EVALUATING WATER MARKETING OPTIONS UNDER DECLINING WATER AVAILABILITY FOR COTTON PRODUCTION IN THE TEXAS SOUTHERN HIGH PLAINS

Rachna Tewari
Jeff W. Johnson
Texas Tech University & Texas AgriLife Research Center
Lubbock, TX
James P. Bordovsky
Texas AgriLife Research
Halfway, TX

Abstract

Increasing pressure on limited and exhaustible natural resources for expanding crop production by way of irrigated agriculture has led to the depletion of the most dependable water supply source in the Southern High Plains, the Ogallala Aquifer. This study focuses on suggestions advocated by policy makers and researchers for increasing the water use efficiency and for promoting judicious use of available water supply for irrigation. Advocating the concept of water savings by economic evaluation of the value of available water is a vital step in the process, considering the rapid depletion and limited recharge into the aquifer. The primary objective of this research was to conduct an analysis to evaluate the water marketing options in cotton production in the Southern High Plains of Texas. This study utilizes data from field experiments conducted from 2001 to 2008 at the Texas AgriLife Research facility at Halfway, Texas, for economic evaluation of potential water marketing. Continuous cotton and cotton sorghum rotation cropping systems were utilized as treatments to explore different scenarios for evaluating water use. The primary focus of the field experiments was on crop management and designing effective cropping systems with the ultimate objective of water conservation. The field study concluded that under current commodity prices and water cost, continuous cotton production was the economically preferred crop production system compared with a cotton-sorghum rotation. To analyze the potential of each production system for water marketing, the water conserved from effective production systems was assigned a value and was compared with the opportunity cost of diverting the same for urban use in the city of Plainview. The water marketing potential was found to be the highest for the cotton-grain sorghum rotation production system at a low irrigation capacity because of the high sustainable use gap, which is the difference between the net value of crop output per irrigated acre and the opportunity cost of diverting the same for urban consumption. Therefore, a producer is faced with varied choices depending on the current production practices and irrigation conditions. This study expects to provide necessary data and knowledge for cotton producers to decide on management practices favorable for water conservation and utilize available water in the most economic sector.

Introduction

Irrigated cotton production in the Southern High Plains of Texas is an important driver of the regional agricultural economy. For irrigation purposes, groundwater is the major source, which is provided by the Ogallala Aquifer. Continued reliance on groundwater has led to depletion of the aquifer, which is aggravated by a low recharge rate for the region. Therefore, the producers in the region as well as policy makers have shifted focus towards increasing '*water savings'* in contrast to water use efficiency. This in turn, has led to research focusing on generating economically viable water saving techniques of crop production and irrigation. Producers have also started exploring ways to understand the profitability of choices they face if the irrigation water is marketed for use in sectors other than agriculture, such as municipal or industrial use. Crop rotations are considered useful production systems in semi-arid regions (Howell et al., 2004), as they have shown positive impacts on biodiversity (Francis and Clegg, 1990) and sustainability (Parr et. al., 1990). Irrigated crop rotations have shown potential economic advantages over continuous cotton production in previous studies (Segarra et al., 1991; Blackshear and Johnson, 2003). Research has also analyzed the performance of crop rotations when coupled with varied irrigation treatments. This study utilizes results from field experiments based on rotational systems in irrigated cotton production to determine the marketing potential of irrigation water under each system.

Sales of water sale as a commodity in Texas have largely been restricted to surface water as groundwater rights are different and largely governed by the rule of capture. This gives priority to ownership of water with few restrictions. However, interest in groundwater sales has been rising in recent years, dating back to May 1993, when the Texas Senate Bill 1477 was passed creating the Edwards Aquifer Authority (Voteller 1998). This enabled the water market for the Edwards Aquifer region and led to subsequent discussion amongst water districts and producers in other parts of the state as they realized the advent of groundwater marketing. Unlike other water conservation districts, the Edwards Aquifer Authority was now vested with the power to issue permits and regulate groundwater withdrawal in the counties overlying the aquifer's recharge and storage areas. While S.B. 1477 stood as a landmark for ending unrestricted groundwater usage of the Edwards Aquifer, other Texas aquifers had no similar mandated restrictions (Kaiser and Phillips, 1998). It is therefore in the interest of producers as well as the society to examine options regarding groundwater marketing in other irrigated regions, to conserve water for future use and explore sources of reliable water supply in urban areas.

A water market organizes economic activity using prevailing prices to communicate values for water across the market, bringing about coordinated economic decisions between buyers and sellers. In order for such a market to work, it must meet three particular characteristics. First, rights must be established for water ownership as a commodity, which allow market participants to buy and sell. Second, the market must be comprehensive, not excluding any willing buyers or sellers. Third, and the commodity marketed (water in this case) must be homogeneous (McCarl, 1998). There are several general principles involved in assessing the economic value of water and the costs associated with its provision. First, it is vital to obtain an understanding of both direct and indirect costs involved with the provision of water. Second is the derivation of a value, which can be affected by the reliability of water supply. The ideal condition to ensure sustainable use of water requires a balance of the costs and values. The value in alternative uses and opportunity costs can be accurately accessed only when water supplies match water demands for user sub-sectors. Water markets, if functioning, will perform these functions of matching water demands with supplies if appropriate regulatory and economic policies are used to balance the effect of externalities. However, in the absence of functioning water markets, a partial equilibrium approach becomes important for such an analysis. This involves estimation of the opportunity cost of water when used in a particular sub-sector in order to determine the cost to society of depriving other sectors of the use of this water. Utilizing this concept, estimating the economic cost of water used in irrigation will require estimation of the value of water used in the urban or industrial sectors (Rogers et al, 2002).

Materials and Methods

Data were collected at the Texas AgriLife Research facility at Halfway, Texas from 2001-2008. Irrigation was supplied using a center-pivot and Low Energy Precision Application (LEPA) techniques. The two cropping systems produced were continuous cotton (CCC) and a 2:1 cotton-grain sorghum rotation (ROT). Both production systems were irrigated according to one of the three following irrigation strategies: 0 gpm / acre, 1.25 gpm / acre, and 2.5 gpm / acre (where gpm means gallons per minute). These strategies simulated dryland, reduced irrigation capacity, and normal irrigation capacity. The average irrigation water applied in season was 0 acre inches for the 0 gpm/ac irrigation treatment, 5.69 acre inches for the 1.25 gpm/ac irrigation treatment, and 10.35 acre inches for the 2.5 gpm/ac irrigation treatment. Price and cost information from 2008 was used to determine cotton price, grain sorghum price, and irrigation cost. The assumed cotton price was $0.6305 per pound. The assumed grain sorghum price was $6.75 per hundredweight. The irrigation cost was assumed to be $8.86 per acre-inch. Yield information per acre was multiplied by the crop price to determine the crop value per acre. Irrigation applied in season was multiplied by the irrigation cost to determine seasonal irrigation cost per acre. The crop value per acre was then subtracted by the irrigation cost per acre and direct expenses for each production cycle to determine returns above direct expenses. Direct expenses were found using 2008 Texas Crop Budgets for Texas Extension District 2 (Texas AgriLife Extension Service, 2008). Returns above direct expenses were calculated and averaged for CCC and Rotation production systems to create 2001-2008 system values. By calculating these system values, returns above direct expenses for CCC were then compared to the returns above direct expenses for "Rotation". Calculations of returns above direct expenses are provided in the results section of this paper.

Analysis for assessing the marketing potential of irrigation water was performed using results from the CCC and ROT systems. The calculations for the net returns over direct expenses on a per acre basis indicated that continuous cotton production was economically preferred over rotation production system, at all levels of irrigation treatments.
This provided a basis for analyzing the economic value and opportunity costs associated with irrigation water for all combinations of productions systems and irrigation treatments. The combination with the least gap between the value of irrigated water and the opportunity cost was expected to hold the highest potential for marketing towards urban use. The results for the irrigation treatments and production systems in terms of average net returns per acre are provided in Table 1. The value of irrigation water ($/acre-inches) is calculated by finding the difference between

the net returns from irrigated production and from dryland production, and then dividing the value by total volume of water pumped for irrigation on a per acre basis. Given, the three irrigation level treatments with pumping capacities of 0, 1.25 and 2.5 gpm / acre, the average net returns from the treatment with 0 gpm / acre served as a base value for dryland production, for calculation purposes. The total value for irrigation water for each combination was a sum of the net returns per acre and the value of recharge water. An annual recharge rate of 0.4 inches per acre was assumed for Hale County (Texas Water Development Board, 2010a).

The cost associated with the irrigation water was broadly the opportunity cost for diverting the water for municipals use. To arrive at the opportunity cost of irrigation water for each combination, the annual water demand (consumption) for the city of Plainview were utilized (Texas Water Development Board, 2010b). Also, the annual consumption per household was calculated by dividing the annual water consumption by the number of household units in the city of Plainview (United States Census Bureau, 2010). Average annual water consumption was estimated to be 0.74 acre-feet per household. These calculations are shown in Table 2. Current municipal tiered rates for the city of Plainview are shown in Table 3. These rates have been procured from the city of Plainview (2010) and were used for calculating the consumer willingness to pay for urban consumption on a per household basis. Table 4 shows the calculations for the economic value and costs associated with each irrigation treatment and production system.

Results and Discussion

Table 1 contains the returns calculated under the assumed prices, irrigation costs, and direct expenses associated with each production system. This table shows that continuous cotton production was the economically preferred production system for each of the irrigation treatments. The table also provides the difference in returns between the continuous cotton production and a cotton-grain sorghum rotation. The difference in returns under the 1.25 gpm / acre irrigation treatment, $28.10, is the smallest of the three irrigation treatments because the marginal physical product is increasing at an increasing rate between the two treatments.

Table 1. Economically preferred production system under assumed prices and costs

Irrigation treatment	Average irrigation water applied (acre-inches)	Production System	Average returns above direct expenses ($ / acre)	Difference from the CCC system
0 gpm/ac	0.00	CCC	62.27	
	0.00	Rotation	29.42	-32.85
1.25 gpm/ac	5.65	CCC	162.21	
	5.72	Rotation	134.11	-28.10
2.50 gpm/ac	10.33	CCC	342.77	
	10.37	Rotation	255.44	-87.33

Table 2. Municipal water consumption statistics for the city of Plainview

Parameters	Values
Population[1]	21,502
Number of Housing Units[1]	9,001
Persons per Household[1]	2.39
Municipal Water consumption (ac-ft)[2]	6,677
Consumption/Household (ac-ft)	0.74
Consumption /Person /Household (ac-ft)	0.31

[1]USGS, 2010 [2]Llano Estacado Regional Water Plan, TWDB, 2010

Table 2 shows the statistics for the Municipal water consumption for the city of Plainview, which is the nearest city to the research site for the experiment. Annual water consumption for this city is 6,677 acre-feet, which is the water demand for urban use. This statistic is divided by the total number of housing units, which gives the average annual consumption per household in the city as 0.74 acre-feet, assuming an average number of 2.39 persons per household. The average consumption per person per household annually is calculated to be 0.31 acre-feet. Current Municipal tiered rates for the city of Plainview are provided in Table 3. An average household in the city will pay a charge of $1.65 for every 1000 gallons consumed in the upper limit of 25,000 gallons. For consumption in excess of 25,000 gallons, the price increases to $1.84 for every thousand gallons consumed. There is a minimum monthly charge of $12.50, levied on water consumption for every household.

Table 3. Current Municipal tiered rates for the city of Plainview

Amount of Water (in gallons)	Pricing
1 - 25,000	$1.65 / 1,000 gallons
25,001 and up	$1.84/ 1,000 gallons
Minimum Monthly Charge	$12.50

From the above three tables, analysis for water value and opportunity costs associated with each production system and irrigation treatment was conducted. Table 4 summarizes the calculations for each production system at irrigation capacities of 1.25 and 2.5 gpm / acre, when compared with no irrigation treatment. The results indicate that the sustainable use gap, which is the difference between the economic value and opportunity cost for urban use, was highest ($12.09) for the rotational system at a lower irrigation capacity of 1.2 gpm / acre. This was followed by the continuous cotton cultivation at 2.5 gpm/ac, which projected a gap of $11.66. The higher irrigation capacity of 2.5 gpm / acre led to a lower gap between the value and costs of both the production systems under continuous cotton and cotton-sorghum rotation respectively, on account of a higher net value of crop output per irrigated acre.

Table 4. Economic value and costs for each irrigation treatment and production system ($/acre-inch)

System	Value components		Cost components		Sustainable use gap
	Net value of crop output	Net benefits from return flows	Opportunity cost for urban use	Pumping cost	(Value- Costs)
CCC (1.25 gpm / acre)	17.96	7.18	44.8	8	
Total		25.14		36.80	-11.66
Rotation (1.25 gpm / acre)	17.65	7.06	44.8	8	
Total		24.71		36.80	-12.09
CCC (2.5 gpm / acre)	27.00	10.79	44.8	8	
Total		37.79		36.80	0.99
Rotation (2.5 gpm / acre)	20.89	8.35	44.8	8	
Total		29.24		36.80	-7.56

Figure 1 provides a comparison of value and gap under different production systems and irrigation treatments. It is clearly observed that a higher irrigation capacity leads to higher net returns per irrigated acre and therefore bridges the gap between the economic value of water in irrigated agriculture and the opportunity cost of the same. The economic value of water from crop output exceeded the opportunity cost for urban use in continuous cotton cultivation at 2.5 gpm / acre, on account of a higher price premium for irrigated cotton in the market as well as higher productivity on a per acre basis. In contrast, the highest sustainable use gap was observed for the rotational system with a lower irrigation capacity of 1.25 gpm / acre. It is therefore concluded that farmers will find the water marketing option more profitable, only when the economic value of crop output is less than the opportunity cost of marketing the same water for urban use. Also, the farmers irrigating the land with a lower pumping capacity well may consider water marketing as an option, because of lower productivity per acre when compared to productivity at a higher pumping capacity on a per acre basis.

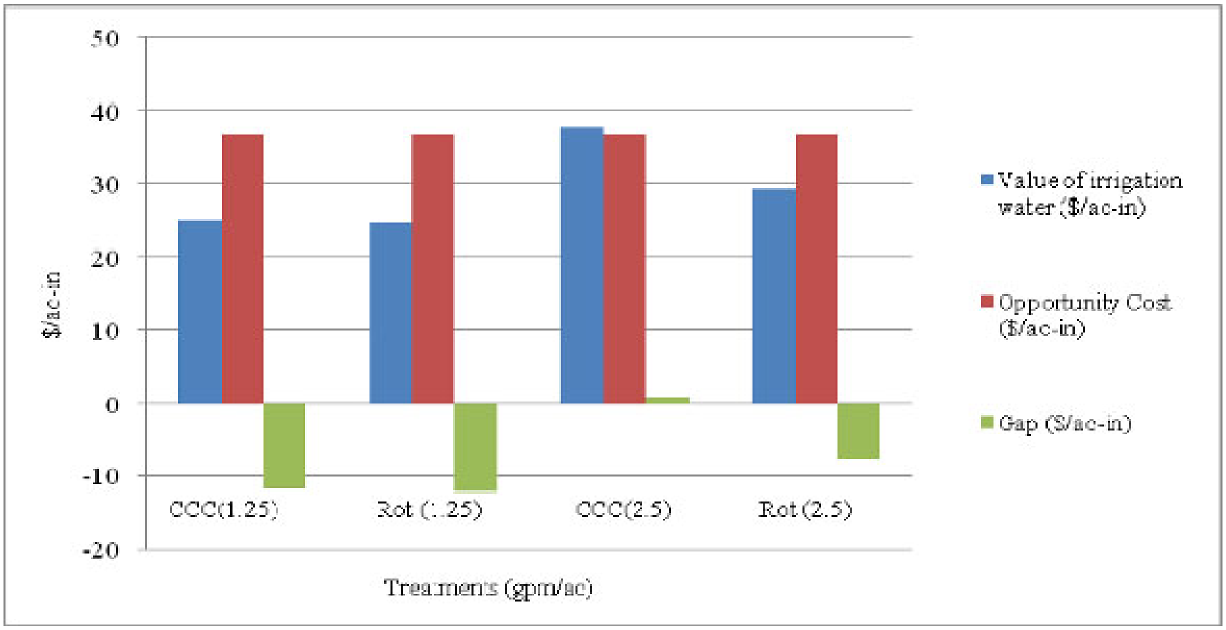

Figure 1. Comparison of value and gap under different production systems

Conclusions

The intent of this study was to determine the marketing potential of irrigation water for urban use under continuous cotton production and a cotton-grain sorghum rotation at varied levels of irrigation treatments. The results of the field experiment clearly indicated the higher economic profitability of continuous cotton production over a 2:1 cotton-grain sorghum rotation at current prices and costs. However, the water marketing potential was found to be the highest for the cotton-grain sorghum rotation production system at a low irrigation capacity because of the high sustainable use gap, which is the difference between the net value of crop output per irrigated acre and the opportunity cost of diverting the same for urban consumption. Therefore, a producer is faced with varied choices depending on the current production practices and irrigation conditions. It is important to realize that water district restrictions on pumping and transfers of water rights will also influence the behavior of water marketing in the region. Future research in this direction could be focused on developing water banks, which are useful tools for leasing water for a limited period of time on a voluntary basis between willing water rights holders and users. It provides temporary transfers of water entitlements without a permanent change in water rights. Also, the incorporation of intrinsic values in finding the total economic value of irrigation water and inclusion of environmental externalities like factors affecting public health and ecosystem through water consumption, for calculating the opportunity cost could provide a more realistic and appropriate scenario for marketing irrigation water for urban use.

Acknowledgements

The authors would like to acknowledge the Ogallala Aquifer Program, which is funded by the USDA Agricultural Research Service who made this study possible.

References

Blackshear, J. and P. Johnson. 2003. Profitability of Irrigated Cotton-Grain Sorghum Rotations in the Southern High Plains of Texas. In: 2003 Proc. Beltwide Cotton Conferences, 474-480. Memphis, TN: National Cotton Council.

City of Plainview. 2010. Water Rate adjustment / Ordinance No. 10-3531, September 2010. Available at: http://weblink.ci.plainview.tx.us/WebLink8/DocView.aspx?id=138645&page=1&dbid=0

Francis, C.A., and M.D. Clegg. 1990. Crop rotations in sustainable production systems. pp.107-121. In: Sustainable Agricultural Systems, Soil and Water Conservation Society, Ankeny, IA.

Howell, T.A., Tolk, J.A., Baumhardt, R.L., Evett, S.R. 2004. Furrow irrigated cotton-sorghum rotation for the Texas northern plains. Agronomy Abstracts, ASA-CSSA-SSSA Annual Meeting, Seattle, Washington.

Kaiser, R. A. and L. M. Phillips. 1998. Dividing the waters: water marketing as a conflict resolution strategy in the Edwards Aquifer Region. Natural Resources Journal 38:411-444.

McCarl B A, 1998. Ground Water Marketing: Economic Explorations Involving the Edwards Aquifer. Proceedings of the 25th Water for Texas Conference, Austin, TX Dec. 1-2, 8, 1998. Available at: http://agecon2.tamu.edu/people/faculty/mccarl-bruce/papers/727.pdf

Parr, J.F., R.I. Papendick, I.G. Young, and R.E. Meyer. 1990. Sustainable agriculture in the United States. pp. 50-76. In: Sustainable Agricultural Systems, Soil and Water Conservation Society, Ankeny, IA.

Rogers, P., Silva, R., & Bhatia, R. 2002. Water is an economic good: How to use prices to promote equity, efficiency, and sustainability. Water Policy 4: 1-17

Segarra, E., J.W. Keeling, and J.R. Abernathy. 1991. Tillage and Cropping System Effects on Cotton Yield and Profitability on the Texas Southern High Plains. Journal of Production Agriculture 4(4):566-571. Texas AgriLife Extension Service. 2008. 2008 Texas Crop and Livestock Budgets: District 2 [Online]. Available at http://agecoext.tamu.edu/resources/crop-livestock-budgets/by-district/district-2/2008.html

Texas Water Development Board, 2010a, Groundwater Availability Modeling Section, GAM Run 09-023. Available at : http://www.twdb.state.tx.us/gam/GAMruns/GR09-23.pdf

Texas Water Development Board, 2010b, Llano Estacado Regional Water Plan, September 2010. Available at: http://www.twdb.state.tx.us/RWPG/rpgm_rpts/0704830700_regionO.pdf

United States Census Bureau, 2010. Fact sheet for the city of Plainview, Texas. Available at: http://factfinder.census.gov/home/saff/main.html?_lang=en.

Votteler, T. H. 1998. The little fish that roared: The Endangered Species Act, state groundwater law, and private property rights collide over the Texas Edwards Aquifer. Environmental Law 28:845-879.