THE EFFECT OF WATER USE REGULATIONS ON NET RETURNS AND MARGINAL USER COSTS

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REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference, held March 26-27, 2001, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, the University of Georgia, Athens, Georgia.

Abstract. A non-linear constrained net-revenue model was used to estimate the effects of groundwater regulations that allow for accumulation and marketing of unused annual irrigation allocations. The research shows that such incentives for voluntary reductions in current water use are effective, but depend on the existence or creation of water rights. The degree of effectiveness also depends on crop prices, production costs, soil type, and evapotransporation requirements.

INTRODUCTION

To examine alternative management approaches, it may be useful for policy makers involved in water use problems in Georgia and other eastern US states to evaluate actions taken by water policy makers in other areas of the US. Situations will not be identical, but there may be lessons to be learned from actions already tried in other states. For example, there is concern in some areas of the High Plains that the current rate of withdrawal of groundwater for irrigation is lowering groundwater levels and, especially in alluvial areas, may be diminishing surface water flows. Policymakers in the area have promulgated regulations and developed incentives for voluntary actions to bring about more efficient use of irrigation water to conserve groundwater and increase net returns.

Questions often arise as to whether local control can be effective in managing groundwater. The Upper Republican River Natural Resources District (URNRD) in Nebraska is an example of successful local control that has developed a creative and effective approach to controlling groundwater withdrawals. The URNRD is a three county area in semi-arid southwest Nebraska with 3,200 irrigation wells and in which groundwater control is under the authority of a locally elected Board of Directors. The District is funded by local taxes. The Board has taken a number of creative and courageous steps to address water table declines and conflicts among groundwater users.

The URNRD requires metering of all irrigation wells (meters are sealed, read, and serviced by URNRD staff). The District has a limit on irrigated acres per well, a moratorium on new wells, and a 14.5"/acre/year allocation for all irrigation wells. Allocations are given in 5-year allotments. Producers can carry forward unused annual allocations to the next year, allowing year-to-year flexibility. Also, they can carry forward unused allocations into the next five-year allotment period. Annual allocations (initially at 22" and now at 14.5") have been in place for 20 years. As allocations were reduced and cost share funds were provided by the District, there was widespread conversion to more efficient irrigation systems (e.g., center pivots, low-pressure drops, and use of rain gauge shut-offs). Average water use in the District during the years of the study was 11.3"/acre, and most farmers have accumulated carryovers (unused allocations), which provide a "cushion" within which to operate.

Exacerbating the concern about pumping rates, the URNRD and three other NRDs in the Republican River Basin are involved in a US Supreme Court lawsuit filed by Kansas against Nebraska and Colorado. Kansas claims that water delivery from the River into Kansas has diminished due to groundwater pumping in Nebraska. If Kansas prevails, there may be pressures to reduce allocations in the URNRD, and to impose allocations elsewhere in the Basin.

BACKGROUND

There are two general approaches that a regulatory agency can take to restrict water use: "command and control" (CC); and incentives for voluntary conservation. Under the CC approach, the agency

specifies an allocation for each producer and monitors for compliance. Because of the cost of gathering information, such regulations are usually uniform for all producers. The CC method can be effective at achieving the desired total water use, but often at a high cost because restrictive uniform regulations are normally economically inefficient. The voluntary incentive approach would provide economic incentives for producers to use less water.

The URNRD Board has instituted a combination of both approaches. Water allocations are imposed on producers, but there are incentives for conservation and flexibility built into the rules. In addition to allowing carryforward of unused allocations, the Board recently instituted a water-banking rule, which provides for deposits and withdrawals of allocations. The "Bank" operated by the District will allow for changes in point of use and/or point of withdrawal, and in type of use. The rule opens the possibility of direct water marketing. Producers know that accumulated allocations enhance land prices for those wishing to sell. They now also know that they have a direct marketing potential for those allocations.

A legal right to water is essential to water marketing. Nebraska law does not designate ownership of groundwater, except that the landowner has the right to beneficial use of groundwater. However, it is argued that URNRD rules and producer action have created usufructuary[1] groundwater rights, which reinforce the new banking rule.

Because producers can accumulate unused allocations, they have an incentive to account for the potential value of future income from each inch of irrigation water conserved for future use or sale. The question they face is whether it is more valuable to use an extra inch now for increased crop yield or to bank that extra inch for use or sale in the future. Stated alternatively, they should consider the marginal user cost of each inch of water, if consumed now. Marginal user cost is the opportunity cost of using the groundwater in the current period, and is equivalent to the present value of foregone marginal net benefits in a future period (Carlson et al., 1993). Marginal user cost for these producers is positive because URNRD regulations have changed an unlimited-access common property resource into a restricted-use common property resource and generated a usufructuary right to hold or market unused allocations.

[1] Webster's II New Riverside University Dictionary: "USUFRUCT. The right to utilize and enjoy the profits and advantages of something belonging to another so long as the property is not damaged or altered."

OBJECTIVES

The objectives of this research were to:

1. Analyze the effect of the current allocation and carryover rules in the URNRD on the water use behavior of the irrigator; and
2. Provide producers and policymakers with information about net revenue effects of existing and future potential water use regulations in southwest Nebraska.

The research did not address the issue of the optimal rate of use of the aquifer.

EXPERIMENTAL DESIGN - MODEL AND DATA

The Model

The model is based on the assumption that the each irrigator attempts to distribute per acre annual use and accumulated allocations of water in a manner that maximizes the present value of net returns from the water, including the value to the irrigator of water saved for future use or sale. The model was formulated in a dynamic optimization framework with the assumption that each producer attempts to maximize present net value of irrigation water use and allocations as affected by:

- the water allocation granted by the Board for the planning period;
- the amount of irrigation water used in each period (inches/acre);
- the amount of accumulated water allocation at end of the individual's planning period;
- a discount factor for discounting future net returns;
- the expected price of corn ($/bu);
- the yield (Y) function for corn (bu/acre);
- non-irrigation inputs;
- exogenous factors such as rainfall, evapotranspiration, and soil characteristics;
- the cost of pumping water ($/acre-inch);
- other input costs; and
- the value of the saved water at the end of the planning period.

The model, following the new URNRD regulation, allows for direct marketing of unused allocations and/or selling the land with the unused allocation capitalized into the land price. The solution to the model is based on the irrigators desire to optimally choose the amount of water used each year so that the marginal net value

(MNV) of an extra inch of irrigation equals the discounted marginal value of an extra inch saved for use/sale in the future (i.e., marginal user cost, MUC).

In order to calculate the marginal values and net returns, a yield-irrigation response function for corn was postulated and estimated. The model predicted yield as a function of:

- inches of irrigation water applied per acre;
- crop irrigation requirement (CIR) of the crop; CIR is equal to potential evapotranspiration (PET) minus effective rainfall (in/acre); and
- average soil water holding capacity for each producer's field (inches per foot of soil).

Standard statistical tests of significance were used for estimated statistical functions and the usual hypotheses.

Data

Water use, yield, and other data were collected through a producer survey and from URNRD water use records. Soil types for each field were obtained from county soils maps and used to estimate the average water-holding capacities of the fields. Crop irrigation requirement was calculated using local rainfall and potential evapotranspiration (PET) data. Daily rainfall and PET data were collected from eleven weather stations located in or adjacent to the URNRD. Effective rainfall during the growing season at these locations was estimated by subtracting runoff from storm rainfall. Runoff amounts were calculated using a method developed by the Soil Conservation Service in 1972 (Chow et al., 1988).

The three nearest stations to each field were identified and crop irrigation requirement (PET minus effective rainfall) was estimated by using an inverse weighted distance formula.

Pumping costs were estimated using software developed by the University of Nebraska (Selley, 1998). Pump costs across producers varied due to energy type, energy price, pumping capacity of the well, feet of pumping lift, and water pressure at the well. Energy prices (electric and diesel) were collected from utility companies and diesel suppliers in the area.

Corn price used was the expected price of corn for the new crop in each year. It was estimated as the average of the June through September weekly future prices for the December corn (new crop) contract minus the expected basis for the area.

STUDY RESULTS

Marginal User Costs Under Current Regulations

For all soils, irrigation use by producers in the survey averaged 11.3 in/acre from 1995-98. Use ranged from 10.8" on high water-holding-capacity (WHC) soils (loams and silt loams) to 12.2" for low WHC sandy soils. Marginal user cost (MUC), which equals marginal net value (MNV) of an extra acre-inch of water (at optimum use), for all soils averaged $2.80/acre. MUC values ranged from $2.10/acre for high WHC soils to $4.01/acre for the low WHC soils.

Estimated Water Use without Water Regulations

The study indicates that if the producers were operating without the water use regulations of the URNRD, they would maximize current net returns per acre by equating the MNV = 0, where marginal user cost (value of saved water) is zero. The estimated irrigation use under this scenario was 12.7 in/acre across all soils, 1.4" more than the actual average use.

Results using Average Values for Climate, Price, and Pump Cost

Under these average conditions, the overall water savings ranged from one-half inch on high WHC soils to 2 in/acre on low WHC soils. Marginal user cost ranged from less than $.80 on high WHC soils to almost $2.50 on the low WHC soils. The cost in foregone current net revenue from voluntarily using less water on a sandy soil was about $3.30/acre, five times higher than on a loamy soil.

Reasons for Conserving Water

Assuming that the producers in the survey are "rational", economic theory implies the irrigators believe conserving some of their water for future use/sale is worth at least as much as the revenue given up by not using the water. There are several reasons for saving water that may explain the different marginal user cost values for producers:

1. Building up the carryover in their water account enhances a producer's ability to have enough water in the event of a multi-year drought.
2. The value of the banked water is capitalized into the value of the land. For the owner, this is a form of investment. For a renter of the pivot, this could mean trying to keep water use to a minimum to enhance the chance of a longer lease. (Some owners impose penalties on renters if they exceed a certain amount of water use within the 5-year allotment period.)
3. Foreseeing the potential to market water in the near future, producers may be banking water with a plan to sell the excess later on.

Because of the URNRD rule allowing accumulation of unused allocations, and the potential to sell these allocations in the future, sacrificing current income to conserve water for future use or sale appears to be the typical behavior by producers in the URNRD.

Potential Effect of Reduced Allocations

Results of this component of the study showed that the average water uses with the 10 and 8-inch allocations are estimated to be 2.1 and 3.6 in/acre less, respectively, than under the current allocation. The corresponding average costs to producers, in terms of decreased net revenue, are $3.79 and $12.91 per acre respectively for the 10" and the 8" allocations. If these costs occurred for every irrigated acre in the district (460,000 acres), the aggregate total costs would be $1.7 to $5.9 million, respectively. If water use reductions equal to the 8-inch allocation occurred for every well in the district, approximately 138,000 acre-feet of water would be conserved annually.

The impact of restrictive allocations varies considerably, from a low of $1.26/acre for the 10-inch allocation on high WHC soils to a high of $24.16/acre for the 8-inch allocation on low WHC soils. Producers with low WHC soils incur the largest costs under both allocations because each acre-inch less they use results in a greater loss of yield as compared to the other soil types. These changes in net revenue could, in part, be mitigated over time by new technology in irrigation techniques and crop genetics, and improved irrigation management.

SUMMARY AND CONCLUSIONS

The past 20 years of metering, regulation of water use, and conservation incentives in the Upper Republican River Natural Resources District led to the adoption by producers of water-conserving irrigation technologies and improved irrigation management. This research indicates that producers have been voluntarily conserving water for future use or sale at the cost of foregone current net income. Clearly, the ability of producers to carryforward unused allocations provides an incentive to reduce current water use in the District.

The economically rational producer will use water to the point where the value of the last inch in current use is equal to the value of that inch in future use or sale. This marginal user cost of another acre-inch of water averaged $2.80 across four years for all producers in the survey. On a per acre basis, producers are voluntarily saving an average of 1.4"/acre at a cost (i.e., foregone current net return) of almost $8.00/acre. Marginal user costs and differences in net returns varied considerably by soil type. The lower the water holding capacity of the soil, the higher the marginal user cost and foregone current net revenue.

If the URNRD Board or a US Supreme Court ruling determines in the future that the allocation needs to be reduced, this study provides a starting point for determining the potential costs to producers of such actions. Aquifer sustainability versus economic viability of agriculture in the region will need to be considered. An 8-inch allocation might sustain irrigated agriculture for longer than a 10-inch allocation, but the average cost is almost 3.5 times higher.

Another question that arises in the URNRD is whether continuing uniform allocations are appropriate, given that, on average, it takes 3.3 more inches/acre to maximize current net returns on sandy soils as compared to high WHC soils. However, with marketing of water a possibility, any such "inequities" might be alleviated. For example, the research determined that with a 10-inch allocation, an irrigator on a high WHC soil would be willing to sell an inch for $1.84 or more, and a sandy soil irrigator would be willing to pay up to $4.77. If water is marketed at a price in between these two levels, then both producers should be better off.

It is important to note that some individuals question the desirability of marketing groundwater, and claim that large cities, for example, may be able to pay more than agriculture. If this is a major concern, it could be overcome by restricting transfers between uses, i.e., agriculture to municipalities. This would, however, impact on the overall economic efficiency of water allocation.

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