IRRIGATION DEVELOPMENT, ADJUSTMENTS AND IMPLICATIONS FOR NORTHWEST KANSAS

by

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CHAPTER I

INTRODUCTION

Irrigation development is one of the major changes currently influencing the agriculture of western Kansas. This adjustment is particularly evident in northwest Kansas where extensive irrigation only recently has been developed.

Water for irrigation in northwest Kansas comes chiefly from ground water sources which are of limited extent. Therefore, an economic problem of obtaining maximum benefits from a fixed resource is implied. There are various economic models available to solve this sort of problem if adequate input-output data are available.

In the case of the study area selected there was not sufficient data available to apply an economic model. Therefore, a more basic type of analysis seemed to be required in order to determine what adjustments have been taking place in the irrigation and what data were available. From this it could then be determined what additional data and information would be required to study more precisely the existing situation and conditions, and subsequently, provide the input requirements for an economic model.

The purpose of this study, then, is to collect available data to describe irrigation in the study area, the adjustments that have occurred, the adjustments that are likely to occur, and the implications of these adjustments in order to provide a basis for additional research and data collection. From this should come the economic model designed to allocate optimally a limited natural resource--ground water--in order to maximize the benefits available from it.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

For this study the area selected was the twelve counties of northwestern Kansas as shown on the map in Figure 1. They are Cheyenne, Decatur, Gove, Graham, Logan, Norton, Rawlins, Sheridan, Sherman, Thomas, Trego, and Wallace.

There are several reasons for this selection. Irrigation development in the study area has been much more recent than in the other irrigating districts of the state, chiefly southwest Kansas. Therefore, by selecting this study area investigation and research are not unduly complicated by differences in time of development. Also, as the study area has only recently been developed extensively for irrigation, little research and study have been devoted to the area and consequently, a descriptive study such as this one is more in order. A considerable amount of work has been completed for southwest Kansas and some other type of study would be more appropriate for that area.

The study area could have been extended westward into Colorado since the aquifer is involved and approximately the same topography, soil type, and climate prevail. However, this area was not included in this study due to a time restriction and the difficulty of obtaining data from out-of-state sources.

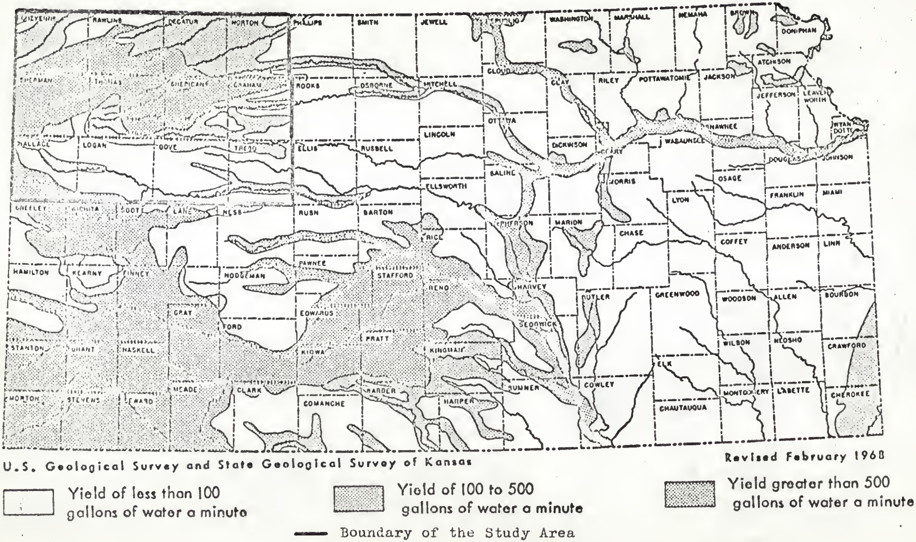

Figure 1. General Availability of Ground Water in Kansas

Turning to the physical characteristics of the area, the climate has been characterized as dry sub-humid to semi-arid. Rainfall averages range from 16 inches in the extreme northwest to 22 inches along the eastern edge of the area. Of this rainfall, most of it (78 percent) falls in the period April to September, thus creating a relatively favorable growing season considering the limited amount of rainfall. As for reliability, 28 inches, 20 inches, and 12 inches of rainfall can be expected with an annual 10, 50, and 90 percent chance, respectively.[1]

Temperature averages 53 to 55 degrees on an annual basis and 67 to 70 degrees for the period April through September. The growing season (average number of freeze free days) ranges from 150 to 165 days with the average date of the last 32°F. in the spring being April 30 to May 5 and the average date of the first 32°F. in the fall being October 5 to October 10. (These dates represent a 50 percent chance that a freeze will occur either earlier than or later than that date.)[2]

Winds are frequent in the study area. The weather bureau station at Goodland reports an average wind velocity of 12.4 miles per hour calm winds 6.1 percent of the time. The wind and temperature combine to create a rather high evapotranspiration rate. One measure of this is the average annual lake evaporation (a measure of the evaporation rate when water is freely exposed for evaporation) which is 55 inches for the area. For

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[1]Kansas Water Resources Board, A Kansas Water Atlas, pp. 10-13.

[2]Ibid., pp. 16-17.

western Kansas as a whole 95 percent of the water that falls as rain is returned to the atmosphere by evapotranspiration.[3]

The study area is in the Great Plains Province of the Interior Plains, and the name adequately describes the topography. Local changes in elevation seldom exceed 100 feet except along some stream courses and a few other isolated areas. According to estimates of the Kansas Water Resources Board, 6,280,698 acres of the 7,197,241 acres of agricultrual land are suitable[4] for irrigation. Of this total, 2,179,048 acres are over ground water regions capable of producing well yields of more than 500 gallons per minute and 4,373,225 acres are over ground water regions capable of producing more than 100 gallons per minute from a well.

The soil types found in the study area are Chestnut, Chernozem, and Brown. All of these soils exhibit an accumulated calcium carbonate layer reflecting their development under dry climatic conditions. As a result, these soils are generally well supplied with base elements. With sufficient water these soils are very productive, especially the Chernozems, which are characterized as "... among the most productive soils of the world."[5]

The ground water geology of the area is described by the following paragraphs:

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[3]Ibid., pp. 22-24.

[4]Suitable is defined as Classes I to IV and some Class VI land as classified by the Soil Conservation Service.

[5]Louis M. Thompson, Soils and Soil Fertility, p. 154.

"The principal water-bearing formation or 'aquifer' supplying water to the wells in the area is called the Ogallala Formation and consists of sand, silt, clay, gravel, and caliche, and resistant ledges called mortar beds, composed of sand and gravel cemented with calcium carbonate. This formation was deposited by streams flowing generally eastward from the Rocky Mountain region. The streams carried heavy loads of material and as the gradients and velocities decreased, the streams deposited their loads, filling their channels and forming broad flood plains. However, later erosion removed the Ogallala between Limon, Colorado, and the Rocky Mountains so that the deposits of the Ogallala are no longer connected with that region, and therefore this area receives no recharge from the mountains, our only source being from precipitation falling upon the area underlain by the Ogallala. The Ogallala deposits underlie much of the surface of the High Plains and extend from Texas to South Dakota in a belt several hundred miles wide.

Additional supplies of ground water are obtained from the more recent deposits called the alluvium. The alluvium, which is derived chiefly from the Ogallala Formation, occurs as channel deposits in streams. Irrigation wells penetrate both the alluvium and Ogallala Formation where the Ogallala is present."[6]

The land surface, water table, and bedrock surfaces slope generally eastward through the study area. The area between the bedrock surface and the water table is called the "saturated thickness," "aquifer," or "zone of saturation" and contains the stock of ground water held in storage and available for pumping. Actually, this water is moving laterally through the zone of saturation in the direction of the slope, but the movement is slow enough that for most purposes it may be considered relatively fixed and therefore in storage. Figure 2 is a map of the saturated thickness of the Ogallala Formation and alluvial deposits,

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[6]Dr. Frank C. Foley, "Ground Water in Northwestern Kansas," text of a speech presented at the meeting called by the Agriculture and Livestock Committee of the Kansas Legislative Council at Colby, Kansas, on October 3, 1967.

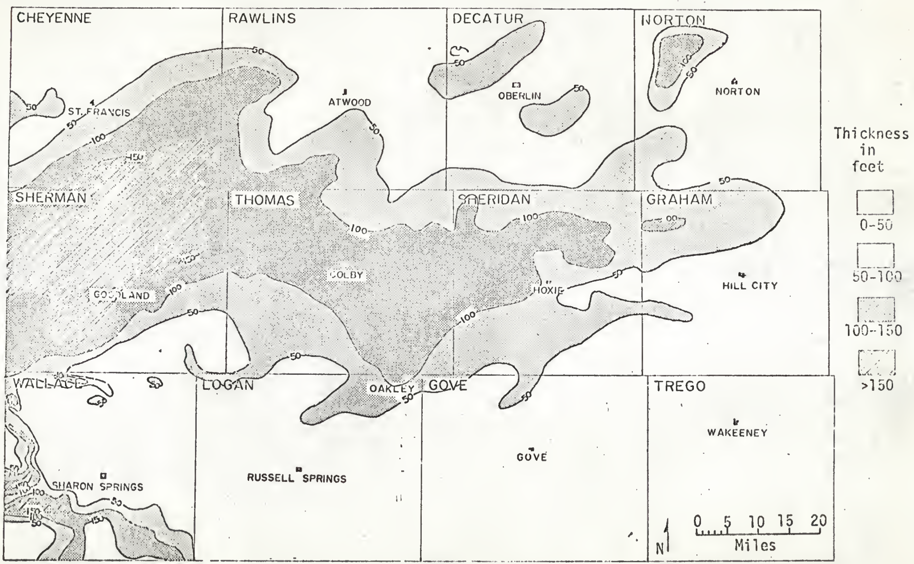

Figure 2. Saturated Thickness of Unconsolidated Deposits in Northwest Kansas

ranging from zero to 150 feet. Comparison of Figure 1 and Figure 2 will show the close relationship between the saturated thickness and the general availability of ground water.

As for the hydrology of the area, the supply of water comes from four sources--precipitation, inflow in the rivers, the movement of ground water in from the west, and the ground water in storage. The precipitation in the area was discussed earlier. The stream inflow is relatively unimportant in the area and very little surface water is used for irrigation. The amount of ground water that flows into the area is very difficult to estimate. However, it is known that ground water movement is very slow--only several hundred feet per year--so this is not a large supplier of ground water.

The ground water in storage is the result of years of accumulation. Part of it has come from precipitation to the west of the area that soaked down to the zone of saturation and began to move slowly eastward. Another part of it came from precipitation in the area that was able to move down through the soil to the aquifer, and it has not yet moved eastward out of the area. Lastly, some water enters the aquifer from streams that lie above the level of the water table.

The quantity of ground water in storage in the area is estimated to be 60 million acre-feet. Of this about 60 percent could be withdrawn feasibly for irrigation. It should be pointed out that any of these methods of recharging are extremely slow as compared to the present means available for withdrawal of ground water.

There are several ways for the water to go back into the atmosphere. Part of the water that falls as precipitation goes into the ground. Of this, the major part moves back to the atmosphere through evapotranspiration. The other part percolates down through the soil to become part of the aquifer. Assuming one-half inch per year recharge, this would amount to 100,000 acre-feet per year for the area if all other natural discharges and other losses were stopped.[7]

Of course, the part of the precipitation that is not absorbed into the soil becomes surface runoff and finds its way into the streams and rivers. Only the South Fork of the Republican normally contains any water flowing into the area, and the total outflow is estimated at 150,000 acre-feet per year (including ground water discharge)[8], most of which is runoff originating in the area. These water courses eventually take the water to the Gulf of Mexico where it is evaporated back into the atmosphere.

Lastly, water that is pumped from the aquifer for irrigation either enters the atmosphere through evaporation and evapotranspiration or percolates back down through the soil to the aquifer. The amount of water that is able to percolate back into the soil depends on the type of irrigation and soil characteristics. Light sprinkler applications on a "tight" (clay) soil would lose very little water through percolation. Flood type systems on sandy soils would have very high (possibly 50 percent or higher) percolation losses.

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[7]Ibid.

[8]Ibid.

The economy of the area can be described as chiefly agricultural. The 1964 Census of Agriculture listed 6,903 farm operators and 24,527 persons in farm operator households out of a total population of 64,912[9] for the twelve county area. Including the services required by these farm units and the agriculturally-related suppliers, it is quite apparent that agriculture is the primary industry in the area. For 1964 the total value of farm products produced was 108,625,140 dollars.[10] By 1966 this value had reached 141,070,310 dollars.[11] For the same time period the area total had moved from 8.77 percent to 9.31 percent of the state total. Much of this increased value of production can be explained by the increased production as a result of irrigation. Of course, the increased irrigation has created additional demands for agricultural inputs such as capital and fertilizer in the area and made the agricultural sector even more important.

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[9]Kansas State Board of Agriculture, "Population of Kansas," January 1, 1964 as reported by county assessors, mimeographed.

[10]Kansas State Board of Agriculture, 1964-65 Kansas Farm Facts, pp. 14F-15F.

[11]Kansas State Board of Agriculture, 1966-67 Kansas Farm Facts, pp. 16F-17F.

CHAPTER III

IRRIGATION DEVELOPMENT

Historically, irrigation on a limited scale has been present for quite some time in northwest Kansas. In fact, the first recorded irrigation by a white man in Kansas was by Mr. Joe McAdams of Northfield in Sherman County in 1875. Mr. George Alloman of Wallace County in 1879 was reported to be the third.[1]

Another account of early irrigation development in the area comes from the writings of Mr. Simon E. Matson[2] of St. Francis in Cheyenne County. According to Mr. Matson an irrigation company was formed in 1891 for the purpose of constructing an irrigation ditch to draw water from the South Fork of the Republican River. Two ditches were eventually built, the longer one being 70 miles long and running from two miles inside the Colorado border to three miles south and two miles east of St. Francis. The project was completed in 1892 at a cost of more than 200,000 dollars. However, the company failed due to the lack of interest and financial support when the supply of water proved insufficient in the summer months.

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[1]Walter H. Schoewe, "The Geography of Kansas," Part III, Transactions, Kansas Academy of Science, Vol. LVI, No. 2, 1953, p. 177.

[2]Simon E. Matson, "Early Day Reminiscence and Latter Day Observations," 1953.

Most of the irrigation up until the middle 1940's was on small tracts, often just gardens, supplied water by windmills pumping from relatively shallow depths. It was not until after approximately 1950 that irrigation of large acreages became economically and technologically feasible with the development of more efficient pumping and power units. Other factors such as the desire to reduce weather risks in production and the need for expanded production per farm unit have speeded the development.

Before examining the available data on irrigation in the study area, some comments concerning the sources of data are in order. There are three chief sources of data readily available--the Census of Agriculture conducted by the U.S. Department of Commerce, the Kansas State Board of Agriculture, and the county agent reports summarized by the Extension Service at Kansas State University. Of course, data collection is by no means an exact science and different methods of data collection will yield different data values. Each of these agencies uses different methods, and as could be expected, their data are not identical. However, generally speaking their data values were in a fairly constant relationship to each other. For example, Figure 3 shows the acreage of irrigated wheat in Kansas as reported by the various agencies. While they all appear to reflect the same trend, it is also obvious that they are not identical.

The reader should now be aware that precise calculations and conclusions are not possible on the basis of the available data, but that only general trends and adjustments could be studied. The reader should also be informed that the U.S. Census of Agriculture source is used

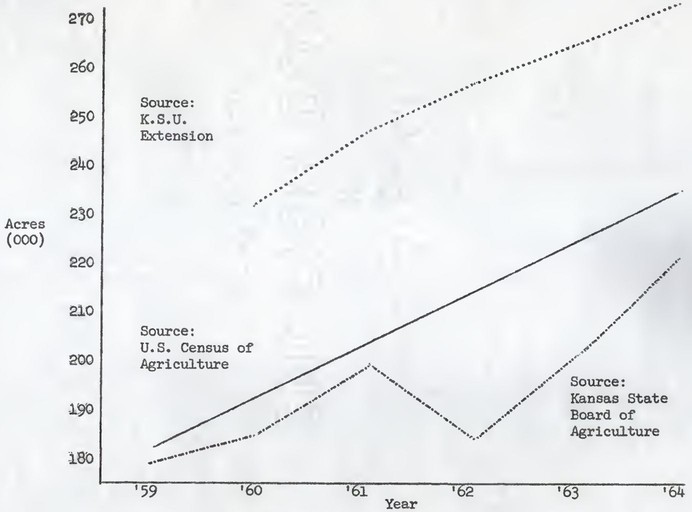


Figure 3. Irrigated Wheat Acreage in Kansas

most often in this study because of its completeness, consistency and method of enumeration, and even though it has obvious deficiencies, e.g., comparatively long time intervals.

Appendix 1 contains the basic data on land area, land in farms, number of farms, land irrigated, crops, yields, and ground water applications approved for irrigation.

Some explanation in addition to that on the individual tables is in order. Census data is satisfactory for looking at trends in numbers of farms, land in farms, land irrigated, and this type of criteria because the changes tend to be in the same direction and relatively uniform over time due to the fixed nature of these items. However, it can be argued that census data is not useful for looking at trends in acreages of specific crops and crop yields as these items are more subject to change and fluctuations. Specifically, factors like weather variability, price expectations and governmental policies change these values from year to year.

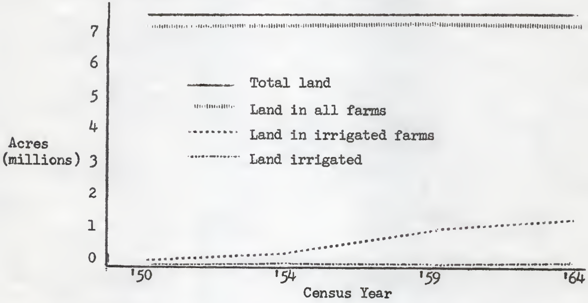
In reply to this argument it should be pointed out that this criticism would be cogent if relatively small yearly changes in specific crops or yields were the question for inquiry. However, the nature of this study is broader and considers changes and adjustments of a larger scale over sufficiently long time periods so that available census data could be used for many calculations even though it contains some yearly variation.

The previous statement should not be construed to mean that only census data is used. When available and where applicable other sources of data are used in conjunction with the census data to give the most accurate picture of the total situation.

An examination of the data in Table 1 reveals that several trends and adjustments have taken place. The remainder of this chapter is devoted to an enumeration of and/or explanation for these trends and adjustments.

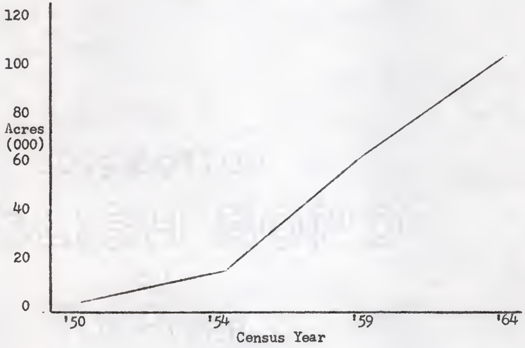
The most obvious trend relates to the development of irrigation in the study area. This is viewed from several aspects. Figure 4 shows the absolute numbers of acres irrigated and acres in irrigated farms in comparison with the total land acres and the land in farms.

Figure 4. Distribution of
Land Between Irrigated and Non-Irrigated Farms



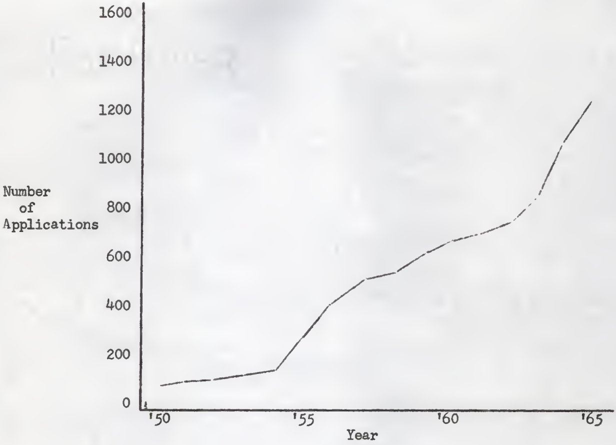
Looking at just the acres irrigated as in Figure 5, the rate of increases is even more apparent. Figure 6 illustrates the increased number of ground water applications approved, an indicator of the trend in irrigation development of ground water. Finally, Figure 7 depicts the declining total number of farms and the increasing number of farms with irrigation (0.6% in 1950 to 11.0% in 1964). All of these measures point to a rapidly developing irrigation sector in the agriculture of the area.

Figure 5. Acreage Irrigated



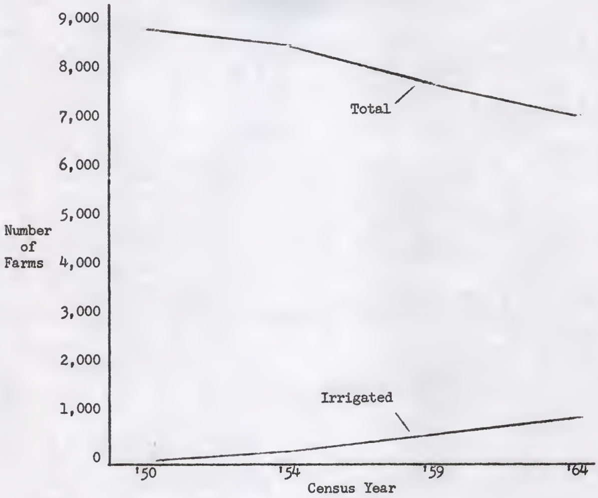
By comparison with the rest of the state of Kansas, the irrigation in the study area has been developing at a more rapid rate. Figure 8 shows that the proportion of irrigated land in the study area has increased from 1.7 percent to 10.6 percent of the total irrigated land in the 1950-64 time period, while the percent of total land in farms remained constant.

Figure 6. Ground Water Applications Approved



The data in Figure 8 indicate that the percent of irrigated land is less than the percent of the total land area when comparing the study area to the state. As a result, larger farm sizes, smaller irrigated acreages or possibly both would be expected in the study area. Figure 9 indicates that both are true. Further it shows that the average size of irrigated farm is larger for the area than for the state. These relationships are expected since farming in the study area typically requires large operations to make a success of dryland farming. Also, since irrigation in the area was not developed as early and not as extensive as in the other parts of the state, the amount of land irrigated per farm in the study area is less than that for the state. Finally, as expected irrigated farms in both cases are larger than all farms since the irrigated farms average tends to consist of a bigger proportion of large farm units than does the all farms average.

Figure 7. Changes in Total and Irrigated Farm Numbers



Unfortunately the data is not very complete to fully examine the irrigated crop acreages. The census data is available for only two years,

Figure 8. Study Area Compared to the State: Land in Farms and Irrigated Land

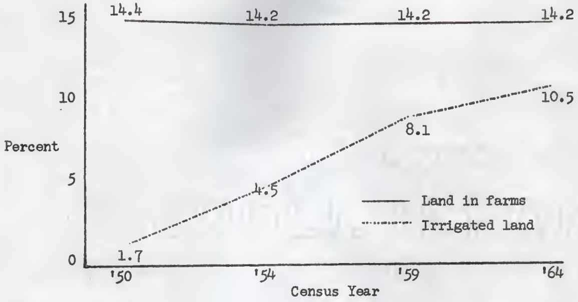
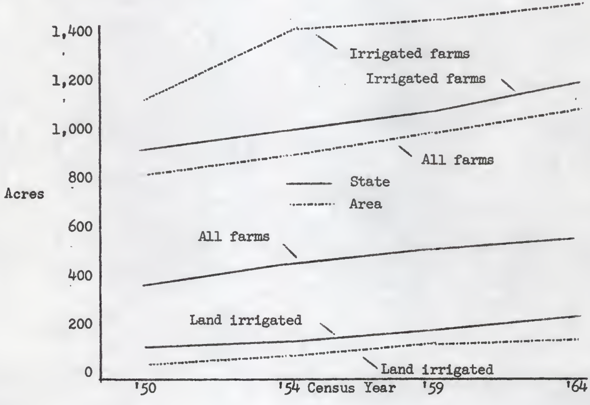


Figure 9. Study Area Compared to the State: Average Size of All Farms, Irrigated Farms, and Average Land Irrigated



and the last census is nearly four years old. Also, it combines forage sorghum and grain sorghum in such a way that exact acreages could not be calculated for either. The K.S.U. Extension Service has no data available for 1965. Finally, the Kansas State Board of Agriculture data includes only two crops. Nevertheless, the data when considered with respect to each other provide fairly clear indications of the trend for each crop. These trends are illustrated by the graphic presentation of the data in Figures 10, 11 and 12, and they are discussed in the following paragraphs.

The most uniform trend is observed in alfalfa. It also exhibits the least gain in acreage. There are two important explanations for this. Yields for alfalfa, which are discussed later in this chapter, did not increase with advancing technology as did crops like corn and

Figure 10. Irrigated Acreage of specific Crops
From Kansas State Board of Agriculture Data

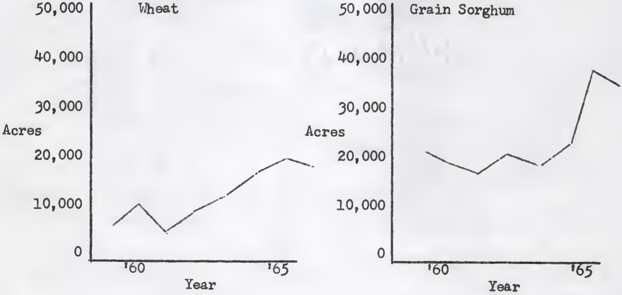


Figure 11. Irrigated Acreage of Specific Crops from Census Data

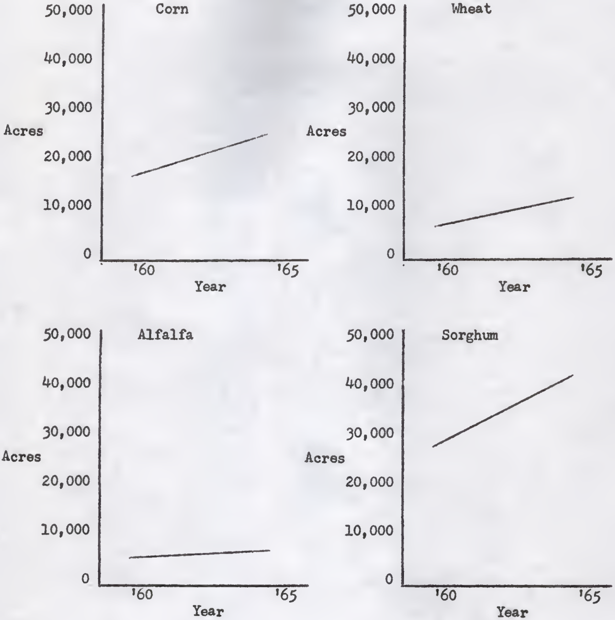


Figure 11. Continued

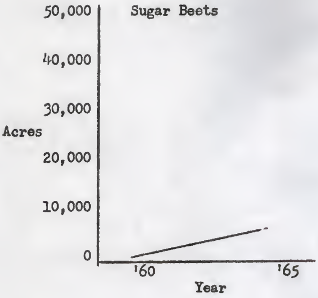
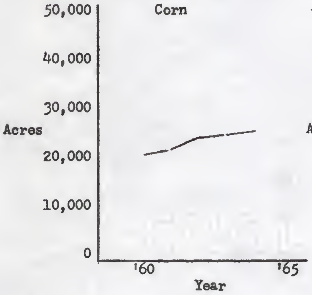


Figure 12. Irrigated Acreage of
Specific Crops from K.S.U. Extension Service Data



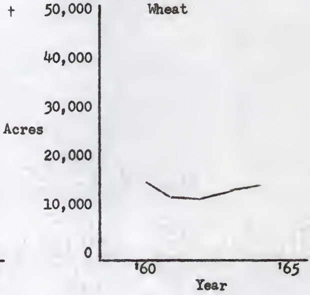
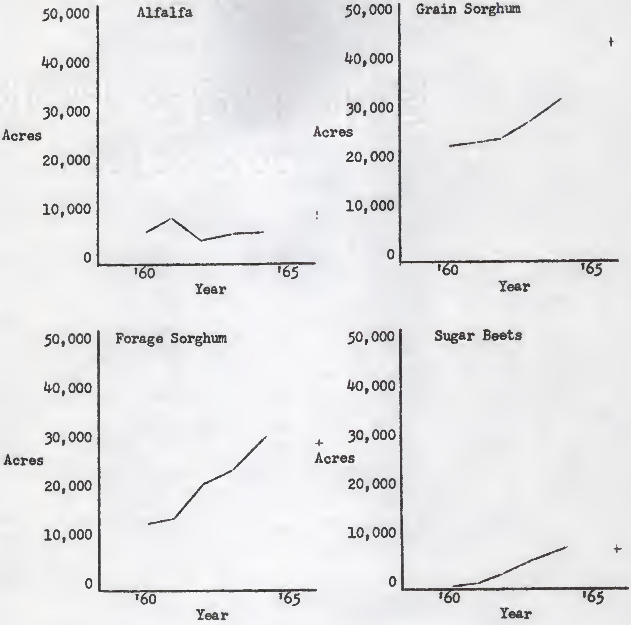


Figure 12. Continued



grain sorghum. In addition, respective commodity prices have not moved in such a way so as to offset the disadvantage in yield and the result was that other crops become relatively more profitable to irrigate. Consequently, irrigated alfalfa has not experienced any marked increase in acreage.

The second factor concerning alfalfa is that it does not lend itself to mechanized handling as easily as other crops. It requires a relatively high labor input and consequently has a higher cost of production. Again, commodity price relationships have not changed sufficiently to offset an increased cost so the irrigated alfalfa acreage has become relatively smaller.

Considering wheat acreage, all three sources of data indicate that it has not increased as rapidly as either total irrigated acreage or some other crops such as corn and sorghum. The reason is again due to yields. The average wheat yields have not kept pace with the increased yields for other crops and commodity price relationships have made wheat even less competitive in the case of irrigated land. Consequently, irrigated wheat acreage has recorded comparatively modest increases.

Increased irrigated forage sorghum acreage was expected in view of an expanding cattle industry in the study area. A major benefit of irrigation is that it tends to stabilize crop yields, and dependable feed supplies are needed in a livestock enterprise. In addition, new varieties of forage sorghums with greater yield potential and changes in feeding practices have made forage sorghums more competitive with other forms of roughages.

Irrigated corn acreage had a moderate increase over most of the time period considered. The data from the Kansas State University Extension Service show that corn was the largest single crop under irrigation in 1966. Although there is no other data available to support this observation, it would appear that this may be true for several reasons. With the rapid development of irrigation, land would be available for irrigated corn production. Considering the price relationships and yields, corn could be expected to increase at a faster rate than sorghum grain, its closest competitor. Corn yields have run slightly higher than sorghum grain yields and, combined with the past price advantages for corn, more than offset a slightly higher production cost for corn. Also, crops like corn (and sorghum grain) are more easily marketed than bulky crops, e.g., forage sorghums or alfalfa, and consequently they are better suited for rapidly expanding irrigated operations.

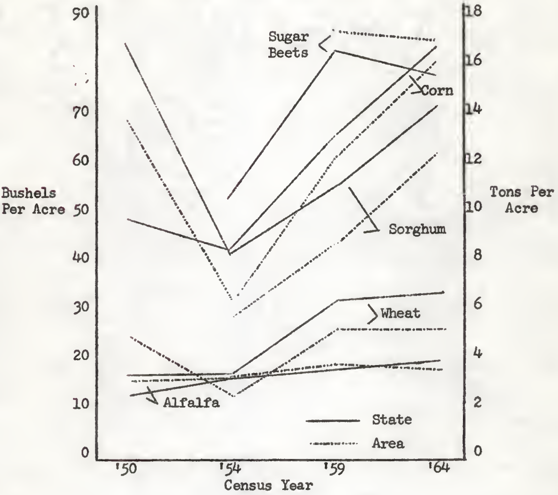
Sugar beet acreage jumped from several hundred acres in 1959 to slightly over 7,000 acres in 1964, and then remained at that level through 1966. Sugar beets require a somewhat different approach for analysis. Specifically, they are grown under contract with a processor. Hence, a prospective grower needs to have a contract in order to have a market for his crop. As a result, entry is restricted and the processors have nearly absolute control over the acreage planted.

Payment for sugar beets is based on sugar content as well as weight, and with proper management they can yield the highest net returns per acre of any crop grown on a large scale in the study area. Still, this high return has some other "costs" to be considered. Despite irrigation, weather risks are still significant. Payment is made as the grower's beets are processed, which means that part of his money is tied up for nearly a year. Sugar beets are very much a soil depleting crop so they cannot be grown continuously. Finally, the high net returns require considerably above average management to handle the special problems of weed control, soil fertility, irrigation and harvesting associated with sugar beet production.

Assessing both the positive and negative pressures for sugar beet acreage expansion, the increased production indicates that there are growers willing to take the risks and supply the management necessary for earning the high per acre returns. However, the leveling off of beet production demonstrates that production is still largely controlled and limited by the processors.

Irrigated crop yields for the study area are generally lower than for the state, the only exception being sugar beets. This is illustrated in Figures 13 and 14. Since these yields are for irrigated acreages, moisture variation should not be the explanation. However, the study area does have a shorter growing season than the other irrigation areas of the state. Then too, the study area lies at a more northerly latitude than do the other irrigating areas (chiefly southwest Kansas) resulting in somewhat less intense sunlight and temperature for photosynthesis. These factors appear to be the best explanation of the lower yields.

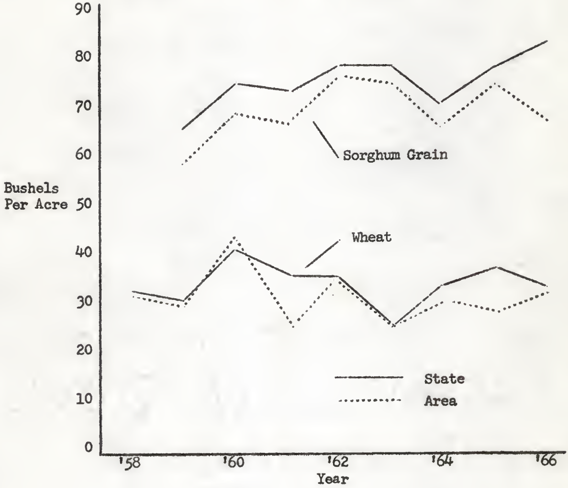
Figure 13. State and Area Crop Yields from Census Data



The data also indicate that corn and sorghum yields have increased proportionately more than yields for sugar beets, wheat and alfalfa which explains many of the trends and adjustments among respective crop acreages noted earlier in this chapter.

The final topic considered in this chapter deals with adjustments in water use practices. To study this area some measure of water used is needed. The only estimate available for the study area is the number

Figure 14. State and Area Crop Yields
From Kansas State Board of Agriculture Data



of approved ground water applications for irrigation. This does not include all of the irrigation wells. The true number of wells is estimated to be 10 to 20 percent greater.[3] While admittedly these data leave much to be desired, it represents the best information available.

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[3]Letter from Mr. Clark I. Stocking, Water Commissioner, Kansas State Board of Agriculture, February 29, 1968.

The method used to calculate the average acres irrigated per well consists of dividing the acres irrigated according to Census data by the number of approved applications. Also, somewhat of a "marginal" approach was used; the increase in acres irrigated was divided by the increase in approved applications.

Obviously, the acres irrigated per well cannot be exactly correct if the number of wells is not percisely known. However, since the approved applications are assumed to represent a relatively constant proportion of the wells, a general trend could then be determined.

In addition it could be argued that all wells do not have the same producing ability. This point was considered, but the inquiry deals with only averages and thus an average well in each case is assumed, an average well with no significantly different production capabilities than those already in existence. This would be a serious assumption if well yields in the area were being reduced by a falling water table, or if well development was taking place only in fringe areas of the aquifer. However, since neither of these conditions prevail in the study area, the average well assumption is used assuming that slightly better or slightly poorer wells would offset each other in considering the number of wells drilled in a five year period.

The results are found in Table 1. Even considering the inadequacy of the data, it seems reasonable to say that irrigation in 1950 was on a rather limited scale both in absolute terms and in terms of acres per well.

Table 1. Average and Marginal Acreages Irrigated

Census Year	Cumulative Total of Applications	Land Irrigated	Acres Per Application	Δ Acres / ΔApplication
1950	70	2,320	33.14	
				155.90
1954	161	14,948	92.84	
				100.89
1959	627	61,963	98.82	
				107.99
1964	1,028	105,265	102.40	

The period 1954 to 1959 had a significantly greater number of additional acres irrigated per additional application approved. This would seem to indicate a more extensive approach to irrigation.

In the following two time periods, the acres irrigated per application approved increased only slightly and the additional acres irrigated per additional application approved decreased to levels approximately equal to the average acres irrigated per application. This would indicate a more intensive approach to irrigation. The shifts to high water use crops like corn and sugar beets from a lower water use crop such as wheat, as discussed earlier, would lend support to this conclusion.

The increase from 100.89 to 107.99 acres irrigated per additional application approved might be explained in part by more off-season irrigation. This would allow either some pre-irrigated crop production in addition to the usual fully irrigated crop production or somewhat more fully irrigated acreage per well by storing water in the soil for use in the next growing season, thereby keeping the amount that had to be applied during the peak irrigation season constant although more acres were being irrigated. This interpretation of the data is based chiefly on personal observations in the study area. Positive justification for this conclusion would require much more complete data than is currently available.

CHAPTER IV

ADJUSTMENTS EXPECTED

Evaluation of the data in the previous chapters could hardly conclude anything but that irrigation development will continue at a rapid rate. Numerous other factors combine to make this development not only possible but indeed almost assured.

The climatic conditions and soil characteristics of the area have one chief limiting factor for crop production--lack of rainfall. This moisture deficiency can be offset by irrigation where adequate water supplies are available. Calculations with the Kansas Water Resources Board data mentioned earlier reveal that total irrigated land[1] in the area currently constitutes only 7.2 percent of the amount of land suitable for irrigation overlying ground water regions capable of producing yields of more than 500 gallons per minute and 3.6 percent of that land in regions capable of yields of more than 100 gallons per minute. Thus, the potential for irrigation is still largely undeveloped.

The recent development of self-propelled sprinkler irrigation systems can be expected to encourage rapid irrigation development. The manufacturers indicate several advantages to these systems which make them

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[1]The Kansas State University Extension Service estimate of land irrigated in 1966 (156,662 acres) was used.

adaptable to situations that rule out either hand-moved sprinkler systems or various flood methods. In addition, these advantages can make self-propelled systems quite competitive in situations where flood or furrow irrigation could be developed. The following advantages are enumerated by a manufacturer and pertain to the pivot type self-propelled unit, probably the most common type of self-propelled system in use in the study area.

"1. The system will operate on grades of 5% to 7%, therefore, eliminating the need for land leveling. The farmer, thereby, saves the cost of leveling the land and also does not decrease the fertility by movement of the top soil.

2. A self-propelled system requires very little labor to operate and maintain--this is extremely important since good labor is becoming expensive and more difficult to find all the time. A self-propelled system will probably not require more than two or three hours labor every three days, for adjustment, routine maintenance, tune-up, repairs, etc.

3. A self-propelled system saves precious water. This aspect is becoming increasingly important every year, as we deplete our underground water supply. Farmers, Conservation Agencies and State Resources Commissions are beginning to realize more and more all the time, the necessity for regulation and control of our water resources. A self-propelled system will operate on one-fourth to one-third the amount of water required with other systems and with flood irrigation.

4. A self-propelled system is the easiest, surest way to irrigate. Practically all instances where a system requires considerable labor, a farmer is going to hesitate to begin irrigation at the time he really should. Many will limit the length of the irrigation system as much as they possibly can. With the self-propelled system he will not hesitate to start his system early and he will certainly be inclined to leave it running as long as he feels it is necessary to do a good job of irrigation.

5. A self-propelled system will provide a better water distribution pattern than any other type of irrigation system. This is important because it will provide increased yields--furthermore, we are moving into new areas of applying herbicides and insecticides through a system, in which case, a good distribution pattern becomes imperative.

6. Another benefit which can be derived from a self-propelled system is the ability to control ground temperature. This is important on crops such as potatoes, cotton, etc., and can also be beneficial to other crops such as corn."[2]

Clearly, these self-propelled sprinkler systems offer significant advantages. Offsetting these advantages are the additional expenses due to the initial cost of the system and the additional power required to operate the system. Also, these systems generally have high application rates which necessitate that they be used on soils with water intake rates high enough to absorb the water being applied. (Most soils in the study area do have high enough intake rates for this type of system.)

No data are available as to the amount of land irrigated by the various types of sprinkler systems in the study area. Personal observation indicates that the amount is increasing relatively as well as absolutely. As rougher land is developed, lower yielding ground water sources utilized, and labor replaced by capital, the various self-propelled systems should become more numerous.

Along with increased irrigation development, the shifts among crops can be expected to continue. As discussed earlier, these shifts result as a combination of several factors, the more important being price relationships, yields, labor requirements, capital requirements, managerial experience, and institutional restrictions. Assuming no radical changes in agricultural policy and economic conditions, the following relative adjustments among crops can be expected with the conditions indicated.

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[2]Letter from Mr. Don Baker, Valmont Industries, Valley, Nebraska, February 15, 1968.

Alfalfa will probably continue to decline due to its high labor requirements and its nearly flat yield curve. Also, the bulky nature of alfalfa means that it is not particularly well suited for use as a cash crop. Development of higher yielding varieties could conceivably provide a stimulus for more mechanized handling methods and hence, larger acreages, but this situation appears unlikely in the foreseeable future.

Irrigated wheat production is difficult to predict. Current price levels and yields make fully irrigated wheat less attractive than it has been in years past; consequently, it has declined in relative importance. However, partially irrigated wheat is still attractive in many operations. In this case water from a well used to fully irrigate another crop during the growing season is applied to the wheat ground during the other part of the year. In effect the water is stored in the soil until the wheat can utilize it. The development of the self-propelled sprinkler systems has helped make this practice feasible in more situations. These systems can be moved to adjacent tracts for irrigation in the off-season, thus spreading the well and equipment costs over more acres while making use of some previously unused labor. This same practice also can be used successfully for sorghum so future adjustments will have to be largely dependent on yields and price relationships. Without significant price increases or yield improvement, wheat appears to be capable of competing for partially irrigated land only, if it is able to compete at all.

Irrigated sorghum forage production will respond to changes in the cattle industry. Irrigation contributes markedly to the stable production of crops required by livestock operations as mentioned earlier. Also, as was indicated previously, sorghum forage is more competitive than alfalfa since it can be handled mechanically and yields have been increased substantially. Irrigated forage sorghum is not likely to increase at a rate significantly greater than the cattle industry since its bulky nature limits its movement to areas more than a few miles distant from the place of production. Forage sorghum and corn silage are close in terms of production costs, yield and feeding value. These relationships do not appear likely to change in the near future so the relative proportion of each crop probably will not change significantly.

Sorghum grain production will certainly continue to account for a significant portion of irrigated crop production in the study area. Under present price relationships and yields, it appears that fully irrigated grain sorghum is slightly less profitable than corn so fully irrigated grain sorghum could be expected to increase at a somewhat slower rate than corn. The outlook for increased partially irrigated grain sorghum production is more optimistic. Musick and Grimes[3] found an increased yield of 41.1 bushels per acre with pre-planting irrigation over dryland fallow. Hence, grain sorghum responds very favorably to this practice, too. Whether larger acreages of grain sorghum or wheat are grown under this practice again depends upon price and yield relationships. At the present

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[3]Jack T. Musick and Donald W. Grimes, Water Management and Consumptive Use by Irrigated Grain Sorghum in Western Kansas, pp. 19-20.

time, sorghum grain appears likely to account for a larger share of any increases in partially irrigated crop production.

Irrigated corn production certainly will account for increasing amounts of irrigation activity. McCoy _et al_.[4] state that corn is "..., probably the most profitable (crop) in many cases." The increased corn acreages as discussed in Chapter III have supported their observation, and the trend appears likely to continue. Some corn is harvested as silage for use in cattle operations. Again, growth in this area will be closely related to the changes in the cattle industry as was the case for forage sorghum and for the same reasons. In addition, the acreage of corn for silage will depend on its competitiveness with forage sorghum as discussed earlier. Therefore, the greatest potential for expansion in corn is as a grain crop, and the current situation gives every indication that this expansion will continue.

Expanded sugar beet production is chiefly dependent on the associated institutional restrictions. These restrictions were explained earlier, and in effect they limit acreage to the amount deemed necessary by the processors in response to their respective demand situations. The increased acreage noted in Chapter III can be attributed largely to the increased demand faced by processors as a result of the exclusion of Cuban and Dominican sugar in early 1961.

Until now most sugar beets grown in the study area have been produced for processing plants located in Colorado. A new sugar beet processing

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[4]J. H. McCoy, O. H. Buller, F. Orazem, and W. B. Thomas, _Relative Profitability of Selected Enterprises on Irrigated, Western Kansas Land_, p. 2.

plant is currently under construction near Goodland, and some additional acreage will be required to supply this plant. At the maximum this plant would be able to handle production from approximately 30,000 acres, a substantial part of which would be from Colorado, so the expansion is obviously limited. Even with projected increases, sugar beet acreage would still rank below irrigated corn, forage sorghum, grain sorghum and possibly wheat.

There has been some interest from time to time in vegetable production on irrigated land in western Kansas, especially southwestern Kansas.[5] However, this appears an unlikely area for significant expansion due to the distance from major consumption centers and the lack of certain other prerequisites for successful vegetable production.

Summarizing then, the expected rate of increase in irrigated acreage is greatest for corn with sorghum grain close behind. Sorghum forage and corn silage should easily exceed alfalfa and wheat might show modest increases. Sugar beet acreage will respond to processor demands, therefore being limited to something less than 15 to 18,000 acres under present conditions. At this time expanded vegetable production appears unlikely.

Individual firm adjustments should continue to reflect the historical trend for the industry of fewer units of larger size. However, increased irrigation may temporarily slow this adjustment for some local areas as more intensive use is made of existing sized units. Still, for the total

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[5]For example, see Some Factors that Affect Costs and Returns of Vegetable Crops in Southwest Kansas, Raymond W. Gieseman and Joseph Barton-Dobenin, Manhattan, Kansas State University Agricultural Experiment Station Circular 388, 1963.

study area the rate of increase in farm size (or decrease in number of farms) should follow closely the projected trend for agriculture as a whole.

Along with larger units and irrigation development come the associated problems of high capital requirements and ownership transfer. Although these problems have been increasing, and they give every indication of continuing to increase, no major adjustments appear to be forthcoming, either at the individual firm level or for the agricultural industry.

More specific individual firm adjustments are beyond the scope of this paper, but the hypothesized shifts in cropping practices imply many questions for further study.

CHAPTER V

IMPLICATIONS

As irrigation development expands in the study area, increasing amounts of water will be pumped from the aquifer. Since the recharge to the aquifer is limited, and the rate of withdrawal already exceeds the estimated recharge rate, the obvious implication is that the supply of ground water will be reduced and possibly exhausted.

As stated in Chapter II, the recharge rate is estimated at only 100,000 acre-feet per year. Assuming annual applications of one and one-half feet per acre[1], the amount pumped in the study area would be 235,000 acre-feet, based on K.S.U. Extension Service estimates of irrigated acreage of 1966. In addition, there are more than 600 irrigation wells in Kit Carson County, Colorado, pumping from the same aquifer.[2] Although it is not possible to determine precisely by what amount, withdrawal already exceeds recharge significantly, with the difference becoming larger each year.

The quantity of water that could be withdrawn feasible for irrigation (or other large capacity uses) is estimated at 36 million acre-feet for the study area as was indicated previously. Although this seems

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[1]Foley, Ground Water in Northwestern Kansas.

[2]Ibid.

like a large supply at the present time, rapid irrigation development could quickly deplete it. (It should be pointed out that depletion for irrigation purposes does not mean that ground water would no longer be available. Due to the nature and characteristics of the aquifer there would still be water available for livestock and domestic use.)

The State Geological Survey of Kansas makes periodic measurements of the water levels in observation wells in order to study changes in the water table. Reports of their findings were published from 1957 through 1966, and they are to be published at five year intervals in the future. Although a definite downward trend in the water level is recorded for the wells in the study area, it is not yet possible to predict precisely what the rate or extent will be. However, with a few more years of observations, and better understanding of the influencing factors, e.g., ground water geology, well interference, etc., reasonably accurate predictions should be available.

Since ground water supplies are being depleted in the study area, it might be useful to look at another area that has experienced similar conditions in order to see what lies ahead. By looking forward perhaps the effects and implications of current practices and policies can be viewed more clearly.

The high plains area of Texas has developed irrigation from a ground water supply in a region quite similar to the study area in geology and extent of land area. However, the Texas high plains region originally had a larger stock of water than the Kansas Study Area. The following paragraphs describe what has happened in the Texas high plains area and are from a Texas Agricultural Experiment Station bulletin by Hughes and Magee.[3]

Irrigation in the high plains area began about 1917. About the mid-1930's irrigation development began to increase rapidly and reached the peak rate in the drought years of 1950-54. During the period 1937-58 the static water level had declined about 43 feet, ranging from a few feet to 100 feet in different parts of the area.

"The principal short-run physical effects of a decline in water levels are reflected by a reduction in well capacities. The long-run effect is a depleted water supply. The types of special practices or adjustments induced by or associated with the decline in water supplies include: (1) increasing the number of hours of pump operation, (2) lowering pumps, (3) installing additional wells, (4) installing closed water-distribution systems, (5) installing smaller pumps in old wells, (6) decreasing the acreage of summer-irrigated crops and increasing the acreage of crops irrigated in fall and winter, (7) staggering grain sorghum planting dates, (8) concentrating the available water supply on cotton, (9) irrigating alternate rows, and (10) reducing the number of acres of cropland irrigated per farm."[4]

"Several factors combine to obscure the full physical and economic effects of water level decline. Among these are: continuation, though at a slower rate, of irrigation development; elimination or reduction of transmission losses through the use of a closed distribution system; inflation; drought and a modified irrigation program; and the shift from butane to natural gas for pumping fuel."[5]

"The effects of adjusting to declining water supplies are reflected in increased per-acre investment in irrigation facilities, increased operating costs per acre and a reduction in the acreage of cropland irrigated per farm."[6]

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[3]William F. Hughes and A. C. Magee, Some Economic Effects of Adjusting to a Changing Water Supply, Texas High Plains.

[4]Ibid., p. 2.

[5]Ibid., p. 2.

[6]Ibid., p. 2.

The Texas high plains experience shows what can and has happened when extensive irrigation is developed from a limited ground water supply. The implication for the Kansas study area should be apparent by now--if irrigation is developed rapidly, declining water levels will inevitably result and certain adjustments, probably many of those witnessed in the Texas high plains, can be expected.

If a resource is limited as the ground water supply in the study area is, and if that resource is to be consumed over time as it appears that the ground water supply will be, then the rational course of action should be to utilize the resource in the most efficient manner possible. This might be viewed from several aspects.

From an engineering standpoint, this would include efficient withdrawal and distribution methods. For example, areas of an aquifer with higher drawdown rates can be pumped at less expense by using a lower pumping rate. Transmission losses are almost eliminated with closed distribution systems of pipe or lined ditches. Significant reductions in distribution losses are available by using shorter runs, proper grades, and methods of irrigation appropriate to the soil type and characteristics.

The biological aspect would involve selection of varieties particularly adapted to irrigation, optimum timing of irrigation for maximum plant response, and irrigation for maximum efficiency of water use--not necessarily maximum crop production. In addition, it would include research to find ways of reducing losses in evapotranspiration.

For economic considerations efficient utilization of a resource over time implies a discounted future returns concept as well as optimum allocation and organization for production. Several studies of this type are available for optimum utilization of ground water.

Li[7] used a dynamic programming technique in studying the high plains area of Texas mentioned earlier. This model considered increasing water costs as well as optimum organization from year to year so as to maximize discounted future returns. His results were generally good, recognizing the limitations of any linear programming model. However, the results are not adaptable to the Kansas study area due to the differences in crops grown in the two areas and the expected variance in input coefficients for the model from the respective regions.

Harman[8] used enterprise budgeting and linear programming to study three alternatives--(1) maintaining the current irrigated acreage by drilling additional wells, (2) maintaining the presently existing wells by replacing pumps and motors, and (3) drilling new wells and/or replacing the depreciated units only when annual farm income can be increased or maintained by the additional investment. He found that Model II provided the greatest total production, but it required the longest time period (24 years). Model III gave the maximum annual income with an

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[7]Tien En Li, Application of a Dynamic Programming Model for Use of Irrigation Water Over Time, unpublished Ph. D. dissertation.

[8]Wyatte L. Harman, An Economic Evaluation of Irrigation Water Over Time on Texas High Plains Farms With a Rapidly Diminishing Water Supply, unpublished M. S. thesis.

economic life of 18 years. Model I maintains the highest average annual production, but it provided the least total production and income, lasting only 13 years. Again, the results are not adaptable to the Kansas study area for the reasons stated earlier. However, these methods of analysis would be suitable using appropriate data and coefficients for the Kansas study area.

The development of a meaningful optimum water use economic model for the study area is chiefly limited by needs for additional research in several other areas in order to provide the basic input coefficients for the model.

Specifically, basic data collection is presently inadequate. The number of wells and amount of water pumped per well or even the amount pumped collectively certainly are preliminary requirements for an accurate model. However, as mentioned earlier, this data is not yet available. Another very basic data item is individual irrigated crop acreages. Here, several sources of data are available, but they are not in agreement which complicates the analysis.

Biological research in order to determine plant water use coefficients would greatly improve the economic model. Even records of water applied to specific crops and the associated production could provide adequate estimates, if this data were available. Currently, only one study of this type is available, and that study involves only one crop.

Geologic and hydrologic research to provide information on the structure, characteristics and capacity of the aquifer are currently being conducted by the State Geological Survey of Kansas. Their estimates of the amount of water available are fundamental to the design of an economic model.

An economic model can hardly be better than the data used in it, so an accurate optimum water use model for the study area is not really possible at this time. If the water resources of the study area are to be used in the most optimum manner in the future, improved data collection and additional research are going to be necessary to provide the basis for a sound economic plan of water utilization.

CHAPTER VI

SUMMARY

As indicated in Chapter II, climatic and physical conditions of northwest Kansas are such that inadequate rainfall is the most important limiting factor to crop production. To compensate for this deficiency, many farms in the study area have irrigation systems to provide the water necessary for expanded crop production. This development has proceeded rapidly in the past several years as was illustrated in Figures 3 and 4.

Nearly all of the water used for irrigation in northwest Kansas comes from ground water supplies. The chief source of this water is the Ogallala Formation which ranges to more than 150 feet in thickness in parts of the study area. Geologic studies indicate that this aquifer contains essentially a fixed supply of water which could be depleted with the means of withdrawal now available.

The data available for the study area were not complete or entirely uniform, but significant trends in specific crops were indicated by Figures 10, 11 and 12. Irrigated acreages of corn, grain sorghum and forage sorghum expanded rapidly. Sugar beet acreage also increased at a rapid relative rate but still accounts for only about 7,000 acres. Wheat and alfalfa acreages grew only slightly. In addition, total land irrigated and land in irrigated farms increased at faster rates in the study area than for the state. In absolute terms irrigated farms in the study area tend to be larger but contain less land irrigated than the average for all irrigated farms in the state.

The adjustments expected in the future include increased corn and sorghums acreages with expansion in sugar beets dependent upon the action of processors. Irrigated alfalfa and wheat acreages appear to be less likely in the future. As for water use, Table 1 indicated that early development (1950 to 1954 Census) was of a more extensive nature than later development (1954 to 1964 Census). Declining water levels have not yet influenced the well yields so this was not determined as the reason for the adjustment. It was also possible that more off-season irrigation was being done although conclusive proof was not available. The anticipated adjustments are based on certain assumptions in regard to price relationships, yields and governmental policies, a change in any one of which might result in a different set of adjustments.

The implication of expanding irrigation development from a limited supply of water is, of course, eventual depletion and possibly exhaustion. To allocate this water in the most efficient manner, various models as indicated in Chapter V could be employed if the input data were available. Since the data are not available, additional data collection and research in several areas are necessary in order to obtain the material required by the economic model.

Only when this material is available and an accurate economic model developed can positive policies be instituted to maximize the benefits obtainable from the limited supply of ground water available.

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TABLE 1

KANSAS AND STUDY AREA CENSUS ACREAGE DATA*

Census Year	Approximate Land Area		Land in Farms		Number of Farms	
	State	Area	State	Area	State	Area
1950	52,549,120	7,518,220	48,611,366	7,022,735	131,394	8,738
1954	52,549,120	7,518,720	50,023,538	7,084,248	120,167	8,390
1959	52,510,720	7,518,720	50,152,870	7,140,592	104,342	7,654
1964	52,510,720	7,518,720	50,271,117	7,124,487	92,440	6,903

Census Year	Land in Irrigated Farms		Number of Irrigated Farms		Land Irrigated	
	State	Area	State	Area	State	Area
1950	1,065,691	61,544	1,166	54	138,686	2,320
1954	2,681,618	284,685	2,736	204	331,551	14,948
1959	4,818,612	776,332	4,592	542	762,101	61,963
1964	6,049,014	1,143,726	5,102	759	1,004,210	105,265

*Source: U.S. Census of Agriculture: 1950, 1954, 1959, 1964, Vol. I, Counties.

Note: All measures of land areas are in acres.

TABLE 2

CENSUS DATA ON FULLY IRRIGATED
CROP ACREAGES, PRODUCTION AND YIELDS FOR KANSAS AND THE STUDY AREA*

	Year	Corn		Sorghum	
		State	Area	State	Area
Acreage	1950	1,439	26	288	-
Production[a]		69,855	1,800	15,815	-
Yield[b]		48.5	69.2	84.1	-
Acreage	1954	5,461	810	50,614	407
Production		224,653	25,740	2,073,466	11,525
Yield		41.1	31.8	41.0	28.3
Acreage	1959	37,391	10,429	123,347	7,516
Production		2,450,957	634,178	6,956,342	319,207
Yield		65.5	60.8	56.4	42.5
Acreage	1964	93,966	14,119	176,390	18,590
Production		7,826,769	1,126,849	12,477,742	1,132,577
Yield		83.3	79.8	70.7	60.9

*Source: U.S. Census of Agriculture: 1950, 1954, 1959, and 1964, Vol. I, Counties.

[a]Production is measured in bushels for corn, sorghum and wheat and in tons for alfalfa and sugar beets.

[b]Yields are measured in bushels per acre for corn, sorghum and wheat and tons per acre for alfalfa and sugar beets.

TABLE 2--Continued

Wheat		Alfalfa		Sugar Beets	
State	Area	State	Area	State	Area
13,624	45	13,858	299	-	-
220,485	1,100	33,236	871	-	-
16.2	24.4	2.4	2.9	-	-
21,012	317	51,093	2,838	6,014	-
341,212	4,075	161,079	8,971	62,806	-
16.2	12.9	3.2	3.2	10.4	-
58,322	1,780	34,093	4,083	7,756	220
1,824,962	47,664	122,963	14,783	126,982	3,760
31.3	26.8	3.5	3.6	16.4	17.1
96,857	3,337	42,291	4,361	23,283	7,237
3,078,597	80,672	159,790	15,220	365,956	120,748
31.8	24.2	3.8	3.5	15.7	16.7

TABLE 3

KANSAS STATE BOARD OF AGRICULTURE DATA ON IRRIGATED CROP ACREAGES, PRODUCTION AND YIELDS FOR KANSAS AND THE STUDY AREA*

	Year	Wheat		Sorghum Grain	
		State	Area	State	Area
Acreage	1958	156,000	5,000	-	-
Production[a]		5,188,000	161,000	-	-
Yield[b]		33.3	32.2	-	-
Acreage	1959	179,000	7,000	336,600	20,400
Production		5,481,000	208,000	21,559,400	1,200,900
Yield		30.6	29.7	64.1	58.9
Acreage	1960	184,000	10,000	335,700	19,700
Production		7,465,000	427,000	24,605,700	1,325,000
Yield		40.6	42.7	73.3	67.3
Acreage	1961	198,000	6,000	261,300	16,600
Production		6,829,000	145,000	18,772,200	1,072,000
Yield		34.5	24.2	71.8	64.6

*Source: "Farm Facts," Kansas State Board of Agriculture, 1958-59 to 1966-67, inclusive.

[a]Production is measured in bushels.

[b]Yields are measured in bushels per acre.

TABLE 3--<u>Continued</u>

Acreage	1962	184,000	9,000	272,100	20,800
Production		6,189,000	301,000	21,439,000	1,582,400
Yield		33.6	33.4	78.8	76.1
Acreage	1963	204,000	11,000	272,200	19,300
Production		5,206,000	278,000	21,422,000	1,424,400
Yield		25.5	25.3	78.7	73.8
Acreage	1964	222,000	16,000	272,600	22,200
Production		7,237,000	469,000	18,988,000	1,449,000
Yield		32.6	29.3	69.7	65.3
Acreage	1965	274,000	19,000	395,000	38,300
Production		9,691,000	515,000	30,562,000	2,805,800
Yield		35.4	27.1	77.4	73.3
Acreage	1966	253,000	17,000	404,500	34,700
Production		7,765,000	511,000	33,153,000	2,308,200
Yield		30.7	30.1	82.0	66.5

TABLE 4--K.S.U. EXTENSION SERVICE DATA ON IRRIGATORS AND IRRIGATED ACREAGE*

Year		Number of Irrigators	Acres Irrigated	Wheat	Corn	Alfalfa	Grain Sorghum	Forage Sorghum	Sugar Beets
1960	Area	593	80,467	15,670	20,595	6,813	22,665	12,535	199
	State	5,770	1,008,624	231,400	176,214	74,308	345,550	117,359	9,070
1961	Area	629	82,164	10,860	21,770	8,810	24,610	13,474	1,000
	State	6,011	998,229	245,782	166,604	62,663	329,637	114,119	9,643
1962	Area	650	92,567	10,729	25,220	5,680	26,455	20,642	2,703
	State	5,893	1,054,304	257,894	183,913	70,673	336,387	125,046	13,818
1963	Area	696	101,763	11,530	26,790	6,035	28,710	22,735	5,183
	State	6,766	1,094,641	264,678	193,651	193,651	353,457	137,001	18,807
1964	Area	894	115,526	12,525	26,850	6,150	31,060	30,020	7,739
	State	6,933	1,159,931	271,830	200,830	74,888	400,296	148,361	24,777
1965			No data available						
1966	Area	995	156,662	17,370	50,294	8,004	43,690	27,000	7,285
	State	7,648	1,379,054	339,563	254,643	76,955	480,168	157,443	21,596

*Source: Extension Service, Kansas State University, mimeographed reports.

TABLE 5

CENSUS DATA ON IRRIGATED[a] ACREAGE OF SPECIFIC CROPS IN THE STUDY AREA*

	1959	1964
Corn	16,097	24,653
Sorghum	27,871	42,883
Wheat	5,020	11,193
Alfalfa	5,348	5,912
Sugar Beets	220	7,237
Sub-total	54,556	91,878
Other crops, pasture, misc.	7,407	13,387
Total land irrigated	61,963	105,265

*Source: U.S. Census of Agriculture, 1959 and 1964, Vol. I, Counties. Equivalent data was not available for either 1950 or 1954.

[a]"Irrigated" is defined to include fully irrigated and partially irrigated.

TABLE 6

APPLICATIONS APPROVED FOR GROUND WATER*

Year	Number	Total	Year	Number	Total
Up to 1949	57	--	1958	45	577
1949	8	65	1959	50	627
1950	5	70	1960	25	652
1951	8	78	1961	52	704
1952	2	80	1962	46	750
1953	7	87	1963	93	843
1954	34	121	1964	185	1,028
1955	40	161	1965	202	1,230
1956	104	265	1966	132	1,362
1957	123	532	1967	165	1,527

*Source: Records of the Division of Water Resources, Kansas State Board of Agriculture.

TABLE 7

HARVESTED ACRES OF SUGAR BEETS
IN THE STUDY AREA*

Year	Acres	Year	Acres
1957	32.7	1962	2,702.6
1958	180.6	1963	5,232.7
1959	530.1	1964	7,966.5
1960	691.0	1965	6,324.9
1961	1,028.3	1966	7,284.9

*Source: A.S.C.S. Statistical Summaries, K.S.U. Extension Service, mimeo.

IRRIGATION DEVELOPMENT, ADJUSTMENTS AND IMPLICATIONS FOR NORTHWEST KANSAS

by

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B. S., Kansas State University, 1967

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The purpose of this study was to provide as much background information and data as possible for later use in developing an economic optimization model for enterprise organization and ground water use in northwest Kansas. Specifically, this study was intended to assemble available data and information or irrigation in the study area; then, analyze and interpret it, and finally, determine what additional data and research would be necessary for the development of the economic model.

The study area included the 12 northwest counties in Kansas--Cheyenne, Decatur, Gove, Graham, Logan, Norton, Rawlins, Sheridan, Sherman, Thomas, Trego, and Wallace. The chief sources of data available were the U.S. Census of Agriculture, the Kansas State Board of Agriculture and the County Agent Reports summarized by the Extension Service of Kansas State University. Much of the other information came from the State Geological Survey of Kansas.

The most limiting factor for crop production in the area is lack of rainfall. However, much of the area overlies an aquifer capable of yielding sufficient irrigation water to compensate for the lack of rainfall. The aquifer contains a limited amount of water in storage, it is subject to extremely slow recharge, and therefore, it represents essentially a fixed resource with a life inversely related to the rate of extraction.

Irrigation development has proceeded rapidly in recent years. Corn accounts for the largest increase in irrigated acreage with sorghum grain and forage sorghum only slightly below it. Sugar beet acreage has experienced the greatest percentage increase, but it represents only about one-fourth to one-sixth of the corn or sorghums acreages. Irrigated wheat and alfalfa have gained modestly in the past ten years.

Assuming no significant changes in price relationships, yield relationships and governmental policies, corn appears likely to continue as the leading irrigated crop with sorghum grain a close second. Sorghum forage should increase, but at a somewhat slower rate than the feed grains. Expansion in sugar beets will be dependent on the processors. Irrigated alfalfa and wheat production will not grow substantially under assumed conditions.

Expanded irrigation will mean depletion and possible exhaustion of the aquifer, hence the need for an optimum pattern of use in order to maximize the benefits available from the water. Improved data collection in several areas and additional biological and geological research will be required in order to develop the input data required for the economic model. Following the development of the model can come the policies and adjustments necessary for optimum utilization of the water.