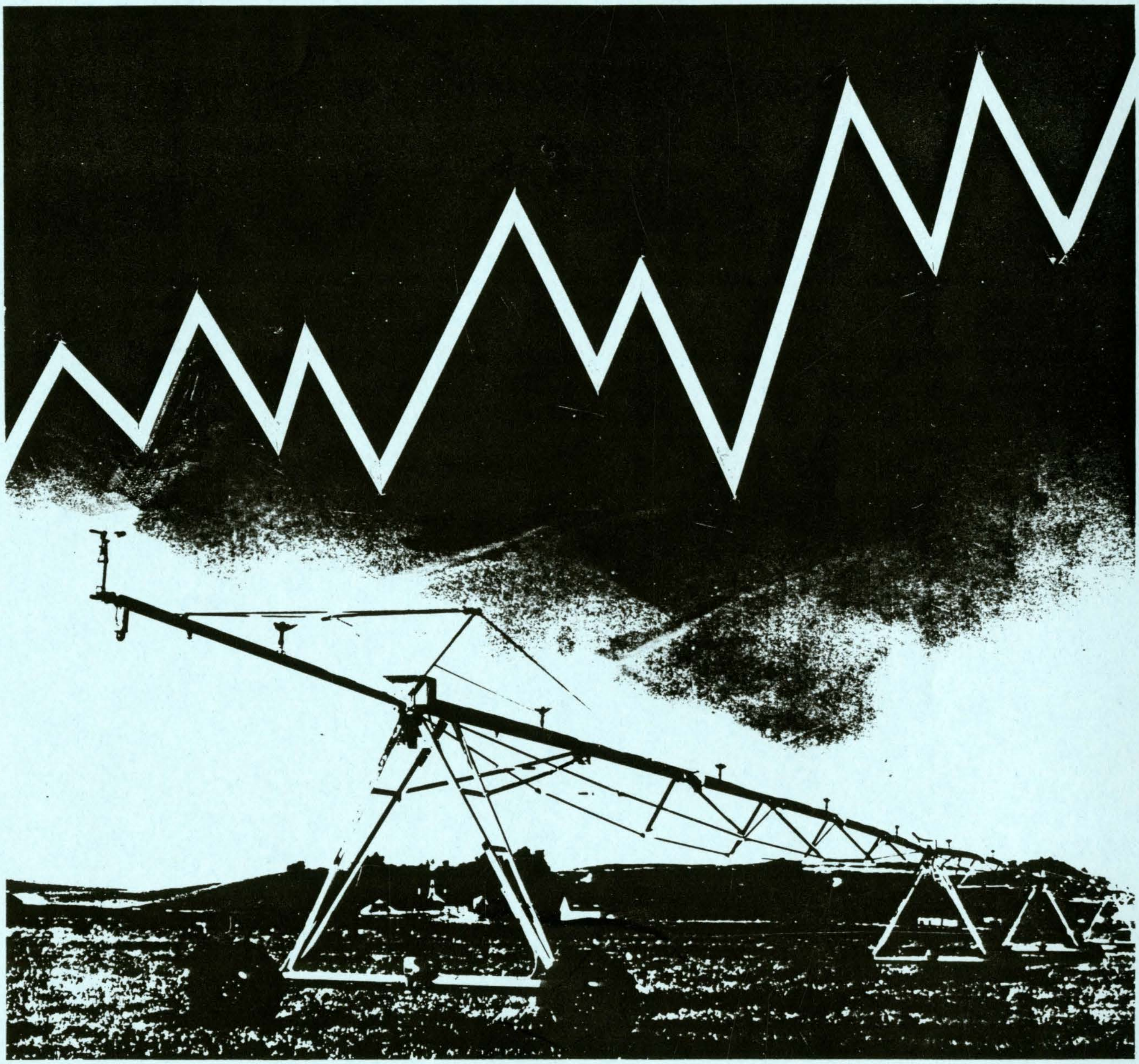
The price of energy:

Impact on irrigation



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Published in accordance with an Act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agriculture College and with the Act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University

The price of energy:

Impact on irrigation

What determines how much water South Dakota irrigators will use? Research on this question, part of a larger project, focused on privately developed irrigation, and sought to find an electricity charge at which irrigators would "turn off their pumps."

Virtually all of South Dakota irrigation water is lifted by pumps, and approximately 85% is distributed under pump pressure (Irrigation Survey, 1982). The variable costs of pumped irrigation water are directly related to the cost of energy for pumping the water. The price of energy can therefore serve as a proxy for the price of water.

Electricity powers about 80% of South Dakota's irrigation pumps (Irrigation Survey, 1982). The price of electricity in South Dakota rose at a compound annual rate of approximately 20% between 1977 and 1983 (Taylor and Shane, 1982; SDREA, 1983).

The principal wholesale supplier of electricity to South Dakota's REA cooperatives is contemplating a 23% increase in rates for 1986. Such rapid increases have pushed up costs of water for irrigation and can be expected to have affected the economics of water use.

If increases in the price of electricity are accompanied by decreases in irrigation and subsequent decreases in consumption, revenues of REA's will be affected. Knowledge of the relationship between energy prices and water use may aid REA's in constructing rate schedules to minimize the impact on revenues.

Expecting to find that South Dakota irrigators who pay more for electricity pump less irrigation water, we specifically focused on the impact of price of electricity on amount of irrigation water pumped. Other factors that influence the amount of water pumped were also included in the analysis.

The area sample was all irrigators who use electricity to power their irrigation systems and who reside within the geographic boundaries of the 16 Rural Electric Cooperative Associations (REA's) which provide more than 80% of the electric power for irrigators in South Dakota. Further delimitations are explained in the procedures section.

The report is divided into four sections: data base and procedures, the model and variables, results of analysis, and summary and implications.

Procedures and Data Base

The South Dakota Department of Water and Natural Resources (DWNR) annually sends a questionnaire to all irrigation permit holders in South Dakota. Due to the nature of the relationship between the department and the permit holders, the response rate is higher than normal for a mail survey and is approximately 80%.

Responses to the 1981 survey[1] provided the primary source of data on quantity of water pumped, crops irrigated, water source, type of system, power source, and location of irrigators.

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[1]1981 data were used because in 1982 there was above average precipitation and below average irrigation and in 1983 the Payment-in-Kind (PIK) distorted farming practices.

The original (DWNR) data set contained 4285 permit holders. Of those who irrigated in 1981, those that used electricity to power some or all of their systems were selected, reducing the number of users to 1022.

Those irrigators who used a second source of power or who were clearly not farm irrigators (e.g., country clubs) were eliminated as were those irrigators not served by the 16 REA's selected for study, leaving 878 in the data set.

Further selection for corn, alfalfa, and soybeans—the most widely irrigated crops in South Dakota—which were watered from May through September eliminated 47. A total of 831 irrigators remained in the final data set.

Weather data were obtained from the State Climatologist at the Agricultural Engineering Department at SDSU. Temperature and precipitation stations were identified by county and town. Total monthly precipitation and average monthly temperature data for each month from May through September were then used.

The final data required were prices charged by each REA for electricity to power irrigation systems. All 16 REA's supplied their irrigation rate schedules.

There are 33 REA's located within South Dakota. They vary considerably in number of irrigators as percent of total consumers, MWH sales to irrigators as percent of total sales, irrigation revenue as a percent of total revenue, and changes in each of these items for the years 1973-1982.

Irrigators as percent of total consumers ranged from zero to 15% in 1982. Similarly, percent of MWH sales to irrigators in relation to total sales ranged from zero to 40%. One REA reported irrigation revenues as 45% of total revenues in 1982 and more than 50% of total revenues for the preceding 2 years. Three additional REA's received more than 20% of total revenues from irrigation.

Sixteen REA's were selected; they included 87.5% of all irrigators served by all REA's. In terms of MWH sales, these 16 sold 89% of all REA power for irrigation in South Dakota. (See Appendix Figure 1 for list of the 16 study REA's and a map showing their locations within the state.)

Model

Demand for irrigation water is based upon its cost, its contribution to agricultural productivity, and the price of the crop being raised. This analysis focuses specifically on the cost of the electricity input. Cost of electricity is a proxy for the cost of water for irrigation.

Farmers will not have information on the specific production function for each crop in the form of formal equations or graphs. It is assumed, however, that a producer, through experience and observation, will have general knowledge of the response of the crops to water, temperature, and water-temperature combination. If sufficient water is not available through rainfall, the producer will irrigate to increase productivity.

The price of the output is not included in this model directly, but economic efficiency implies that the producer apply water to the point where the value of the added output (price times quantity of additional output) equals the cost of applying added water.

The model hypothesized was

Q = F(X1, X2, X3, X4, X5) where

Q = Quantity of water applied in acre inches

X1 = Price of energy as defined for various models

X2 = Precipitation variable as defined

X3 = Temperature variable as defined

X4 = Dummy variable for source of water

X5 = Dummy variable for type of system

Separate linear additive regression models were formulated for each of three crops: corn, soybeans, and alfalfa. Each variable is described, along with the variations used in some models.

Quantity of Water: Survey information was available to calculate acre inches of water applied by crop by month. In initial regression models, the dependent variable was total acre inches of water applied per season (May through September).

Price of Energy: For all REA's, the rate schedules for electricity for irrigation have some combination of the following three components:

1. Charge per measured horsepower--usually assessed one time at beginning of season and based on size of pump.
2. Demand charges per KW per month--based upon peak power use per month.
3. Energy charge per KWH--this may be a flat rate or may be a declining block structure.

Categorizing costs into the classic fixed and variable dichotomy from this combination of energy charges is not straightforward. Fixed costs are defined as short-run costs which do not vary with the level of production and must be met even if no production occurs (e.g., the irrigation system is not turned on). Under this definition, all energy charges are variable at the beginning of the season. However, once the decision is made to irrigate, the horsepower charge becomes fixed.

A variable cost is defined as a cost which varies with the level of production; KW demand charges and charges/KWH fall into this category. Generally, all variable costs form the basis for calculating marginal costs.

Because of the difficulty of calculating KW demand charges, marginal cost was defined as the lowest energy charge/KWH for each REA.

The correct specification for the marginal cost variable is critical, since economic theory suggests this is the basis for producer decisions. However, producers would know only the charge/KWH.

For efficient resource use, the marginal cost of an input should equal its marginal value product. Thus, one of the price variables used in the model is marginal cost, the charge for each additional KWH, which ranged from \$.011 to \$.042/KWH over the 16 REA's.

Demand and/or horsepower charges cannot be ignored, however, as they add to the total cost of irrigation. All of the REA's in the study levied at least one of the above charges in addition to an energy charge per KWH.

To include these charges, the average cost of energy/KWH was used as a second measure of the cost of energy. Average cost of energy was calculated by dividing total irrigation revenue for each REA by total MWH sold by that REA. Again, costs varied widely across REAs, ranging from \$.043 to \$.099 per KWH.

Each configuration of the remaining independent variables was used in two equations, one utilizing marginal cost and one average cost as defined above. For both price variables, an inverse price-quantity relationship was hypothesized.

Climatic Variables: Precipitation records are maintained at approximately 150 stations throughout the state. It was possible, therefore, to obtain nearby seasonal and monthly data for each operator.

It was expected that there would be an inverse relationship between rainfall and application of irrigation water. While the day-to-day timing of rainfall is also important, it was not possible to include precipitation data on less than a monthly basis.

Temperature data were similarly gathered and used in the models as seasonal average temperatures or monthly average temperatures. It was hypothesized that higher temperatures would increase evapotranspiration and, therefore, increase the need for higher applications of irrigation water.

In some models, the interaction between temperature and precipitation was included as a variable.

Dummy - Source: Source of water (ground or surface) was included as a dummy variable with ground water equal to 1 and surface equal to 0. There was no *a priori* expectation on the sign of the variable.

Dummy - System: For purposes of the analysis, irrigation systems were divided into two classes, sprinkler and other. A value of 1 was assigned to sprinkler systems and 0 to other non-pressurized types of systems. Smaller quantities of water were hypothesized with sprinkler systems.

Results

Variables were used in various combinations for each crop in developing regression equations to explain the impact of each variable on quantity of irrigation water applied. Using SAS procedures, we ran an ordinary least squares regression analysis.

In an initial set of equations for corn and soybeans, total acre inches of water applied per season was the dependent variable. The independent variables included total seasonal precipitation, average seasonal temperature, dummy variables for source of water and type of system, and either marginal or average cost. See equations 1 and 2 in Tables 1 and 3 for corn and soybeans.

Since the results of the first sets of equations failed to explain more than about 25% of the variation in water applied and since timeliness of precipitation and temperature is important and differs from crop to crop, additional sets of equations were developed using various combinations of monthly or bi-monthly climatic data. Stepwise regression procedures were used and the "best" equation was chosen from those that resulted.

To determine if differences not reflected in price exist between sprinkler and non-sprinkler type systems, a third set of regressions was run in which sprinkler and non-sprinkler systems were analyzed separately. There were no significant differences, and since non-sprinkler type systems comprised less than 10% of the total systems, the results of the third set of equations are not reported.

Selection of equations to report was based on the highest adjusted R^2, number of significant variables, and conformity to economic theory. Equations are reported in pairs where similar independent variables were included in the initial stepwise function except that one equation in each pair used marginal cost and the other average cost as the cost variable. As a result of the selection process for the stepwise regression equations, some reported equations (e.g., alfalfa #1 and 3; soybean #3) do not include a cost variable in the "best" equation, indicating the cost variable did not enter the regression until late in the procedure.

For the initial sets of equations for corn and soybeans, the overall F-test indicated that the equations were all significant at the .01 level. Generally the cost variables had the expected sign, and average cost was more significant than marginal cost. Total seasonal precipitation was significant with the expected sign. Average seasonal temperature proved to be insignificant and often had an unexpected sign. Dummy variables for source seldom were significant and signs were not consistent. On the other hand, the dummy variables for type of system were generally significant with the expected negative signs.

The adjusted R^2's (indicating the percent of variation explained by each set of independent variables) were slightly higher for the equations using average cost than for marginal cost and were highest for corn.

For the selected stepwise equations, the overall F-tests indicated all equations were significant at the .01 level. The number of and level of significance of the variables for monthly temperature and precipitation were greatest for corn and least for soybeans. Generally, as with the initial equations, average cost was more significant than marginal cost. The dummy variable for system was always included and usually highly significant while the dummy variable for source was seldom included and not significant.

The difference between the initial sets of regression equations and the stepwise regressions was the use of seasonal climatic data in the former and monthly in the latter. In both sets of equations, the precipitation variables were usually more significant than the temperature variables. Also, the adjusted R^2's were slightly higher for equations using monthly data than for those utilizing seasonal data. Generally, the magnitude of the cost coefficients was greater when seasonal data were used.

Specific results for each crop are discussed below.

Corn Results: Corn is the most widely irrigated crop in South Dakota as judged by the number of irrigators and number of acres irrigated (Appendix Table 1). For the entire sample, the total amount of water applied to corn by all irrigators was double that for alfalfa and almost 6 times as great as that applied to soybeans. While corn is irrigated in all months from May through September, peak irrigation occurs in July and August (Appendix Table 2).

Equations 1 and 2 in Table 1 represent the regression equations for the largest number of observations, 699. Results of a stepwise regression are shown in equations 3 and 4. The R^2's are slightly higher than in equations 1 and 2. As shown, cost of energy, various monthly precipitation rates and average monthly temperatures, and type of system are significant and generally have the expected signs.

A closer examination of one of the equations will provide a fuller interpretation of the results of the study. Equation 3 in Table 1 provides an excellent example with a number of significant variables. The overall F-ratio indicates the entire equation is significant. An R^2 of .2422 shows that about 24% of the variation in acre inches of water applied is explained by the variables included in the equation.

The coefficient for cost of energy, -106.57, indicates that for every $.01/KWH increase in the price of energy, an irrigator would reduce water applied by slightly more than 1.06 inches.

The precipitation coefficients indicate that if rainfall increases by 1 inch, water application would decrease by 1.28, .67, and 1.63 inches in June, August, and September, respectively.

The expectation is that normally as temperature increases, water use would increase, as is shown by the positive coefficient for July and September.

The coefficient for May average temperature, -1.90, indicates that for every 1 degree rise in average temperature, water application would decrease by 1.9 inches. One possible explanation for the unexpected inverse relationship in May would be that irrigators are uncertain of upcoming precipitation and, to ensure sufficient moisture for germination and early growth, apply water without regard to climatic variables.

The coefficient for the dummy-system variable differs significantly from zero and is, as hypothesized, negative in sign. The result shows 2.3 inches less of irrigation per season being used for sprinkler systems compared to non-pressurized systems.

Alfalfa Results: The "best" equations resulting from one stepwise multiple regression are illustrated in equations 1 and 2 in Table 2. As shown, marginal cost did not enter the equation while average cost was highly significant. Type of system was significant and of the expected sign in both equations.

In equation 1, both May and July precipitation were significant but May precipitation had a positive sign. This may reflect the fact that flood irrigation is prevalent for alfalfa and, due to the availability of water, this occurs in the early spring without regard to precipitation.

Results of another type of stepwise regression are illustrated in equations 3 and 4. The R^2's were not high for any of the alfalfa equations. Unexpected signs for some significant variables and the large coefficients for type of system may be explained by the type of irrigation usually used for alfalfa.

For those who irrigated, water application for alfalfa was almost uniform across the months of May through September, as opposed to other crops in which peak months occurred (Appendix Table 2).

Soybean Results: The regression equations for soybeans are shown in Table 3. Less than 20% of the variation in water application is explained in any model.

The results of the "best" stepwise multiple regression equations are shown in numbers 3 and 4. The R^2's are slightly higher than in the first pair of equations. In equation 3, marginal cost did not enter into the selected equation. August precipitation, May and July temperature, and type of system were all significant. In equation 4, average price was significant. Type of system and June precipitation were also significant at the .05 level.

Price Elasticity of Demand: The coefficient of price elasticity of demand provides another measure of how water use will change with change in price of electricity. A coefficient with an absolute value of less than one indicates inelasticity and relative unresponsiveness; i.e., a 1% change in price will elicit a less than 1% change in quantity demanded in the opposite direction.

Elasticity was computed at the mean for those equations which included a price coefficient. Coefficients are shown in Table 4. For alfalfa the quantity demanded is very inelastic with respect to changes in price. Again, this may be a reflection of the type of irrigation used for much of alfalfa (flood).

Both corn and soybeans are generally inelastic but less so than alfalfa, with coefficients for corn and soybeans at the high end of the inelastic range. Equation 2 for corn indicates unitary elasticity while equation 4 approaches unity. Both are average price equations.

While few studies on price elasticity of demand are found for irrigation water, Platek (1978) found demand for residential water to be very inelastic with coefficients ranging from -.02 to -1.09 (elasticities greater than -1.00 were found in only 3 of 34 studies). Because of the nature of the demand for residential water and the small portion of discretionary income involved, demand for residential water is expected to be inelastic.

Circumstances differ for irrigation water demand, however, in that the cost for energy for irrigation is a substantial portion of total production costs. Also, a reduction of water used in irrigation is not life-threatening as a reduction in residential water might be. In one study of demand elasticities for electricity for irrigation, Maddigan (1982) reported short- and long-term elasticities of -1.1 and -2.1 respectively. The short-term elasticity is comparable to the very highest elasticity found in this current study.

TABLE 1. Regression parameters and coefficients for equations estimating irrigation water application for corn, 1981

	EQUATION NUMBER 1	2	3	4
Regression Parameters				
F-ratio of the equation	26.38***	51.57***	28.84***	47.05***
No. of observations	699	699	697	697
Adjusted R^2	.1536	.2656	.2422	.2839
No. of Statistically significant coefficients	3	3	8	6
Cost Coefficients				
Marginal cost	-276.79***		-106.57**	
Average cost		-174.97***		-154.59***
Precipitation Coefficients				
Total seasonal	-0.91***	-0.24**		
May				0.77***
June			-1.28***	-0.56*
July				-0.58***
August			-0.67***	
September			-1.63***	-1.09**
Temperature Coefficients				
Seasonal average	0.03	0.06		
May			-1.90***	
June				
July			0.73***	
August				
September			1.01***	
Dummy -- Source	-1.48*	-0.73		
Dummy -- System	-1.30	-3.89***	-2.29***	-3.65***

*** - denotes a .01 level of significance
** - denotes a .05 level of significance
* - denotes a .10 level of significance

TABLE 2. Regression parameters and coefficients for equations estimating irrigation water application for alfalfa, 1981

	EQUATION NUMBER			
	1	2	3	4
Regression Parameters				
F-ratio of the equation	7.04***	8.55***	4.19***	6.22***
No. of observations	254	254	250	250
Adjusted R^2	.0666	.0878	(.1076)[1]	(.1125)[1]
No. of Statistically signifiant coefficients	3	3	6	4
Cost Coefficients				
Marginal Cost				
Average Cost		-207.75***		-170.46***
Precipitation Coefficients				
Total Seasonal				
May	1.49***		1.11**	0.72
June			-1.07*	
July	-1.47***		-1.40***	-0.90*
August				
September				
Temperature Coefficients				
Seasonal Average				
May				
June		-0.57***	-0.88**	-0.46*
July				
August			-0.65	-0.70
September			1.25**	
Dummy -- Source				
Dummy — System	-3.73**	-4.98***	-3.19*	-4.87***

*** - denotes a .01 level of significance
** - denotes a .05 level of significance
* - denotes a .10 level of significance

[1] Adjusted R^2's were not available; unadjusted are shown in parentheses.

TABLE 3. Regression parameters and coefficients for equations estimating irrigation water application for soybeans, 1981

	EQUATION NUMBER 1	2	3	4
Regression Parameters				
F-ratio of the equation	6.07***	7.38***	5.98***	7.69***
No. of observations	174	174	174	174
Adjusted R^2	.1274	.1551	(.2003)[1]	(.1854)[1]
No. of Statistically significant coefficients	2	3	4	3
Cost Coefficients				
Marginal cost	-221.69*			
Average Cost		-86.42***		-63.64*
Precipitation Coefficients				
Total Seasonal	-0.91***	-0.47**		
May				
June				-1.08**
July				
August			-1.08**	-0.72
September			-0.83	
Temperature Coefficients				
Seasonal average	-0.30	-0.04		
May			-2.23***	
June			0.46	
July			-1.26***	
August				
September				
Dummy -- Source	0.36	0.38	0.95	1.41
Dummy -- System	-1.89	-2.74**	-2.56*	-2.83**

[1]Adjusted R^2's were not available; unadjusted are shown in parentheses.

*** - denotes a .01 level of significance
** - denotes a .05 level of significance
* - denotes a .10 level of significance

TABLE 4. Price elasticity of demand for irrigation water for various crops, 1981

CROP	EQUATION 1	2	3	4
Corn	-.69	-1.01	-.27	-.90
Alfalfa	NA	- .09	NA	-.07
Soybeans	-.84	- .85	NA	-.76

Summary and Implications

Research was undertaken to estimate the effects of several factors on the amount of water applied to three crops in privately developed irrigation in South Dakota. The focus was on the impact of energy prices, but climatic variables, water source, and type of system were also investigated.

Both marginal and average price variables were used in ordinary least squares regression equations. Generally, the average price equations had higher R^2's and more significant coefficients than the marginal price equations. Both price variables always had the expected sign.

The overall F-ratios for the equations were always significant. In all equations the R^2's were less than .30 but were especially low for alfalfa. The model did not appear to explain well the important factors involved in irrigation of alfalfa, but was a better fit for corn and soybeans.

Total seasonal precipitation and monthly precipitation variables were employed in the various models. Generally, precipitation variables had the correct sign and were significant whether seasonal or monthly data were used. Average seasonal and average monthly temperatures were used in combinations. Often the variable had an unexpected sign and was insignificant.

The results showed the source of water was insignificant. Type of system was generally highly significant and of the expected sign.

Price elasticities of demand were calculated for the equations which included price as an independent variable. With one exception, quantity demanded was inelastic with respect to price. The marginal price equations were more inelastic than the average price equations.

Implications

The inelasticity of water demand with respect to price of energy has important implications for the providers of electricity.

Within the range of prices used in these models, providers could increase the price of electricity and the quantity demanded would not decrease past the point where total revenue would decline.

Within the definition of price as used in this study, marginal price (the cost/KWH for electricity) elasticity was lower than average price elasticity (which includes demand and horsepower charges). Therefore, to increase revenues, REA's might consider increasing their KWH charges rather than demand and/or horsepower charges.

REA's should also be aware that customers with sprinkler-type systems are likely to apply less water than those with other types of systems.

Finally, early season precipitation and temperature are unlikely to affect the amount of water applied. However, if adequate precipitation continues throughout the growing season, application of irrigation water and, consequently, use of electricity can be expected to decline.

REFERENCES CITED

Irrigation survey. 1982. Published by the Irrigation Journal (Brantwood Publications, Elmgrove, Wis.)

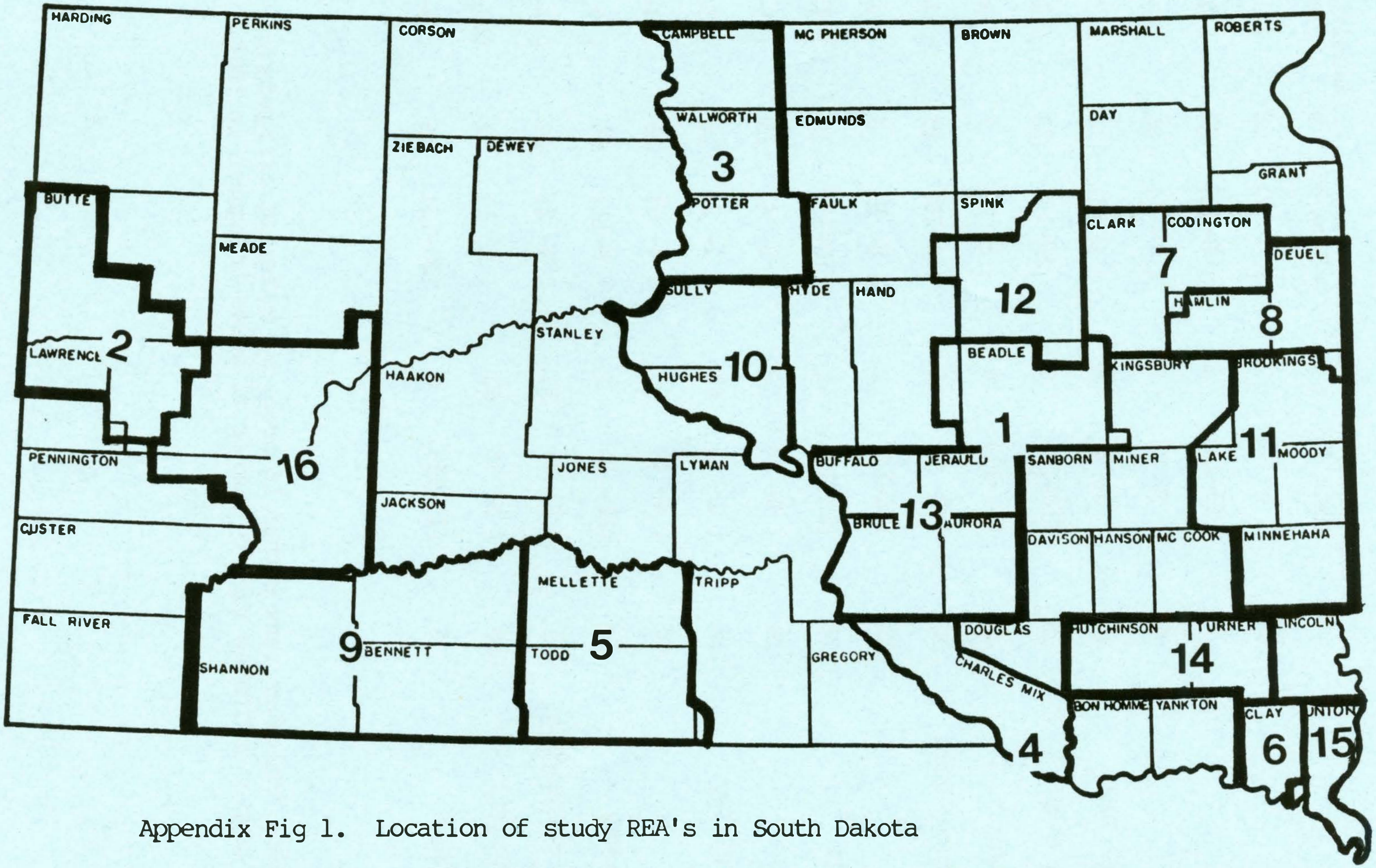
Maddigan, Ruth J., Wen S. Chern, and Colleen G. Rizy. 1982. Irrigation demand for electricity. Amer J of Agric Econ LXIV(4):673.

Platek, Jeffrey. 1978. Study of residential water demand in and around the Big Sioux River Basin. MS thesis, Econ Dept, SDSU.

South Dakota Rural Electric Association. Personal communication to Donald C. Taylor, June 16, 1983.

Taylor, Donald C., and Richard C. Shane. 1982. Economics of irrigated crop production in eastern South Dakota. Res Rep 82-3, Econ Dept, SDSU.

APPENDIX



Appendix Fig 1. Location of study REA's in South Dakota

1. Beadle	5. Cherry-Todd	9. Lacreek	13. Tri-County
2. Butte	6. Clay-Union	10. Oahe	14. Turner-Hutchinson
3. Cam Wal	7. Codington-Clark	11. Sioux Valley	15. Union County
4. Charles Mix	8. H-D	12. Spink	16. West River

APPENDIX TABLE 1. Number of irrigators by REA by crop, 1981.

REA	Corn #	Corn Rank *	Soybeans #	Soybeans Rank *	Alfalfa #	Alfalfa Rank *
1. Beadle	48	(5- 8)	6	(5- 7)	28	(1- 2)
2. Butte	18	(12-13)	2	(8-12)	27	(2- 4)
3. CamWal	40	(7- 7)	3	(7- 5)	26	(3- 1)
4. Charles Mix	42	(6- 5)	5	(6- 8)	12	(7- 7)
5. Cherry-Todd	25	(10-10)	0	(10-13)	13	(6- 8)
6. Clay-Union	23	(11-11)	6	(5- 6)	7	(8-14)
7. Codington-Clark	33	(8- 9)	1	(9-10)	16	(4-11)
8. H-D	11	(14-14)	2	(8- 9)	6	(9-15)
9. Lacreek	14	(13-12)	0	(10-13)	15	(5- 5)
10. Oahe	29	(9- 1)	6	(5- 4)	15	(5- 6)
11. Sioux Valley	128	(1- 2)	42	(2- 2)	26	(3-10)
12. Spink	68	(4- 6)	9	(4- 6)	26	(3- 3)
13. Tri-County	23	(11- 8)	1	(9-11)	16	(4- 9)
14. Turner-Hutchinson	83	(3- 4)	33	(3- 3)	16	(4-13)
15. Union County	116	(2- 3)	60	(1- 1)	1	(10-16)
16. West River	0	(15-15)	0	(10-13)	6	(9-12)

* First number indicates rank within 16 areas by number of irrigators; second number indicates rank by number of acres irrigated in 1981.

APPENDIX TABLE 2. Monthly water use by crop

	Corn		Soybeans		Alfalfa	
	Avg. acre inches[1]	%[2]	Avg. acre inches[1]	%[2]	Avg. Acre inches[1]	%[2]
May	1.7	6.0	1.3	4.4	3.6	15.9
June	2.8	17.1	2.2	15.6	4.1	22.6
July	4.4	36.8	3.7	37.4	4.5	25.2
August	4.1	31.7	3.4	36.2	4.3	23.4
September	2.3	8.4	2.0	6.4	3.6	12.9

[1]Averages reflect only those who irrigated each month.

[2]Percent of <u>total</u> seasonal water applied each month.