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STAFF PAPER

POTENTIAL ECONOMIC EFFECTS OF A ZERO DEPLETION POLICY FOR THE OGALLALA AQUIFER IN NORTHWEST KANSAS

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by

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INTRODUCTION

Agriculture is the major industry of Northwest Kansas. It is diversified and provides small grains, forage crops, and grassland for the cash and livestock economy. An important component of the agricultural economy is the value of irrigated crop production. Irrigated crop acres account for about 25 percent of total crop acres harvested in this region. Irrigated crops are more input-intensive and, thus, more productive than dryland crops. This increase in productivity provides a higher level of income from the irrigated acres.

Irrigation in Northwest Kansas has affected more than the irrigator's production and income. An agribusiness infrastructure was needed to supply the increased inputs. Services of some businesses expanded and new services were developed by other business. New businesses provided for well drilling and irrigation equipment that were needed to develop irrigation. Sales of fertilizer, pesticides, and herbicides and repair services for equipment and machinery expanded. Equipment, facilities, and businesses for grain handling increased in capacity. Transportation facilities and services enlarged. The number of financial institutions and their services expanded, as use of capital increased to meet required capital for loans for operations, working and land. The development of this infrastructure raised the tax base of the region and affected population growth, the life style of the people, and the environment.

The increase and stability in feed grain production helped foster the development of the feeder livestock economy. The expansion in livestock production also increased the need for and use of related agribusinesses. Consumer and other services indirectly related to irrigation also expanded.

The average size of an irrigated farm is usually smaller than that of a nonirrigated farm; thus, more farmers were employed and the consolidation of farms was less than it would have been with only nonirrigated agriculture. The average sizes of farms in Southwest Kansas in 1989 were 1899 crop acres for the cash crop - dryland type and 1498 crop acres for the cash-crop irrigated type. The average crop acres per person were 1407 for the cash-crop dryland farms and 851 for the cash-crop irrigated farms for Southwest Kansas in 1989 (1). Similar data for Northwest Kansas was not readily available. The impact of irrigation was that the population base declined less than it would have without irrigation.

The Kansas Geological Survey has reported a decline in the water table in Western Kansas, including the northwest district. This overdraft has been a concern of irrigators and agricultural leaders of the region. In response to the problem of declining groundwater supplies, the Kansas Legislature adopted the Groundwater Management Act of 1972. This act enabled the formation of groundwater management districts to help control and manage the use of groundwater. In 1978, the Six-States High Plains Ogallala Aquifer Study was funded by the U.S. Department of Commerce to study the groundwater issue in the entire area. The concern over groundwater has persisted as the depletion of the Ogallala aquifer has continued.

The leadership of Groundwater Management District Number 4 is proposing a bold initiative in the grassroots management of a depleting natural resource. There zero depletion policy would reduce water withdrawal from the aquifer to be equal to recharge. It is bold in the sense that local citizens are not waiting for the state or federal government to develop and enact legislation to control and conserve water use. It is encouraging to see this process and the involvement of irrigators and community leaders in the discussion of how to manage and preserve the natural resource base so vital to the economy of the region.

The leaders of the district are concerned about the long-term consequences of the use and conservation of the aquifer. Their initiative calls attention to the long-term use and management of the water supply for irrigation. Most irrigators base investment decisions in wells, land preparation, and equipment on the rate of return to be expected over the life of the investment. These investment decisions may or may not coincide with the long-term interests in the management and use of the aquifer. Any change in policy that affects the rate of return to the investment in irrigation will be of concern to irrigators.

A change in water policy, although perceived to be of long-term benefit to the region, is not without risk and cost; but not changing the policy also has a risk and cost. The risk of changing a policy is that the impact and consequences will be very different than anticipated. Long-term endeavors are difficult to accurately project, because so many variables have a major influence in such a dynamic environment. Testing several scenarios, each one representing a possible set of future events, is one way to form a judgement on the riskiness and credibility of the policy. These scenarios might include alternatives such as the adoption of techniques to conserve more water, different time tables for the implementation of a zero-depletion policy, different amounts of water to be maintained in the aquifer, and alternative water policies. But the risk associated with no change in policy is not well understood, either. How long will the aquifer and irrigation be sustained if there is no change in policy?

The costs associated with a change in policy probably will not be shared equally by all the people in northwest Kansas. A change in policy will shift the costs and benefits among irrigators, businesses, and residents of the region. Income, land values, and the tax base likely will be affected by a change in water policy. Such effects are already impacting some irrigators in the region. However, with a change in policy the consequences and costs will likely shift to another group. The redistribution and reallocation of costs and benefits are the concerns associated with a change in policy.

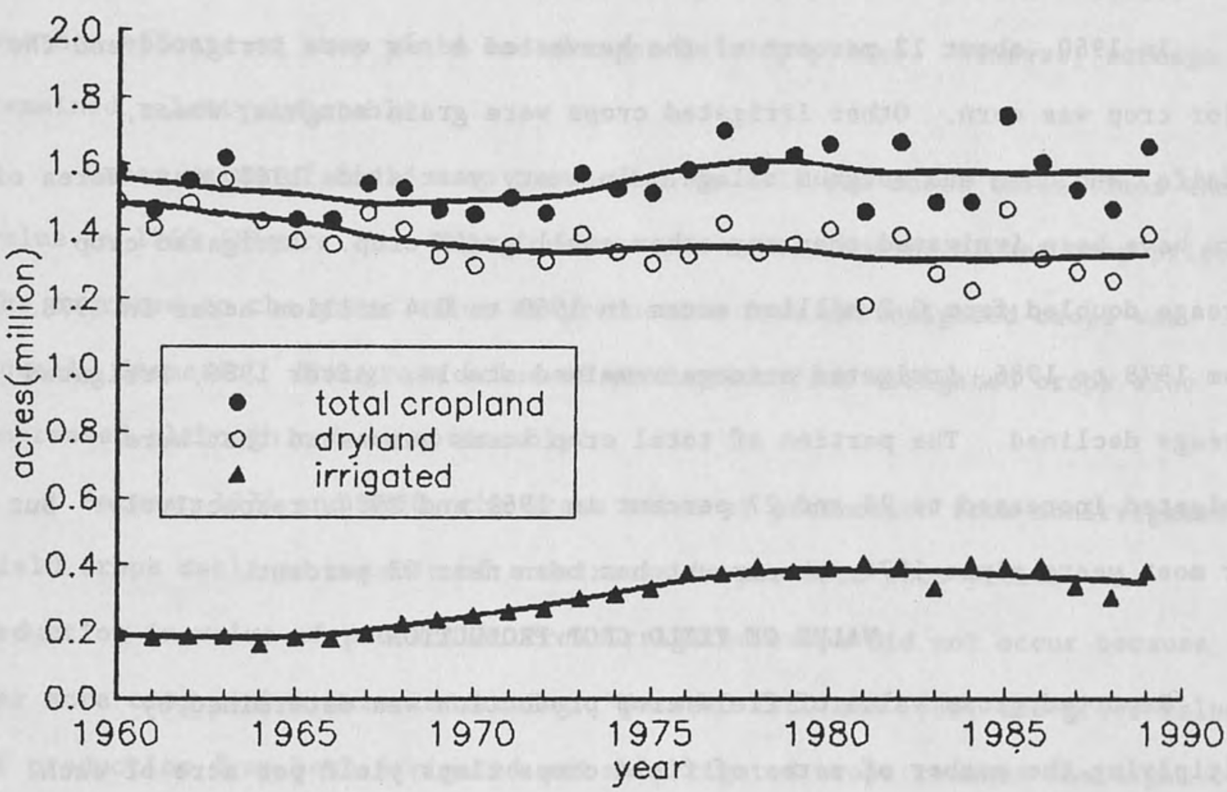
To evaluate the potential impact of a zero depletion policy, the following factors will be considered: the historical land use for nonirrigated and irrigated crops, value of field crops produced under nonirrigated and irrigated systems, gross and net irrigation requirements using Soil Conservation Service standards, value per crop acre for nonirrigated and irrigated crops, and issues associated with the zero-depletion policy.

This report is based on production and water use in eight counties of Northwest Kansas. This area includes most of the Groundwater Management District Number 4. The economy of the Northwest region involves more than this district, but most of the irrigation occurs within the district and policies that influence irrigation will be studied from this perspective. The data for this report come from annual reports of Kansas Farm Facts for 1960-1989 (2).

LAND USE

All data on land use are shown in Appendix Table A-1. The total harvested acres in Northwest Kansas remained relatively stable from 1960 through 1989 (Figure 1). Kansas Farm Facts reports about 1.5 million harvested acres in 1960 and 1.7 million in 1989 for the Northwest district.

FIGURE 1: TOTAL, DRYLAND, AND IRRIGATED CROPLAND
Northwest Kansas



This acreage does not include fallow land associated with nonirrigated wheat and grain sorghum acreage. The major small grain crops harvested were wheat, corn, grain sorghum, barley, and oats; and soybeans were harvested as an oilseed crop. Forage crops were alfalfa, corn silage, sorghum silage, and sorghum forage. Nonirrigated harvested crop acreage was nearly 1.5 million acres in 1960 and gradually declined to 1.4 million acres in 1989. The nonirrigated crops were the major small grains and forages.

In 1960, about 12 percent of the harvested acres were irrigated and the major crop was corn. Other irrigated crops were grain sorghum, wheat, alfalfa, and corn and sorghum silage. In every year since 1960, more acres of corn have been irrigated than any other small grain crop. Irrigated crop acreage doubled from 0.2 million acres in 1960 to 0.4 million acres in 1978. From 1978 to 1986, irrigated acreage remained stable. After 1986, irrigated acreage declined. The portion of total crop acres harvested that were irrigated increased to 28 and 27 percent in 1981 and 1984, respectively. But for most years since 1974, the amount has been near 23 percent.

VALUE OF FIELD CROP PRODUCTION

Reported gross value of field crop production was determined by multiplying the number of acres of field crops times yield per acre of each crop times the per unit market value of each. Costs of production were not subtracted. Gross value of field crop production was the total revenue received if the crop was sold, plus the value of feeds and forages fed. Data for value of field crops are shown in Table A-2.

The irrigator is more interested in net value of crop production than gross value. Net value is the gross value less cost of inputs and fixed costs. Net crop value is defined as the irrigator's return to his labor and management. However, the gross value of crop production is important to the rest of the economy, because it shows how much money in total is spent by the irrigator.

The prices used in calculating the value of field crop production were marketing year average prices, which, after 1985, did not include an allowance for government loans outstanding and government purchases.

The value of production varied greatly from year to year because of weather effects on crop yield and changes in crop prices. However, acreage remained relatively stable.

Gross value of field crop production in 1973 was about three times the value in 1960 (Figure 2). This increase was mostly due to higher crop prices. The increase in the gross value of production from nonirrigated crops was equally dramatic. The gross value of production from irrigated crops also increased although not as noticeably.

Between 1974 and 1980, the gross value of production from nonirrigated field crops declined because of a decrease in per acre crop yields. A reduction in value of production from irrigated crops did not occur because per acre crop yields were increasing. Between 1980 and 1985, the gross values of production from both irrigated and nonirrigated crops reached the highest levels for the study period. Changing values of irrigated and nonirrigated field crops during the 1980's were determined mostly by changes in crop prices.

The gross value of production from nonirrigated field crops shows much greater year-to-year variability than that for production of irrigated crops. This illustrates the other positive effect of irrigation: the reduction in income variability.

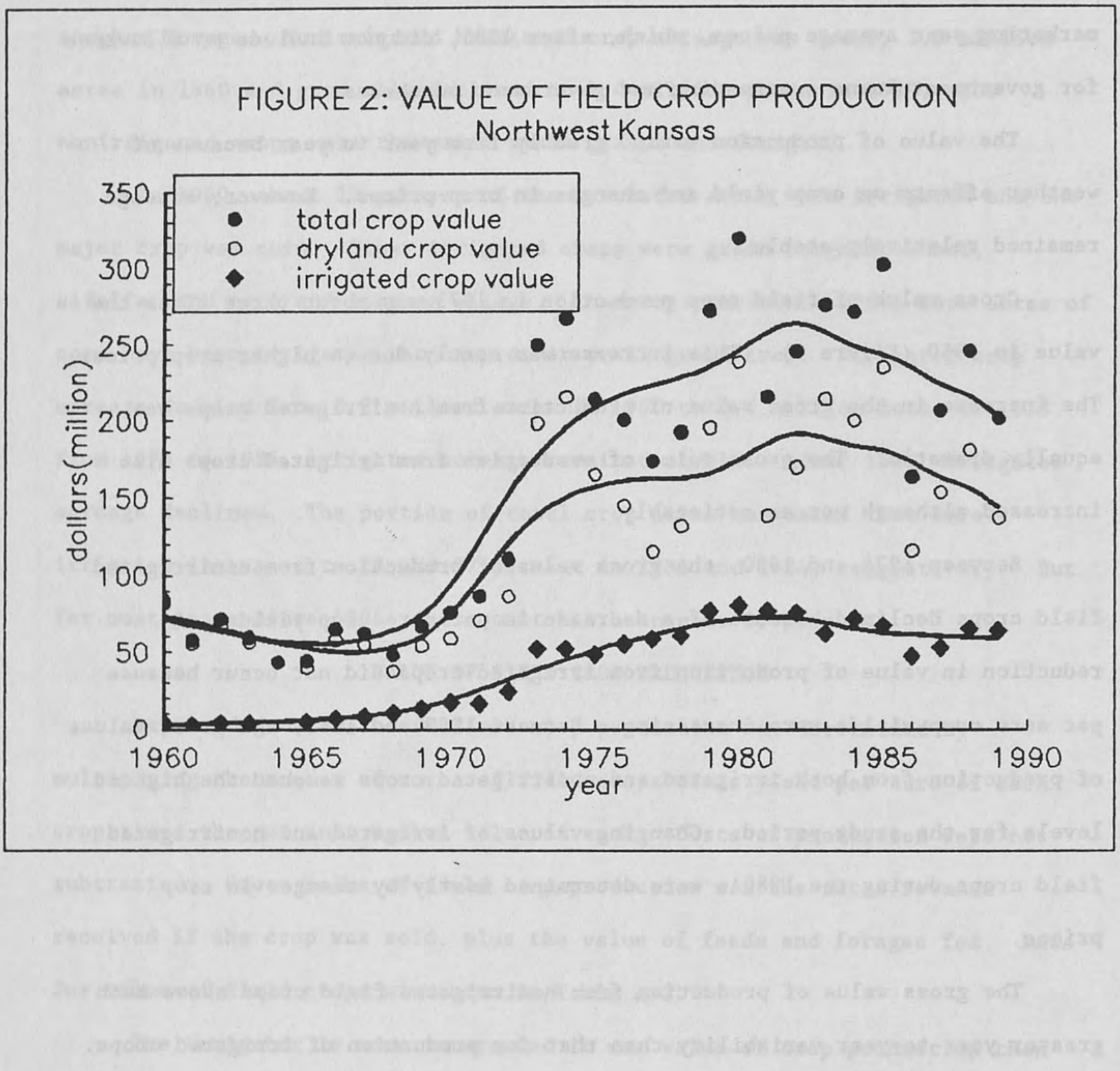


FIGURE 2: VALUE OF FIELD CROP PRODUCTION
Northwest Kansas

WATER USE

As irrigated acres increased, so did the amount of water pumped. Rainfall in Northwest Kansas in most years is inadequate to provide for maximum potential crop yield. Thus, irrigation is needed to enhance crop production. Water use for irrigation is presented as gross and net irrigation requirements (Figure 3). Data on irrigation requirements are shown in Table A-3. Gross irrigation is an estimate of the total amount of water pumped. Net irrigation is an estimate of the amount of water used by the crop. Soil Conservation Service (SCS) guidelines were used to estimate both amounts (3). Gross irrigation requirements were based on an 80 percent chance rainfall and 65 percent irrigation efficiency. An 80 percent chance rainfall is the amount that can be expected to be equaled or exceeded 8 years out of 10. In only 20 percent of the years will more irrigation be needed because of low rainfall. A 65 percent efficient irrigation system means that 65 percent of the water pumped is used by the crop and 35 percent is lost through runoff, infiltration, and evaporation. The SCS considered the gross and net irrigation requirements representative of maximum in-season irrigation water demand for general considerations.

Nearly 300,000 acre feet of water were pumped in 1960 to irrigate about 200,000 acres of field crops (Figure 3). The amount of water pumped remained relatively stable until 1967. After 1967, a dramatic increase in the amount of water pumped occurred, coincident with the increase in irrigated acres. By 1976, the amount of water pumped had nearly doubled from that in 1960. The increase in water pumped was relatively larger than the increase in irrigated acres, because irrigated corn acreage increased relative to other crops. After 1982, a slight decrease occurred in water pumped.

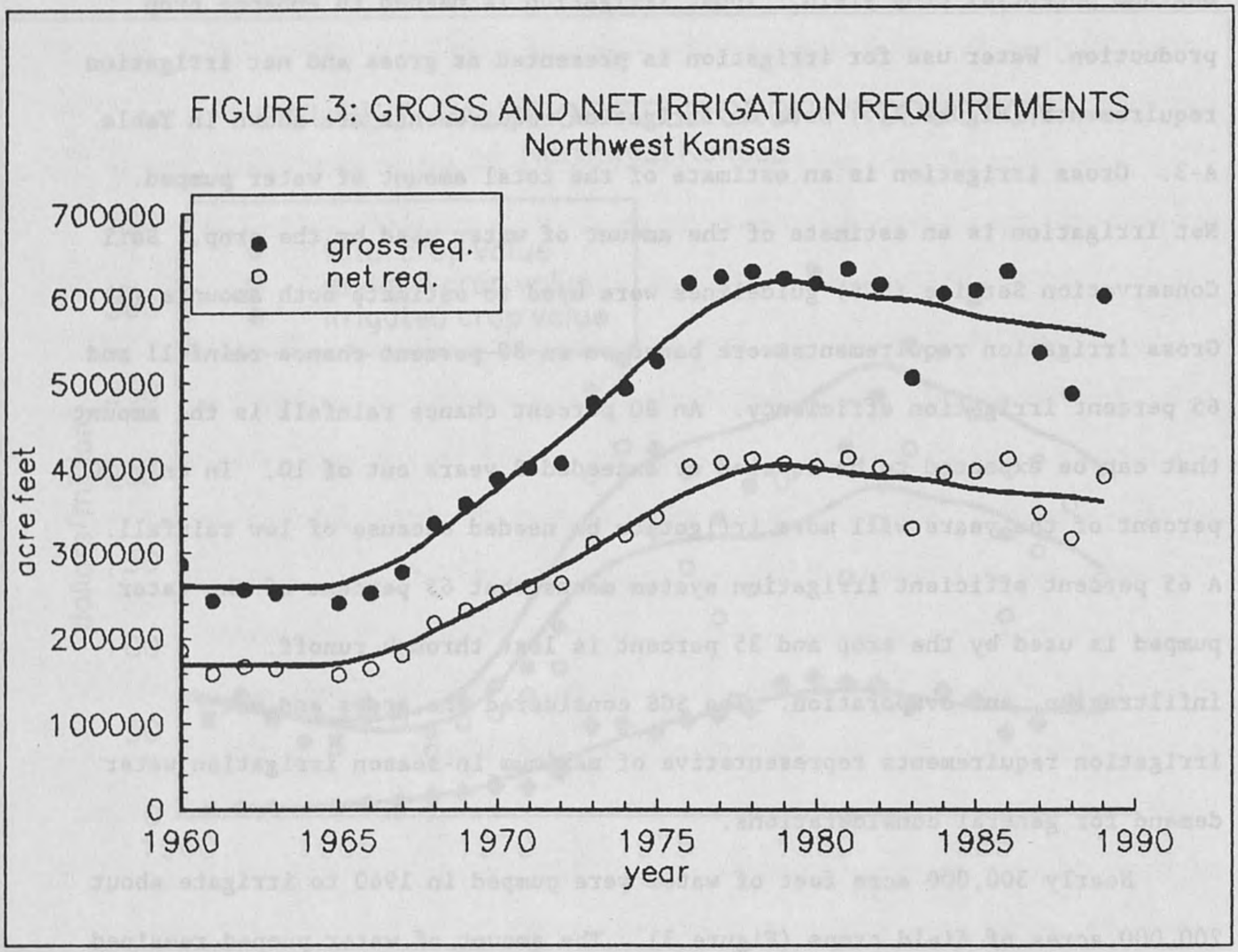


FIGURE 3: GROSS AND NET IRRIGATION REQUIREMENTS
Northwest Kansas
gross req.
net req.
acre feet
700000
600000
500000
400000
300000
200000
100000
0
1960
1965
1970
1975
1980
1985
1990
year

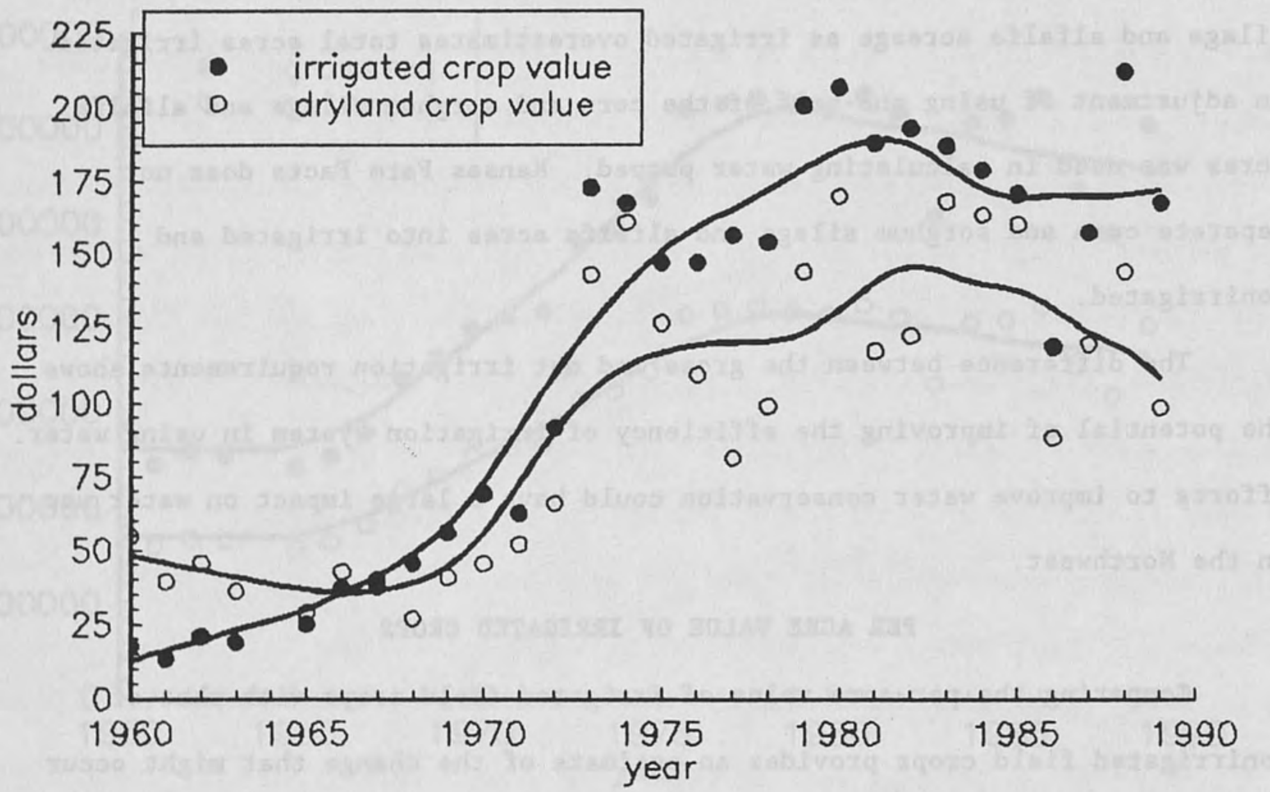
Estimate of water use by the crops, which is the net irrigation requirement, began with less than 200,000 acre feet in 1960 and increased to about 400,000 acre feet in 1976. Since 1976, net irrigation requirements have been relatively constant. The method of using gross and net irrigation requirements based on an 80 percent chance rainfall situation likely overestimates water pumped and used by the crop for most years. Years of near average rainfall will require less water. Also, including corn and sorghum silage and alfalfa acreage as irrigated overestimates total acres irrigated. An adjustment of using one-half of the corn and sorghum silage and alfalfa acres was used in calculating water pumped. Kansas Farm Facts does not separate corn and sorghum silage and alfalfa acres into irrigated and nonirrigated.

The difference between the gross and net irrigation requirements shows the potential of improving the efficiency of irrigation system in using water. Efforts to improve water conservation could have a large impact on water use in the Northwest.

PER ACRE VALUE OF IRRIGATED CROPS

Comparing the per acre value of irrigated field crops with that of nonirrigated field crops provides an estimate of the change that might occur in total value of field crops if nonirrigated field crops replace irrigated (Figure 4). The per acre values were calculated by dividing the gross value of field crop production estimates by the number of acres. The per acre values, both nonirrigated and irrigated, were composites of the values from several crops. The share that each crop was of the total differed for irrigated and nonirrigated. Additional data on yield and prices of irrigated crops are shown in Table A-4.

FIG. 4: PER ACRE VALUE OF IRRIGATED AND DRYLAND CROPS
Northwest Kansas



As expected, the per acre value generally was higher for irrigated than for nonirrigated crops. Rising per acre production values were influenced by trends for increasing crop yields and prices. Crop prices remained relatively unchanged until 1972, so the trend for rising per acre value was caused primarily by increases in per acre yield. After 1972, crop prices generally increased, and the difference between the per acre yields from irrigated and nonirrigated crops also increased. The per acre value from nonirrigated crops was mostly from wheat and grain sorghum. The per acre value from irrigated crops was mostly from corn. The per acre yield of irrigated corn increased much faster than yields of wheat and sorghum. Consequently, the difference increased.

From 1985 through 1989 the average value of crop production was $43 higher for an irrigated acre than for a nonirrigated acre. This does not allow for the fallow acreage needed for nonirrigated wheat. Thus, almost two acres of irrigated crops must be given up for one acre of nonirrigated crops: one acre for the harvested crop and one acre for fallow.

SUMMARY

A policy that changes the use of water in Northwest Kansas will affect the regional economy in many ways. Some irrigators have faced and others now are facing the problem of changing their farming and irrigation practices because the water table has declined to a level at which irrigation is no longer warranted. Because the aquifer is being mined, a diminution of irrigated agriculture is inevitable. The question is not if, but when and how fast the adjustments within the region are going to happen.

Planning for use of the water in the Ogallala aquifer should consider the long-run consequences of water policy. Annual changes in the aquifer may appear to be too small to require immediate action. It is necessary to consider the cumulative effects of all irrigators over many years. This leaves the policy analyst in the situation of having to anticipate the future courses of institutions, markets, producers, and consumers. Appendix B gives a list of issues and questions that should be considered. However difficult it may be, the public needs the best estimates of the effects of alternative water use policies on their economy, environment, tax base, and quality of life. Planning the future use of the aquifer should be based on a historical perspective of irrigation in Northwest Kansas. Information on the development of irrigation and the magnitude of irrigation, such that provided in this report, is necessary for assessing the impact of any change in water policy.

Adjustments among individual irrigators will differ. The hydrology of the aquifer varies greatly throughout the region. Developing an equitable policy will be a great challenge, because it is difficult to accept immediate costs as a trade-off for long-term benefits. Also, the distribution of costs may not coincide with the recipients of the benefits. It may be necessary to develop some type of incentive, reward, or compensations for those groups adversely affected.

The evaluation of the consequences of a change in water policy should consider the possible risks, costs, and benefits of the policy. The problem facing the citizens of Northwest Kansas is how best to manage the water resource for long-term as well as short-term benefits.

References

1. Kansas Farm Management Association, 1989. Records Report, Southwest Association, Department of Agricultural Economics and Cooperative Extension Service, Kansas State University, Manhattan.

2. Kansas Farm Facts, 1960-1989. Annual Reports, Kansas State Board of Agriculture, U.S. Department of Agriculture, Topeka, Kansas.

3. Kansas Irrigation Guide, revised, 1989. Soil Conservation Service, U.S. Department of Agriculture.

Appendix A

Table A-1. Total Dryland and Irrigated Acres, Irrigated Acres by Crop and by Year.

Year	Irrigated corn	Irrigated gr. sorg	Irrigated wheat	Total irrigated	Forage acres	Total dryland	Total acres	% Irrig. of total
1960	77900	10800	8000	193400	96700	1485000	1581700	12.2
1961	40900	10600	3000	183970	129470	1408000	1462500	12.6
1962	51100	13400	3000	185700	118200	1481000	1548500	12.0
1963	46200	14200	6000	185070	118670	1550600	1617000	11.4
1964	21000	M	M	160180	M	1429800	M	
1965	31500	23400	8000	180310	117410	1369400	1432300	12.6
1966	47500	21100	7000	179580	103980	1357300	1432900	12.5
1967	57050	22900	6000	194740	108790	1451900	1537850	12.7
1968	80900	31000	10000	223260	101360	1404000	1525900	14.6
1969	92000	34300	10000	233930	97630	1326300	1462600	16.0
1970	107000	36100	7000	249680	99580	1298300	1448400	17.2
1971	117700	24000	2000	259750	116050	1354700	1498400	17.3
1972	112000	29500	3000	266250	121750	1309500	1454000	18.3
1973	156000	18400	9000	301050	117650	1389400	1572800	19.1
1974	165300	14900	7600	311860	124060	1338500	1526300	20.4
1975	174700	18800	14700	329800	121600	1304760	1512960	21.8
1976	220500	19600	18400	377050	118550	1328000	1586500	23.8
1977	216800	39600	23100	374790	95290	1424400	1703900	22.0
1978	197400	42800	21000	394300	133100	1336400	1597600	24.7
1979	203800	40600	21500	382500	116600	1363300	1629200	23.5
1980	184000	40600	32300	389450	132550	1406700	1663600	23.4
1981	150700	68200	57800	408700	132000	1183600	1460300	28.0
1982	145400	64600	69200	394180	114980	1389300	1668500	23.6
1983	114900	39500	59500	333050	119150	1274700	1488600	22.4
1984	111300	76100	77200	401900	137300	1225500	1490100	27.0
1985	128100	72000	80600	394600	113900	1469500	1750200	22.5
1986	155400	72000	61900	399200	109900	1319500	1608800	24.8
1987	141000	44000	61500	337000	90500	1282300	1528800	22.0
1988	138200	32000	44700	307200	92300	1256500	1471400	20.9
1989	163500	40000	60000	382000	118500	1393600	1657100	23.1

"M" denotes missing data. Source: Kansas Farm Facts (2).

Table A-2. Value of Irrigated and Nonirrigated Field Crops, Northwest Kansas.

Year	Value of Field Crops				% Irrig	Per Acre Value	
	Total	C,GS,WHT	Irrigated	Nonirr	Of total	Nonirr	Irrigated
	$(000)	$(000)	$(000)	$(000)	%	$	$
1960	84711	3435	3440	81271	4.1	54.73	17.78
1961	57904	2522	2526	55378	4.4	39.33	13.73
1962	71439	3881	3888	67551	5.4	45.61	20.94
1963	59579	3526	3535	56044	5.9	36.14	19.10
1964	43335	M	M	43335	0.0	M	M
1965	44092	4550	4557	39535	10.3	28.87	25.27
1966	64670	6629	6637	58033	10.3	42.76	36.96
1967	62449	7809	7818	54631	12.5	37.63	40.15
1968	48071	10184	10192	37879	21.2	26.98	45.65
1969	67120	13059	13066	54054	19.5	40.76	55.86
1970	75997	17199	17206	58791	22.6	45.28	68.91
1971	86634	16199	16208	70426	18.7	51.99	62.40
1972	110529	24316	24330	86199	22.0	65.83	91.38
1973	250219	51912	51928	198291	20.8	142.72	172.49
1974	267374	52159	52179	215195	19.5	160.77	167.32
1975	213556	48406	48425	165131	22.7	126.56	146.83
1976	200255	55355	55375	144880	27.7	109.10	146.86
1977	173843	58518	58539	115304	33.7	80.95	156.19
1978	192513	60607	60628	131885	31.5	98.69	153.76
1979	271995	76582	76607	195388	28.2	143.32	200.28
1980	318893	80285	80309	238584	25.2	169.61	206.21
1981	215169	76631	76662	138507	35.6	117.02	187.58
1982	245439	75802	75829	169610	30.9	122.08	192.37
1983	275709	62050	62080	213629	22.5	167.59	186.40
1984	271270	71606	71646	199624	26.4	162.89	178.27
1985	301777	67104	67127	234650	22.2	159.68	170.11
1986	163286	47363	47379	115907	29.0	87.84	118.69
1987	206188	52849	52870	153318	25.6	119.57	156.88
1988	245593	64987	65013	180580	26.5	143.72	211.63

M" denotes missing data. Source: Kansas Farm Facts (2).

Table A-3. Gross and Net Irrigation Requirements, Northwest Kansas by Year (80%

Year	Irrigation Requirement Gross (ac. ft.)	Irrigation Requirement Net (ac. ft.)	Irrig. Acres (acres)	Per Acre Requirement Gross (ac. ft.)	Per Acre Requirement Net (ac. ft.)
1960	286936	186672	193400	1.48	0.97
1961	244309	158937	183970	1.33	0.86
1962	256158	166658	185700	1.38	0.90
1963	252776	164441	185070	1.37	0.89
1964	M	M	160180	M	M
1965	240973	156759	180310	1.34	0.87
1966	251810	163822	179580	1.40	0.91
1967	277157	180325	194740	1.42	0.93
1968	334064	217355	223260	1.50	0.97
1969	356835	232181	233930	1.53	0.99
1970	386716	251646	249680	1.55	1.01
1971	398609	259392	259750	1.53	1.00
1972	404398	263157	266250	1.52	0.99
1973	475105	309136	301050	1.58	1.03
1974	492432	320413	311860	1.58	1.03
1975	524372	341169	329800	1.59	1.03
1976	616100	400854	377050	1.63	1.06
1977	622825	405240	374790	1.66	1.08
1978	629529	409598	394300	1.60	1.04
1979	620693	403851	382500	1.62	1.06
1980	615391	400333	389450	1.58	1.03
1981	632067	411079	408700	1.55	1.01
1982	613166	398721	394180	1.56	1.01
1983	503665	327474	333050	1.51	0.98
1984	602286	391597	401900	1.50	0.97
1985	606883	394579	394600	1.54	1.00
1986	628738	408906	399200	1.57	1.02
1987	532629	346335	337000	1.58	1.03
1988	485611	315810	307200	1.58	1.03
1989	598438	389156	382000	1.57	1.02

"M" denotes missing data. Source: Kansas Farm Facts (2).

Table A-4. Irrigated per Acre Yield and Crop Prices by Year.

Year	Irrigated Crop Yield			Crop Prices, $ per Bu.			
	corn	gr. sorgh	wheat	corn	gr. sorgh	soybean	wheat
1960	29.6	69.1	42.6	0.98	0.78	1.98	1.74
1961	38.8	66.6	24.3	1.08	0.96	2.17	1.79
1962	48.0	78.0	29.0	1.10	0.96	2.17	2.06
1963	44.2	73.1	25.5	1.12	0.92	2.45	1.86
1964	54.7	M	M	1.19	1.04	2.51	1.37
1965	69.7	73.0	30.0	1.17	0.97	2.39	1.35
1966	79.6	65.1	32.6	1.28	1.03	2.70	1.64
1967	95.9	80.2	35.0	1.06	0.91	2.42	1.35
1968	92.4	69.4	24.8	1.06	0.91	2.30	1.22
1969	97.7	73.0	35.6	1.13	0.99	2.22	1.19
1970	96.2	81.0	50.1	1.31	1.12	2.74	1.25
1971	108.1	81.0	38.5	1.12	0.95	2.99	1.32
1972	120.0	89.4	44.0	1.52	1.39	4.10	1.68
1973	122.9	76.7	51.6	2.46	2.13	5.67	3.75
1974	97.3	58.5	47.8	3.01	2.69	7.34	3.86
1975	99.9	63.1	41.4	2.50	2.27	4.77	3.42
1976	108.5	71.6	42.5	2.12	1.86	6.52	2.59
1977	112.5	112.5	43.1	1.99	1.74	5.50	2.24
1978	111.4	74.7	42.3	2.35	1.99	6.64	2.89
1979	125.1	96.7	49.4	2.51	2.2	5.97	3.72
1980	105.9	80.1	50.2	3.32	2.91	7.55	3.78
1981	143.5	91.0	30.2	2.58	2.3	5.80	3.76
1982	121.7	85.2	49.8	2.76	2.67	5.57	3.56
1983	114.8	87.0	48.1	3.25	2.7	7.79	3.46
1984	140.6	86.9	52.2	2.77	2.25	5.74	3.32
1985	140.7	80.7	57.4	2.37	1.92	4.95	2.86
1986	132.8	87.1	43.1	1.60	1.33	4.60	2.25
1987	149.0	100.1	48.4	1.84	1.58	5.49	2.43
1988	144.4	97.0	39.0	2.60	2.21	7.26	3.58
1989	131.4	64.0	46.5	2.25	1.99	5.35	3.75

"M" denotes missing data. Source: Kansas Farm Facts (2).

Appendix B

Issues Regarding Zero Depletion

The following are some issues and questions that should be considered with a change in water policy such as the zero-depletion policy.

1. What are the estimated short-run and long-run effects in the region on:

    total acres irrigated

    acreage of specific crops

    production by commodity

    total water use

    water use by specific crop

    feedlot and livestock industry

    land values

    farm income

    agribusiness income by type of business

    total income

    viability of services provided

        fewer service

        consolidation of services

    employment

    population

    tax base

2. To what extent can the effects of zero depletion be reduced by adopting water conservation practices?

3. Will the effect of reducing water pumped increase the risk to producers and agribusinesses because of increased variability of production?

4. How does the water policy affect communities within the region?

5. How do government programs interact with the water policy?

6. How will retaining a good water supply enhance the location of business to the community?

7. What are some alternative to zero depletion?

8. Are other incentives possible that result in zero depletion?

9. Suppose that zero-depletion policy is implemented, but the overdraft of the aquifer continues ...then what?