Ogallala Aquifer
Funded by USDA ARS Research Initiative
A research consortium between USDA-Agricultural Research Service, Kansas State University, Texas AgriLife Research and Extension, Texas Tech University, and West Texas A&M University

Project Plan from FY2014
(Fiscal Years 2015-2016)

Title: Economic and policy implications of underground water use in the Southern Ogallala Region

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Summary/abstract
The analysis of alternative water conservation policies and scenarios is essential in providing information to policymakers within the region. The demand for economic analysis of groundwater conservation policy has expanded greatly in the past several years as a result of OAP funded projects and stakeholder outreach efforts. In order to provide accurate and timely results, it is necessary to have economic policy analysis models that are both easily adaptable and well versed in the information that they use and provide. Existing economic models constructed under the OAP project have been useful in analyzing broad policies for the Southern Ogallala Region. However, the models and tools used by the economic team need to be updated in order to provide more specific information that stakeholders are seeking and maintain consistency with the current literature. This project will allow for several important updates and enhancements to existing economic policy analysis models.

Project narrative
Objective:
The objective for FY14 is to update the economic policy analysis tools, as has been requested by several stakeholders within the Southern Ogallala Region**.** The objective for CY14 specifically is:

1) Develop, refine, and validate economic policy analysis tools by incorporating recent data changes and flexibility in linking with other models such as risk, climate variability, and hydrology and analyze a baseline scenario (status-quo with the exception of water use restrictions) (Objectives 3 and 4);

Rationale/Literature Review/Conceptual framework
In 2002, the economic team of the OAP began the development of intertemporal dynamic models which have been used extensively in policy development and analysis throughout the Southern Ogallala Region (Amosson et al., 2014, Golden and Johnson, 2013; Golden et al., 2008; Weinheimer et al., 2011a;2011b). While these models have

been utilized and widely accepted, stakeholders and policymakers have requested model improvements and updates. These updates will make the models consistent with the current literature. This will also be a springboard for future external funding in the water policy area. Model updates will allow for more sophisticated analysis under alternative policies and changing conditions, such as the introduction of new drought tolerant crops to the region, possible increases in irrigated acreage due to CRP contract terminations, varying climatic conditions, and the potential for cover crops to reduce soil erosion and enhance air quality.

<u>How the objective will be met</u>
There were two types of economic models used in previous policy analyses. The economic optimization models consisted of individual models for each of the counties in the study area that estimate changes in the aquifer and farm net income over a 60-year planning period using the general algebraic modeling system (GAMS). Then, socioeconomic IMPLAN models evaluated impacts on the regional economy and employment. These models will be updated using MATLAB, which is a more versatile, and widely accepted, modeling software. In addition, various data parameters including current prices, costs of production, irrigated acres, crop mix, production functions, and hydrologic information will be updated. Information needed to develop production functions and the necessary hydrological data will be obtained from appropriate OAP researchers.

The models will also incorporate enhanced capabilities to allow the analysis of a theoretically correct estimation of crop mix and the option to incorporate measures of risk, community economic impacts, and valuation of conserved groundwater into the objective function. Finally, production functions will be enhanced with weather/climate variability and technological growth projections.

Changes in future crop mix will be estimated using Positive Mathematical Programming (PMP). This approach calibrates models using historical data without ‘flexibility’ constraints (Howitt, 1995). The benefits of this technique are two-fold. First, it allows the model to be calibrated to the existing data. Secondly, it eliminates the need for ‘ad-hoc’ flexibility constraints to simulate potential changes in decision variables. Adoption of PMP provides a theoretically sound method to model the dynamic changes of crop choice by producers.

Past models assume that the producer has a single objective function, which is profit maximization. The assumption that a producer has only this objective may be too simplistic to adequately mimic producer decisions in an environment where uncertain crop yields and prices induce risk associated with the expected profit. In particular, producer decisions are best described as “trading off” risk and profit. Consequently, producers often will accept a crop-land-water combination that generates a lower than maximum expected net return if the combination also generates less risk. Additionally, management decisions (crop insurance selection, forward contracting and hedging, the quasi-fixed nature of some input, and marketing loan programs) may lead to the distributional mean (expected value of net returns) being different from the simple computation of expected yield times expected price less expected cost. As such, two modules will be incorporated into the revised model. One module will allow sensitivity analysis of key variables such as prices and discount rates. The second module will allow for Monte Carlo simulations, which is essentially a repetitive/iterative “what-if” game. A single iteration answers the question: What would the net return for the crop-land-water possibility have been if the yield had been equal to the simulated yield, where the simulated yield may be different from the expected yield? Practically speaking, a single iteration in our Monte Carlo procedure represents a single year that is as likely to occur as any other possibility. Historic price, cost yield, and weather data will be used to define the probability distributions needed for the Monte Carlo simulation.

As previously stated, measures of producer profit have historically defined the objective optimization function. Recent research by our team suggests that conservation policies which maximize long-run producer profits may not maximize the long-run welfare of rural communities (Golden and Johnson, 2013). In this research we will incorporate IMPLAN multipliers into the intertemporal model which will allow a module to be developed to incorporate measures of regional economic welfare into the objective function of the optimization process. All IMPLAN datasets for the region will be updated by county to include new data from the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, the U.S. Census Bureau, the U.S. Department of Agriculture, and the U.S. Geological Survey. This will allow for a more current status of the interrelationships of agricultural industries with the regional economy.

It is relatively straight-forward to compare the differences in variables such as producer revenues, well capacity and saturated thickness. However, much of our outreach modeling considers policies which restrict water use relative to a status quo scenario and results in less total groundwater consumed. In most temporal allocation studies, economists very rarely estimate the value of the remaining conserved groundwater (Amosson et al., 2009; Golden et al., 2008). This may be because from a purely agricultural production economics standpoint, groundwater has no value until it is brought to the surface and used to produce agricultural products. Amosson et al. (2006) suggests 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. Based on stakeholder input, this research will develop a module which will place a value on the conserved water.

The ability of the aforementioned objective functions to accurately predict crop-land-water choices is a function of the quality of the crop production functions used for analysis. Improved production functions will be developed using Decision Support System for Agrotechnology Transfer (DSSAT), incorporating climate variability and technological growth rates.

Uncertainty regarding future meteorological conditions generates uncertainty with respect to crop need for, and response to, applied water resources. We will therefore incorporate projections of meteorological data for the study region into the development of crop production functions. Meteorological data, including temperature and precipitation, will be obtained from downscaled global climate models of the Intergovernmental Panel on Climate Change (IPCC). Production functions will then be generated for multiple periods into the future.

For several decades there have been significant adoptions of new crop varieties and cultural practices. The more recent adoption of biotechnology (virus resistant, herbicide resistant, and insect resistant crops) has allowed producers to increase yields and decrease input use. Currently there are drought resistant biotechnology-derived crops being marketed. These advances have increased yields in crops produced in the area overlying the Ogallala aquifer. Technological advances have proven successful in the ability to increase yield per acre while holding water use constant. In some instances, the these advances have induced producers to increase their water use, contributing to an wider spread between irrigated crop yields and non-irrigated yields. Given the expectation of an increasing positive differential between irrigated and non-irrigated crop revenues, it is relevant to create a module that will model this possibility. There has been little economic research aimed at quantifying the growth rate differential between irrigated and non-irrigated crop yield and/or revenues. The development of this module will be an important addition to the literature.

The proposed methodology is economically sound based on the previous reviews of economic researchers.

Expected outcomes

The results of this project will be shared through peer-reviewed papers and professional meetings within the scientific community. To ensure that results are disseminated to stakeholder groups, the analysis generated will also be presented in multiple meetings specifically designed to target legislative, regulatory, and producer groups. This research will primarily be used to educate and enlighten stakeholders as to the ramifications associated with alternative water conservation policies, including direct, indirect, unexpected, and external impacts of those policies.

Relevant Publications

Amosson, S., L. Almas, B. Golden, B. Guerrero, J. Johnson, R. Taylor, and E. Wheeler-Cook. "Economic impacts of selected water conservation policies in the Ogallala Aquifer." *Ogallala Aquifer Project* (2009): 50.

Golden, B., and J. Johnson. "Potential economic impacts of water-use changes in Southwest Kansas." *Journal of Natural Resources Policy Research* 5.2-3 (2013): 129-145.

Guerrero, B., S. Amosson, and L. Almas. "Integrating stakeholder input into water policy development and analysis." *Journal of Agricultural and Applied Economics* 40.02 (2008).

Johnson, J., P. Johnson, B. Guerrero, J. Weinheimer, S. Amosson, L. Almas, B. Golden, and E. Wheeler-Cook. "Groundwater Policy Research: Collaboration with Groundwater Conservation Districts in Texas." *Journal of Agricultural and Applied Economics* 43.3 (2011): 345-356.

Tewari, R., L. Almas, J. Johnson, B. Golden, S. Amosson, and B. Guerrero. 2014. “Multi-year water allocation: an economic approach towards future planning and management of declining groundwater resources in the Texas Panhandle.” *Texas Water Journal*. 5(1):1-11.

Literature Cited/References

Amosson, S. H., L. K. Almas, F. Bretz, D. Gaskins, B. Guerrero, D. Jones, T. Marek, L. New, and N. Simpson. “Water Management Strategies for Reducing Irrigation Demands in Region A.” Texas Water Development Board. (2006). July 2007. http://www.twdb.state.tx.us/home/index.asp.

Amosson, S., L. Almas, B. Golden, B. Guerrero, J. Johnson, R. Taylor, and E. Wheeler-Cook. “Economic Impacts of Selected Water Conservation Policies in the Ogallala Aquifer.” Kansas State University Agricultural Experiment Station and Cooperative Extension Service. Staff Paper No. 09-04 June, 2009.

Amosson, S., B. Guerrero, D. Mitchell, J. Johnson, and P. Johnson. “Evaluation of Changing Land Use and Potential Water Conservation Strategies: North Plains Groundwater Conservation District.” Texas A&M AgriLife Extension Service, West Texas A&M University, and Texas Tech University, January 2014. 25 pp.

Golden, B., & Johnson, J. (2013). “Potential Economic Impacts of Water Use Changes in Southwest Kansas.” *Journal of Natural Resources Policy Research*, 5(2-3):129-145.

Golden, B., J. Peterson, and D. O’Brien. “Potential Economic Impact of Water Use Changes in Northwest Kansas.” Kansas State University Agricultural Experiment Station and Cooperative Extension Service. Staff Paper No. 08-02 February, 2008.

Howitt, R.E. “Positive Mathematical Programming.” *American Journal of Agricultural Economics* 77(1995):329-342.

Weinheimer, J., P. Johnson, J. Johnson, B. Guerrero, and S. Amosson. 2011a. “Economic Impacts of Groundwater Management Standards in the Panhandle Groundwater Conservation District of Texas.” Texas Tech University and Texas AgriLife Extension Service. 28 pp.

Weinheimer, J., P. Johnson, J. Johnson, B. Guerrero, and S. Amosson. 2011b. “Economic Assessment of Proposed Groundwater Management Strategies in Groundwater Management Area 2.” Texas Tech University and Texas AgriLife Extension Service. 73 pp.

Schedule:

	1st Qtr CY15	2nd Qtr CY15	3rd Qtr CY15	4th Qtr CY15	1st Qtr CY16	2nd Qtr CY16	3rd Qtr CY16	4th Qtr CY16
1. Develop and refine policy analysis tools and analyze a baseline scenario.								
Data collection								
Model Development								
Model validation								
Run baseline scenario								
Publish & distribute results								