Potential Economic Impact of the Wichita County Local Enhanced Management Area for the 2007 – 2023 Time Period

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Study Objective

The purpose of this study is to provide the methods, assumptions, and estimates of the likely economic impacts associated with groundwater use reductions from conservation efforts in Wichita County Kansas, including the Wichita County Water Conservation Area (WCA, 2017), and in particular, the Wichita County Local Enhanced Management Area (LEMA, 2021). This will be accomplished by analyzing various data sources for the appropriate years.

Background

The Ogallala Aquifer is significantly over-appropriated. Past efforts to slow the decline and ensure the future economic viability of irrigated agriculture in the region have been largely unsuccessful. The 2012 Legislature passed 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 locally defined goals. LEMAs are proactive, locally designed, and initiated water management strategies for a specific geographic area and for a specific time period that are developed by a GMD and then reviewed and implemented by the Chief Engineer. Once approved by the Chief Engineer the LEMA plan becomes law, effectively modifying prior appropriation regulations for the LEMA period. 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.

In April 2015, the Legislature passed a bill to create Water Conservation Areas (WCAs), a simple, streamlined and flexible tool that allows a water right owner or group of owners the opportunity to develop a management plan to reduce withdrawals in an effort to extend the usable life of the Ogallala-High Plains Aquifer. While the underlying goals of WCAs, and LEMAs are similar, WCAs have the benefit of ease of implementation[1].

On March 7, 2017 a county-wide WCA plan was approved by the Chief Engineer for Wichita County, allowing water users to voluntarily enroll in the WCA, being provided its flexibilities in exchange for a commitment to conservation. The WCA includes 9,433 irrigated acres via these voluntary enrollments. Participants committed to a 29% decrease in groundwater use based on an average of 2009 – 2015 usage[2] during the first of four 7-year periods, and escalating conservation reductions in subsequent periods (up to 50% reductions in 2038)[3].

On February 2, 2021, the Chief Engineer of the Division of Water Resources, Kansas Department of Agriculture (DWR) signed an Order of Designation creating the Wichita County Local Enhanced Management Area (LEMA) as submitted by the Western Kansas Groundwater Management District No. 1 (GMD1). The Wichita County LEMA will be in effect through December 31, 2025. The LEMA plan calls for reductions in water use in those areas of Wichita County within GMD1. Details about the LEMA plan are available in the 2021-2025 Wichita County LEMA file[4]. The plan required most users to reduce groundwater use by 25% based on an average of 2009 – 2015 usage[5]. In 2022 approximately 47,000 irrigated acres were included in the LEMA. Figure 1 illustrates GMD1 and the Wichita County LEMA area (as well as the more recent Four County LEMA, implemented in 2023 for the remainder of the District).

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1 Source: Water Conservation Areas (WCAs) | Department of Agriculture (ks.gov)

2 Source: https://www.gmd1.org/lema/

3 Source: https://www.gmd1.org/documents/wichita_county_wca.pdf

4 Documents tables are available at https://www.agriculture.ks.gov/divisions-programs/division-of-water-resources/managing-kansas-water-resources/local-enhanced-management-areas/wichita-county-lema

5 Source: https://www.gmd1.org/lema/

The Wichita County Local Enhanced Management Area Order of Designation requires annual reviews of the LEMA. It indicates that the Review Board shall conduct a more comprehensive review in the fourth year of the LEMA Period. The review will focus on the economic impacts, as data is available.[6] This analysis will assist in determining the economic impacts.

Data

Water Rights Information System

Data was obtained from the Kansas Water Right Information System (WRIS) for 2007 to 2023. The WRIS dataset provides time series data on each point of diversion (PDIV), typically a single water well. Producer-generated annual water use reports provide the basis for the WRIS dataset. For each PDIV the dataset includes total annual acre-foot groundwater usage, total acres irrigated, and crop type. The crop type is listed as a code number - for example the crop code for a field that is 100% corn is '2' and the crop code for a field that that has both corn and wheat is '25'. In this report, all mixed crop or minor crop designations are all referred to an 'Other', except for crop code '25'. Table 1 lists the crop name and frequency in the WRIS data set used in this report. Unfortunately, producers only report total acre-foot groundwater usage for a mixed crop field, and no reasonable method has been developed to allocate the total groundwater usage in acre-feet to individual crops. Therefore, when crop-specific groundwater usage is discussed below, only fields that were comprised of a single crop were included in the calculation.

The WRIS data set has a field titled *source*, which designates the source of water supply (G = groundwater, S = surface water). The data set used in this analysis includes only the data where the source was groundwater. The WRIS data set has a field titled *umw_code*, which designates the use of groundwater. The data set used in this analysis includes only the data where the use was for irrigation. The WRIS data set has a field titled *sua_name*, which designates the special use area name. The data set used in this analysis includes only the data where the special use area name was *Wichita County LEMA*.

Figure 2 illustrates the time series for irrigated acres. From 2007 to 2023 irrigated acres declined by 21.3%. Figure 3 illustrates the time series for groundwater use. From 2007 to 2023 groundwater use declined by 52.3%. Figure 4 illustrates the time series for average water use per acre. From 2007 to 2023 groundwater use per acre declined by 39.4%. These data highlight the need for groundwater use reductions in the area. Figure 5 illustrates the time series for irrigated acres by crop. These data indicate that the percentage of 'Other' crop acreage and 'Corn and Wheat' crop acreage has declined over the period while 'Corn' and 'Wheat' crop acreage has remained relatively stable. This finding is somewhat surprising because Buller (1988) and Wu, Bernardo, and Mapp (1996) suggest that, as groundwater use is reduced, producers will change crop mix by shifting from high water-use crops, such as corn, into crops with lower consumptive use. Figure 6 illustrates the time series for groundwater use by crop and Figure 7 illustrates the time series for average water use per acre by crop. These data indicate that for all crop categories total groundwater use and groundwater use per acre have been declining. Groundwater use per acre for 'Corn' has declined by 40.3% (based on the 5-year average comparing the 2007 – 2011 period to the 2019 – 2023 period). Surprisingly, groundwater use per acre for 'Corn and Wheat' generally exceeds that of 'Corn'. Additional research is needed to explain this finding.

[6] Source: https://www.gmd1.org/documents/WHC%20LEMA%20Order%20of%20Designation-FINAL%202.2.2021.pdf

Impact Analysis for Planning (IMPLAN) Data
Input-output (I-O) analysis is often used to estimate the impacts that changes in policy have on regional economies. Given estimates of direct economic impacts, software such as the Impact Analysis for Planning (IMPLAN) estimates endogenous linkages between production, labor and capital income, trade, and household expenditures, providing estimated effects on sector output, value-added, household income, and employment (MIG, 1999). IMPLAN is often used to analyze water-use impacts on agriculture (Deines et al. 2020, Golden and Guerrero 2017; Guerrero et al. 2013; Guerrero et al. 2017; and Benavidez et al. 2019).

IMPLAN's industry classifications are generally based on the North American Industry Classification System codes. There are 546 classifications in the IMPLAN data base. IMPLAN’s Industry data was collected for the 2007 to 2023 period. These county-level data provide information on employment, total industry output, and value-added. The employment data is based on the Bureau of Labor Statistic’s annual totals from the Quarterly Census of Employment and Wages. Total industry output, is the value of annual calendar year production (basically total revenues). It can be measured as the total value of purchases by intermediate and final consumers or as intermediate outlay plus value added. Output data for most sectors come from the BEA’s Annual Industry Accounts and the Annual Survey of Manufacturers. Retail output data come from the U.S. Census Bureau’s Annual Census of Retail Trade. Value added can be generalized as a sector’s total profit[7].

For the purpose of this analysis the IMPLAN sectors have been combined into three categories Crop Production, Livestock Production, and Total. Table 2 reports the IMPLAN sector codes included in each category. Table 3 reports the employment data, Table 4 reports the total output data, and Table 5 reports the value-added data used in this analysis. Several issues associated with these data need to be discussed. First, there are several industry classifications associated with Crop Production that have not been included in Table 2. IMPLAN reports data on cotton production, tobacco production, etc. These classifications were not included because all values were zero. Second, the reader should not assume that combining the Crop Production and Livestock Production figures provides a meaningful value of agriculture to the Wichita County economy. Combining these data underestimates the value of agriculture to the Wichita County economy. The purpose of this analysis is to estimate the impact that the LEMA has on the crop production sectors of the economy. As a result, sectors such as crop processing, livestock slaughter, and support industry trade have not been included.

The Livestock Production data is not used in this analysis. However, of interest is the relationship between the Crop Production and Livestock Production categories. On average the Livestock Production category employs 2.4 times the employment of the Crop Production Category. On average, the Livestock Production category generates 2.8 times the total industry output of that produced in the Crop Production category. On average, the Livestock Production category generates 2.9 times the value added of that produced in the Crop Production category. This result does not imply that the Crop Production category is not a vital part of the Wichita County economy; it is only that the Livestock Production category is significantly larger. This finding may suggest that when groundwater use is restricted, special consideration may be appropriate for the Livestock Production category.

IMPLAN does not distinguish between irrigated and non-irrigated crop production. As previously noted there are approximately 47,000 irrigated acres in Wichita County. There are

[7] Source: https://implan.com/wp-content/uploads/IMPLAN-Data-Overview-and-Sources.pdf

approximately 368,000 total cropland acres[8]. Approximately 13% of the cropland acres are irrigated, but a much larger percentage of revenue per acre comes from irrigated cropland. Additional research may be needed to account for these factors.

Precipitation Data

Precipitation is generally viewed as a critical determinant of crop yield, which impacts crop revenues and profits. Precipitation data for Wichita County was obtained from the National Oceanic and Atmospheric Administration (NOAA) data center. These data are illustrated in Figure 8. The graph depicts the annual precipitation and seasonal precipitation (April through September). These time series have a correlation coefficient of 92.4% during the study period, so either would be suitable for the analysis. Since there is substantial acreage of wheat (a winter crop) in the area, the annual precipitation data will be used in the analysis.

Crop Price Data

Crop prices impact both crop revenue and profit. For our purpose corn prices are considered a proxy for the price level of all crops. Corn prices were obtained from the Kansas State University Research and Extension Farm Management Guides. Figure 9 reports these data.

National Agricultural Statistic Service Data

The National Agricultural Statistic Service (NASS) conducts hundreds of surveys each year on issues such as agricultural production, economics, demographics and the environment. The Agricultural Yield survey provides farmer-reported survey data on expected crop yields. NASS data for irrigated corn yield was collected and illustrated in Figure 10. NASS data is often used to estimate trends and as input to economic models of groundwater use (Amosson et al., 2009; Hendricks et al., 2018).

These data compare irrigated corn yield for Wichita County to Southwest Kansas. As shown, these data are not reported every year, and the data was not reported after 2018. County-level data for Southwest Kansas was sparse. As a result, the NASS series for the entire area was used in this comparison. While the data does not help estimate the economic impact of the LEMA, it is none-the-less informative. The trend lines indicate that Southwest Kansas has generally higher yields. However, the slopes of the trend lines look remarkably similar. A simple t-test suggests that the slopes of the trend lines are not statistically different. The importance of this is that groundwater use on corn has declined significantly in Wichita County (Figure 7). In contrast corn yields have continued to increase. This finding is consistent with Golden and Leatherman (2017) and Golden and Guerrero (2020) findings that when faced with groundwater use reductions (either by mandate or normal aquifer declines) producers develop strategies to mitigate potential losses by increasing their input use efficiencies (for example, groundwater, fertilizer, and seed). Additional research is needed to verify that this hypothesis is relevant for Wichita County.

Wichita County Groundwater Use and Acreage Reduction

It is beyond the scope of this research to quantify the groundwater use reductions resulting from the implementation of the Wichita County LEMA. However, this research should note the success of the LEMA in reducing groundwater use. The data on groundwater use reductions are available from other sources. One such source is the Kansas Geological Survey (KGS). They report that on average there has been a 40% decrease in water use for similar climatic conditions[9]. Figure 11 illustrates the relationship between groundwater use and water level

[8] Source: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/cp20203.pdf

[9] Source: https://www.gmd1.org/wp-content/uploads/2024/09/Aug.-28.2024-WC-LEMA-OUTREACH-PCKT.pdf

change, before and after the LEMA & WAC[10]. Additionally, a recent KGS report[11] stated that total savings could be broken down to 23.9% from improved irrigation management, and 15.6% from decreased irrigated areas and other factors. Figure 12 illustrates the relationship between groundwater use and precipitation before and after the LEMA & WAC.

KGS indicated that as much as 15.6% of the groundwater use reduction could have come from a decrease in irrigated areas. A review of Figure 2 suggests a similar finding. Trend lines have been added to Figure 2. These trend lines indicate that during the years preceding the LEMA & WAC irrigated acres were declining at a rate of 2,853 acres per year. During the years after the LEMA & WAC irrigated acres were only declining at a rate of 648 acres per year. This might imply that the LEMA & WAC might have positively impacted the decline in irrigated acreage. Additional research is needed to confirm this hypothesis.

Data Analysis

This study considers four models to infer the impact of the LEMA on the local economies of Wichita County. The first two models consider the Total Industry Output (TIO) and Value Added (VA) at the county level. The second two models consider the Total Industry Output (TIO) and Value Added (VA) in the crop production sectors. In a regression model, the independent variables are the variables used to predict the outcome and are on the right side of the equation, while the dependent variable is the variable being predicted which is on the left side of the equation. Essentially, the equation states that the independent variables cause the dependent variable. The magnitude and direction of the impact of an independent variable on the dependent variable is estimated in a regression model as the beta (β) or variable coefficient (also called parameter).

The models are:

1) $TIO_{County} = \beta_0 + \beta_1 * TREND + \beta_2 * CommodityPrices + \beta_3 * Precipitation + \beta_4 * LEMAImpact + u_{TIO}$

2) $VA_{County} = \beta_0 + \beta_1 * TREND + \beta_2 * CommodityPrices + \beta_3 * Precipitation + \beta_4 * LEMAImpact + u_{VA}$

3) $TIO_{CropSector} = \beta_0 + \beta_1 * TREND + \beta_2 * CommodityPrices + \beta_3 * Precipitation + \beta_4 * LEMAImpact + u_{TIOC}$

4) $VA_{CropSector} = \beta_0 + \beta_1 * TREND + \beta_2 * CommodityPrices + \beta_3 * Precipitation + \beta_4 * LEMAImpact + u_{VAC}$

The independent variables in the models can be defined as: *Trend* is a time trend variable starting with 1 in the first year. The hypothesis is that economies tend to grow over time and the trend variable will capture this effect. *CommodityPrice* is the time series for corn prices in western Kansas and is a proxy for commodity prices. The hypothesis is that commodity prices impact crop revenues and profits and should have an impact on the economies. *Precipitation* is the time series for annual precipitation. The hypothesis is that precipitation impacts crop yield which impact crop revenues and profits and should have an impact on the economies. *LEMAImpact* is a binary variable (sometimes called a dummy variable) that has a value of zero for years 2007 to 2020, and a value one for years 2021 and 2023 (the years the LEMA was in effect). The parameter estimate on this variable will infer the magnitude and direction the LEMA had on the economies.

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[10] Source: Brownie Wilson of the Kansas Geological Survey shared this graph.
[11] Source: Summary of the 2023 Wichita County LEMA Annual Review available at https://www.gmd1.org/wp-content/uploads/2024/04/2023-Wichita-County-LEMA-annual-review-draft-2024-02-16-2-page-handout.pdf

The results of the regression models are reported in Table 6. In the table if a parameter estimate is not statistically significant the implication is that the parameter estimate is not statistically different from zero. The time trend is positive and statistically significant for both TIO and VA at the county level. However, it is not statistically significant at the crop production level. Commodity price is positive and statistically significant for VA at the county level, but is only positive and statistically significant for the VA model at the crop production level and negative and statistically significant TIO model at the crop production level. Precipitation is negative and statistically significant for TIO at the crop production level and not statistically significant for the other models. The LEMA impact parameter estimates are not statistically significant for any model suggesting the LEMA had no negative impact on the economies.

As previously mentioned, The Wichita County WCA started in 2017. The WCA encompassed 9,433 acres or approximately 20.0% of the LEMA area. These pre-LEMA reductions may impact the estimates generated by the previous models. It is appropriate to estimate models that include the pre-LEMA impacts associated with the WCA. The previously described models were modified by changing the *LEMAImpact* variable to *LEMA/WCAimpact* variable. The new binary variable has a value of zero for 2007 to 2016, and a value one for 2017 to 2023 (the years the LEMA and WCA were both in effect). The results of these regression models are reported in Table 7. These models confirm the results of the previous models in that there was no statistically significant impact due to the water use reductions for VA at the county level and TIO and VA at the crop production level. The model for TIO at the county level suggests a negative statistically significant impact. This may be a spurious result as it is difficult to explain why there is no impact on the crop production sector.

Conclusions and Recommendations

There is a limitation to this analysis. The analysis was performed with no economic data and no data that relates specifically to irrigated crop production. Information on the crop yield versus applied irrigation relationship that is normally used in a typical impact analysis was not available. While the use of IMPLAN data is a novel approach, given data limitations, it is a reasonable approach. However, with only three years of IMPLAN data available at this time, the models may generate unusual results. However, given the data available and model results, it can be concluded that, on average, the LEMA has not had a negative economic impact on the county or crop sector economies during the study period. It should be noted that the models indicated that the LEMA had no statistically significant impact on the economies modeled. This finding is not to say that some individual irrigated producers may have experienced economic losses.

In order to improve this analysis, three recommendations are needed. First, this analysis needs to be conducted annually as more IMPLAN data becomes available. Second, an effort should be made to combine the WRIS data base with the USDA-RMA crop yield data base. Finally, while not an economic analysis, the GMD1 might consider surveying producers in Wichita County to determine their subjective views on profitability before and after the LEMA.

Tables

Table 1. Frequency of the Crop Name in the WRIS Data Set for 2007 – 2023

Crop Name	Frequency
Other	17975
Corn and Wheat	3878
Corn	2622
Wheat	599
Grain Sorghum	336

Table 2. Designation of IMPLAN Industry Sector Codes

Industry Code	Description	Category
1	Oilseed farming	Crop Production
2	Grain farming	Crop Production
10	All other crop farming	Crop Production
11	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	Livestock Production
13	Poultry and egg production	Livestock Production
14	Animal production, except cattle and poultry and eggs	Livestock Production
All IMPLAN Sectors	All IMPLAN Sectors	Total

Table 3. IMPLAN Employment Data for Designated Categories

Year	Crop Production	Livestock Production	Total All Sectors
2007	101.18	299.37	1486.82
2008	108.39	269.31	1507.58
2009	107.61	252.79	1470.7
2010	108.38	258.45	1451.07
2011	109.76	268.71	1463.19
2012	106.48	243.57	1464.78
2013	85.75	250.34	1472.65
2014	90.93	276.79	1450.69
2014	90.93	276.79	1450.69
2016	98.75	277.78	1409.85
2017	83.14	270.49	1355.37
2018	110.06	243.49	1724.93
2019	119.72	238.15	1712.98
2020	137.41	229.01	1458.34
2021	167.05	229.71	1386.74
2022	155.33	260.51	1343.93
2023	45.96	279.32	1258.56
Average	107.46	260.27	1462.87
Percentage of Economy	7.35%	17.79%	100%
Correlation to Economy	17.79%	-35.20%	100%

Table 4. IMPLAN Total Industry Output Data for Designated Categories

Year	Crop Production	Livestock Production	Total All Sectors
2007	$59,703,547	$211,886,125	$405,322,389
2008	$73,581,019	$205,912,015	$410,742,980
2009	$73,143,136	$183,513,691	$405,930,142
2010	$86,161,660	$220,573,936	$478,151,440
2011	$77,502,600	$253,381,081	$508,002,495
2012	$91,996,672	$258,561,575	$555,726,394
2013	$78,598,928	$257,910,783	$621,168,942
2014	$73,500,113	$303,595,028	$616,562,931
2015	$68,557,856	$298,650,090	$578,322,223
2016	$72,161,806	$263,859,359	$545,686,930
2017	$68,288,240	$277,800,369	$534,983,223
2018	$73,980,955	$173,999,412	$527,823,856
2019	$83,337,013	$176,351,657	$580,860,936
2020	$97,719,471	$174,122,219	$492,746,815
2021	$133,700,624	$208,285,409	$560,198,765
2022	$107,394,336	$243,676,429	$584,965,426
2023	$83,871,777	$220,621,242	$496,835,623
Average	$82,541,162	$231,335,319	$523,766,560
Percentage of Economy	15.76%	44.17%	100%
Correlation to Economy	28.66%	52.82%	100%

Table 5. IMPLAN Value Added Data for Designated Categories

Year	Crop Production	Livestock Production	Total All Sectors
2007	$15,155,555	$49,636,754	$112,830,402
2008	$20,067,004	$53,646,420	$127,842,639
2009	$19,853,798	$49,474,429	$126,579,597
2010	$20,635,245	$58,984,493	$142,619,518
2011	$28,246,843	$82,835,966	$174,498,228
2012	$32,759,740	$64,851,378	$165,617,664
2013	$26,134,430	$114,490,089	$216,687,841
2014	$19,260,212	$69,596,158	$162,324,908
2015	$21,284,031	$53,602,956	$146,086,549
2016	$19,771,243	$63,032,712	$154,381,773
2017	$16,765,778	$51,568,150	$140,441,712
2018	$18,690,514	$30,246,967	$159,587,924
2019	$14,362,709	$44,837,159	$167,319,872
2020	$2,578,558	$43,147,271	$134,942,569
2021	$18,802,724	$48,443,382	$150,318,601
2022	$21,204,106	$57,129,317	$164,292,888
2023	$25,840,693	$52,064,828	$166,779,928
Average	$20,083,128	$58,093,437	$153,714,860
Percentage of Economy	13.07%	37.79%	100%
Correlation to Economy	51.43%	70.29%	100%

Table 6. Regression Results for LEMA Impact.

Variable	Description	TIOcounty Parameter Estimate	VAcounty Parameter Estimate	TIOcrop prod Parameter Estimate	VAcrop prod Parameter Estimate
Intercept	Intercept	306564016.5*	33607988.6	156120072.8*	-14739994.4*
Trend	Time Trend	11455341.1*	2675973.5*	529047.7	-483741.2
Commodity Prices	Corn Price	27553548.3	19107068.1*	-7722884.0*	6125009.7*
Precipitation	Annual Precipitation	58198.8	655264.6	-2669781.3*	568761.9
LEMA Impact	Impact of LEMA	-86302116.1	-25882075.3	28113040.1	3233865.6
R2	Degree of Fit	46.2%	54.9%	69.8%	68.2%

* Statistically significant at the 10% level

Table 7. Regression Results for LEMA & WCA Impact.

Variable	Description	TIOcounty Parameter Estimate	VAcounty Parameter Estimate	TIOcrop prod Parameter Estimate	VAcrop prod Parameter Estimate
Intercept	Intercept	466,432,909.0*	67,665,118.1	133,301,545.9*	-15,938,094.9
Trend	Time Trend	17,686,890.0*	2,851,686.8	2,066,257.1	-132,972.9
Commodity Prices	Corn Price	-2,132,135.9	13,426,840.0*	-4,842,060.9	6,125,330.4*
Precipitation	Annual Precipitation	-2,328,478.6	281,021.7	-2,611,850.1*	540,339.8
LEMA/WCA Impact	Impact of LEMA/WCA	-122,963,348.2*	-17,291,794.1	-1,206,824.4	-2,150,863.2
R2	Degree of Fit	51.2%	48.4%	50.1%	66.9%

* Statistically significant at the 10% level

Figures

Figure 1. Wichita County LEMA Area

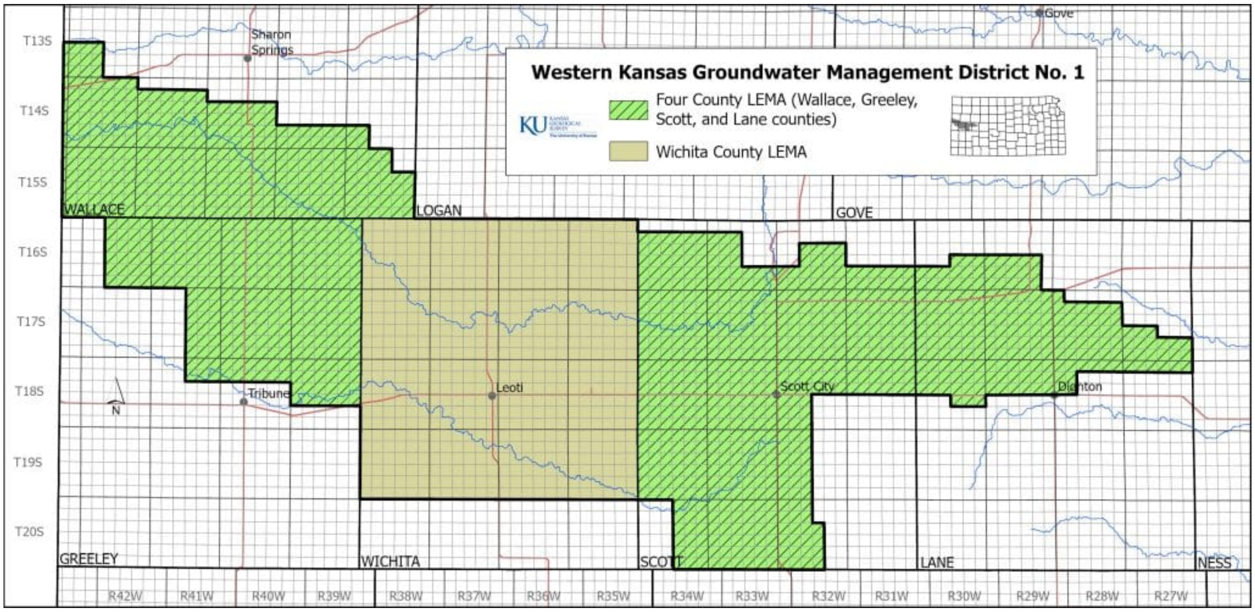


Figure 2. Wichita County LEMA Irrigated Acres with Trend Lines

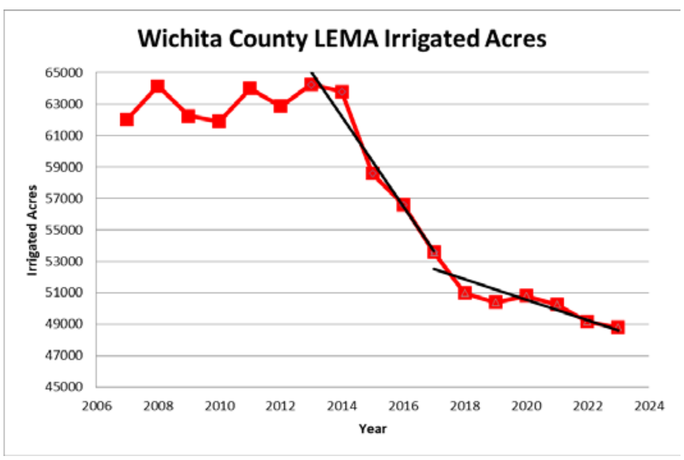


Figure 3. Wichita County LEMA Groundwater Use

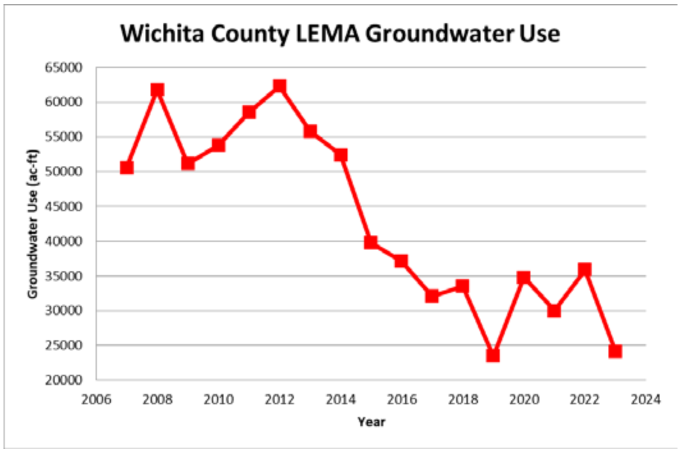


Figure 4. Wichita County LEMA Groundwater Use per Acre

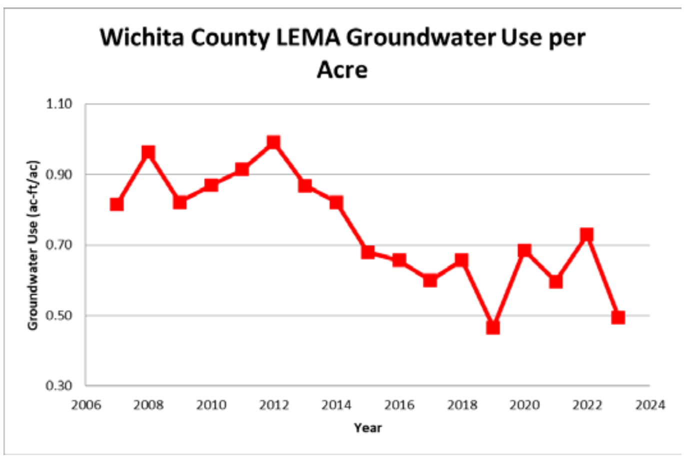


Figure 5. Wichita County LEMA Irrigated Acres by Crop

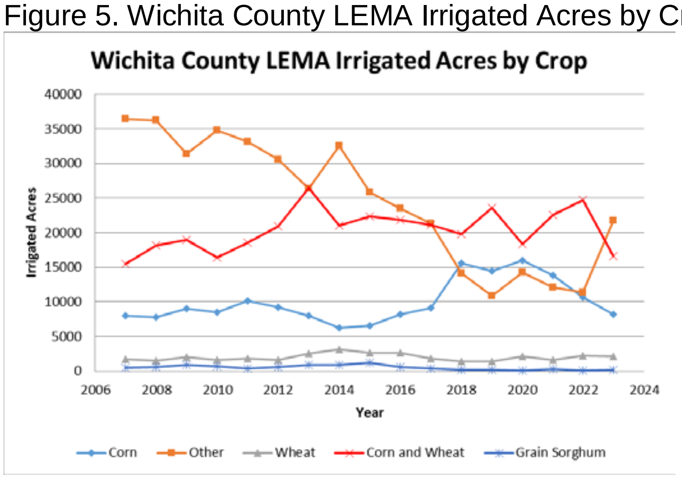


Figure 6. Wichita County LEMA Groundwater Use by Crop

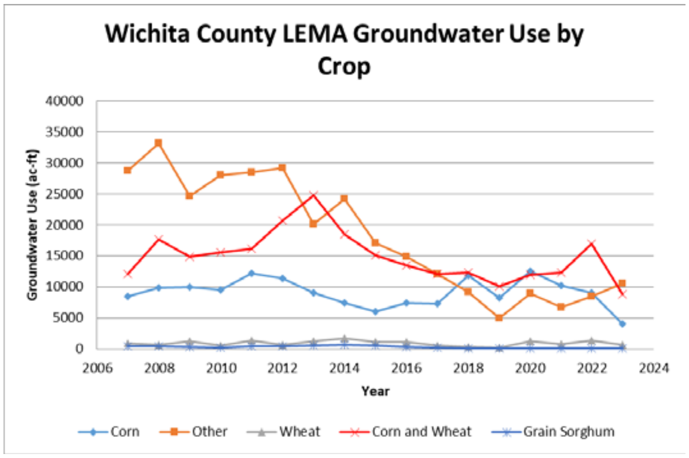


Figure 7. Wichita County LEMA Groundwater Use per Acre by Crop

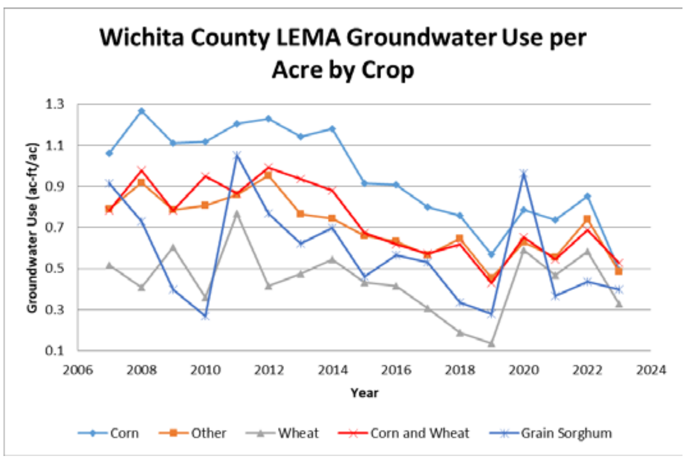


Figure 8. Wichita County Precipitation

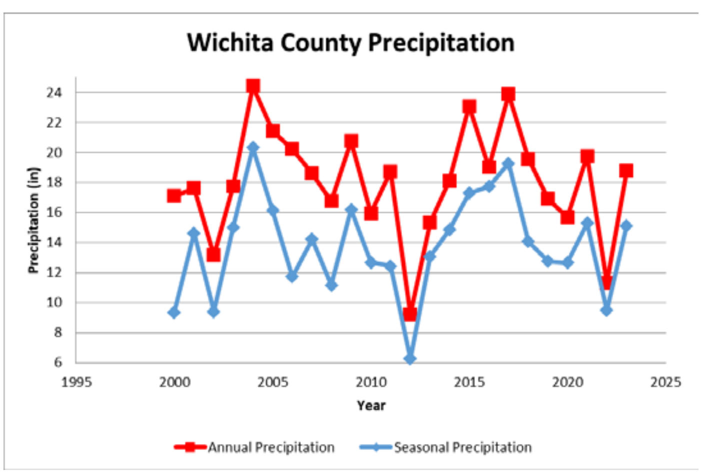


Figure 9. Corn Prices for Western Kansas

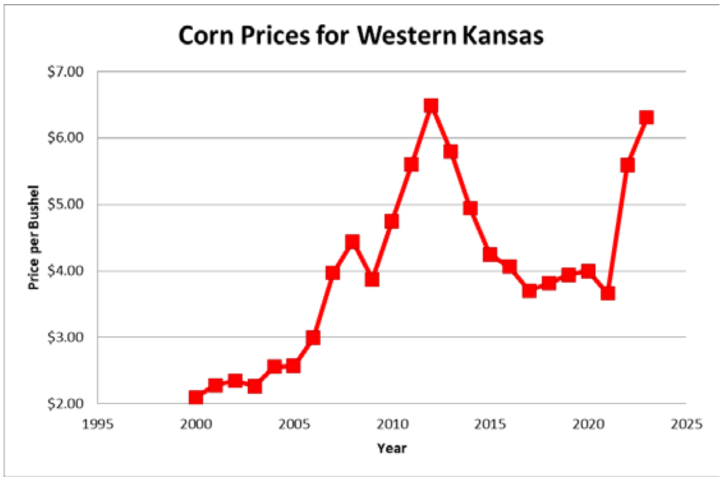


Figure 10. NASS Irrigated Corn Yield Data

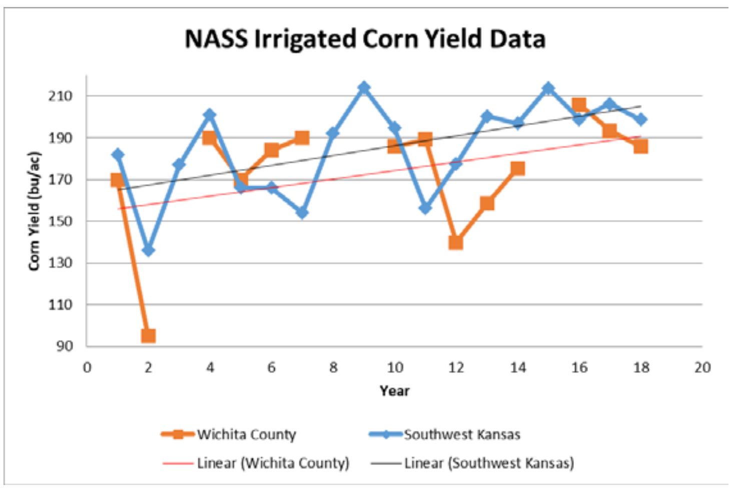
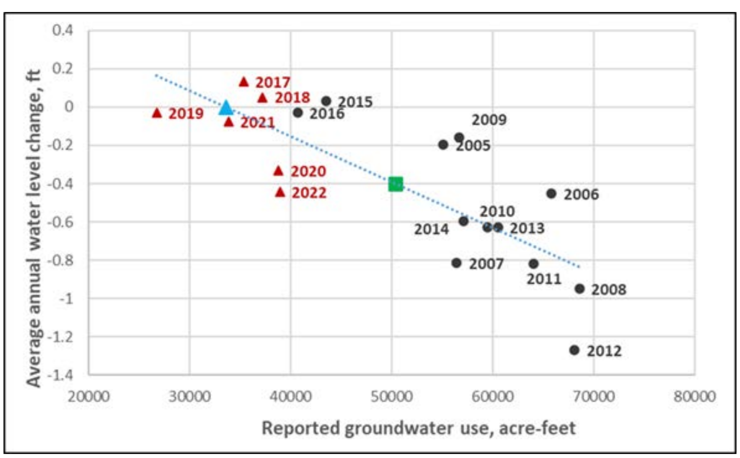
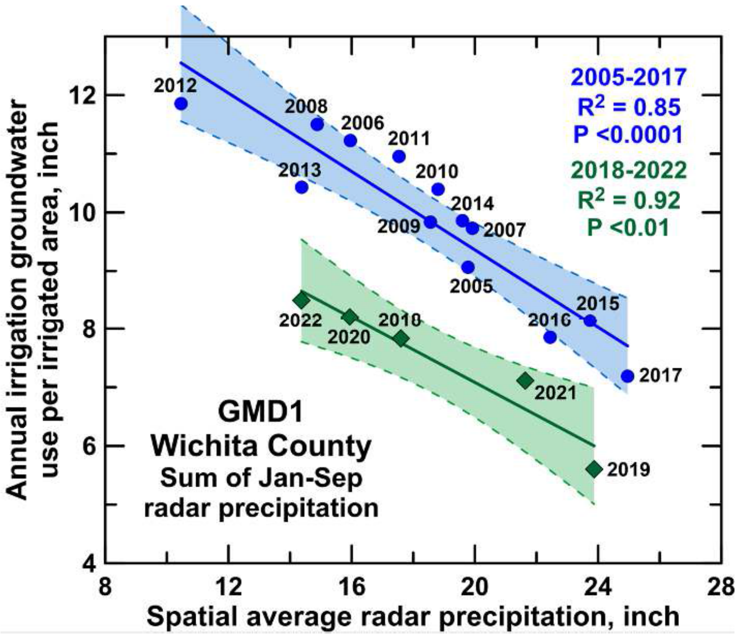


Figure 11. The Relationship Between Groundwater Use and Water Level Change



Source: Brownie Wilson of the Kansas Geological Survey shared this graph.

Figure 12. The Relationship Between Groundwater Use and Rainfall



Source: Summary of the 2023 Wichita County LEMA Annual Review available at https://www.gmd1.org/wp-content/uploads/2024/04/2023-Wichita-County-LEMA-annual-review-draft-2024-02-16-2-page-handout.pdf

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