AN ECONOMIC ANALYSIS OF IRRIGATION WITH A LIMITED SUPPLY OF WATER IN SOUTHWEST KANSAS

by

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TABLE OF CONTENTS

I

INTRODUCTION

Irrigation development in Kansas has progressed rapidly in the past 20 years. In this period of time irrigated acreage has doubled to a total area of over 1.1 million acres. (Fig. 1) This same rate of development has been experienced in a seven county area of southwest Kansas (Finney, Haskell, Seward, Stevens, Morton, Stanton and Grant) to which this report is directed. Nearly 40 percent of the total irrigated acreage in Kansas is contained in this seven county area (Fig. 1).

For southwest Kansas, the development of irrigation has added considerable stability to farming in a semi-arid region and to the total agricultural community. It has also brought many adjustments compatable with a more intensive, highly productive agriculture.

Irrigation wells are the primary source of water for irrigation. The availability of underground water supplies is not uniform throughout the area which causes concentration of wells in certain areas and variation of the level of output of water from wells from farm to farm.

Land area suitable for irrigation exceeds the availability of water. With the rapid expansion of irrigation, some areas are depleting water supplies faster than the natural rate of recharge of the underground water.

This presents a problem of allocation of resources with a limited supply of water and a relatively larger quantity of land suitable for irrigation.

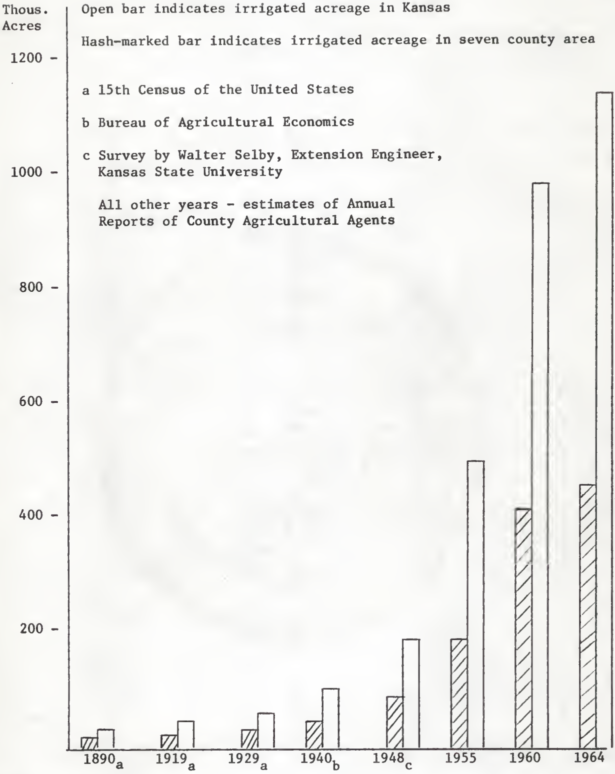

Figure 1.

Irrigated acreage in Kansas and the seven
southwest county area -- selected years

The primary objective of this report is to consider the most profitable and efficient use of a limited supply of irrigation water in relation to a relatively large quantity of land suitable for irrigation. With a limited supply, this consideration becomes paramount in importance.

The limitation on the supply of water may take several forms. The cause of the limitation will determine the alternatives available for the irrigation farmer's consideration.

Water available for irrigation may be limited by:

> 1. The capacity of the irrigation well. An irrigation well will produce a given quantity of water in a given period of time. The capacity of irrigation wells in southwest Kansas will range from 300 gallons per minute up to 4000 gallons per minute (gpm). Crops to be irrigated have various water requirements. For example, wheat requires less water for maximum production than does grain sorghums.[1] Different crops also have different seasons of peak use or high rates of water consumption. This limits given capacity of water due to necessary frequency of application. Soil type and structure will determine the amount of water that can be applied with each application. So the well of a given capacity is limited by the amount of water that can be pumped in a given period of time determined by the frequency of application necessary to achieve the desired level of production. Potential crop yields are reduced rapidly as stress increases due to neglect or inability to supply water applications at desirable intervals of time.
>
> With this type of limitation (most common limitation at the present time in southwest Kansas) an irrigation farmer may organize various combinations of crops suitable to his farming operation to extend the peak season water requirements. He may also extend the effectiveness and acreage irrigated by a given water output by supplemental or off-season irrigation. Deep soils inherent to southwest Kansas have the capacity to store water in the soil profile in the form of a reserve to reduce the frequency of irrigation during the peak season. Good yield responses have also been achieved from partial or a less intensive irrigation using an intermediate level of irrigation.

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[1] Irrigation Requirements, Kansas State University Engineering Experiment Station, Bulletin No. 69, table 1, p. 6.

> 2. Depletion of groundwater supplies. Many are of the opinion that water supplies for irrigation in southwest Kansas will be limited in the future due to the exhaustion of the groundwater supplies. Studies conducted by the United States Geological Survey and State Geological Survey Agencies definitely indicate that this phenomena is occurring over time in some areas. This is due to rapid expansion of irrigation which has resulted in drawing from groundwater supplies more rapidly than normal rates of recharge will replenish the supply.[2]
>
> Should this consequency develop, the alternative most relevant for consideration is the most efficient level of irrigation intensity. This approach emphasizes the advantages and disadvantages of extensive irrigation versus intensive irrigation.
>
> 3. Governmental regulation. Although the Kansas water rights laws are presently somewhat general and vague concerning regulation of water use, the tools are available to instigate regulation. Until the present laws are implemented or the need becomes pressing, it is questionable as to what form water regulation would be administered. Present water rights are established by application to the Chief Engineer of the Division of Water Resources, Kansas State Board of Agriculture. Preference is associated with the age of a given water right. However, should state regulation become necessary, it is questionable that the more recently established irrigation wells would be required to cease pumping or be subject to more severe curtailment than those established in some early period. In any event, should governmental regulation of water for irrigation become necessary and if a limited supply is allocated for irrigation, then the same consideration of the merits of extensive versus intensive irrigation would be of major importance.

Production responses of various levels of intensity of irrigation and associated various cropping practices have been developed through applied research of the Kansas State University Experiment Stations.[3] These results

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[2] Carl E. Nuzman and Walter E. Meyer, Water Level Changes in Grant and Stanton Counties, 1939-1965. State Geological Survey, University of Kansas: Special Distribution Publication 18, 1965. pp. 1-8.

[3] Jack T. Musick and Donald W. Grimes, Water Management and Consumptive Use by Irrigated Grain Sorghums in Western Kansas. Kansas Agricultural Experiment Station: Technical Bulletin 113, 1961. p. 11.

furnish an excellent basis for estimating the income potential of the alternatives available under a given set of conditions.

The cost of irrigation in southwest Kansas in relation to various levels of irrigation intensity are somewhat less certain. Cost studies to date have projected data collected outside the area synthesized with theoretical estimates with a given set of assumptions.

For this study cost data were collected from farms in southwest Kansas with existing conditions, efficiencies and technologies. The purpose of this study is to determine the costs of irrigation in southwest Kansas in a framework suitable for estimating profitableness of the alternatives that prevail in the presence of a limited water supply.

II

REVIEW OF LITERATURE

The determination of the cost of pumping and distributing irrigation water is complicated due to the high degree of variation among farms in inputs, methods employed in the study and difficulty in distributing costs of irrigation. These problems are of major importance in preparing economic analysis of irrigation and must be confined within a given set of assumptions or ranges applicable to an area or problem. These tend to limit the use of specific recommendations with respect to optimum levels of production in relation to costs of production to a specified set of conditions. It may also bring conflicting opinions concerning recommendations.

Zimmerman points out,

> There is a recurrent controversy as to whether the benefit from crop returns is increased by spreading available water over a large area, in quantities well below plant moisture requirements, or by irrigating according to the optimum water demand of a smaller area. The former approach is favored by many authorities, often for political reasons, because it permits an egalitarian water distribution policy, that is, drought insurance for all. ...It must be understood that the conveyance system and irrigation efficiency for a low overall irrigation application via a crude application system is bound to decrease as the area to be irrigated with the same amount of water is increased.
>
> Alternatively, in order to prevent this, the cost of an excessively long, lined main and internal field irrigation conveyance network and land preparation for a sophisticated irrigation system has to increase enormously to really convey an appreciable percentage of the available water to the area to be irrigated. This is an expenditure which is, however, not practical for extensive

> supplementary irrigation. Moreover, in order to really benefit from irrigation and cover the increase production costs, the project must be on a reasonably efficient irrigation system with an adequate supply of water, applied to improved crop varieties, supplemented by application of fertilizer, and accompanied by disease and pest control, as well as by appropriate crop rotation. The cost of this intensification is high and can only be recovered by ample yields of high value crops per unit area.
>
> Supplemental irrigation is, however, highly recommended where it can be done both efficiently and economical.[4]

Zimmerman's statement is rather broad and necessarily general. It refers to canal irrigation which involves relatively long distances of water transportation. The reference to costs and production are relative but the principles involved are well defined.

An example to illustrate this controversy can be cited concerning the use of a limited supply of irrigation water in relation to a relatively large quantity of land.

Pine, Feyerherm and Sirohi point out in a study of irrigated grain sorghums and wheat in western Kansas, "The results indicate that if 3000 acre-inches of water were available for grain sorghum or wheat, in all likelihood, a larger profit would be realized from applying nine inches on 333 acres than 15 inches on 200 acres."[5] Swanson and Thaxton however, express a diametrically opposite view that, "High moisture levels are most profit-

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[4] Josef D. Zimmerman, Irrigation. (New York, London, Sydney: Wiley and Sons, Inc., 1966), pp. 9-10.

[5] Wilfred H. Pine, Arlin M. Feyerherm, and Amar S. Sirohi, Irrigating Grain Sorghums and Wheat in Western Kansas: An Economic Appraisal. Kansas Agricultural Experiment Station, (Unpublished manuscript) 1966, p. iv.

able; if the irrigation water supply becomes inadequate, the acreage to which water is applied should be reduced."[6]

The statement from Pine, Feyerherm and Sirohi is based on production functions developed by Amar S. Sirohi for his Ph. D. dissertation, An Economic Analysis of Irrigation in Western Kansas (1962). In this thesis, Sirohi goes into considerable detail in developing production functions with which, "Curvilinear regression analysis was performed to study the yield-water relation of the four crops (grain sorghums, alfalfa, wheat and sugar beets) grown in western Kansas."[7] He further states, "The production equations developed in this study from the experimental data are reliable and dependable."[8] This statement is subject to question with equations showing extreme sensitivity in yield reductions at higher levels water application. Personal observations of farmers irrigating in an area of highly variable rainfall patterns have not shown such yield reduction in a narrow range of maximum water applications.

Experimental work in this area indicates similar results. "Irrigation water management greatly influenced yield in drouth years of 1955 and 1956. Very little effect occurred in the wetter year, 1954. In all years highest yields were produced from the wettest soil moisture treatments."[9]

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[6] Norris P. Swanson and E. L. Thaxton, Jr., Requirements for Grain Sorghum Production on the High Plains. Texas Agricultural Experiment Station in cooperation with the United States Department of Agriculture, Bulletin 846, 1957, p. 2.

[7] Amar Singh Sirohi, An Economic Analysis of Irrigation in Western Kansas. A Ph. D. Dissertation, Kansas State University, 1962, p. 35.

[8] Ibid. p. 108.

[9] D. W. Grimes and J. T. Musick, "Effect of Plant Spacing, Fertility, and Irrigation Managements on Grain Sorghum Production", Agronomy Journal, Volume 52:647-650, 1960, p. 649.

Much of this can be explained by the very deep soils, inherent to the area, which allow deep percolation of excess water quickly enough to prevent yield reductions in crop production within a wide range of high levels of irrigation.

Swanson and Thaxton state,

> The water requirements of grain sorghum is not a fixed value. In hot dry years transportation by the plant is higher than in cool, relatively humid seasons. Low relative humidities, high temperatures and wind movement also increase evaporation from the soil surface, adding further to the consumptive use. Other factors can also cause important differences in consumptive use and water requirement. Restricted soil moisture reduces transpiration. Frequent irrigation increases evaporation. Unavoidable run off of rainfall and irrigation water or loss by deep percolation increases the water required."[10]

These same phenomena exist in southwest Kansas, which is very similar in most respects to the High Plains area of Texas.

Experimental work done by Jack T. Musick for his masters thesis in 1954 indicated that irrigation for maximum yields decreases water use efficiency. This is further substantiated by experimental work done at the Garden City Experiment Station.[11]

"The water available for irrigation from underground storage is definitely limited; therefore, its efficient use and conservation are of utmost importance."[12] This statement illustrates the concern for underground water supplies in western Kansas which are believed to be large underground pools with very limited amounts of recharge. Nuzman and Meyer state, "The amount

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[10] Swanson and Thaxton, op. cit.

[11] J. T. Musick and W. D. Grimes and G. M. Herron, Water Management, Consumptive Use and Nitrogen Fertilization of Irrigated Wheat in Western Kansas, United States Department of Agriculture in Cooperation with Kansas Agricultural Experiment Station: Prod. Res. Report, No. 75, p. 1.

[12] Ibid.

and distribution of pumping will determine the number of years that irrigation will remain practical in parts of the area [Grant and Stanton Counties]. As the use of water from storage continues, the water remaining in storage diminishes."[13]

The decline in water levels in the Grant-Stanton County area in a period from 1939-1965 has ranged from 10 feet to 100 feet. However 97 percent of the area surveyed show water-level declines of less than 40 feet and nearly 75 percent show declines of less than 10 feet.[14]

Most areas of southwest Kansas show indications of some decline in water-level but the Grant-Stanton County area is the most severely affected.

"Many new wells and replacement wells have penetrated the Mesozoic sandstone and have obtained 500 to 700 gpm from these consolidated sediments. Some older wells have been reconditioned, and pump design has been changed to maintain original yields. Yields of older wells in the area of greatest decline have been reduced owing to increase in pumping lift."[15] These same conditions have been more severly experienced by the High Plains Area of Texas (Cochran, Hockley, Lubbock, Crosby, Hale and Lamb Counties) which has forced some farmers to cease irrigation and others to seriously modify their irrigation programs due to water depletion.[16]

Dr. E. S. Bagley in an article published in the Kansas Agricultural Situation[17] made inference to the similarity of the High Plains area of

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[13] Nuzman and Meyer, op. cit. p. 1.

[14] *Ibid*. p. 8.

[15] *Ibid*.

[16] William F. Hughes and A. C. Magee, *Some Economic Effects of Adjusting to a Changing Water Supply, Texas High Plains*, Texas Agricultural Experiment Station, Bulletin 966, 1960. p. 22.

[17] E. S. Bagley, Ground Water Depletion Under Federal Income Tax Laws, *The Kansas Agricultural Situation*, Kan. St. Univ., Vol. 42:12, May, 1966, pp. 6-7.

Texas and southwest Kansas in regard to permanent water depletion and suggested that investigation should be given to this in respect to water depletion allowances for income tax purposes.

Rapid expansion of irrigation development in southwest Kansas (as indicated in the introduction of this report) requires more serious consideration of this possibility than is presently prevailing. This situation as well as cost of pumping and distributing irrigation water make it imperative that the utmost consideration be given to efficiency of water use in relation to most profitable yield levels.

"Results from irrigation studies in Texas, Oklahoma and Kansas indicate that maximum water use efficiency occurred when seasonal consumptive use was less than or about 22 inches (water available to the plant for crop production). High yields of 115 to 120 bushels have occurred where maximum water use efficiency was obtained. ...Recommendations to farmers based on percentage of available soil moisture or soil moisture tension are difficult for practical use. Most farmers will not adequately sample their soil for moisture and few are able to interpret the results for timing of irrigations."[18]

Recognizing the importance of timing of irrigation in relation to water-use efficiency, Musick and Grimes, developed their experimental work and analysis with grain sorghums on the basis of water application in relation to stages of plant growth.

Irrigation applications were applied prior to planting, at a 10 to 14 inch plant height at boot stage and at milk stage. The yields of various

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[18] Jack T. Musick and Donald W. Grimes, op. cit., p. 4.

combinations of these irrigation treatments compared with yields of dryland fallow were reported.[19] Water efficiency decreased with a seasonal water use beyond 21.3 inches in 1957, 22.2 inches in 1958, and 18.9 inches in 1959, although total yield continued to increase at a decreasing rate.[20]

Other factors influencing yields of grain sorghums include fertility, seeding rate, variety, row spacing and weed control. These factors are controlled by management which varies among farmers. "Good management practices are necessary for high yields and efficient production. Sufficient water and a good irrigation system will not produce optimum yields unless good cultural practices are followed and sufficient fertilizer is added."[21] Since the level of management is extremely difficult to measure in terms that can be transcribed into economic analysis, most analyses assume this human quality as constant at a satisfactory level for optimum production. This however often explains much of the difference between results under controlled conditions at an experiment station and the application of the recommendations at the farm level.

Sirohi points out in his study that the interaction between water and nitrogen was not statistically significant and arrives at the conclusion, "Therefore, application of nitrogen does not affect the profitability of irrigation in western Kansas."[22] Personal observation of substantial increases in the use of nitrogen fertilizer on irrigated farms in western Kansas by this writer would raise question to this statement. Results pub-

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[19] Ibid. Table 6, p. 11.

[20] Ibid. Table 10, p. 15.

[21] M. E. Jensen and J. T. Musick, Irrigating Grain Sorghums, United States Department of Agriculture Leaflet No. 511, 1962, p. 6.

[22] Amar S. Sirohi, op. cit., p. 106.

lished in <u>Soil Fertility Investigations in Southwestern Kansas</u>[23] indicate significant responses to nitrogen fertilizer applications on irrigated soils.

Row spacing, seeding rate and fertilization of grain sorghums has received considerable study at experiment stations. Results of this type of study have been reported by Grimes and Musick.[24] In plant spacing -- fertility experiments grain yields were significantly higher in two of three years in response to the addition of nitrogen. The year with no significant increase was expected since the area had grown alfalfa the preceding year. No significant interaction of plant spacing and fertility rates occurred, but it is pointed out that this may have been due to relatively small increases in yield from added nitrogen.

Yield responses to nitrogen have increased at the Garden City Experiment Station in recent years as the production of grain sorghum has become more distant to alfalfa in the rotation. In 1962, Grimes and Musick reported, "Greatest response to added nitrogen occurred when sufficient irrigation water was added to produce high yields. Nitrogen at 120 pounds per acre boosted yield over unfertilized plots by 2,371 and 3,120 pounds of grain, respectively, for one and three irrigations."[25]

In regard to plant spacing, in years with low seasonal rainfall, wider row spacings produced higher yields with a pre-plant irrigation only.

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[23] N. L. Nossaman and others, <u>Soil Fertility Investigations in Southwest Kansas</u>, Garden City Branch, Kansas Agricultural Experiment Station. Progress Report 107, May, 1965, pp. 3-45.

[24] W. D. Grimes and J. T. Musick, "Effects of Plant Spacing, Fertility and Irrigation Managements on Grain Sorghum Production," <u>Agronomy Journal</u>. Volume 52:647-650, 1960.

[25] W. D. Grimes and J. T. Musick, "Irrigation, Nitrogen, Gives Best Water Use", <u>Crops and Soils</u>, April-May, 1962, p. 57.

With one or more additional irrigations this trend was reversed. "Plant populations in this range (112,000 to 179,000 plants per acre) are not expected to materially influence yield, therefore, the interaction can be attributed to row width."[26]

Similar work was conducted and reported by Porter, Jensen and Sletten with similar results except, "Interaction between fertility x spacing, years x fertility, and years x spacing x fertility were all significant at the 1 percent level. However interactions may have been the result of lack of homogeneity in the three years of experimental work."[27]

Later work cited by Musick, Grimes and Herron tends to amend earlier statements in relation to interaction of fertilizer and irrigation water applications. "Applied nitrogen increased seasonal ET (evapotranspiration) by 1 to 2 inches under conditions of appreciable response. Increased yields were disproportionately greater than the slight increases in seasonal ET; therefore, nitrogen considerably increases water use efficiency."[28]

Nitrogen has been the only commercial fertilizer to produce significant yield increases on irrigated grain sorghums. Herron and Erhart reported data gathered from experimental work at 19 locations in southwest Kansas from 1953 through 1957. "Phosphorus fertilization did not produce

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[26] W. D. Grimes and J. T. Musick, "Effects of Spacing, Fertility, and Irrigation on Grain Sorghums", Agronomy Journal, Volume 52:647-650, 1960, p. 649.

[27] K. B. Porter, M. E. Jensen and W. H. Sletten, "The Effects of Row Spacing, Fertilizer, and Planting Rate on the Yield and Water Use of Irrigated Grain Sorghums", Agronomy Journal, August, 1960, pp. 431-434.

[28] J. T. Musick, W. D. Grimes and G. M. Herron, "Irrigation Water Management and Nitrogen Fertilization of Grain Sorghums", Agronomy Journal, Volume 55:295-298, 1963, pp. 298.

significant increases in yield. Regression lines for yield data show greatest responses to nitrogen fertilizer under conditions where average yields were less than 55 bushels per acre without fertilization. Where production without nitrogen was above 75 bushels per acre, smaller increases in yield were obtained with nitrogenous fertilizer. Soil organic matter was not a good index to nitrogen response."[29]

With this information concerning irrigation production, a return to cost of irrigation is necessary for economic analysis. In theoretical framework, the farmer should extend irrigation to the point where the value of the marginal product is equal to the marginal unit cost. The same principle applies in practical application although the exact points of marginal return and marginal cost are often difficult to determine. This is due to lack of control over many of the variables involved, such as weather and markets.

Amar Sirohi in his thesis, An Economic Analysis of Irrigation in Western Kansas,[30] developed a cost analysis by synthesizing data from many sources. He points out a high degree of variation in the cost of irrigation water and develops a marginal analysis on the basis of a range of variable costs.

Hartman and Whittelsey, Colorado State University, present an interesting approach to this problem in their Marginal Values of Irrigation Water.[31] This study consists of a linear programming analysis of farm adjust-

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[29] George M. Herron and Andrew B. Erhart, "Effects of Nitrogen and Phosphorus Fertilizers on the Yield of Irrigated Grain Sorghum in Southwestern Kansas", Agronomy Journal, Volume 52:499-501, 1960, p. 501.

[30] Sirohi, op. cit.

[31] L. M. Hartman and Norman Whittelsey, Marginal Values of Irrigation Water, Colorado Agricultural Experiment Station, Technical Bulletin 70, pp. 1-28.

ments to the change in water supply. Marginal water values range from 39 cents to approximately $41 per acre foot. The purpose of the study, however, was not to derive a value for water, but to estimate the relative effect of certain factors upon the water values and to derive a range of water values. Lack of data available in the area made necessary the synthesis of data from many outside sources. The requirement of a large number of rather restrictive assumptions limits the value of this analysis for making recommendations with a high degree of confidence. It does, however, do an excellent job of demonstrating the model for this type of analysis.

Baumol points out, "Programming is concerned with the determination of optimal solutions to problems. As a result, it is well suited to analysis of rational behavior. It has, therefore, like marginal analysis, been somewhat less successful in describing what is than in indicating what (given some pre-assigned goals) ought to be."[32]

Moore developed a method of calculating least-cost combinations of water, labor and capital under several assumed sets of factor prices. Quantification of the variables did not lend itself to the use of survey or controlled field plot data. So a panel of four experienced engineers developed construction specifications, labor inputs and application efficiencies with their best estimates. A cube root production function was assumed and least-cost lines with variable interest rates, labor prices and water costs were calculated for a 640 acre farm. Moore concludes that results from this theoretical approach would be helpful in policy implications for agencies devel-

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[32] William J. Baumol, Economic Theory and Operations Analysis, (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1961) pp. 64-65.

oping and selling water and for those interested in conserving water by subsidizing conservation practices.[33]

Moore fails to show derived results or data used which makes an evaluation of this work difficult.

Myles, Fogel and Batchelder in Economics of Well Irrigation Systems[34] report the results of a survey conducted to determine efficiences of irrigation pumping plants in Nevada. The table of the survey information presents an interesting comparison of fuel or power costs (of 12 different wells) computed on a theoretical basis in relation to costs as reported. In every case there is considerable difference with six wells showing a higher reported cost than the derived theoretical cost and six wells having lower reported costs. The conclusion of this study is that most irrigators have various inefficiencies in well installation and operation that could be overcome by planning, budgeting and proper management.

Another Fogel and Myles publication, Pumping from Irrigation Wells,[35] outlines considerations in planning a pumping installation and constructing the well. Estimated guide lines of typical costs (fixed and operating) with a table of suggested depreciation rates are well illustrated. This plus a guide for budgeting gives a farmer a basis for initial planning. Final basis for decision making would probably require more specific information.

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[33] Charles V. Moore, "A Method of Selecting Least-Cost Irrigation Water Distribution Systems", Journal of Farm Economics, Volume 45: No. 5, December, 1963, pp. 1238-1242.

[34] George Myles, Martin Fogel and Fred Batchelder, Economics of Well Irrigation Systems, Nevada Agricultural Experiment Station, Circular 38, July, 1962, pp. 1-10.

[35] Martin M. Fogel and George A. Myles, Pumping From Irrigation Wells, Nevada Agricultural Experiment Station, Bulletin 110, July, 1962, pp. 1-23.

In regard to planning development, Zimmerman states, "If development is carried out by private investment, underestimation may mean ruin. ...Therefore the planner should over-estimate both cost and development time. The opposite practice has been the reason the original developer is seldom the one who completes the project he has started."[36]

This statement emphasizes the importance of thorough study of development cost prior to making the investment. But over-estimation of any large degree might be as serious a mistake as under-estimating. In southwest Kansas, experience with irrigation development plus capable technical assistance from the Soil Conservation Service and Cooperative Extension Service closely associated with the Kansas Agricultural Experiment Station and Kansas State University would render the statement concerning the original developer as not completing the development completely invalid.

Zimmerman continues, "The economic unit water and unit land development prices may vary considerably. They depend upon the kinds of crops that can be grown in the area. ...In small projects the cost has to be in direct relationship to the farmer's benefit; his crop returns will have to pay off all the investment."[37]

These are illustrative of the positive statements Zimmerman makes in regard to costs and cost analysis throughout his book which are so general in content that they have little practical usefulness.

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[36] Zimmerman, op. cit. p. 16.

[37] Ibid. p. 17.

Otto and Pine conducted an empirical study of Sprinkler Irrigation Costs and Returns in South Central Kansas in 1954.[38] They found that, "The total costs increased as the acreage irrigated increased, but the cost per acre decreased as the acreage irrigated increased."[39] This demonstrates cost economies related to scale. This is apparent with their average cost of irrigating an acre at $15.15 costs of annual depreciation, taxes and interest on investment. Installation costs for irrigation system and well development ranged from $2,090 to $15,935, averaging about $7,000.

Hughes and Magee[40] studied irrigation costs in the lower coast prairie area along the upper gulf region in Texas. This presented a unique irrigation problem in which part of the risk is due to some years with excessive rainfall during either the growing or harvesting season. They found average investment costs of $53 per acre with operating expenses ranging from $2.25 to $4.00 per acre depending upon the number of times the crops were irrigated. The study included 10 farms over a three year period. Weather damage during the harvesting season lowers average yields limiting profitable irrigation primarily to cotton, a relatively high price-income crop.

Hughes and Magee have devoted considerable time to the study of the economic effects of water depletion in the Texas High Plains, publishing three bulletins in a period from March, 1956, to April, 1964. The first

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[38] Merton L. Otto and Wilfred H. Pine, Sprinkler Irrigation Costs and Returns in South Central Kansas, Kansas Agricultural Experiment Station: Bulletin 381, August, 1956, pp. 3-23.

[39] Ibid. p. 3.

[40] William F. Hughes and A. D. Magee, Production Practices and Specified Costs of Irrigating Row Crops, Lower Coast Prairie, 1958-60, Texas Agricultural Experiment Station: Misc Pub. 616, November, 1962, pp. 1-8.

study, Changes in Investment and Irrigation Water Costs, Texas High Plains, 1950-54,[41] illustrates the phenomena which occurred. The acreage irrigated per well decreased 26 percent from 1949 to 1954 while pumping lifts increased 16 percent from 1938 to 1951. In the area surveyed one or more well was added on the old farms; approximately 40 percent of the old farms installed underground concrete tile or surface pipe systems and 49 percent lower pumps. Pumps operated an average of 2,207 hours in 1954 or approximately 2.5 times longer than the 1947-49 average. A change from butane fuel to natural gas was observed in progress incorporating the less expensive fuel at an average gas line cost of a little under $1,000 per well.

In their analysis of cost, the cost of irrigation increased rapidly during this period due to increased investment, increased pumping time and increased water lifts distributed on fewer acres. They report the highest yield on record indicating farmers chose to reduce acreage rather than spread water with a limited supply. Data indicated the investment due to adjustment was $10.77 per acre greater on old farms than for newly developed irrigation systems.

This study is of particular interest due to the fact that some areas in southwest Kansas are beginning to experience some of the same phenomena experienced by irrigation farmers of this high plains area. It also indicates the adjustments farmers have made as a result of a decreasing water supply.

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[41] William F. Hughes and A. C. Magee, Changes in Investment and Irrigation Water Costs, 1950-54, Texas Agricultural Experiment Station: Bulletin 828, March, 1956, pp. 1-8.

A second Hughes and Magee publication, Some Economic Effects of Adjusting to a Changing Water Supply,[42] updates and refines some of the findings of the original report with a longer and more intense study period. Areas are divided into five subareas ranging from severely affected areas in which water depletion in combination with increases in operating costs impair the economic feasibility of continuing irrigation, to areas which are not particularily affected by water level decline. Compensating adjustments identified were increased hours of water pumping, lowering of pumps, installation of additional wells and closed distribution systems. Other adjustments included watering every other row, (more extensive irrigations) installation of smaller pumps in old wells, decreasing acres of summer irrigated crops and increasing acres of fall and winter irrigated crops (principally wheat and off season irrigation for grain sorghums), staggering grain sorghum planting dates, (to relieve critical water demand stages of plant development) concentrating the available water on cotton, (higher income crop) reduction in the portion of cropland irrigated, and shifting from butane to natural gas fuel. Tables listing comparisons of increased fuel cost, investment cost, and operating cost demonstrate the impact of these adjustments.

The third publication, Economics of Low-Capacity Irrigation Wells,[43] emphasizes special management practices associated with relatively high per

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[42] William F. Hughes and A. C. Magee, Some Effects of Adjusting to a Changing Water Supply, Texas High Plains, Texas Agricultural Experiment Station: Bulletin 966, October, 1960, pp. 1-27.

[43] William F. Hughes and A. C. Magee, Economics of Low-Capacity Irrigation Wells, Texas High Plains, Texas Agricultural Experiment Station: MP-710, April, 1964, pp. 1-16.

acre investment costs and long pumping seasons required to utilize the low heads of water available for irrigation. Cotton was the principal crop grown with low capacity wells. Overhead costs (annual fixed or annual investment costs) ranged from $15 to $21 per allotted acre, depending upon depth of the well, and operating costs were from $8 to $10 per allotted acre in 1962. Irrigation labor was of particular concern requiring approximately 12 hours per acre. Irrigation labor requirements have a far greater impact than the figures would indicate because labor is expended for short periods, usually twice a day over an extended irrigation season which may last six months.

Low capacity wells considered were as small as two inch submersible pumps producing less than 100 gallons per minute. Data were obtained from 27 farms with about 12,000 acres of cropland and 155 irrigation wells in 1962.

Extension engineers at Kansas State University have conducted intensive irrigation case studies on individual cooperating farms with the objective of demonstrating suitable methods and techniques for developing land for irrigation, engineering practices and agronomic practices. The 1965 report on the Mitchell County Farm[44] shows an annual investment cost (depreciation, interest on investment, repairs, and taxes) of $28.17 per acre. Hours of labor required to irrigate an acre, three times, on corn ranged from 1 to 1.5 hours. Total cost per acre, on this farm, was $77.67 of which $12.37 was water costs. Water for irrigation was pumped out of the river with a centrifugal pump and distributed through portable aluminum pipe.

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[44] Russell L. Herpick and Lynn R. Shuyler, Annual Report, Mitchell County Irrigation Demonstration Farm, Kansas State University, Extension Division, File Code: Engr. 3-3, pp. 1-18.

Two farms with well irrigation under this same demonstrational program in 1960 were located in Pawnee and Lane counties. The Pawnee county farm reported[45] annual investment cost of $23.79 per acre with labor requirements varying from 0.5 to 1 hour per acre for irrigating, depending upon the crop involved.

The Lane County Report[46] shows an annual investment cost of $25.84 with similar labor requirements. Operating costs for irrigation are difficult to determine because of classification of costs. Repair costs are included in investment costs. The method of data collection was the actual records of costs and time kept by the cooperating farmer but the reports lack adequate explanation of this.

A classification of costs is well outlined in Sprinkler Irrigation edited by Woodward.[47] Costs are divided into fixed costs and operational and maintenance costs. Annual fixed costs include interest on investment and depreciation. Two methods of figuring interest on investment are suggested:

1) on the annual basis of one half the original purchase price at an appropriate rate of interest,
2) a compound interest rate based on a capital recovery factor.

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[45] Lyndell W. Fitzgerald, 1960 Annual Report, Pawnee County Irrigation Demonstration Farm, Kansas State University, Division of Extension, pp. 1-22.

[46] Lyndell W. Fitzgerald, 1960 Annual Report, Lane County Irrigation Demonstration Farm, Kansas State University, Division of Extension, pp. 1-25.

[47] Guy O. Woodward, ed, Sprinkler Irrigation, (Washington, D. C.: Darby Printing Company, Second Edition, 1959) pp. 261-284.

Depreciation is defined by the Federal Internal Revenue Service as, "A reasonable allowance for exhaustion, wear and tear, and obsolescence of property...."[48]

Woodward points out, "There are many factors to be considered in determining depreciation."[49] Included would be the amount of annual use, care and maintenance, operating conditions and off season storage. A table of suggested depreciation periods for components of an irrigation system includes the following:[50]

Component	Depreciation Period: Years
Well	25
Pump	15
Power Units	
Diesel	15
LP & Natural Gas	12
Gasoline	9
Electric Power Units	25
Concrete Pipe System	20
Pipe, Surface, Gated	8

In regard to land grading, Woodward suggests that if proper maintenance is practiced, only the interest on the leveling costs should be charged to the annual fixed costs.

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[48] Farmers Tax Guide, 1966 Edition, United States Treasury Department, Internal Revenue Service, Publication No. 225, p. 34.

[49] Guy O. Woodward, op. cit., p. 262.

[50] Ibid. p. 264.

"Annual operation and maintenance costs can be computed by using observed average costs for fuel, power and labor."[51]

Woodward points out, "A most important item is having the system designed properly to be adequate to meet the irrigation needs while giving a high degree of efficiency and uniformity of distribution of water over the designed area."[52]

As a concluding statement for this section on the review of literature, a quotation from Israelsen and Hansen seems appropriate. "Irrigation is an age-old art. Historically, civilization has followed the development of irrigation. Civilizations have risen on irrigated lands; they have also decayed and disintegrated in irrigated regions. Most men who are well informed on irrigation are certain of its perpetuity, as long as it is intelligently practiced."[53]

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[51] Ibid. p. 267.

[52] Ibid. p. 284.

[53] Orson W. Israelsen and Vaughn E. Hansen, Irrigation Principles and Practices, (New York, London, Sydney: John Wiley and Sons, Inc., Third Edition, 1965) p. 1.

III

PROCEDURE OF ANALYSIS

Applied research at the Garden City Branch Experiment Station provides experimental yield information for irrigated crops in southwest Kansas. Average yields over a period of eight years (1958-1965) will be used to project income for case studies of alternatives. In this period of years, five were near normal annual rainfall, one was drier than normal and two were above normal in annual precipitation. R.S. 610 hybrid grain sorghum was used in all tests for this study. An average over this period of time tends to reduce the effects of weather which would have considerable influence if any particular year was used as standard. Extremely wet years or extremely dry years in western Kansas will often have influence on the succeeding year. Table I shows annual precipitation and yields for the period as reported by the Garden City Experiment Station.

Average annual precipitation for this period is 2.75 inches above normal. However a shorter period would be less representative of all weather conditions including temperatures, hail, early frosts, etc. Data with exact duplication of methods for all tests for a longer period were not available.

Irrigation costs for southwest Kansas are not readily available. To develop costs of irrigation in this particular area, a questionnaire (Irrigation Survey of Farm Management Association Members in Southwest Kansas[54]) was mailed to each association member in the seven county area (Finney, Haskell, Seward, Stevens, Morton, Stanton and Grant Counties).

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[54] See copy in appendix, pp. 68-69.

Table I

Yields of grain sorghums; full irrigation, pre-season irrigation only, and summer fallow, at the Garden City Experiment Station, 1958-1965.

	Annual precipitation	Fallow gr. sorghums[b] N applied=0	Full irrig. gr. sorghums[b] N applied = 150	Pre-irrig. only gr. sorghums[c] N applied=0
	inches	bu./ac.	bu./ac.	bu./ac.
1958	28.37	50	125	76
1959	18.07	58	136	53
1960	16.81	63	107	64
1961	19.39	74	126	82
1962	18.64	49	131	84
1963	15.78	54	134	53
1964	12.23	30	119	48
1965	27.70	55	125	83
AVERAGE	19.62[a]	54	125	68

Yields rounded off to nearest full bushel for table.

[a] Normal (average 1931-1960) 16.87 as reported in Weekly Precipitation Amounts for Kansas, Kansas Agricultural Experiment Station, Kansas State University: Technical Bulletin 126, 1963.

[b] Kansas Performance Test (1958-1965), Kansas Agricultural Experiment Station Annual Publications.

[c] Published results of field day reports, Garden City Experiment Station.

This questionnaire was mailed to 123 association members and 75 were returned in complete and usable form. The completed questionnaires, constituting a 61 percent return, were used as the source of data to compile the irrigation cost information developed in this report.

The Kansas Farm Management Association Program, sponsored by Kansas State University and supervised by extension economists of the university, assists farmers in developing complete and accurate farm records for management assistance in their business and for research in the field of farm management. This record system provides for recording of more information giving association members better access to more complete and accurate cost information. For this reason, association members were selected to be surveyed for gathering cost information for this report.

To verify representativeness of the sample of questionnaires completed and returned as compared to the total group to which the questionnaires were mailed, key indicators were summarized for the same group from their 1965 records. Table 2 shows the results of this comparison.

Table 2

Summary of comparison of 1965 records
of farms surveyed and those returning questionnaires*

	Per farm average	
	Farms questionnaire was mailed to	Farms returning usable reports
Gross income	$ 58,511	$ 59,623
Total expense	$ 41,010	$ 41,363
Net income	$ 17,501	$ 18,260
Total cropland acres	1,541	1,539
Total acres irrigated land	616	586
Total investment managed	$308,542	$305,705

*Summary included 112 farms. Questionnaires were mailed to six new members with no previous records in the association and five members who developed irrigation for the first time in 1966.

Total expense, total crop acreage and total investment managed are essentially the same for both groups. Those who returned the survey reports were slightly higher in income with less acres of irrigated land. This difference is small and insignificant with the farms involved.

The latest figure available shows in 1964, 440,814 acres of irrigated land in the seven county area. (Fig. 1) In 1966, the 75 farms included in the summary of this survey produced 35,673 acres of irrigated crops. Farm

Management Association record summaries show approximately 20 percent of the cropland on irrigated farms is summer fallowed, due to government restrictions and other factors. With these considerations, approximately eight to ten percent of the total irrigated land in the seven southwest Kansas counties is included in the survey summary.

The average irrigated acreage in crops per farm, according to the summary of the survey, was 476 acres. This was 226 acres of irrigated crop per well with an average output of 1510 gpm. This in itself indicates the extension of a limited supply of water at the present time in southwest Kansas.

Although farm management association members are believed to have a higher average net income than the average farmer in the area, conditions of irrigation costs is similar for all irrigation farmers in a given area. The cost of developing and equipping a well is dependent upon the depth of the well and the amount of water to be pumped. Fuel and repair costs are directly related to the size of the pumping plant and the care and maintenance provided. Labor cost is dependent to a large extent upon the design of the irrigation system. These costs are primarily dependent upon size and design of the irrigation system and not highly variable due to management ability. Differences in income are due more to timeliness of operations and proper cultural practices which increase production rather than variations in the cost of irrigation. Therefore, it is reasonable to project costs derived from this survey of association members to general farm conditions for the seven county area.

The cost of tillage operations for budgeting the case studies of this report are reasonable in light of custom rates for 1965 reported by the Kansas Crop and Livestock Reporting Service and the experience of Farm Management Association Extension Economists.

IV

IRRIGATION COSTS

Cost analysts generally divide cost into two classifications. Variable costs, sometimes referred to as operating costs, include current annual expenditures for the purchase of inputs. These costs vary with the level of the intensity of farming, scale of operation and organizational ability of management. These costs are usually projected in a linear relationship to acres or hours of pumping.

Fixed costs, also referred to as overhead costs or ownership costs, are costs which remain the same in total regardless of amount of use received in a particular period of time. This classification includes such expense items as depreciation, taxes, interest on investment and insurance.

Depreciation is an annual allowance for wear and tear and obsolescence of certain capital expenditures purchased for business use in large, discrete, indivisible units. This leads to some difficulty in determining the useful life of the capital expenditures with varying degrees of care and maintenance being exercised by the operator. Also, during an extremely long life, certain improvements are more apt to lose value due to obsolescence than by wearing out.

For a farmer considering the economic merits of developing or expanding irrigation, it seems appropriate to make a third classification of costs. This category will be referred to as <u>development costs (Dc)</u> which are those costs necessary to the establishment of irrigation and have a long indeterminate useful life with existing conditions and technology. These costs include the expense of the development of the irrigation well (wc), initial land grading (gc) necessary for efficient water distribution, and permanent underground concrete pipe (uc) installation for the transportation of water. Development cost then takes the form:

$$Dc = wc + gc + uc$$

These are the initial investment costs that the farmer must consider and present a unique problem for each unit of development depending upon the depth and availability of the water supply and the topography of the land. These costs must be estimated by those with engineering skills and abilities in the field of irrigation development for each unit of land to be developed. In southwest Kansas this service is available from the Soil Conservation Service and several reliable commercial firms specialized in well drilling and irrigation development.

Since the life of the capital investments considered as development cost have an indeterminate life with reasonable care, with existing conditions and level of technology, the question of how these costs should properly be charged into the analysis of irrigation costs for planning development or expansion becomes pertinent.

If it was known with reasonable certainty that present conditions and level of technology would exist for an indefinitely long period of time, the development costs would be properly reflected in charging interest on the investment as an annual cost of irrigation. If this situation existed, the development costs could be compounded and anticipated income could be discounted to present values and the decision of development of irrigation could be determined with a high degree of confidence.

However the future of irrigation for an indefinitely long time in southwest Kansas is not known with this degree of certainty. Most geological experts are reasonably certain that there is a limit to the available ground water supply. Should water resources be depleted beyond the point of feasible irrigation, these development costs would essentially become worthless. Experience in the high plains area of Texas illustrates the possibility of extensive water depletion.[55]

With the advances in technology in the past quarter of this century, it is difficult for the most imaginative mind to look very far in the future of the development of agriculture. It is doubtful that any other major source of water will exist for southwest Kansas (although this possibility is not completely non-existent), but advanced technology could develop dryland farming and other areas for more economical irrigation to the point that present methods of irrigation could not compete satisfactorily.

Changes in demand, shifts in population, innovations in transportation all add to the degree of uncertainty of the future.

So with a high degree of uncertainty in the very long run, it seems desirable to reduce the effects of uncertainty by limiting development cost to a reasonable period of time. The development costs should then be recovered in full by the investor in this period of time. This time period becomes arbitrary depending upon the optimism or pessimism of the person required to make the judgment. With the present knowledge of the conditions of the area, for this study the period for recovery of development costs will be 25 years. So this will be charged to the cost of irrigation with annual development costs (dc) expressed as:

$$dc = \frac{Dc}{25}$$

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[55] William F. Hughes and A. C. Magee, <u>Some Effects of Adjusting to a Change in Water Supply, Texas High Plains</u>, Texas Agricultural Experiment Station: Bulletin 966, 1960, pp. 1-27.

In the survey of 75 farms in southwest Kansas, 54 wells were developed since 1960. These were selected to compute an average cost of well development so that the problem of inflation could be reduced and to reflect the efficient methods employed by present day well drilling companies. Cost of well development includes drilling, casing and gravel packing of the irrigation well. It also includes exploratory costs in the form of test drilling.

The average cost of developing 54 irrigation wells in southwest Kansas since 1960 was $13.33 per foot of depth of the well. Irrigation wells vary in depth (according to this survey) in southwest Kansas from 100 feet to over 600 feet. Table 3 indicates average costs of well development according to well capacity and depths under and over 300 feet.

Table 3

Average per foot cost of developing 54 irrigation wells in southwest Kansas, 1960-1966[56]

Well capacity rated in gpm	Average well output gpm	Well depth	
		300' or less	301' and over
800 gpm or less	529	$16.39	$13.72
801 - 1600 gpm	1249	$12.72	$13.26
1601 and over	1973	$16.32	$13.05
Average	1118	$14.47	---
	1679	---	$13.17

Average depth of 54 wells = 368 feet.

Concrete pipe is most commonly used for underground transportation of water although some plastic underground lines are being used in recent

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[56] Data shown in appendix, table 4.

years. Concrete pipe has been used for many years and is approved for government ASCS cost share payments for improving the efficiency of irrigation systems and water conservation.

Concrete pipe with rubber gasket sealing connections in 1966 ranged from \$1.45 per foot to \$2.95 per foot installed, depending upon the size of the pipe. Pipe 12 inches in diameter will carry 900 - 1800 gpm and 15 inch pipe will transport heads ranging from 1800 - 3000 gpm. In 1966, this pipe was priced at \$1.65 and \$2.15 per foot, respectively. This price includes guaranteed installation of the pipe.

In the development stages of irrigation, the installation of concrete pipe is often postponed if there are no serious problems due to slope of the land or water limitation where open ditches or surface pipe will transport water. This is due to:

1. Other development is needed such as land grading.
2. It sometimes is advantageous to test system prior to permanent installation.
3. Capital limitations may delay permanent installation.
4. Government cost sharing is for improvement of existing irrigation system which requires that irrigation must be used at least two years prior to underground pipe to qualify for cost sharing.

In recent years, permanent underground pipe for water transportation has gained general acceptance by farmers. Its use is increasing rapidly because of increased efficiency in water conservation, labor saving, and the fact that water transportation is affected less by inclement weather.

Land grading is dependent upon the topography of the individual field for irrigation. Cost of land grading varies from nothing to approximately \$250 per acre on a field basis in southwest Kansas. Land grading in the development stage may be done in a minimal degree necessary for satisfactory water distribution. As the system is established and tested, additional grading may be done. Cost sharing for land leveling by the government also specifies improvement of an existing system, established and used for at least two years prior to qualification for cost sharing.

Irrigation equipment costs (Ec) would be the next major concern of the farmer contemplating irrigation development or expansion. Equipment includes the irrigation pump (pc), the power unit (mc) and surface pipe (ac) for water distribution. Irrigation equipment falls in a reasonable range of life due to wear and tear. Variation in the useful life of this equipment will depend upon somewhat on the degree of care and maintenance exercised by the individual operator but this falls within limits. Through extended research, engineers have developed satisfactory guide lines for charging annual depreciation for equipment (ec) into the cost analysis.[57] So for planning purposes:

$$Ec = mc + pc + ac$$

and

$$ec = \frac{mc}{12} + \frac{pc}{15} + \frac{ac}{15}$$

In stages of planning, a farmer would be interested in average equipment costs such as shown in Table 4 and Table 5.

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[57] Op. cit., p. 264.

Table 4

Average costs of power units for 54 wells
developed in southwest Kansas, 1960-1966

Range of lift feet	Aver. lift feet	Well capacity - gpm* 1600 gpm or less	1601 gpm and over
150 or less	126	$1200	$2801
151 - 250	206	$2215	$3411
251 and over	310	$2622	$4254

*Capacity divided into two categories because in this general area (over or under 1600 gpm) the size of the pump would usually change from an 8 inch pump to a 10 inch pump. Deep turbine pumps are used exclusively in Southwest Kansas.

Table 5

Average cost of deep-turbine pumps
for 54 irrigation wells, developed 1960-1966

Range gpm	Aver. gpm	Average pump cost* 150' lift or less	151' lift or more
1600 gpm or less	1056	1875	4976
1601 gpm and over	2047	3036	5111
Average of 54 wells	1552	2614	5040

*Cost includes gear head and drive shaft.

These average costs as guides for planning are satisfactory. Definite costs of the power unit and pump cannot be determined until the well has been drilled and test pumped.

Aluminum surface pipe used for water transportation and distribution laterals for underground pipe systems range in cost from $1.00 to $2.00 per foot depending upon size and quality. Gates in aluminum pipe are adjustable for easy head control in water distribution. For gravity flow, surface irrigation aluminum surface pipe is generally used for water transportation on rented land or for transition from an open ditch system to a permanent underground installation.

The amount necessary for efficient irrigation is dependent upon the individual field situations.

Operating costs (Oc) of pumping and distributing irrigation water includes fuel and oil (fc), repairs (rc) of well and pumping equipment, and labor (lc) required to distribute water and service the pumping plant. These costs are assumed to be of a linear nature related to scale and intensity, so can be projected on a per unit basis (per hour of pumping).

$$Oc = fc + rc + lc$$

Natural gas is the primary source of fuel for power for irrigation pumping in southwest Kansas. This is due to its availability with commercial gas wells distributed throughout most of the area. This is by far the cheapest source of power and other types of fuel are used only when natural gas is not readily available to the power plant.

The survey of 75 farms in southwest Kansas reveals that 155 of the 158 irrigation wells are powered with natural gas. Table 6 summarizes the results of this survey.

The average lift of the 155 wells powered by natural gas was 220 feet with an average output of 1510 gpm. The average pumping cost for fuel and oil was 23.02 cents per hour.

Table 6

Average per hour fuel cost of pumping irrigation water
in southwest Kansas with natural gas fuel, 1966

Range of output gpm	Range of lift -- feet		
	150 or less	151-250	250 and over
	cts	cts	cts
800 gpm or less	---	10.27	14.04
801-1600 gpm	12.06	18.30	24.88
1601 gpm and over	22.50	29.15	29.63

Repair costs include those costs for the repair of the power unit, the irrigation well and pump and other irrigation equipment.

Repair cost in 1966 on 155 irrigation power units of various ages and sizes was:

$$\frac{\$41{,}526 \text{ Repair Cost}}{155 \quad \text{Power Units}} = \$267.91 \text{ Average Repair Per Power Unit}$$

Repair to irrigation pumps and wells was computed on the basis of the owner-operated wells since tenants, under most lease arrangements, are not required to pay any of the repair cost for the well or pump. The results show:

$$\frac{\$17{,}725 \text{ Pump and Well Repair}}{95 \text{ Wells (Owner-operator)}} = \$186.57 \text{ Average Repair Per Well}$$

The average cost for 95 owner-operator wells was projected for the 155 irrigation wells (155 x $186.57 = $28,918) to make the necessary adjustment.

Other repairs included repairs on irrigation pipe, valves, small supplies, etc. The total cost on 75 farms for repair of other irrigation equipment was $6,819.

With this information, repair costs can be projected on a per hour of pumping basis.

$$\frac{\text{\$41,526 power unit repair + \$28,918 well and pump repair + \$6,819 other irrigation equipment repair}}{\text{361,360 hours pumped}} = \text{21.38 cents repair cost per hour of pumping}$$

Irrigation systems in southwest Kansas are designed so that regular attendance is necessary for distributing water and servicing the pumping plant. In most cases, the systems are designed to distribute a given amount of water in a single setting to a given acreage in twelve hours. This requires labor for a relatively short period of time twice a day (each 24 hour period) to change the setting of water. The labor time involves preparing temporary ditches, setting dams and siphon tubes or moving aluminum pipe and opening and closing gates in the pipe. Either system will require approximately the same labor time including some time for servicing the power unit, water flow adjustment, and observation of results.

With this operation being supplied by both operator and hired labor in relatively short periods during the course of the day's work, some problem of proper valuation for this labor may be present. For this analysis, an arbitrary value of $1.50 per hour will be used as this would be representative of the cost of capable hired labor.

Hours required for pumping (h) can be computed with the known output of the well. A well will produce one acre inch of water per hour for each 450 gallon per minute of output. For example, a well with 1350 gpm output will produce three acre inches of water per hour (1350/450). A farmer can compute the time necessary to apply a given amount of water to a given acreage with:

$$\frac{\text{Inches of water to be applied}}{\text{Well output (gpm)/450}} \times \frac{\text{acres to be}}{\text{irrigated}} = h$$

The survey of irrigated farms in southwest Kansas[58] shows that an average of 2.143 hours per day is required to pump and distribute water per irrigation well, so labor cost per hour of pumping is

$$\frac{2.143 \times \$1.50}{24 \text{ hours}} = 13.39 \text{ cents per hour}$$

and

$$lc = .1339\ h$$

Operating costs then consist of fuel and oil, repairs and labor and can be projected on a cost per hour (oc) basis. The tables in this section provide average figures that can be used for budgeting these costs for planning purposes.

Using the average cost for the average lift and capacity of irrigation wells included in the survey, the average operating cost of pumping and distributing irrigation water in southwest Kansas is 57.79¢ per hour of pumping.

Two other costs must be considered in an analysis of irrigation costs. These are real estate taxes and interest on investment.

Real estate taxes (tc) vary from county to county, ranging from 82 cents per acre in Morton County to $2.28 per acre in Finney County for irrigated land according to the survey conducted. The average real estate tax for the seven county area in 1966 was $1.63 per acre for irrigated land.

Interest on investment can be computed by amortization over the period of the investment or by a simple interest method using one-half of the current interest rate. For planning with budgeting, the latter method lends itself

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[58] See appendix, pp. 68-69.

best to ease of computation for any particular year or an average for budgeting the annual expense per year.

With this method:

$$\text{Average annual interest (ic) on investment} = \frac{\text{Interest rate X investment}}{2}$$

Investment is the sum of the original costs of development and equipment for irrigation.

So in budgeting the annual costs (Ac) of irrigation, a summation of the annual costs involved will give satisfactory results for planning:

$$Ac = dc + ec + oc(h) + ic + tc$$

This can be used with any or all of the costs determined that are applicable to a particular development or expansion of irrigation in southwest Kansas. It must be recognized that each irrigation enterprise presents a unique problem and that average costs have value only as guides or tools to assist the farm manager in planning and budgeting. Exact costs of development, equipment and operation of any individual irrigation enterprise can be determined only after the capital commitments have been made and good records of the operation have been summarized. Cost must be estimated within the best framework available for a-priori decisions. This is the purpose of the development of this section of this report dealing specifically with conditions in southwest Kansas.

V

CASE STUDIES

To illustrate how the preceding cost information can be used by a farmer in considering expansion with a limited water supply and a relatively large acreage of land suitable for irrigation, the following hypothetical situation is proposed.

A farmer in Southwest Kansas has an irrigation well with 1200 gallon per minute capacity with a lift of 220 feet.[59] He owns 480 of land suitable for irrigation, in one connecting unit of land in the same section. One hundred sixty acres have been fully developed for irrigation at a cost of $17,171.[60]

He is presently irrigating 160 acres and farming 320 acres dryland. (One-half summer fallow and one-half crop.) He wants to consider other alternatives available to him that will offer more profit.

With grain sorghum his high income crop, the total acreage will be devoted to the production of this crop. It is assumed there are no restrictions by government programs as this can be managed by substitution from additional farm acreage the farmer operates. The three quarters of land under consideration are only part of his total operation. It is also assumed that capital for development and operation of the unit is not limited.

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[59] This was the average lift of 155 wells reported in the Survey of Irrigation in Southwest Kansas, 1966.

[60] Cost developed from averages from survey. Well cost (350 ft. @ 13.33) $4665, 2640 ft. of underground 15" concrete pipe plus valves, $4506 and land grading @ $50 per ac., $4000.

The following are the alternatives considered. There are other possible alternatives and combinations of crops that would be considered in the planning process. The cost data set forth in the previous section could be used equally well for other irrigated crops.

Case I (as the unit is presently being farmed).

Full irrigation of 160 acres of grain sorghum applying enough water to make 18 inches of water available to the plant. This will require three irrigations pumping and distributing 27 acre inches of water at 65% irrigation efficiency. This will require approximately 60 days or 1680 hours of pumping.

The additional 320 acres is farmed dryland, with 160 acres seeded to grain sorghum and 160 acres summer fallowed.

Case II (if water is limited by government regulation or other means to the amount pumped in Case I.)

In this case, the farmer would apply approximately the same amount of water to 320 acres during the growing season in two irrigations supplying 9 inches of water available for plant use. This would require pumping 14 acre inches of water per acre and would require about the same pumping time of 70 days or 1680 hours.

The additional 160 acres is dryland with 80 acres grain sorghum and 80 acres summer fallow.

Case III (if water was limited by the well capacity and could be expanded by pumping more hours.)

This case offers the opportunity of off-season irrigation. By using the well more hours during the year, it would be possible to pump 24 acre inches on 320 acres. This can be done by pumping 12 acre inches off-season and saturating the root zone prior to seeding. Two irrigations during the growing season will supply the additional 12 acre inches. With 65% irrigation efficiency, this will make 15.6 inches of water available for plant use from irrigation. This will require approximately 140 days or 3360 hours of pumping.

The additional quarter of land will be farmed dryland with 80 acres grain sorghum and 80 acres summer fallow.

Case IV (if water is limited only by well capacity, as in Case III.)

With this alternative, 160 acres can be fully irrigated during the growing season as in Case I and the additional 320 acres irrigated in off-season only. With this off-season irrigation 12 acre inches will be pumped and distributed. This land will then be farmed as dryland using dryland methods of seed bed preparation, planting and seeding rates. This method has produced acceptable yield increases in practice at the Garden City Experiment Station over an extended period of time. This case requires approximately 130 days or 3120 hours of pumping.

To project this case study the following yields will be used.

Full irrigation (Case I, IV)	125	bu. per ac.	[a]
Near full irrigation (Case III)	115	" " "	[b]
Half irrigation (Case II)	90	" " "	[b]
Off-season irrigation (Case IV)	68	" " "	[c]
Dryland fallow (Case I, II, III)	54	" " "	[a]

[a] Eight year average (1958-1965) of Kansas Performance Tests at the Garden City Experiment Station.

[b] Yields interpolated on the basis of information in Musick, Jack T. and Grimes, Donald W., *Water Management and Consumptive Use by Irrigated Grain Sorghum in Western Kansas*, Kansas Agricultural Experiment Station, Technical Bulletin 113, 1961, Table 10, p. 15.

[c] Published results of off-season irrigation studies by the Garden City Experiment Station, 8 year average (1958-1965).

Yields for full irrigation were achieved with applications of 150 pounds of N per acre applied. Dryland and off-season irrigation only have no applications of nitrogen fertilizer. The off-season irrigation test have been continuously conducted on the same field for over 10 years.

The following table projects the yields of the four cases with the previously given assumptions.

With production of alternatives computed it is necessary to turn to cost of production for evaluation of the alternatives. It would be convenient to project cost from the basic case to other alternatives by computing those costs directly associated with irrigation; development costs, equipment costs and operating costs. However, changes in the organization involve changes in other costs such as tillage, seed and fertilizer, and harvesting costs.

Cost of production must include tillage costs for seed bed preparation, planting and cultivating. The number of tillage operations necessary will vary due to management and weather. Wet seasons will require additional operations for weed control and seed bed preparation. Dry seasons may require less operations for the same results. Assuming an average number of operations for most conditions and levels of management, full irrigation will require 10 tillage operations, summer fallow 4 tillage operations, dryland grain sorghums on fallow land 5 operations and off-season irrigation only will require 6 (one more than dryland) tillage operations.

Tillage operations will be charged at $1.50 per operation per acre. This is considered sufficient to cover machine cost and labor for the farm operator. Heavy tillage operations such as plowing would cost more but lighter operations such as discing would be less with an average near this cost. An individual operator with good records could determine this cost more specifically for his operations.

Custom rates for the necessary operations in 1965 as reported by the Kansas Crop and Livestock Reporting Service are shown on table 8.

Table 7

Projected production of case studies.

Case I

Full irrigation

160 ac. X 125 bu. = 20,000 bu.

Dryland fallow grain sorghum

160 ac. X 54 bu. = 8640 bu.

Summer fallow

160 ac. = --

Total production 28,640 bu.

Case II

Half irrigation

320 ac. X 90 bu. = 28,800 bu.

Dryland fallow grain sorghum

80 ac. X 54 bu. = 4320 bu.

Summer fallow

80 ac. = --

Total production 33,130 bu.

Case III

Near full irrigation

320 ac. X 115 bu. = 36,800 bu.

Dryland fallow grain sorghum

80 ac. X 54 bu. = 4320 bu.

Summer fallow

80 ac. = --

Total production 41,120 bu.

Case IV

Full irrigation

160 ac. X 125 bu. = 20,000 bu.

Off-season irrigation

320 ac. X 68 bu. = 21,440 bu.

Total production 41,760 bu.

Table 8

Custom rates for land tillage operations in southwest Kansas, 1965[61]

Tillage operation		
Moldboard plowing	1.00 - 5.50	3.27
Oneway plowing	.75 - 2.50	1.20
Tandem discing	.75 - 1.50	1.18
Spring tooth harrowing	.50 - 1.50	.90
Noble blade	1.00 - 2.50	1.31
Rotary hoe	.50 - 1.25	.77
Planting grain sorghum	1.00 - 2.50	1.50

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[61] Rates for Custom Farm Operations, 1965 Kansas Crop and Livestock Reporting Service: United States Department of Agriculture and Kansas State Board of Agriculture, January 7, 1966.

Harvesting costs will be charged at 10 cents per bushel which would include hauling of the grain. This is comparable to current custom rates in the area.

Fertilizer cost will be computed at 10 cents per pound of N. which would cover the farmers cost of the material and his cost of application in Southwest Kansas.

Seed cost for hybrid grain sorghum is 20 cents per pound and will be charged at the recommended seed rate for the particular cropping method.

Cost of pumping and distributing water and irrigation equipment and development costs will be charged as outlined in the previous section of this report for costs.

Operating costs for pumping and distributing cost can be determined on a per hour basis. Fuel and oil costs for a well with 1200 gpm output and 220 feet of lift, using natural gas as fuel in southwest Kansas is 18.30 cents per hour.[62] Labor costs[63] and repair costs[64] for southwest Kansas are 13.39 cents and 21.38 cents per hour respectively. Total cost for this case study is 53¢ per hour of pumping required.

Development costs include the cost of the well, land grading costs and underground concrete pipe. For the 160 acres developed for irrigation in the present case study it will be assumed that land grading costs were $50 per acre and one-half mile of 15 inch concrete underground pipe was installed. This represents a fairly typical situation in southwest Kansas. At current prices, the concrete pipe would cost $4356 (2640 ft. X $1.65) plus

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[62] See Table 6, page 39 of this report.

[63] See page 41 of this report.

[64] See page 40 of this report.

$150 for two outlet valves. Well development cost would be $4641.00 (350 ft. X $13.26)[65] and land grading would be $8000.00. This would make a total development cost of $17,147.

Additional development cost for bringing additional land into irrigation for case II, III, and IV will be assumed to average $50 per acre for additional land grading and will be the only additional cost needed.

Equipment costs include a power unit, $2215,[66] an irrigation pump, $4976[67] and 1315 ft. of 10 inch aluminum surface pipe. This would require 650 feet of gated pipe and 665 feet of pipe without gates. At current prices of $1.50 per foot and $1.25 per foot respectively, the total cost of the pipe would be $1806, making the total equipment cost, $8997.

Real estate taxes for dryland cropland in southwest Kansas will average approximately $1.00 per acre. According to the survey for this report, taxes on irrigated land averages $1.63 per acre.

Interest on investment will be computed at six percent on one-half of the original investment.

With these costs set out for the case study, tables 9 summarizes the costs of the four alternatives.

Costs used to compute direct crop costs for the annual summaries of the Kansas Farm Management Association include the same costs as used to develop production costs for this report with the exception of development costs. With association records, land grading costs are written off as a

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[65] See Table 3, page 34 of this report.

[66] See Table 4, page 37 of this report.

[67] See Table 5, page 37 of this report.

Case I

Table 9a

Production Activity	Description	Costs
Tillage cost seed bed preparation, planting & cultivation	160 ac. full irrigation (10 operations) 160 ac. dryland grain sorgh. (5 operations) 160 ac. summer fallow (4 operations) @ $1.50 per ac. per operation	$4560.00
Harvesting costs	28,640 bu. @ 10¢ per bu.	2864.00
Seed costs	1840 lbs. hybrid seed @ 20¢ per lb.	368.00
Fertilizer costs	160 ac., 150 lbs of N per ac. @ 10¢ per lb.	2400.00
Operating costs pumping & distributing water	1680 hours @ 53¢ per hour	890.40
Annual equipment costs	$2215 power unit/12 years life $4976 pump + 1806 alum. pipe/15 years life	635.30
Annual development costs	$17,147/25 years for recovery	685.90
Interest on investment	$26,144 x 6%/2	784.30
Real estate taxes	160 ac. @ $1.63; 320 ac. @ $1.00	580.80
Total annual cost of production		$13,768.70
Average cost per acre		28.48

Case II

Table 9b

Production Activity	Description	Costs
Tillage costs seed bed preparation, planting & cultivation	320 ac. irrigated (10 operations) 80 ac. dryland grain sorgh. (5 operations) 80 ac. summer fallow (4 operations) @ $1.50 per ac. per operation	$6080.00
Harvesting costs	33,130 bu. @ 10¢ per bu.	3313.00
Seed costs	3320 lbs. of hybrid seed @ 20¢ per lb.	664.00
Fertilizer cost	320 ac., 100 lbs N per ac. @ 10¢ per lb.	3200.00
Operating costs pumping & distributing water	1680 hours @ 53¢ per hour	890.40
Annual equipment costs	same as Case I	635.30
Annual development costs	$17,147 + $8000 land grading/25 years	1005.90
Interest on investment	$34,144 x 6%/2	1024.30
Real estate taxes	320 ac. x $1.63; 160 ac. x $1.00	691.60
Total annual production cost		$17,504.50
Average cost per acre		36.47

Case III

Table 9c

Production Activity	Description	Costs
Tillage costs seed bed preparation, planting & cultivating	320 ac. irrigated (10 operations) 80 ac. dryland grain sorgh. (5 operations) 80 ac. summer fallow (4 operations) @ $1.50 per ac. per operation	$6080.00
Havesting costs	41,120 bu. @ 10¢ per bu.	4112.00
Seed costs	3320 lbs. hybrid seed @ 20¢ per lb.	664.00
Fertilizer costs	320 ac., 150 lbs. N per ac. @ 10¢ per lb.	4800.00
Operating costs pumping & distributing water	3360 hours pumping @ 53¢ per hour	1780.80
Annual equipment costs	same as Case I	635.30
Annual development costs	same as Case II	1005.90
Interest on investments	same as Case II	1024.30
Real estate taxes	same as Case I	691.60
Total annual production costs		$20,793.90
Average cost per acre		43.32

Table 9d

Case IV

Production Activity	Description	Costs
Tillage costs seed bed preparation, planting & cultivation	160 ac. full irrigation (10 operations) 320 ac. off-season irrigation only (6 operations) @ $1.50 per ac. per operation	$5280.00
Harvesting costs	41,440 bu. @ 10¢ per bu.	4176.00
Seed cost	2080 lbs. of hybrid seed @ 20¢ per lb.	416.00
Fertilizer costs	160 ac., 150 lbs. N per ac. @ 10¢ per lb.	2400.00
Operating costs pumping & distributing water	3120 hours of pumping @ 53¢ per hour	1653.60
Annual equipment costs	same as Case I	635.30
Annual development costs	$25,147 + $8000 land grading/25 years	1325.90
Interest on investments	$42,144 x 6%/2	1264.30
Real estate taxes	480 ac. @ $1.63	782.40
Total annual production costs		$17,933.50
Average cost per acre		37.36

Costs used to compute direct crop costs for the annual summaries of the Kansas Farm Management Association include the same costs as used to develop production costs for this report with the exception of development costs. With association records, land grading costs are written off as a current expense the year they are paid and do not enter into the computation of direct costs. Also development costs are the expense of the landlord on leased land. With over half of the irrigated land operated by Association members being leased and the exclusion of land grading cost, direct cost reported would be two to five dollars less per acre.

For comparison, direct costs reported for Farm Management Association #3 in southwest Kansas[68] for case crop irrigated farms were $32.77 in 1965, $37.39 in 1964, and $33.14 in 1963 for a simple average of $34.43 per acre. These are averages of actual costs on irrigated farms of the area and are comparable to costs projected on Tables 9.

With the price of grain sorghum at $1.00 per bushel, the following comparison can be made.

	Case I	Case II	Case III	Case IV
Total income	$28,640	$33,130	$41,120	$41,760
Production costs	13,769	17,505	20,794	17,934
Income over cost	14,871	15,625	20,326	23,826
Margin of income over Case I		754	5,445	8,955

Income over cost would not be a true profit figure since there are other indirect costs involved with in most farm operations. These indirect costs would include farm share of the automobile, utilities, fees, dues and

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[68] Farm Management Summary and Analysis Report for Association No. 3, Extension Service, Kansas State University: 1963, 1964, 1965.

depreciation of farm buildings, interest paid for operating capital, land costs and insurance. These costs are highly dependent upon the financial position and age of the operator.

However, income over projected direct costs does give a fair appraisal of the alternatives.

In Case I, with the same amount of water used more extensively, the increase of $754 annually would probably not be enough to induce a change to a program involving higher risk and additional capital expenditures.

Should the price of grain sorghums fall to 80¢ per bushel the margin would be nearly eliminated. The same effect would be felt if production was reduced by a lower level of management or by hail, high winds, early frost or other weather hazards.

If the assumption of no restrictions due to government programs and the ability to substitute from other acreages on the farm was dropped, the margin would also be reduced.

The margins in Case III and Case IV would be sufficient to warrant consideration of change in the cropping program. In these cases, however, the only limitation on the water supply was the capacity of the well with regard to the frequency of water demands by the grain sorghum plant. Both cases stress the importance of off-season irrigation.

If development cost were increased in any of the cases due to higher land grading costs and for the necessity of the installation of underground concrete pipe for adequate water transportation, the situation would change somewhat. To illustrate these implications with grain sorghums at 90¢ per bushel and a 20 percent reduction in production due to a lower level of management and weather hazards:

	Case I	Case II	Case III	Case IV
Total production, bu.	22,912	26,504	32,896	33,408
Total income	$20,620	$23,853	$29,606	$30,076
Production cost + $50 per ac. increase in development costs	13,196	16,842	19,973	17,098
Income over costs	$ 7,424	$ 6,691	$ 9,313	$12,338
Margin of income over Case I		$ - 733	$ 1,889	$ 4,914

With water limited due to the capacity of the well as in Case III and IV and with no capital limitation for development, another alternative should receive consideration. This would be the possibility of developing a second well and irrigating the entire three quarters at the full irrigation level. Case III and IV would then become transitional stages to complete development for an intense, highly productive irrigation program.

IV

SUMMARY

The profitability of extending a limited amount of irrigation water is dependent upon the type of limitation and the degree of extension. Should water be limited to a given quantity that could be pumped annually by governmental restriction or serious water depletion, alternatives for profitably extending irrigation water would fall in a narrow range with present technology. Implications of this study indicate extension of water beyond 50 percent of full irrigation requirements would not be profitable. On the other hand, if water was limited only by the capacity of the irrigation well and necessary frequency of water application, opportunities to profitably extend irrigation water with off-season or supplementary irrigation practices are excellent.

Limitation to a given quantity of water is a theoretical question anticipating water depletion to the point requiring governmental regulation. With present technological trends in irrigation development and knowledge of ground water supplies in southwest Kansas, this is a definite possibility sometime in the future. How soon this phenomenon will become a critical problem is of major concern and considerable debate.

Limitation by the capacity of existing irrigation wells due to the inability to develop additional wells is a real problem now existing in southwest Kansas. Inability to develop additional wells may be due to the lack of water source in fringe areas, lack of necessary capital, insufficient supply of capable labor, present land ownership structure, conservativeness of the operator and many other reasons.

Increased efficiency of irrigation water at lower levels of intensity have been adequately demonstrated with applied experimental work at various experiment stations. This however falls within certain ranges. For example, evaporation due to low humidity, high temperatures, and wind velocity would cause relatively constant absolute losses of water in a given period of time. This would constitute a greater loss in proportion with a light water application (say four acre inches) as compared to a heavier application (say nine acre inches).

Even with increased water efficiency (relative to production per inch of water applied) total yields are decreased due to decreases in the total amount of water applied. The only exception is in years with unusually high rainfall during the growing season. These years are offset by greater reductions in extremely dry years. With a decrease in absolute yield, the profitability of extending water depends upon the ability of the operator to reduce production cost accordingly. This is much more difficult with the limited opportunities afforded in extending a given quantity of water than in extending water with off-season or supplementary irrigation. This is especially true of those costs related to the degree of necessary intensity of tillage practices.

In actual practice a majority of the irrigation farmers in southwest Kansas are currently extending irrigation water as demonstrated with Case III and Case IV of this report. Extension of water as illustrated by Case II presently would be considered only in a very limited degree. Extensive spreading of water would be associated with lack of experience, poor management or the unforeseen problems of breakdown of the pumping plant during critical irrigation periods.

Irrigation farming is a highly intensive, relatively expensive method of crop production. Profitability depends upon high yields of crops. Reduced yields of extensive irrigation methods require similar reductions in production costs. With present technology, spreading a given amount of water over more acres can be profitably done within narrow limits. Development of less expensive minimum tillage practices in the future would lend itself to this approach. Should water regulation become a reality, there is little question technology would develop rapidly in this direction.

However, with present conditions and technology, it is more profitable to maintain relatively high levels of irrigation in combination with off-season and supplementary irrigation.

VII

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VIII

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IX

APPENDIX

IRRIGATION SURVEY OF FARM MANAGEMENT ASSOCIATION MEMBERS IN SOUTHWEST KANSAS

Name ______________________________

1. List acreage of each crop irrigated in your farm operation in 1966:

Wheat ____________________ac.	List others		
Grain Sorghum ____________ac.	____________________	__________ac.	
Corn _____________________ac.	____________________	__________ac.	
Alfalfa __________________ac.	____________________	__________ac.	

2. Complete this question if you produced grain sorghums in 1966.

__________ acres irrigated prior to the growing season (pre-irrigation)
__________ estimated acre inches of water applied for pre-irrigation
__________ acres (if any) that was pre-irrigated only. ______ pounds of N (actual nitrogen) applied. _________ bushels of grain produced on this acreage.

Irrigation for grain sorghum production during the growing season, (after the crop was planted).

	No. of times the crop was irrig. after the crop was seeded.			
	Once	Twice	3 times	4 times
Acres irrigated				
Ac. inches of water applied				
Total bushels produced				
Lbs. of actual nitrogen applied per acre				
Any other fertilizer used: kind				
Amount per acre				

(Do not enter the same acreage in more than one column. For example, enter any acreage irrigated 3 times only in the column designed as 3 times. The sum of the acreage enter in the column plus any acreage pre-irrigated only should equal the total acres irrigated.)

3. Type of fuel used for power in your irrigation pumping plant? __________ ______________. (natural gas, diesel, LP, electricity)

4. Total cost of fuel and oil used for irrigation pumping in 1966 to date: $______________. (If you have unpaid fuel bills for this year, include the amount of these in the total dollar figure.)

5. Estimated hours of labor (hired and operator's) required per day to irrigate on your farm _____________ hours. (Time required for setting water, moving pipe, setting tubes, checking water sets, opening and closing ditches, servicing pumping plant, etc.)

6. Cost of repairs in 1966 for the irrigation plant. (Include any unpaid bills due and if more than one well is involved, combine into one total for the following catagories.)

   a. Irrigation power unit $ __________.
   b. Irrigation well and pump $ ___________.
   c. Other irrigation equipment $ ____________.
      (repairs on pipe, valves, etc.)

7. Acres of irrigated land owned _____________ ac.
   1966 real estate tax on owned land $ _____________.

8. Information on irrigation well. If you operate more than one well, list wells separately.

   a. Capacity of well _____________ gallons per minute.
      Depth of well ________ ft. Pump set at ___________ ft.
      Hours pumped in 1966 _________ hrs.
      _________ year well was developed.
      Original cost: Power Unit $ ________
      (Depreciation basis on your depreciation Well $ ________
      schedule Form 19, Original Cost) Pump $ ________
      (If the well is on leased land, mark rented across the cost items listed)

   b. Capacity of well _____________ gallons per minute.
      Depth of well ________ ft. Pump set at ___________ ft.
      Hours pumped in 1966 _________ hrs.
      _________ year well was developed.
      Original cost: Power Unit $ ________
      (Depreciation basis on your depreciation Well $ ________
      schedule Form 19, Original Cost) Pump $ ________
      (If the well is on leased land, mark rented across the cost items listed)

   c. Capacity of well _____________ gallons per minute.
      Depth of well ________ ft. Pump set at ____________ ft.
      Hours pumped in 1966 _________ hrs.
      _________ year well was developed.
      Original cost: Power Unit $ ________
      (Depreciation basis on your depreciation Well $ ________
      schedule Form 19, Original Cost) Pump $ ________
      (If the well is on leased land, mark rented across the cost items listed)

   d. Capacity of well _____________ gallons per minute.
      Depth of well ________ ft. Pump set at ___________ ft.
      Hours pumped in 1966 __________ hrs.
      _________ year well was developed.
      Original cost: Power Unit $ ________
      (Depreciation basis on your depreciation Well $ ________
      schedule Form 19, Original Cost) Pump $ ________
      (If the well is on leased land, mark rented across the cost items listed)

   If you operate more than four wells, please put the same information for additional wells on the back of this sheet.

TABLE 1.--Summary of irrigation survey of farm management association members in southwest Kansas--1966

		1966 Expense					
Farm No.	Type of Fuel	Fuel Cost	Power unit Repair	Well & Pump Repair	Other Irrig. Equipt. Repair	Well Capacity	Hrs. Pumped
		$	$	$	$	GPM	Hrs.
GT-1	NG	289	51	--	--	1200	1530
GT-2	NG	305	100	15	--	900	4098
GT-4	NG	460	90	185	55	450	1050
						400	870
						650	2450
GT-8	NG	585	475	--	--	1000	3600
						600	1440
GT-9	NG	795	500	--	--	3000	990
						700	650
GT-10	NG	519	180	--	--	1500	2100
GT-11	NG	693	2142	--	117	1200	4803
GT-12	NG	793	1091	--	33	1600	2400
						1500	2512
MT-4	NG	400	3500	--	250	1000	1000
						500	1000
						250	1000
						300	1000
MT-15	NG	1529	500	100	49	600	4300
						400	4300
MT-24	NG	1901	603	--	--	600	5000
						860	5000
						600	5000
SW-1	NG	1083	538	--	25	1700	3000
						1300	2868
SW-5	NG	750	439	--	--	1960	3696
SW-12	NG	686	314	--	--	2000	2530
SW-20	LP&NG	943	342	--	--	1700	2960
						1500	1800
SW-23	NG	1700	344	480	89	1800	1800
SW-24	NG	700	104	--	75	2100	1100
FI-5	NG	927	118	46	20	1200	2000
						1800	2700
FI-12	NG	290	72	77	--	2285	3000
FI-14	NG	800	1500	--	145	2000	3840
FI-19	LP&NG	7707	1240	565	125	850	1860
						1500	2280
						1500	2815
						1500	1497
FI-20	NG	1104	300	--	129	972	1400
						1500	1250
						760	1170

TABLE 1--Continued

		1966 Expense					
Farm No.	Type of Fuel	Fuel Cost	Power unit Repair	Well & Pump Repair	Other Irrig. Equipt. Repair	Well Capacity	Hrs. Pumped
		$	$	$	$	GPM	Hrs.
FI-37	NG	870	250	2100	160	2000	907
						2200	1133
						1600	1500
						1600	1012
FI-44	NG	640	385	390	35	1200	2000
						1300	1500
						1800	700
						2000	500
FI-48	NG	2040	1701	595	430	1500	3550
						2500	1400
						700	2000
						1300	5100
						1200	2800
FI-49	NG	60	20	--	--	1154	1248
FI-53	NG	770	140	--	65	1700	1934
						1400	2180
						1200	1982
FI-56	NG	920	600	--	500	1800	2500
						1500	2000
						1500	1750
						400	4000
						600	3000
FI-57	NG	200	10	--	--	2000	1000
FI-67	NG	662	100	--	286	2250	1500
						1800	1860
FI-69	NG	700	200	550	--	1000	2000
						1800	1800
FI-72	NG	850	600	20	300	1700	4000
						1500	4000
FI-73	NG	359	885	2100	65	1400	4620
FI-77	NG	1200	600	--	200	2400	2410
						2200	1800
						2000	600
						2000	540
FI-81	D	790	--	--	--	1685	1369
FI-85	NG	2500	100	10	80	1500	3600
						1670	1200
						1600	4000
						1200	2000
ST-1	NG	947	1481	--	22	1960	1800
						1780	1900
						2000	400

TABLE 1--Continued

		1966 Expense					
Farm No.	Type of Fuel	Fuel Cost	Power unit Repair	Well & Pump Repair	Other Irrig. Equipt. Repair	Well Capacity	Hrs. Pumped
		$	$	$	$	GPM	Hrs.
ST-2	NG	1670	110	25	--	2060	2586
						2000	1800
ST-6	NG	900	200	--	--	1000	1450
						1400	1220
ST-9	NG	841	685	200	--	700	1922
						1400	2700
						2100	2000
ST-10	NG	603	102	--	18	1000	1500
						1000	2100
ST-11	NG	2078	599	1906	27	1850	2400
						1850	2600
						1100	3200
ST-13	NG	872	35	--	--	1400	800
ST-14	NG	971	450		220	1500	4500
						2000	1500
ST-16	NG	1800	1700	850	450	2500	4500
						2500	3700
ST-17	NG	2300	2500	--	--	1500	2400
						1500	2400
						1500	2400
						1500	2400
						1500	2400
ST-19	NG	580	75	70	--	1200	680
ST-22	NG	1000	72	--	4	1950	3130
ST-23	NG	310	92	--	70	1200	1008
ST-24	NG	300	50	--	60	900	4600
ST-26	NG	1541	196	--	348	1200	3688
ST-27	NG	311	68	--	42	2000	968
SV-12	NG	972	83	359	56	1800	1985
						1800	987
SV-13	NG	300	146	--	--	1000	1168
SV-16	NG	776	28	--	--	1650	2200
ME-16	NG	1200	--	815	40	2000	3000
HS-1	NG	1447	907	3364	825	650	3600
						1900	3000
HS-3	NG	3150	2000	500	100	2000	4000
						1800	3000
HS-4	NG	550	33	12	9	1500	1720
HS-5	NG	1020	650	--	65	1800	1600
						1100	1500
HS-7	NG	1400	1000	--	250	2000	4000
						2100	4154

TABLE 1--Continued

		1966 Expense					
Farm No.	Type of Fuel	Fuel Cost	Power unit Repair	Well & Pump Repair	Other Irrig. Equipt. Repair	Well Capacity	Hrs. Pumped
		$	$	$	$	GPM	Hrs.
HS-13	NG	1885	73	769	--	2000	1500
						2000	1250
HS-14	NG	1500	600	700	100	1100	950
						2000	1350
						1500	1200
HS-15	NG	1500	200	--	200	1600	2000
						2000	1600
HS-16	NG	1200	400	50	75	1450	2600
						1200	2800
HS-17	NG	630	425	--	150	1400	2500
						1100	2000
HS-18	NG	2000	1300	392	--	1800	4000
						1200	4000
						2000	2500
HS-19	NG	589	552	--	--	1170	3000
HS-20	NG	1044	289	--	95	2000	2900
HS-22	NG	836	150	350	185	1800	3860
						1400	1490
						1400	1690
HS-23	NG	2050	530	--	--	2000	2500
						2000	2000
						2000	2000
						2000	2000
HS-24	NG	1160	75	--	25	1100	1100
						2000	1500
						1100	150
HS-25	NG	2825	2200	130	150	1200	2400
						2300	3200
						2500	400
HS-26	NG	1250	300	--	--	2000	900
						2000	800
HS-27	NG	1850	1045	--	--	1000	5000
						1600	5000
Totals		85678	41535	17725	6819		361360

TABLE 2.--Summary of irrigation survey of farm management association members in southwest Kansas--1966

Farm No.	Hrs. of Labor per Day for Irrig. Hrs.	No. of Wells	Depth of Wells Ft.	Pump Setting Ft.	Orig. Cost Power Unit $	Orig. Cost Well $	Orig. Cost Pump $	Year Devel.
GT-1	6	1	590	210	3442	8488	5327	1966
GT-2	5	1	293	250	2671	5200	750	1945
GT-4	9	3	370	180	2000	4000	2400	1948
			417	280	2000	5000	4200	1956
			355	220	4000	2600	3500	1959
GT-8	2	2	310	265	1360	3010	5000	1962
			300	265	5000	R--	R--	1947
GT-9	3	2	393	140	2399	4912	3773	1963
			320	270	2199	4943	4701	1965
GT-10	3	1	390	230	1947	2340	3533	1954
GT-11	6	1	330	240	4000	7000	4500	1956
GT-12	3.5	2	315	270	R--	R--	R--	1951
			320	250	R--	R--	R--	1954
MT-4	10	4	265	240	3000	R--	R--	1965
			198	180	1517	R--	R--	1962
			140	135	R--	R--	R--	1948
			130	125	900	2000	1900	1963
MT-15	2	2	285	280	614	5152	2732	1964
			280	200	735	4242	3435	1963
MT-24	4	3	360	340	1215	4942	3685	1965
			600	370	3824	7364	6568	1966
			600	450	1802	R--	6313	1966
SW-1	3	2	358	270	R--	R--	R--	1948
			415	220	2600	4980	2950	1956
SW-5	2	1	400	250	3500	5200	5010	1953
SW-12	4	1	635	275	6765	7910	6200	1965
SW-20	2	2	400	260	R--	R--	R--	1955
			396	230	3813	4586	5451	1956
SW-23	3	1	390	240	R--	R--	R--	1956
SW-24	2	1	--	--	--	--	--	1956
FI-5	5	2	320	175	4200	R--	R--	1949
			448	220	4356	5644	5457	1965
FI-12	1.3	1	417	140	4500	4000	4500	1956
FI-14	2	1	220	190	R--	R--	R--	1955
FI-19	16	4	265	240	R--	R--	R--	1949
			300	265	R--	R--	R--	1955
			300	285	2715	3731	6856	1956
			295	280	2050	3840	6867	1963
FI-20	8	3	126	120	1860	R--	R--	--
			150	110	1720	R--	R--	--
			150	120	1720	R--	R--	--

TABLE 2--Continued

Farm No.	Hrs. of Labor per Day for Irrig. Hrs.	No. of Wells	Depth of Wells Ft.	Pump Setting Ft.	Orig. Cost Power Unit $	Orig. Cost Well $	Orig. Cost Pump $	Year Devel.
FI-37	6	4	300	110	2700	3000	2500	1955
			297	40	2250	3000	2000	1956
			100	90	1500	1660	1300	1965
			200	180	1300	2200	3000	1964
FI-44	15	4	250	150	400	2250	2000	1952
			250	170	800	R--	R--	1953
			250	150	3200	2750	1750	1955
			235	180	1400	3000	2400	1966
FI-48	7.5	5	320	200	4400	4433	5051	1964
			130	130	1850	1690	3260	1959
			180	160	1500	2400	1900	1949
			290	160	2355	3700	3200	--
			250	160	2400	3000	2700	1965
FI-49	2	1	200	180	1000	2600	4402	1966
FI-53	14	3	203	120	3000	2900	3200	--
			216	140	2915	2878	3455	--
			250	160	1900	3350	3100	--
FI-56	7.5	5	300	195	1600	R--	R--	1950
			--	130	2500	R--	R--	1957
			--	130	1200	R--	R--	1957
			--	130	1200	R--	R--	1948
			--	210	1000	R--	R--	1951
FI-57	2	1	300	200	R--	R--	R--	1965
FI-67	4	2	340	130	R--	R--	R--	1957
			320	130	R--	R--	R--	--
FI-69	2	2	307	200	5510	3990	6500	1939
			322	240	3500	4000	5500	1965
FI-72	4	2	270	200	2560	2511	3674	1958
			270	180	2560	2500	3800	1948
FI-73	4	1	256	250	3080	3328	4272	1950
FI-77	5	4	385	150	4000	3000	5000	1956
			383	140	3000	5000	2900	1956
			372	135	2800	5000	2300	1965
			373	140	2000	5600	2300	1966
FI-81	2	1	282	277	R--	R--	R--	1965
FI-85	8	4	315	220	1500	4095	4505	1955
			310	210	2700	4030	4970	1965
			320	285	R--	R--	R--	1963
			300	190	R--	R--	R--	1958
ST-1	4	3	440	170	5100	5200	3800	1956
			442	190	4000	5200	4200	1959
			435	190	4600	5500	4800	1963
ST-2	4.5	2	400	150	3280	6591	3559	1964
			400	150	2800	4940	4353	1957

TABLE 2--Continued

Farm No.	Hrs. of Labor per Day for Irrig. Hrs.	No. of Wells	Depth of Wells Ft.	Pump Setting Ft.	Orig. Cost Power Unit $	Orig. Cost Well $	Orig. Cost Pump $	Year Devel.
ST-6	2	2	320	160	R--	R--	R--	1960
			300	160	R--	R--	R--	1947
ST-9	4	3	390	120	3200	2337	2384	1953
			400	200	3000	5525	3000	1963
			400	200	4458	R--	R--	1963
ST-10	3	2	254	145	2500	3302	2398	1952
			425	220	2400	5525	4475	1964
ST-11	4	3	325	190	2620	4225	2685	1962
			325	200	3849	4225	3980	1964
			390	260	4490	5129	5592	1965
ST-13	1	1	428	270	3843	5756	5271	1963
ST-14	3	2	390	210	2250	R--	R--	1956
			393	240	3190	5422	5626	1966
ST-16	8	2	400	110	4325	5165	4570	1957
			400	110	3700	4400	2600	1962
ST-17	14	5	440	210	6000	6000	4500	--
			440	210	5200	5720	4550	--
			440	210	5250	5020	6000	--
			440	210	5800	5500	5500	--
			440	210	5450	5720	5650	--
ST-19	3	1	300	220	2872	4050	4289	1956✓
ST-22	2.5	1	450	250	3060	5460	5597	1964
ST-23	4	1	300	180	3500	4200	5000	1956
ST-24	2	1	363	200	1959	4888	3736	1960
ST-26	3	1	420	260	3725	6015	5826	1963
ST-27	5	1	373	220	2800	4243	4611	1964
SV-12	2	2	400	220	2400	5050	5550	1958
			400	235	2500	6414	4634	1965
SV-13	3	1	532	420	3650	7918	6886	1965
SV-16	2	1	430	373	3500	5100	7200	1966
ME-16	6	1	416	185	R--	R--	R--	1954
HS-1	4	2	416	270	3234	4908	3613	1950
			475	320	3336	6650	5001	1954
HS-3	4	2	400	250	5000	5000	5000	1954
			420	280	5000	5000	7600	1959
HS-4	4	1	360	180	5400	4300	3700	1954
HS-5	2	2	445	250	3500	5500	5500	1955
			288	220	R--	R--	R--	1951
HS-7	6	2	410	380	6000	6000	2000	1957
			380	320	3575	6136	6172	1964
HS-13	4	2	450	230	5500	8700	7300	1955
			597	305	4429	7805	7761	1966

TABLE 2--Continued

Farm No.	Hrs. of Labor per Day for Irrig. Hrs.	No. of Wells	Depth of Wells Ft.	Pump Setting Ft.	Orig. Cost Power Unit $	Orig. Cost Well $	Orig. Cost Pump $	Year Devel.
HS-14	4	3	460	260	R--	R--	R--	1955
			490	360	R--	R--	R--	1955
			460	360	R--	R--	R--	--
HS-15	4	2	422	250	4000	4500	5500	1955
			425	255	4000	4500	5500	1964
HS-16	4	2	396	300	3678	5137	6822	1964
			369	280	3500	4500	5500	1956
HS-17	3	2	400	280	4113	6395	7000	1954
			400	260	3177	4000	6092	1955
HS-18	5	3	425	300	3500	R--	R--	1956
			475	350	4000	6000	5000	1955
			375	280	2500	6000	5000	1964
HS-19	2.5	1	405	260	5803	6418	3522	1955
HS-20	4	1	450	250	4430	6750	6750	1956
HS-22	4	3	425	297	7000	5100	5400	1947
			418	200	R--	R--	R--	1954
			420	180	R--	R--	R--	1965
HS-23	3.3	4	380	240	R--	R--	R--	1964
			490	310	R--	R--	R--	1966
			410	210	R--	R--	R--	1965
			380	340	R--	R--	R--	1956
HS-24	3	3	172	120	1000	1720	1280	1954
			200	100	2000	4100	2000	1961
			185	160	1250	2350	1400	1966
HS-25	2	3	187	145	2390	2400	2000	1956
			415	240	5105	5395	5500	1961
			350	145	3425	4550	4718	1966
HS-26	3	2	440	220	3536	4800	5675	1965
			440	220	3494	4800	5040	1965
HS-27	1.5	2	340	280	R--	R--	R--	1951
			420	340	R--	R--	R--	1965
Totals	322.1	158	54098	34087	398150	508103	482715	

TABLE 3.--Summary of irrigation survey of farm management association members in southwest Kansas--1966

Farm No.	Acres of Irrig. crop 1966	Acres Irrig. land owner	1966 Real estate taxes $
GT-1	171	--	--
GT-2	320	320	420
GT-4	267	400	725
GT-8	263	145	279
GT-9	258	320	580
GT-10	249	350	580
GT-11	305	160	187
GT-12	491	--	--
MT-4	850	--	--
MT-15	290	320	316
MT-24	500	320	210
SW-1	539	160	318
SW-5	324	324	467
SW-12	240	240	620
SW-20	696	--	--
SW-23	175	--	--
SW-24	400	400	600
FI-5	714	160	389
FI-12	369	--	--
FI-14	306	--	--
FI-19	699	350	620
FI-20	691	--	--
FI-37	595	613	3043
FI-44	792	200	350
FI-48	810	320	633
FI-49	114	94	87
FI-53	843	630	1022
FI-56	747	--	--
FI-57	199	--	--
FI-67	565	--	--
FI-69	406	400	1125
FI-72	416	600	1367
FI-73	240	--	--
FI-77	757	710	750
FI-81	147	--	--
FI-85	964	160	267
ST-1	775	960	1734
ST-2	460	480	899
ST-6	404	--	--
ST-9	570	542	940
ST-10	304	410	636
ST-11	655	160	188
ST-13	149	--	--
ST-14	523	320	358

TABLE 3--Continued

Farm No.	Acres of Irrig. crop 1966	Acres Irrig. land owner	1966 Real estate taxes $
ST-16	468	1760	2430
ST-17	1400	1600	1800
ST-19	127	190	280
ST-22	348	433	696
ST-23	121	325	450
ST-24	376	140	180
ST-26	320	160	141
ST-27	180	265	365
SV-12	361	486	294
SV-13	232	240	300
SV-16	128	--	--
ME-16	562	--	--
HS-1	468	320	378
HS-3	1410	1200	1250
HS-4	158	158	179
HS-5	365	156	204
HS-7	680	1000	3400
HS-13	482	640	769
HS-14	400	260	463
HS-15	488	480	470
HS-16	664	315	370
HS-17	538	714	1500
HS-18	887	280	380
HS-19	286	--	--
HS-20	349	--	--
HS-22	445	--	--
HS-23	768	--	--
HS-24	304	630	700
HS-25	686	265	225
HS-26	650	418	520
HS-27	470	480	550
Totals	35673	23483	38004

TABLE 4.--Summary of 54 irrigation wells developed in southwest Kansas--1960-1966

Farm No.	Year Devel.	Well Capacity GPM	Depth of Well Ft.	Pump Setting Ft.	Original Cost Power Unit $	Original Cost Well $	Original Cost Pump $
800 GPM or Less Depth 300 ft. or Less							
MT-4	1962	500	198	180	1517	R--	R--
MT-4	1963	300	130	125	900	2000	1900
MT-15	1964	600	285	280	614	5152	2732
MT-15	1963	400	280	200	735	4242	3435
Totals		1800	893	785	3766	11394	8067
800 GPM or Less Depth 301 ft. & Over							
GT-9	1965	700	320	270	2199	4943	4701
MT-24	1965	600	360	340	1215	4942	3685
MT-24	1966	600	600	450	1812	7680	6313
Totals		1900	1280	1060	5226	17565	14699
801-1600 GPM Depth 300 ft. or Less							
FI-19	1963	1500	295	280	2050	3840	6867
FI-48	1965	1200	250	160	2400	3000	2700
FI-49	1966	1154	200	180	1000	2600	4402
FI-37	1965	1600	100	90	1500	1660	1500
FI-37	1964	1600	200	180	1300	2200	3000
HS-24	1966	1100	185	160	1250	2350	1400
MT-4	1965	1000	265	240	3000	R--	R--
Totals		9154	1495	1290	12500	15650	19869
801-1600 GPM Depth 301 ft. & Over							
FI-48	1964	1500	320	200	4400	4433	5051
HS-16	1964	1450	396	300	3678	5137	6822
ST-9	1963	1400	400	200	3000	5525	3000
ST-10	1964	1000	425	220	2400	5525	4475
ST-11	1965	1100	390	260	4490	5129	5592
ST-13	1963	1400	428	270	3834	5756	5271
ST-24	1960	900	363	200	1959	4888	3736
ST-26	1963	1200	420	260	3725	6015	5826
SV-13	1965	1000	532	420	3650	7918	6886
SV-16	1966	1650	430	373	3500	5100	7200
GT-1	1966	1200	590	210	3442	8488	5327
GT-8	1962	1000	310	265	1360	3010	3600
MT-24	1966	860	600	370	3824	7364	6568
Totals		15660	5604	3548	43262	74288	69354

TABLE 4--Continued

Farm No.	Year Devel.	Well Capacity GPM	Depth of Well Ft.	Pump Setting Ft.	Original Cost Power Unit $	Original Cost Well $	Original Cost Pump $
1601 GPM & Over Depth 300 ft. or Less							
FI-44	1966	2000	235	180	1400	3000	2400
HS-24	1961	2000	200	100	2000	4100	2000
Totals		4000	435	280	3400	7100	4400
1601 GPM & Over Depth 301 ft. & Over							
GT-9	1963	3000	393	140	2399	4912	3773
FI-5	1965	1800	448	220	4356	5644	5457
FI-77	1965	2000	372	135	2800	5000	2300
FI-77	1966	2000	373	140	2000	5600	2300
FI-85	1965	1670	310	210	2700	4030	4970
FI-69	1965	1800	322	240	3500	4000	5500
HS-7	1964	2100	380	320	3575	6136	6172
HS-13	1966	2000	597	305	4429	7805	7761
HS-15	1964	2000	425	255	4000	4500	5500
HS-18	1964	2000	375	280	2500	6000	5000
HS-25	1961	2300	415	240	5105	5395	5500
HS-26	1965	2000	440	220	3536	4800	5675
HS-26	1965	2000	440	220	3494	4800	5040
ST-1	1963	2000	435	190	4600	5500	4800
ST-2	1964	2060	400	150	3280	6591	3559
ST-9	1963	2100	400	200	4458	R--	R--
ST-11	1964	1850	325	200	3847	4225	3980
ST-11	1962	1850	325	190	2620	4225	2685
ST-14	1966	2000	393	240	3190	5422	5626
ST-22	1964	1950	450	250	3060	5460	5597
ST-27	1964	2000	373	220	2800	4243	4611
SV-12	1965	1800	400	235	2500	6416	4634
SW-12	1965	2000	635	275	6765	7910	6200
HS-25	1966	2500	350	145	3425	4550	4718
ST-16	1962	2500	400	110	3700	4400	2600
Totals		51280	10176	5330	88639	127564	113958

TABLE 5.--Summary of fuel and oil cost

Farm No.	800 GPM or Less			Hours Pumped
	Feet of Lift			
	150 or Less $	151-250 $	251 and over $	
GT-8			585	5000
GT-4		460		4370
MT-4		400		4000
MT-15			1529	8600
MT-24			1901	15000
Totals		860	8370	36970
		801-1600 GPM		
GT-1		289		1530
GT-2		305		4098
GT-9		795		1650
GT-10		519		2100
GT-11		693		4803
GT-12			793	4912
SW-1			1083	5868
ST-6		900		2670
ST-9		841		6622
ST-10		603		3600
ST-13			872	800
ST-17		2300		12000
ST-19		580		680
ST-23		310		1008
ST-24		300		4600
ST-26			1541	3688
SV-13			300	1168
HS-1			1447	6600
HS-3			3150	7000
HS-4		550		1720
HS-5		1020		3100
HS-14			1500	3500
HS-16			1200	5400
HS-17			630	4500
HS-19			589	3000
HS-22			836	7020
HS-24		1160		2750
HS-27			1850	10000
FI-5		927		4700
FI-20	1104			3820
FI-44		640		4700
FI-48		2040		14850
FI-49		160		1248
FI-53	770			6096
FI-56	920			13250

TABLE 5--Continued

Farm No.	801-1600 GPM			Hours Pumped
	Feet of Lift			
	150 or Less $	151-250 $	251 and Over $	
FI-73		357		4620
FI-85		2500		10800
FI-69		700		3800
FI-72		850		8000
Totals	2794	19339	15791	192271
		1601 GPM & Over		
SW-5			750	3696
SW-12			686	2530
SW-20			943	4760
SW-23		470		1800
SW-24			700	1100
FI-14		800		3840
ST-1		974		4100
ST-2	1670			4386
ST-11		2078		8200
ST-14		971		6000
ST-16	1800			8200
ST-22		1000		3130
ST-27		311		968
SV-12		972		2945
SV-16			776	2200
ME-16		1200		3000
HS-7			1400	4154
HS-13			1885	2750
HS-15			1500	3600
HS-18			2000	10500
HS-20		1044		2900
HS-23			2050	8500
HS-25		2825		6000
HS-26		350		1700
FI-12	290			3000
FI-57			200	1000
FI-67	662			3360
FI-77	1200			5350
FI-81			790	1396
FI-37	870			4552
Totals	6492	12995	13680	119617

AN ECONOMIC ANALYSIS OF IRRIGATION WITH A LIMITED SUPPLY OF WATER IN SOUTHWEST KANSAS

by

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The problem of determination of the most efficient and profitable use of a limited supply of water for irrigation in relation to a relatively large quantity of land suitable for irrigation in southwest Kansas is a current controversy of importance. Water supply may be limited by the capacity of the irrigation well to produce water in relation to timeliness of application necessary for high yields. Water for irrigation may also be limited by depletion of the available ground water resources to the extent that only a given quantity of water could be used annually due to government regulation or available water supply. Consideration is given to both types of limitation in this thesis.

Yield data for grain sorghums were obtained from experimental work done at the Garden City Branch of the Kansas Agricultural Experiment Station in a period from 1958-1965. The experiments during this period used the same methods of production.

Major emphasis was directed to the determination of the cost of irrigation in southwest Kansas. A survey of farm management association members was conducted to develop these costs. Association members were selected for the survey because of known accuracy and accessability of farm records of costs. This record program is supervised by extension economists in farm management, Kansas State University. Questionnaires were completed by 75 farmers operating 158 pumping units with approximately eight to ten percent of the total irrigated land in the seven county area of southwest Kansas.

Irrigation costs were divided into three categories: development costs, equipment costs and operating costs. Development costs included capital expenditures for irrigation improvements with an indeterminate life due to wear and tear. These expenditures include the cost of developing the irrigation well, installation of underground concrete pipe and land grading.

Irrigation equipment subject to depreciation (including the power unit, irrigation pump and aluminum surface pipe) were classified as equipment costs. Operating costs were those costs with a linear relationship to hours of pumping. These include fuel and oil, repairs and labor for water distribution.

Cost information was developed in a form suitable for appraisal of alternatives available with a limited supply of water. Hypothetical case studies considering the production of grain sorghum were employed to demonstrate the use of these cost data. Although the case studies were limited to grain sorghum production, these costs are cast in a framework suitable for the appraisal of cost of any irrigated crop in southwest Kansas.

The case studies reveal that spreading of a fixed quantity of water (suitable to fully irrigate 160 acres) to 320 acres would increase total production due to increased water efficiency. However, the increase in total production costs reduced the margin of profit to a point that would not justify water extension to this degree in light of the additional risk involved and present technology. Although this investigation did not include studies of water extension to a lesser degree (say 240 acres instead of 320 acres) implications would indicate that this could be done profitably.

If the water limitation was due to well capacity during the growing season, case studies show that pumping additional water during the off-season months would increase profits sufficiently to justify this method of water extension.