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The Economics of Local Enhanced Management Areas in Southwest Kansas

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Abstract: The purpose of this research is to provide input into the water planning process for select subareas in southwest Kansas. Stakeholder input suggests that a reduction in groundwater use may be desirable in order to preserve the Ogallala Aquifer and extend its economic contribution to both the producer and the regional economy. In an endeavor to define the benefits and costs of water conservation policy, this research estimates measures of producer net profits and regional value added and places a monetary value on the conserved groundwater. The results of the models that assume the goal is to maximize producer profits, suggest that the Local Enhanced Management Areas (LEMAs) framework of groundwater management will provide benefits to both the agricultural producer and rural communities. Subarea 1 will receive the greatest benefit, increasing cumulative net revenue by 6.3%, while Subareas 2 and 3 increase cumulative net revenue by 2.1% and 2.7%, respectively. The results suggest that generally, the rural economy receives as much, if not more, benefits from groundwater conservation than the agricultural producer. Subareas 1, 2, and 3 generated 8.3%, 2.7%, and 1.8%, respectively, more cumulative value added under the LEMA scenario as compared to the Status Quo scenario. If Subarea 3 were to manage their groundwater based on implementing a LEMA plan and maximizing value added, cumulative value added would increase from a 1.8% gain to an increase of 18.7%.

Keywords: *groundwater, net present value, Ogallala Aquifer, value added, water conservation*

Groundwater consumption in southwest Kansas far exceeds the amount of recharge in the Ogallala Aquifer. This raises concerns relative to the long-term feasibility of irrigated agriculture in the area and the industries that rely on it. The depletion of the Ogallala Aquifer in this area will have serious negative economic impacts on agricultural producer profits and the associated value-added of the regional economy. In order to extend the economic life of the aquifer and maintain the economic base of the region, policy intervention may need to be considered.

Past efforts to slow the decline and ensure the future economic viability of the region have been largely unsuccessful (Peterson et al. 2003; Griggs 2014). The 2012 Kansas Legislature passed Senate Bill (SB) 310 making Local Enhanced Management Areas (LEMAs) a part of Kansas water law. This law gives groundwater management districts (GMDs) the authority to initiate a voluntary public hearing process to consider a specific conservation plan to meet local goals. LEMAs are proactive, locally designed, and initiate water management strategies for specific geographic areas that are promoted through a GMD and then reviewed and approved by the Chief Engineer. Once approved by the Chief Engineer, the LEMA plan becomes law, effectively modifying prior appropriation regulations. The stated purpose of the LEMA legislation was to reduce groundwater consumption in order to conserve the state's water supply and extend the life of the Ogallala Aquifer.

The objective of this study is to provide assistance to the stakeholders in GMD#3 in their water planning process. This report documents the methods, assumptions, and estimates of the likely economic impacts associated with the implementation of LEMAs in three high priority subareas located within GMD#3 as illustrated in Figure 1. Various hydrological parameters associated with the subareas are reported in Table 1. This analysis compares a Status Quo scenario to a LEMA scenario for each of the three subareas. The Status Quo scenario assumes that there is no change in groundwater use behavior and producers keep pumping all wells into the future based on historic pumping. Based on input from the stakeholders, the LEMA scenario assumes there is an immediate 20% reduction, based on historic pumping. Both scenarios are simulated under normal or average climatic conditions. Note that the term ‘water use’ throughout this article takes the meaning of ‘consumptive water use’.

Methodology

Economic models that forecast future conditions are subject to error, and the results are generally viewed as only one possible prediction. From a policy analysis perspective, it is not necessary that the individual scenario predictions be perfectly accurate; it is important to focus on the ‘difference’ between scenarios. As long as consistency is maintained, and stakeholders agree with the methodology and assumptions, comparisons of different scenarios are appropriate to evaluate groundwater management options.

This study relies heavily on models previously developed by Golden and Johnson (2013) which provides a very detailed model description. The study requires the development of two broad classes of economic models. The temporal allocation portion of the model is linked with a hydrological model previously developed by the Kansas Geological Service (KGS), and provides the required time series forecast on groundwater use, irrigated acreage, and economic productivity for the Status Quo and LEMA scenarios. The models of regional economic impact utilize the output from the temporal allocation models to predict the economic value added for the two scenarios. The model is illustrated in Figure 2.

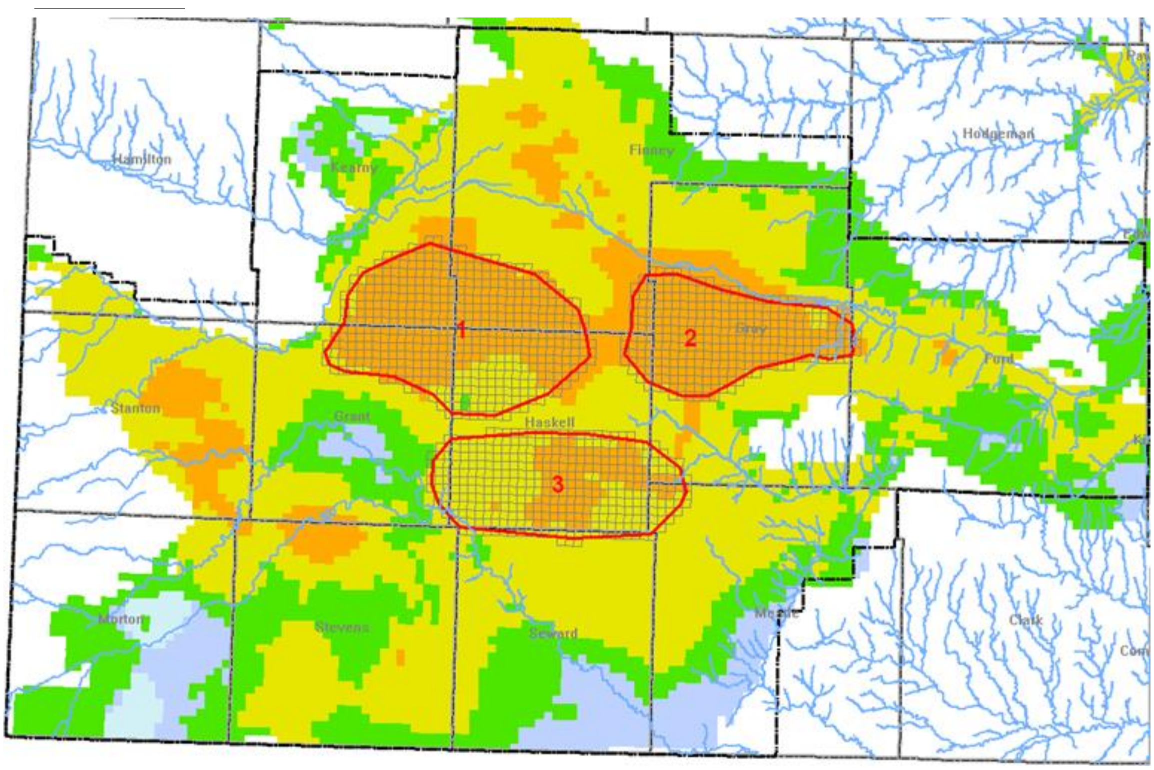

Figure 1. Three high priority subareas located in Groundwater Management District 3 in Kansas.

Table 1. Subarea hydrological parameters.

Item	High Priority Area		
	1	2	3
Recharge (inches/year)	1.94	2.24	1.01
Depth to Water (feet)	227.93	145.22	268.58
Saturated Thickness (feet)	222.55	120.43	227.37
Hydraulic Conductivity (feet/day)	43.64	53.06	46.29
Specific Yield	0.17	0.17	0.18
Average Well Capacity (gallons per minute)	633.19	489.74	665.31
Average Decline in Saturated Thickness (feet)	2.98	2.44	2.28
Average Water Use per Acre (feet)	1.45	1.32	1.13
Average Annual Water Use (acre-feet)	178,284.60	115,994.60	145,964.00

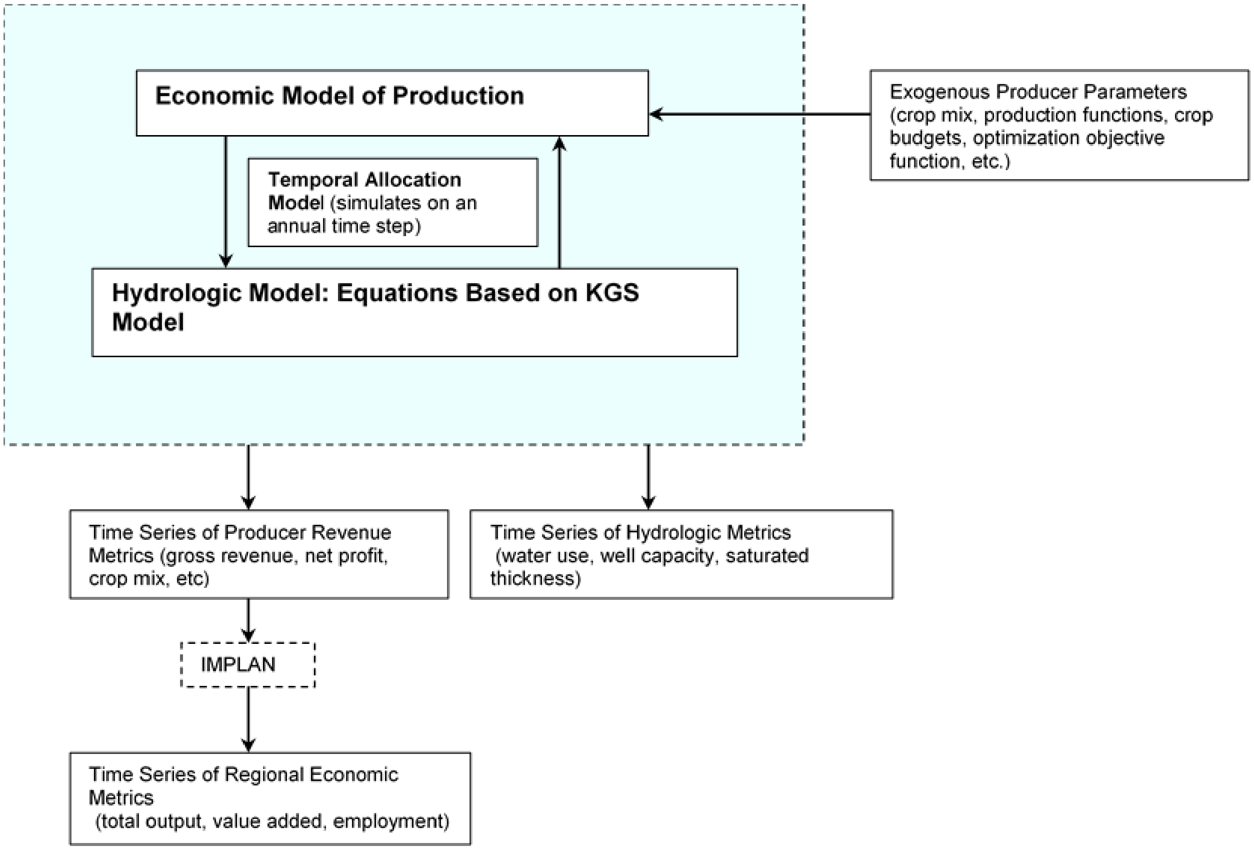

Figure 2. Regional economic impact model.

The producer's annual objective function for the dynamic simulation model is normally based on the concept that an agricultural producer will maximize profits (Amosson et al. 2009; Golden and Johnson 2013). This objective function implicitly assumes that what is best for the producer is also best for the rural economy. The annual profit maximizing objective function can be defined as:

$$\max_{A,w} \sum_{i=1}^{n} P_i Y_{i,t}(w_{i,t}) A_{i,t} - C_{i,t}(w_{i,t}) A_{i,t}$$

$$s.t.\ \sum_{i=1}^{n} w_{i,t}\, A_{i,t} = TW_{KGS,t}$$

$$s.t.\ ST_t = ST_{KGS,t}$$

$$s.t.\ \sum_{i=1}^{n} A_{i,t} = TA \qquad (1)$$

where $w_{i,t}$ is the water allocation for crop i in time period t; $A_{i,t}$ is the acreage allocation for crop i in time period t; $Y_{i,t}$, a function of $w_{i,t}$, is the per acre yield for crop i in time period t; $C_{i,t}$, a function of $w_{i,t}$, is the per acre cost for crop i in time period t; and P_i is the per unit price of crop i. The previously described equation is maximized subject to (s.t.) several constraints. The model is simulated on an annual basis for a period of t = 1… 61 years. Golden and Johnson (2013) reported the prices and costs for irrigated and non-irrigated crop production used in this analysis.

The typical single cell aquifer model and the associated equations of motion for saturated thickness, annual water use, and well capacity have been replaced by hydrologic equations of motion. These equations are based on regression analysis of the output of the KGS Model utilized by Golden and Johnson (2013). The first two constraints state that model-generated total water use (*TW*) and saturated thickness (*ST*) at any point in time has to be equal to a previously determined total groundwater use and saturated thickness as provided by the KGS Model.

The third constraint implies that total acreage (*TA*) cannot change over time. This model only considers the current irrigated acreage in the subareas. The model predicts how irrigated crop mix might change over time due to declining groundwater availability. The current irrigated crop mix and the average per acre water use for these crops for each of the subareas are reported in Table 2 and Table 3, respectively. The model also forecasts when irrigated acreage will shift to dryland production. As irrigated acreage converts to dryland it is assumed these acres will shift to the crop mix reported in Table 4. The percent pasture is based on the percentage of land that falls into Natural Resources Conservation Service (NRCS) Class 5 soils or greater[1] (Table 4). For this analysis, the net returns associated with pasture are assumed to be $10.00 per acre and the costs associated with fallowed land are assumed to be $30.00 per acre.

Models of Regional Economic Impact

When agricultural groundwater use is restricted, either from policy intervention or declining well capacity, crop production will, in all likelihood, be reduced in the near term and producers and local communities will incur negative economic impacts. The magnitude of the reduction in crop yields will depend upon the magnitude of the groundwater use reductions, the current level of groundwater use efficiency in the production process, the number of acres involved, the crop mix for the area, crop yields (which are dependent on crop-specific production functions, impacted by local precipitation and temperature), prices and costs, and the relative economic importance of agriculture to the affected communities. The direct impacts (changes in gross revenue) estimated by the temporal allocation models, for various scenarios, are used as input for the regional economic impact models. IMpact analysis for PLANning (IMPLAN) software is used to quantify the indirect and induced economic impacts to the regional economy (IMPLAN Group, LLC 2009).

The most relevant measure of the local economic impact may be 'value added'. Value added consists of four components: 1) employment compensation (wage, salary, and benefits paid by the employers); 2) proprietor income (payments received by self-employed individuals as income); 3) other property income (payments to individuals in the form of rents); and 4) indirect business taxes (basically

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[1] Per the NRCS handbook available at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054226: Class V (5) soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Table 2. High priority subarea irrigated crop mix.*

High Priority Subarea	Alfalfa	Corn	Sorghum	Soybeans	Wheat
1	38.9%	49.7%	1.6%	4.3%	5.4%
2	35.5%	43.5%	2.5%	6.0%	12.2%
3	3.8%	83.1%	2.8%	3.3%	6.5%

*Based on average data (2000-2009) obtained from the Water Right Information System (WRIS) database.

Table 3. High priority subarea current average use (acre-inches).*

High Priority Subarea	Alfalfa	Corn	Sorghum	Soybeans	Wheat
1	21.7	19.6	12.0	18.3	12.2
2	20.0	18.3	9.9	15.9	7.2
3	18.4	17.6	11.8	13.1	9.2

*Based on average data (2000-2009) obtained from the Water Right Information System (WRIS) database.

Table 4. High priority subarea projected dryland crop mix.*

High Priority Subarea	Corn	Sorghum	Wheat	Fallow	Pasture**
1	4.2%	13.1%	28.3%	15.2%	39.4%
2	3.0%	9.5%	20.4%	11.0%	56.2%
3	6.6%	20.6%	44.6%	23.9%	4.3%

* The percentage of acreage for corn, sorghum, wheat, and fallow is based on NASS averages for CRD 30 (1999-2009).

**The percent pasture is based on the percentage of land that falls into NRCS Class 5 soils or greater.

all taxes with the exception of income tax) (IMPLAN Group, LLC 2009). Thorvaldson and Prichett (2007) and BBC Research & Consulting et al. (1996) suggest that value added is the most appropriate measure of community economic impact. This research reports the measure of value added and uses the metric to compare policy options. The value added multipliers used in this analysis are reported in Table 5.

Net Present Value Analysis

Net present value comparison is a standard method used to compare long-term projects. The calculation discounts future cash flows to present values and sums the resulting income stream. Net present value calculations require a 'discount rate' that transforms future values into present values. The use of a positive discount rate would imply the conventional view, that profits today are more valuable than profits in the future. A positive discount rate might be chosen by a producer that focuses on the near term cash flows necessary to meet current obligations such as land and equipment payments. A zero percent discount rate would imply neutrality as to the timing of cash flows. The use of a negative discount rate would imply that profits, and by extension water, is valued more highly in the future than it is today. Such a stance might be taken by a producer that wants to ensure that water resources are conserved today so that his children might enjoy the stability of irrigated production in the future. Consistent with Golden and Johnson (2013), this analysis uses a zero percent discount rate to make non-bias comparisons between policy

Table 5. Value-added multipliers for irrigated and non-irrigated crops in Southwest Kansas.

	Direct	Indirect	Induced	Total
Irrigated	0.37	0.13	0.11	0.61
Non-Irrigated	0.50	0.11	0.15	0.75

alternatives. A comparison of alternative discount rates utilized in this type of analysis can be found in Vestal et al. (2017).

The Value of Groundwater

It is straight-forward to compare the scenario differences in variables such as producer revenues, well capacity, and saturated thickness. However, a policy such as the LEMA Model restricts water use relative to a Status Quo scenario and over the 61-year time frame generally results in less total groundwater consumed. In most temporal allocation studies, economists rarely estimate the value of the remaining conserved groundwater (Golden et al. 2008; Amosson et al. 2009). This may be because from a purely production standpoint, groundwater has no value until it is brought to the surface and used and it is uncertain what it may be used for in the future. Additionally, studies that discount future values (positive discount rates) may find that any remaining water in the future (after 61 years) has negligible value today. Amosson et al. (2017) suggest that the cost of generating water savings must be weighed against the benefit of doing so and to accomplish this, a ‘price tag’ needs to be given to the water that is conserved.

Golden and Johnson (2013) valued the conserved groundwater based on the difference in the non-discounted cumulative net returns, over the 61-year modeling period, divided by the cumulative groundwater use, over the 61-year modeling period. This metric yielded an average value of groundwater over the 61-year modeling period. While this method was consistent with stakeholder input at the time, more recent input from reviewers and stakeholders suggests that using the average method undervalues conserved groundwater if growth in crop yield is assumed. This analysis assumes that the value of conserved groundwater is the difference in the non-discounted cumulative net returns, during the 61st year of the modeling period, divided by the cumulative groundwater use, during the 61st year of the modeling period.

Growth in Crop Yield

For several decades there have been significant adoptions of new crop varieties and cultural practices. The more recent adoption of biotechnology has allowed producers to increase yields and decrease input use. When projecting groundwater use into the future, it is important to include estimates of the growth in crop yields. Amosson et al. (2009) assumed all irrigated crop yields increase at the rate of 0.5% per year. Golden and Johnson (2013) assumed that irrigated crop revenues increase at 0.5% per year relative to non-irrigated crop revenues.

Rogers and Lamm (2012) provide data on the long-term growth rate of the major irrigated crops in Kansas. The interpolation of these data is reported in Table 6. There is little economic research quantifying how various factors (cultural practices, genetics, water availability, etc.) are impacting the growth rates, so it is unclear if the growth rate should be expected to increase or decrease into the future. As a result, this research utilizes conservative estimates of future growth rates at 50% of those values interpolated from Rogers and Lamm (2012).

Results and Discussion

Typically, a Status Quo scenario is constructed that represents a baseline and assumes unconstrained producer behavior. A second scenario is constructed that represents the exogenous impact of a policy option which imposes a constraint on producer behavior. In this study, the implementation of a LEMA, which reduces current groundwater use by 20%, is the imposed constraint. Since there is an immediate reduction in groundwater usage of 20%, declines in saturated

Table 6. Estimates of future crop yield growth.

Crop	Estimated Growth Rate	Conservative Growth Rate
Irrigated Alfalfa	0.00%	0.00%
Irrigated Corn	1.31%	0.66%
Irrigated Sorghum	0.54%	0.27%
Irrigated Soybeans	0.95%	0.47%
Irrigated Wheat	0.64%	0.32%
Dryland	0.51%	0.25%

thickness are slowed, and future pumping capacity is increased. As a result, more groundwater is available to be used in the future in the LEMA scenario when compared to the Status Quo scenario. The impact of this is that the cumulative groundwater use for the LEMA scenario will be less than 20% relative to the Status Quo scenario (Figure 3). Since less groundwater is used in the short-term under the LEMA scenario, annual crop yields and net revenues are also reduced. In the long-run, however, the LEMA scenario uses more groundwater in the latter years of the study when crop yields are higher due to technological growth, and as a result, overall net revenue is increased (Figure 4). The time series results of the two dynamic simulation models are then compared to assess the impact of the exogenous shock.

The cumulative groundwater use for the Status Quo and LEMA scenarios for Subarea 1 is reported in Table 7. The LEMA scenario uses approximately 9.5% less groundwater over the 61-year modeling horizon, and adds approximately 9.5 years (15.4% more time) relative to the groundwater use associated with the Status Quo scenario. The LEMA scenario results in 6.3% more cumulative net revenue (Table 8) and a gain of 8.3% in cumulative value-added (Table 9).

The cumulative groundwater use for the Status Quo and LEMA scenarios for Subarea 2 is reported in Table 10. The LEMA scenario uses approximately 0.1% less groundwater over the 61-year modeling horizon, and adds less than a year, relative to the groundwater use associated with the Status Quo scenario. The LEMA scenario results in 2.1% more cumulative net revenue (Table 11) and a gain of 2.7% in cumulative value-added (Table 12).

The cumulative groundwater use for the Status Quo and LEMA scenarios for Subarea 3 is reported in Table 13. The LEMA scenario uses approximately 4.1% less groundwater over the 61-year modeling horizon, and adds approximately 4.8 years (7.9% more time) relative to the groundwater use associated with the Status Quo scenario. The LEMA scenario results in 2.7% more cumulative net revenue (Table 14) and a gain of 1.8% in cumulative value-added (Table 15).

Kansas administers groundwater rights based on a *prior appropriation* doctrine. This implies that all the groundwater is owned by the state and dedicated to the use of the citizens as specified in the state's water appropriation act (K.S.A. 82a-701). This law is designed to protect both the land owners' right to use groundwater today as well as protect the supply of groundwater for future generations. K.S.A. 82a-702 states that "all water within the state of Kansas is hereby dedicated to the use of the people of the state, subject to the control and regulation of the state in the manner herein prescribed." This might imply that groundwater management, to some extent, be based on what is most beneficial to rural communities. As previously stated, dynamic simulation models have historically been based on the assumption that an agricultural producer will maximize profits, which implicitly assumes that groundwater management should be based solely on what is best for the agricultural producer. As an alternative, dynamic simulation models were developed which are based on the assumption that the goal is to maximize value added generated in the rural economy. This implicitly assumes

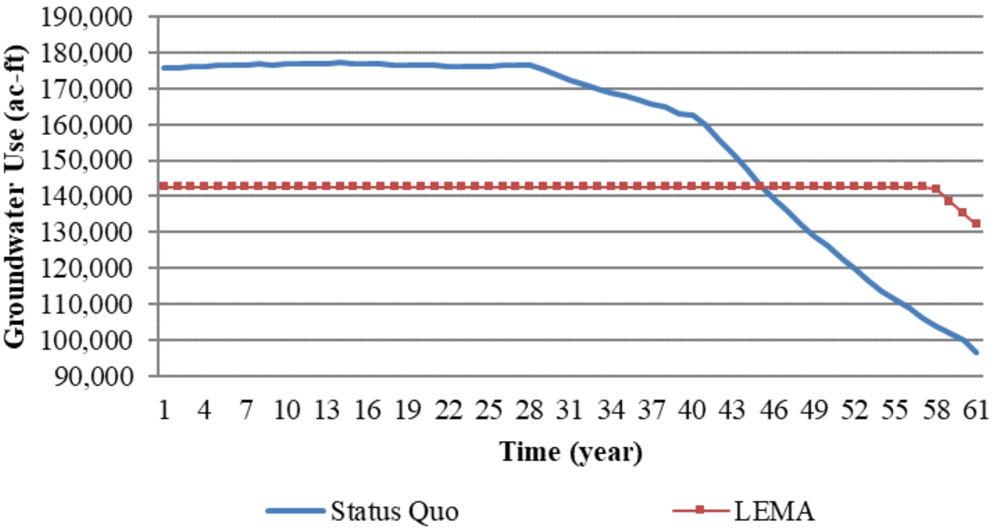

Figure 3. Cumulative groundwater use for Subarea 1.

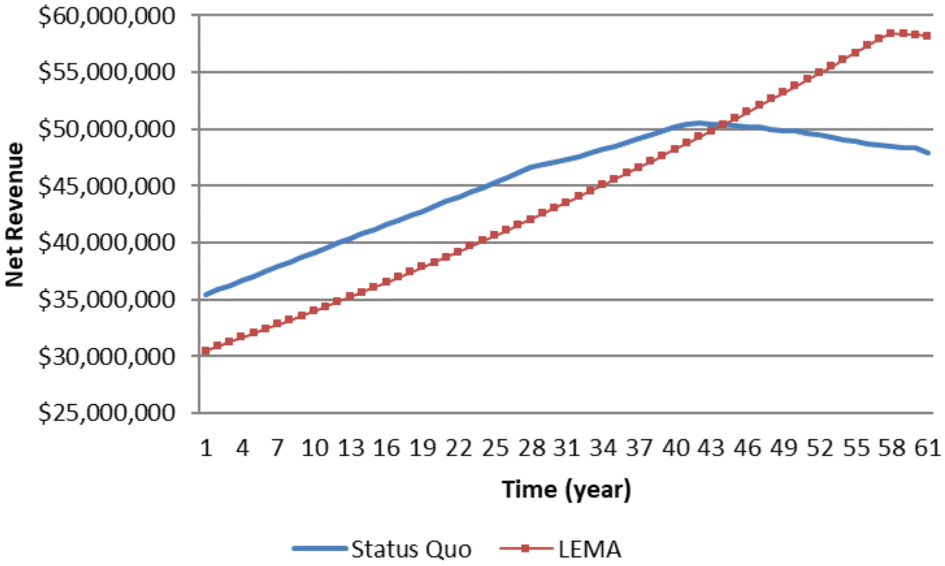

Figure 4. Cumulative producer net revenue from crop production for Subarea 1.

that groundwater management is based solely on what is best for the rural community. Results from this alternative dynamic simulation model are presented below.

Utilizing the dynamic simulation model which assumes that the objective function is to maximize the rural communities' value added, the cumulative groundwater use for the Status Quo and LEMA scenarios for Subarea 3 over the 61-year modeling horizon is reported in Table 16. The LEMA scenario uses approximately 4.1% less groundwater over the 61-year modeling horizon, and adds approximately 4.8 years (7.9% more time) relative to the groundwater use associated with the Status Quo scenario. The LEMA scenario results in 0.0% more cumulative net revenue (Table 17) and a gain of 18.7% in cumulative value-added (Table 18).

The results of the models, that assume the goal is to maximize producer profits, suggest that the LEMA framework of groundwater management will provide benefits to both the agricultural

Table 7. Cumulative groundwater use for **Subarea 1** (acre-feet).

Scenario	Cumulative Groundwater Use	Relative Groundwater Use
Status Quo	9,583,338	0
LEMA	8,677,622	-905,716

Table 8. Cumulative producer net revenue ($ millions) for **Subarea 1.**

Scenario	Cumulative Net Revenue	Relative Net Revenue	Value of Remaining Water	Net
Status Quo	$2,767.8	$0	$0	$2,767.8
LEMA	$2,691.1	-$76.7	$328.2	$2,942.6

Table 9. Cumulative value added ($ millions) for **Subarea 1.**

Scenario	Cumulative Total Value Added	Relative Value Added	Value of Remaining Water	Net
Status Quo	$4,926.0	$0	$0	$4,926.0
LEMA	$4,821.4	-$104.6	$618.1	$5,335.0

Table 10. Cumulative groundwater use for **Subarea 2** (acre-feet).

Scenario	Cumulative Groundwater Use	Relative Groundwater Use
Status Quo	4,692,522	0
LEMA	4,687,627	-4,894

Table 11. Cumulative producer net revenue ($ millions) for **Subarea 2.**

Scenario	Cumulative Net Revenue	Relative Net Revenue	Value of Remaining Water	Net
Status Quo	$1,586.9	$0	$0	$1,586.9
LEMA	$1,602.1	$15.2	$2.7	$1,620.1

Table 12. Cumulative value added ($ millions) for **Subarea 2.**

Scenario	Cumulative Total Value Added	Relative Value Added	Value of Remaining Water	Net
Status Quo	$2,782.2	$0	$0	$2,782.2
LEMA	$2,817.0	$34.7	$4.8	$2,856.4

Table 13. Cumulative groundwater use for **Subarea 3** (acre-feet).

Scenario	Cumulative Groundwater Use	Relative Groundwater Use
Status Quo	7,164,649	0
LEMA	6,874,580	-290,070

Table 14. Cumulative producer net revenue ($ millions) for **Subarea 3.**

Scenario	Cumulative Net Revenue	Relative Net Revenue	Value of Remaining Water	Net
Status Quo	$2,287.2	$0	$0	$2,287.2
LEMA	$2,257.4	-$29.8	$121.5	$2,349.1

Table 15. Cumulative value added ($ millions) for **Subarea 3.**

Scenario	Cumulative Total Value Added	Relative Value Added	Value of Remaining Water	Net
Status Quo	$4,326.2	$0	$0	$4,326.2
LEMA	$4,159.2	-$166.9	$255.6	$4,248.0

Table 16. Cumulative groundwater use for **Subarea 3** (acre-feet) (VA as the Objective Function).

Scenario	Cumulative Groundwater Use	Relative Groundwater Use
Status Quo	7,164,649	0
LEMA	6,877,179	-287,471

Table 17. Cumulative producer net revenue ($ millions) for **Subarea 3** (VA as the Objective Function).

Scenario	Cumulative Net Revenue	Relative Net Revenue	Value of Remaining Water	Net
Status Quo	$2,287.2	$0	$0	$2,287.2
LEMA	$2,226.7	-$60.5	$120.2	$2,226.7

Table 18. Cumulative value added ($ millions) for **Subarea 3** (VA as the Objective Function).

Scenario	Cumulative Total Value Added	Relative Value Added	Value of Remaining Water	Net
Status Quo	$4,326.2	$0	$0	$4,326.2
LEMA	$4,597.6	$271.4	$268.1	$5,137.0

producer and the rural communities. The magnitude of these benefits varies by subarea. Subarea 1 will receive the greatest benefit with an increase in cumulative net revenue of 6.3%, while Subareas 2 and 3 are expected to have increases in cumulative net revenue of 2.1% and 2.7%, respectively. The variation in subarea specific results are due to variations in initial hydrological conditions, current and projected irrigated crop mix, and dryland production options, which determine how the irrigated crop mix varies over time and the rate at which irrigated cropland is converted to dryland production.

Consistent with Golden and Johnson (2013), this research suggests that the rural economy receives as much, if not more, benefit from groundwater conservation as does the agricultural producer. Subarea 1, Subarea 2, and Subarea 3 generated 8.3%, 2.7%, and 1.8%, respectively, more cumulative value added under the LEMA scenario as compared to the Status Quo scenario. These findings raise the question as to the extent to which value added could be increased if groundwater was managed based on maximizing value added as opposed to maximizing producer profits. If Subarea 3 were to manage their groundwater based on implementing a LEMA and maximizing value added, cumulative value added would increase from a 1.8% gain to an increase of 18.7%. While an in-depth analysis of how this concept would impact other areas in southwest Kansas, and how we might implement such a policy, goes beyond the scope of this research, the topic certainly requires future research.

Conclusions

The purpose of this research was to provide input into the water planning process for select subareas in southwest Kansas. The study considered two groundwater use scenarios, a Status Quo scenario and a LEMA scenario. Stakeholder input suggests that a reduction in groundwater use may be desirable in order to conserve the Ogallala Aquifer and extend its economic contribution to both the producer and the regional economy. This research estimates measures of cumulative producer net profits and regional value added in order to estimate the benefits and costs of the LEMA water conservation policy. This research placed a monetary value on the conserved groundwater and considers a future where continued growth in irrigated crop yields is assumed.

In order to accomplish the goals of this research, previously developed economic and hydrological models were modified and used to estimate impacts over a 61-year time horizon. Since the development of economic models for predicting the future is, by its very nature subject to error, the results of such models are most appropriately viewed as a ‘best guess’. The estimated impacts were based on a variety of assumptions. A different set of assumptions will alter the magnitude of impacts. So long as consistency of assumptions is maintained across policy options, different assumptions may not impact the relative order of policy choices.

While the results are sensitive to assumptions regarding the future value of groundwater and crop yield growth, they suggest that LEMA groundwater use restrictions may lead to economic benefits for both the producer and rural economies. The variation in subarea specific results is due to differences in initial hydrological conditions and dryland production options which determine how the irrigated crop mix varies over time and the rate at which irrigated cropland is converted to dryland production.

The adoption of a LEMA as a water conservation policy may reduce groundwater consumption in the short-run but will not reduce groundwater consumption over an infinite horizon. Even with rather severe reductions in groundwater use today, the subareas will remain over-appropriated and water saved today will eventually be used and the water resource exhausted.

This research is based on a LEMA that imposes a 20% water use restriction. A 20% water use restriction may not be appropriate for all areas of southwest Kansas. This research did not attempt to find the magnitude of a water use restriction which maximized cumulative net producer profit over the 61-year time horizon. Additional research is needed to define those values.

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Bridget L. Guerrero (corresponding author), Ph.D., received a Bachelor of Science in Agribusiness in 2002 and a Master of Business Administration in 2003 from West Texas A&M University. She earned her doctoral degree in Agricultural and Applied Economics from Texas Tech University in 2010. Bridget worked for the Texas A&M AgriLife Extension Service for 10 years prior to joining the Department of Agricultural Sciences in 2013 as an Assistant Professor of Agricultural Business and Economics at West Texas A&M University in Canyon, TX. Bridget's research interests include socioeconomic modeling, water policy, production agriculture, and renewable energy. She may be contacted at bguerrero@wtamu.edu.

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