AN ECONOMIC ANALYSIS OF WELL IRRIGATION IN HARMON COUNTY, OKLAHOMA

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CHAPTER I

INTRODUCTION

Water is an essential element to plant growth. Not only is it necessary to have a sufficient supply of moisture but there must be adequate distribution throughout the growing season in keeping with plant needs. The average annual rainfall in Harmon County, Oklahoma, is about 24 inches, which, if properly distributed, would be adequate for most of the major crops grown in the county. Unfortunately both the amount and distribution are uncertain. These variations in moisture cause wide fluctuation in yields from year to year and render decision-making at the farm level difficult and often quite ineffective.

Faced with these fluctuations in yield and income due to inadequate moisture, the farmers in Harmon County began to explore the possibilities of correcting these inadequacies with the age-old practice of irrigation. Although, irrigation is a cultural practice that is as old as agriculture itself, it has not been practiced extensively in Oklahoma until recent years. One farmer, near Hollis, the county seat, reports that he did some irrigating of truck crops as early as 1921. Water was pumped from a well with an improvised shop-made pump at about 150 gallons per minute. It was as late as 1948 and 1949 that the farmers in Harmon County began to observe their neighbors in the high plains of Texas with envy and started to explore and develop their own underground resources.

Successive droughty years and crop failures over the state caused farmers to ask the question: Is irrigation a possibility in Oklahoma? Farmers in Harmon County have answered this question in the affirmative, but a positive answer brings forth the specific question: Will net income be increased enough to justify the additional investment required?

It is recognized that the development of irrigation is only one of many alternative uses for capital. For instance an individual could invest his capital in additional land or improved methods of farming, such as using better seed, more fertilizer and insecticides, and more productive livestock. This study will not attempt to evaluate these alternatives. The objective will be to determine the net returns that can be expected from an investment in irrigation. This evaluation of irrigation then can be used to compare with other alternatives. Every farmer who is considering irrigation has this problem to resolve: Will investment in irrigation pay as great or greater returns than the next best alternative? The purpose of this study is to provide a basis for making this decision.

It will be assumed that investment opportunities other than irrigation have been exploited. This is an arbitrary assumption and is made to establish a framework for evaluating the results obtained from irrigation. It also provides the limits of the study.

The information required to evaluate this alternative can be grouped into five broad categories: (1) cost of developing an irrigation system, (2) cost of operating an irrigation system, (3) costs of added cultural practices that are due to irrigation, (4) increased yields that result from irrigation and (5) value of the commodities produced.

By combining this information into a budget an objective and systematic decision can be reached. The value of this decision depends on the accuracy of the estimates of the five items named. Cost of developing and cost of operating an irrigation system are determined from records and estimates given by farmers in Harmon County who recently have established irrigation plants. Cost of added cultural practices are determined by charging custom rates on the common practices which these irrigation farmers indicated they were adding to the regular practices performed in dryland farming. Increased yields are estimated from production records on the farms studied for the years 1954-55. Yields of the major crops grown under irrigation are compared with yields of these same crops without irrigation on the same farm under similar conditions. Prices of farm commodities are estimated on the basis of the average prices received for the period 1951-55 and adjusted to 86 percent parity.

It must be recognized that this study should be used only as a guide by which each farmer can make an estimate of his own situation and then compare the returns expected from irrigation with other investments.

Data relating to installation and operating costs of wells on 21 farms in Harmon County were obtained for 1955 and 1956 by interviews with operators. These farms were suggested by business men and agricultural workers of the area as being typical situations. The sample was found to be uniformly distributed over the area when the farms included in the study were plotted on a county map showing all the claims filed for water rights with the Oklahoma Planning and Resource Board.

It was not the purpose of this study to discuss the merits or demerits of the system of farming or the management practices followed. However, by making a careful analysis of the experiences of these 21 farmers a basis is provided for estimating the cost of developing and operating an irrigation system and the expected returns.

Pumping plant details, including installation costs and estimates of operating costs, were secured directly from farm operations. It should be noted that irrigation development in this area is realtively new. It continues to be initiated and operated on a trial-and-error basis to a great extent. Data with respect to pumping lift and well yields, and several items related to operating costs are not precise but are the best estimates by the operators. Pumping lift and well yields were measured in most cases only at the time the driller completed the well to determine the size of pump and motor. Wells measured after pumps were operated indicate a strong probability that yields may be lower than indicated at the time the wells were drilled.

Hours of plant operation essential to determination of quantities of water pumped and unit costs are explicit. Most operators could give the exact number of days required for each irrigation. Total fuel consumption was determined by multiplying the hours operated by the hourly rate of fuel consumption. Data relative to cost of fuel oil and energy are from farm records and reflect the actual cash outlays for these purposes.

Pump and power unit repairs are calculated from estimates of pump and motor repairmen since the plants have not been in operation long enough to have experience in the cost of overhauling. Outlay for repairs was obtained by converting the costs of overhauling the pumps and power plants to an hourly basis and multiplying by the actual hours the plants were operated.

Increases in yields are estimates computed from yields obtained under irrigation by 21 farmers compared with the yields obtained without irrigation. Yields obtained in experimental plots of variety tests by the Oklahoma A. & M. College in the immediate and surrounding areas and the county average yield were used to verify estimates.

It is not to be inferred that the increase in yields obtained by these farmers could be expected by farmers in other areas with different soils and climatic conditions. Water is only one of the many factors that affects yield. Soil fertility, insects, plant diseases, management and many other factors have their effect and must not be overlooked. On the basis of comparison of yields obtained under irrigation and under dry farming conditions in the same period on similar soil, and with the same management, it can be concluded that the increase in yield obtained in a given situation can be attributed to irrigation.

CHAPTER II

DESCRIPTION OF AREA

Harmon County is in the extreme southwest corner of Oklahoma, bordered on the west and south by Texas. Red River forms the southern boundary of the county as well as the boundary line between the states of Oklahoma and Texas. There are approximately 340,480 acres in Harmon County. The U.S. Census of 1954 reports 195,790 acres in cropland in Harmon County and the Oklahoma Planning and Resource Board gives an estimate of 12,137 acres irrigated in 1955. Slightly less than 8 percent of the cropland of the county was irrigated in 1955. This irrigated area lies between the Salt Fork of Red River that passes through the northern part of the county and the Prairie Dog Town Fork of Red River. (Figure 1). This region is drained by Lebos Creek and its tributaries. Lebos Creek heads a few miles northwest of Hollis, flows in a southeasterly direction through the county passing on the south of Hollis and continues through Louis, a community in the southeast corner of the county, crosses a segment of Jackson County and empties into Prairie Dog Town Fork of Red River, more commonly called South Fork. Small areas drain into shallow depressions from which water is removed largely by evaporation. There are small areas throughout the county that drain into gypsum sinks.

A large section of the area ranges from level to gently undulating slopes of less than 1 or 1½ percent, and a great part of the irrigation

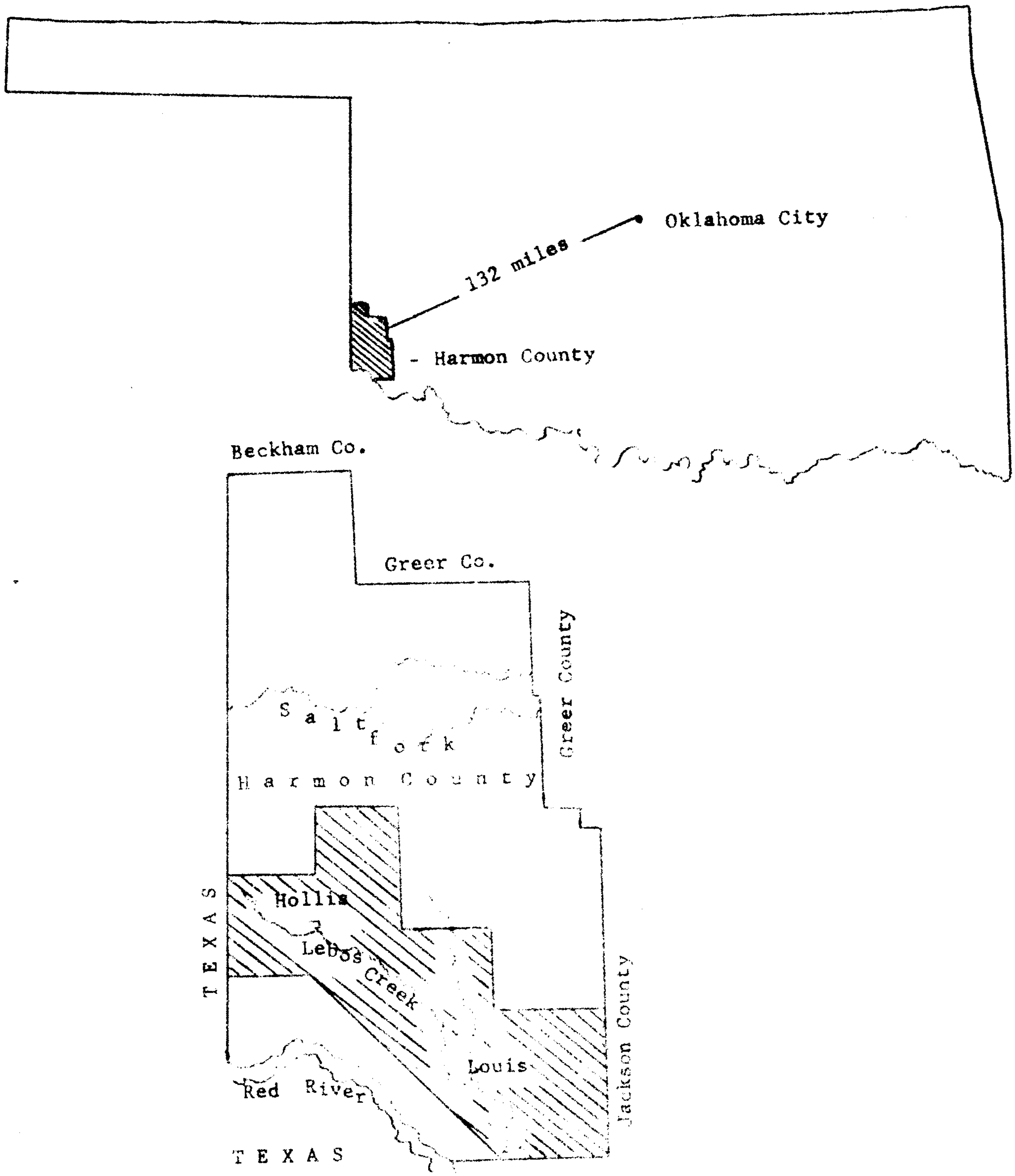

Fig. 1 Map of Harmon County with general area used in irrigation study shaded.

is practiced on these soils. Very little land leveling has been practiced in the area to facilitate irrigation. Only one of the irrigation farms observed was using a sprinkler system where the soil was very sandy. Sprinkler systems may be a means of increasing efficiency of irrigation on farms that have an abundant supply of water but a limited amount of land that can be prepared for gravity flow irrigation.

Climate

The climate of the district is classified as semi-arid. Weather bureau records reveal an annual average precipitation of 24.42 inches. Records at Hollis from 1922 to 1930 show an average annual precipitation of 24.86 inches and from 1931 to 1941 an average of 25.24 inches. These averages conceal the extreme variations in precipitation. Total precipitation in 1944 was 45.15 inches, the highest for the twenty year period; the low was 13.47 inches in 1947. The annual average for the critical growing months of June, July, August and September for the years 1949 through 1955 was 9 inches with a variation from 5.01 inches in 1948 to 20.64 inches in 1950. Rainfall within the area during a given storm period is also unevenly distributed. One area may receive a heavy rainfall while another area may receive very little as a result of narrow paths followed by the cyclonic storms. Rains are often of short duration and high intensity, consequently much of the water is lost through runoff.

The last killing frost in the spring is usually March 10 and the first in the fall is about October 10. The area has a frost free growing season of 225 days, according to climatological reports.

Soils

The soils of Harmon County have been classified into eight land use groups for the purpose of applying farm practices and land-conservation measures.[1] This grouping is used to describe the soils of the area.

Soil Group I consists of deep, moderately permeable sandy or loamy soils, located on the uplands or on terraces along the streams. This group consists mainly of such soils as Carey fine sandy loam, St. Paul silt loams, Sentinel fine sandy loams, Abilene fine sandy loams, Tipton fine sandy loam and Enterprise fine sandy loam. This group covers 73,647 acres of the county's 340,480 acres and contains much of the best farming land in the area; productivity is moderate to high and the soils are well suited for growing row crops, small grains and alfalfa. Water is absorbed readily and the moisture holding capacity is moderate to high. Slopes are for the most part less than 1½ percent. These soils are considered ideal by the soil technician for irrigation when water is available, because they are permeable and absorb water readily and hold the moisture for a relatively long time.

Group II soils are fine textured and do not absorb water as readily as Group I. Neither is the water given up to the plants as readily. They are productive soils but require more care in applying irrigation water. With insufficient rainfall and without irrigation, yields can drop drastically.

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[1]Ralph H. Bond, Physical Land Conditions in the Farm Security Soil Conservation District, Harmon County, Oklahoma (USDA, SCS, Physical Land Survey No. 40, Washington, D. C. 1946) pp. 28-29.

Group III contains shallow permeable to coarse soils that absorb water readily but has a sub-soil that catches and holds the moisture in the plant-root zone of the plants. These soils are not as fertile as Groups I and II but respond well to irrigation. Because of the water absorbing and holding qualities of these soils they produce greater yields during extremely dry years without irrigation than the deeper more fertile soils. However, with normal rainfall or with irrigation the deeper finer textured soils are considered to be more productive.

Group IV includes shallow fine textured sandy or clay loam soils with rather low productivity. However, the one farm represented in the study in this group reported a yield of 750 pounds of lint cotton and 2,300 pounds of milo under irrigation with no fertilizer applied. Such yields could not be expected to be maintained without the use of commercial fertilizer or green manure crops.

Group V is composed of mixed soils that range from fine to medium fine textured. These are productive soils and respond well to irrigation because of their water holding capacity.

Group VI, VII, and VIII include such soils as range grazing land, badly eroded soils, sand dunes, and river beds. These are not adapted to irrigation. For the most part irrigation is limited to Groups I, II, III, and V.

A greater percentage of the irrigation practiced was on the medium to fine textured loamy soils that are deep and moderate to high in productivity. These soils made greater response to irrigation.

Principal Crops Grown in Harmon County

According to the 1954 census the principal crops grown in the county are cotton, wheat, grain sorghums, barley, and alfalfa for hay and seed. The acreage devoted to these and other crops at ten year intervals beginning with 1909 and ending with the last census is shown in Table I.

Cotton

Cotton acreage increased rapidly from 1900 to 1930, but was greatly reduced following the sharp decline in prices after 1930. Acreage was increased slightly after 1940 in response to war prices but the agricultural program and drought have reduced the acreage greatly since 1950. Cotton yields vary considerably from year to year depending largely upon the amount of rainfall. Yields also vary within the district according to type of soil. Yield for the county in 1955 was 300 pounds of lint and for 1954 it was 191 pounds of lint per harvested acre. However, the year 1955 was considered by local farmers to be an exceptionally good year with a total of 25 inches of rainfall, 10 inches of this occurred during the growing season June, July, August, and September. The 1954 yield of 191 pounds of lint for the county reflects both the small amount of rainfall received during the year and during the growing season. A total of 15 inches was recorded for the year and only 4 inches of this was in the growing season, June - September. In 1939, the average yield was 100 pounds of lint per acre. The ten year average yield for the period 1945-54 was 152.6 pounds lint per acre.

Wheat

Wheat was not an important crop in the early agriculture, but increased greatly during World War I. Thereafter it declined until 1930. Following mechanization in the latter 20's and an increase in size of units, wheat has increased in importance. Wheat culture is easily adapted to the nearly level fine textured and fertile soils in the district. The average dry land yield per acre harvested was 5.9 bushels in 1955, 8 bushels per acre in 1954 and the 10 year average yield per acre for the period 1945-54 was 10.6 bushels.

TABLE I

ACREAGE DEVOTED TO THE PRINCIPAL CROPS IN HARMON COUNTY, OKLAHOMA, IN STATED YEARS

Crop	1909	1919	1929	1939	1949	1954
Cropland, total harvested acres			201,243	179,247	162,479	178,445
Cotton	71,039	55,147	135,271	49,150	75,603	57,468
Corn	19,098	9,679	2,441	623	426	256
Wheat	2,036	39,710	12,751	34,411	44,204	53,073
Oats	1,928	6,730	459	2,177	1,768	1,713
Barley	----	262	275	4,315	437	8,135
Hay	6,142	4,246	2,277	4,177	9,449	7,971
Alfalfa	859	2,956	1,872	3,441	8,884	5,962
Sorghums	----	8,303	41,599	39,454	17,622	31,227
Grain	----	----	30,105	27,202	10,085	12,684
Forage	----	----	11,494	12,252	7,537	18,543

Source: U. S. Census: 1909, 1919, 1929, 1939, 1949, and 1954

Grain Sorghums

Sorghums have been an important crop since the beginning of agriculture in the area. Their importance has increased over the years due to their ability to withstand drought. Grain sorghums have largely replaced corn since they are much better adapted to hot dry summers. Yields for the area are moderate. The average yield on 12,684 acres harvested for grain in 1954 was 952 pounds. The average yield per acre for the ten year period 1945-54 was 761.6 pounds. The average yield for corn for the period 1945-54 was 11 bushels. The average number of acres annually planted in the county for this period was 660 acres.

Alfalfa

Alfalfa for hay and seed has always been an important crop for feed and cash. The deep fertile soils of the area are well adapted to alfalfa production. The agricultural census reports yields of 1 ton to $1\frac{1}{2}$ tons of hay per acre. Yields of seed per acre are reported to range from 100 pounds to 150 pounds. The average yield per acre for the four census years of 1940, 1945, 1949 and 1954 was 118 pounds of seed and 1.14 tons of hay.

CHAPTER III

WHAT DOES IT COST TO DEVELOP AN IRRIGATION SYSTEM?

How Costs were Determined

To evaluate the net income from irrigation it was necessary to determine the resource costs per unit of in-put. To determine the cost per acre foot of water, it was necessary to consider (1) the capital outlay involved in establishing an irrigation system and (2) the cost of operating the plant. These cost data were obtained from 21 farmers in Harmon County by personal interviews.

The total cash outlay or investment of each of the systems was allocated on an annual basis by spreading the investment over an eight year period to give an "annual fixed cost." The "annual fixed cost" was then divided by the acre feet of water pumped to give the fixed cost per acre foot of water.

The "operating cost per acre foot" of water was determined by dividing the total annual operating costs[1] by the estimated number of acre feet of water pumped.

Development Costs

Development costs were classified into divisions, (1) primary and

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[1]Total annual operating costs include cost of fuel, cost of oil, repair of motor and repair of pump. No charge was made for attendance.

(2) adjunct costs. Primary costs include all capital outlay involved in locating the water supply, drilling and developing the well, and installing the pump and power plant. Under adjunct costs were included the cost of leveling the land to grade for flood irrigation, the cost of conveyance structures, and sprinkler systems if they are used.

Primary Development Cost

Test Drilling

To locate the supply of water and determine the amount of water available, 4 inch test holes are usually drilled. The most desirable location, in terms of land utilization and water distribution, was tested and if unsuccessful a move was made to less desirable locations in the field. An experienced driller can usually tell the approximate yields of a well as soon as he drills through a water bearing formation. He may drill several test wells, then select the one that shows the greatest possibilities to develop into a well. Costs of drilling these wells vary from locality to locality but were usually from $0.60 to $1.00 per foot. The cost of the test hole that was selected for developing was applied against the cost of the well.

Well Drilling

The test hole selected as showing the greatest possibilities was then reamed to 20 or 32 inches in diameter. It was usually considered essential to case the well to a solid formation. In the Harmon County area this generally means casing the well the entire depth in an unconsolidated aquifer. Where the well was cased to the impervious red-beds, it was necessary to have the lower section of the well casing perforated to permit the flow of water from the aquifer. Many drillers, have improvised by slitting the lower section of steel well casing with an aceteline torch. In most instances this was a part of the contractual services provided by the drillers. This was cheaper but may not be as desirable, functionally, as a patented prefabricated sand screen specifically designed for the aquifer. There are a number of recommended prefabricated sand screens on the market today that range in price from $7.50 to $30.00 per foot. The casing and screen installed were usually 12 to 16 inches in diameter depending on the capacity of the aquifer, size of pump and particularly on the diameter of bowls installed. After centering the casing and screen in the hole, washed pea gravel was packed around the casing. A well developed in this manner should not cave and at the same time should allow the free flow of water to the pump. The average development cost for the 25 wells studied was $10 per foot.

After the casing was set properly, the wells were tested to determine the well capacity and size of pump to be installed. The driller usually had a test pump that he used to make the test. There was an additional charge for this service which was seldom less than $50. Testing a well was of greater importance to the farmer than generally recognized, judging from comments of the farmers. Testing provides an engineer with data needed to design an efficient pump and power plant. The important facts learned from testing were, the number of gallons per minute the well was capable of yielding, the draw-down the well has at different rates of pumping, and the amount of lift.[1] These quantitative variables are the ultimate determinates of pumping costs. Lift, as applied to a

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[1] Ivan D. Wood, Pumping for Irrigation, USDA,SCS, TP-89, Washington, D. C., May 1950, p. 20

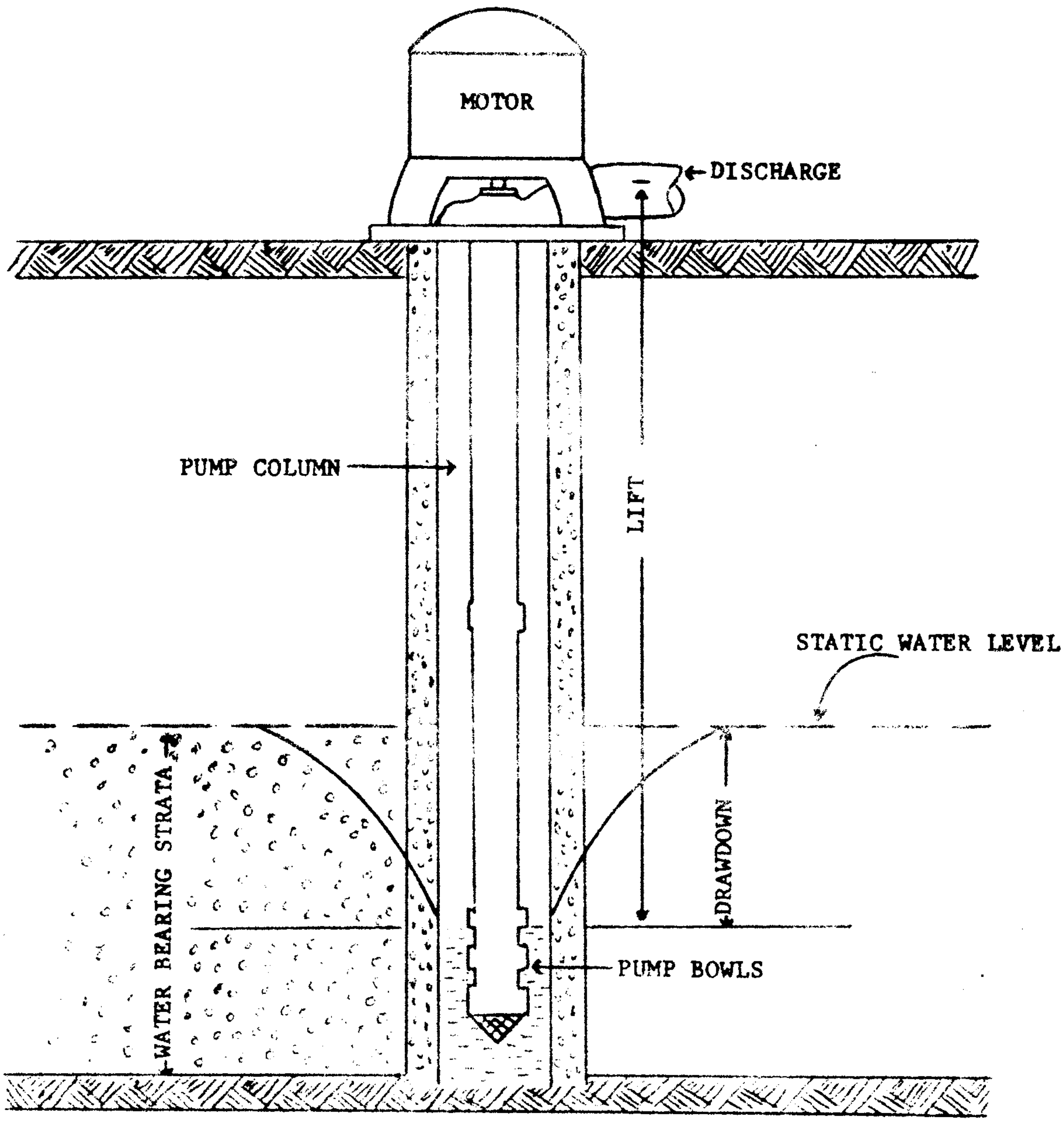

Fig. 2: Vertical cross section of a typical water well in a non-artesian formation with casing, sand screen and pump installed.

pumped well, is the vertical distance from the water level in the well during pumping to the ground surface or other specified points such as the center of the discharge pipe. Hence, total lift is a function of the static water level and draw-down. (Figure 2)

Pumps

Deep well turbine pumps were used exclusively. These are pumps suspended by the discharge column within which the drive shaft is located. They operate on the centrifugal principle and have diffuser veins within the bowl or case. The bowls remain below the water level at all times and this depth determined the length of the well column. Pumps with only one bowl and impeller are classified as "single stage," two bowls and impellers as two stage pumps. The number of stages required can be determined by an engineer when given: (1) the discharge of well at various stages of draw-down; (2) the diameter of the well casing; (3) the type of power to be used; (4) the quantity of water to be pumped; and (5) amount of lift.[1]

The cost of the pump including gearhead was closely related to the number of gallons pumped per minute and the vertical lift. The average total cost of pump and gearhead was about $25 per foot of setting for the wells studied. For example: a 10 inch pump and gearhead with a 100 foot setting cost approximately $2,500.00.

Power Plant

The type of power plant to be used depended somewhat on the type of energy available. Three general classification of motors were used by the Harmon County farmers: electric, automotive, and industrial.

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[1]Ibid.

Electric motors had a cheaper first cost and are more convenient to operate but the cost of energy was generally considered higher than for liquid gas or diesel motors. Automotive type motors had a lower first cost than the industrial motors, the cost of overhauling was about the same, but the automotive type motor did not run as long between overhaul jobs. Of the twenty-five plants studied, 11 were using automotive motors, 13 industrial motors, and 1 electric motor. The thirteen plants powered by industrial type motors had costs which ranged from $850 to $1,400 for an average cost per plant of $1,001.23. The eleven plants powered by automotive type motors had an average cost of $694.09. The costs of these ranged from a low of $250 to a high of $1,050. Since two of these were not bought as new motors the first costs were much lower. Cost of fuel was 9 cents per hour for the motors on natural gas, 32 cents per hour on propane, and operating cost on the electric motor was considered inadequate to make an estimate.

Additional Equipment

An average of $691.74 was spent by 21 farmers on additional equipment. Such items as shovels, siphons, canvas dams and ditchers were bought the first year indicating that they were essential. It was evident that investment in additional equipment increased over time. One way plows were traded for two way plows, the old conventional stalk-cutters were traded for the rotary power driven stalk shredders. Investments in equipment adapted to irrigation farming naturally increased as a farmer adjusted from dryland practices to irrigation. Many farmers managed with $75 to $300 worth of additional equipment, at least for the first year.

Adjunct Costs

After considering the primary development costs it was necessary to consider some costs that more or less depend entirely upon individual situations. Land leveling, conveyance structure, and additional equipment will be discussed separately. For purposes of this study, when two wells were drilled on the same farm the costs were divided equally between the wells.

Land Leveling

Land leveling cost as considered in this study is the expense involved in moving dirt by the yard with heavy equipment. This does not include floating which is also for the purpose of leveling but is an annual procedure in the seed bed preparation process. Only 12 of the 21 farmers interviewed indicated expenditures for land leveling. These expenditures ranged from $100 to $4,000 per farm for an average of $1,292.75. This is an item that can only be evaluated in a given situation. A partial budget can be used to compare the cost of land leveling and a sprinkler system. However, it may be necessary to install a sprinkler system even at greater expense than the cost of leveling if the soil is open and porus or the top soil is too shallow to allow the necessary amount of land leveling.

Conveyance Structures

These included flumes across ditches and creeks, elevated ditches, plastic pipe, steel and concrete underground pipe, aluminum gated pipe, and clay lined ditches. Many of these are absolutely necessary items. If it was necessary to drill a well at a lower elevation than the land to be irrigated then it was necessary to build an elevated ditch or use some form of pipe to carry the water to the level of the land to be irrigated. The topography of the land was not the only factor involved here. If the water were to be moved a long distance through open ditches over sandy soil, much of the water would be lost by percolation. Moving a long distance through an open ditch would also increase evaporation loss. No attempt was made in this study to determine the losses due to seepage and evaporation. It was estimated from observations that as much as one-third of the water was lost. The siphons used at the end of long open ditches were generally about two-thirds the number used near the well.

A total of $12,364 was spent for conveyance structures by 11 of 21 farmers, or an average of $1,124.00. Others indicated they were considering some type of prefabricated ditch, either to conserve and make better use of a scarce resource or to minimize the labor involved in conveying water from the well to the field. Most types of prefabricated conveyances reduced the amount of labor required to irrigate.

Total Investment

A total of $151,810.56 was invested by 21 farmers in 25 wells to get established in irrigation-farming, an investment per plant of $6,072.42. Investments ranged from $2,973.50 to $12,976.55. It should be observed that the most expensive plant, with an investment of $12,976.55 had only $5,129.00 invested in primary costs and the balance of $7,847.55 was adjunct costs.

To study more closely investments that were made, the wells were grouped according to depth since this factor had more influence on development cost than any other. The 16 wells drilled to a depth of 50 to 149 feet had an average investment of $58.79 per acre of land irrigated in 1955. (Table II). The average number of acres irrigated by these 16 wells was 96.4.

The average irrigation investment per acre irrigated was $61.63 on the farms in this study.

TABLE II

AVERAGE COST OF DEVELOPING IRRIGATION SYSTEMS BY DEPTH OF WELLS IRRIGATED IN HARMON COUNTY, OKLAHOMA

Depth of Well	No. of Wells	Av. No. of Ac. Irrigated Per Well	Primary Development Cost		Adjunct Costs Per Well	Total Costs Per Well	Av. Investment Per Ac. Irrigated in 1955
			Per Well	Per Ac. Irrigated In 1955			
50-149	16	96.4	3,992.59	41.41	1,676.64	5,669.23	58.79
150-199	3	93.9	4,692.16	49.88	765.00	5,457.17	57.50
200-400	6	105.3	5,270.16	50.03	702.29	5,972.45	56.70
Average	xx	xxxx	4,361.53	44.62	1,663.27	6,924.81	61.63

Fixed Costs

These costs are incurred annually regardless of the amount of water applied (Table III). They consist of annual investment charges (depreciation), interest on investment, and taxes.[1]

Annual Investment Charge

For the purpose of this study the depreciation was calculated at 12½ per cent of the total investment. It was realized that some of the installation should be depreciated at a greater rate and some at a lesser rate. This corresponds however to the rate used for income tax purposes by the local certified public accountant.

Interest

Interest on investment was calculated on 5 percent on one-half the

[1]No charge was made for insurance as this had not been practiced.

total initial investment.

Taxes

Irrigation wells are assessed in Harmon County according to the size of the pump. A ten inch pump adds $800 to the value of the personal property of the operator and did not change the assessed valuation of the land on which it was located. An 8 inch pump adds $600, a 6 inch pump adds $400 and a 4 inch pump adds $200 to the value of personal property. The amount of taxes on each irrigation installation reflected the tax levy for each school district in which the well was located.

Although fixed costs must be recovered in the long-run they are not considered in deciding whether to apply water in a season. Only the operating or variable cost was considered in making this decision. In this study the fixed costs were attributed to the major crops, such as wheat or cotton. These crops had a relatively high cash income. Grain sorghums and alfalfa for hay and seed were considered supplementary crops and carried only the variable costs. The fixed costs per acre foot of water pumped for the major crops ranged from a low of $2.38 to a high of $25.66 and averaged $7.20.

As a guide to farmers planning the development of wells for irrigation, estimates of plant costs were made by adding the approximate primary cost and the average adjunct cost. (Table III).

Total investment figures were used to determine the annual fixed cost. These are not actual cost figures but estimates made from cash outlays as shown by survey data. These estimates were made for illustrative purposes only.

TABLE III

ESTIMATED FIXED COST OF DEVELOPING IRRIGATION PLANTS OF DIFFERENT CAPACITIES AND TO DIFFERENT DEPTHS IN HARMON COUNTY, OKLAHOMA

Pump Size	Feet of Lift									
	50	60	70	80	90	100	110	120	135	180
8 inch Pump										
650 to 1000 GPM										
Total Investment ($)	4,475	4,975	5,275	5,475	5,975	6,475	6,675	6,775	6,975	7,475
Annual Fixed Cost * ($)	687	762	807	837	913	987	1,017	1,032	1,062	1,137
10 inch Pump										
1,000 to 1,500 GPM										
Total Investment ($)	5,775	5,975	6,275	6,575	6,875	7,175	7,275	7,475	7,975	
Annual Fixed Cost* ($)	890	920	965	1,010	1,055	1,100	1,115	1,145	1,220	

*Annual fixed cost represents 5 percent interest on one-half of the total investment, plus the annual depreciation ($12\frac{1}{2}$ percent of the total investment), plus taxes ($6.00 on 4 inch wells, $10.00 on 6 inch wells, $16.00 on 8 inch wells and $24.00 on 10 inch wells).

CHAPTER IV

WHAT DOES IT COST TO OPERATE AN IRRIGATION SYSTEM?

Operation costs include the (1) cost of fuel or energy, (2) the cost of oil for lubrication of the power plant and (3) cost of repairs for the power plant and the pump. No charge was made for an attendant as most of the farms studied were considered family farms with a fixed supply of labor and no additional labor was hired. In a few instances additional help was hired to assist with irrigation at the peak of the season but for the most part this was done with family labor.

Cost of Fuel or Energy

Liquid petroleum gas was used by 21 of the 25 plants, 3 used natural gas and one used electricity. No attempt was made to make comparative study of the different types of fuel or energy used but it was evident that natural gas was the most economical fuel to use if the irrigation plant was situated close enough to a natural gas line. The cost of liquid petroleum gas was about 8.5 cents per gallon with a half cent off per gallon in some instances if large quantities were used. Natural gas had a $15 minimum charge. The rate was 33 cents per thousand if 50 thousand or more cubit feet were used. Higher rates were charged if less than this were used. The electric plant reported a $10 per month stand-by charge with a 1.2 cents per Kwh rate.

There was no significant difference in the amount of liquid petroleum used by industrial motors and automotive type motors other conditions being equal.

Cost of Oil Per Year

These are estimates given by the operators and the usual pattern was to change oil every 100 hours, using 5 quarts to change and 1 to 2 quarts between changes. Oil was figured at 30 cents per quart.

Repair of Motors and Pumps

Most of the plants in Harmon County have been established only a short time. Only one of the plants studied was established in 1950 and the remainder dated from 1952, 1953, 1954 and 1955. Very little repair work has been necessary. For the purpose of this study an estimate was made of the cost of removing, overhauling and resetting both the pump and motors for a period of 10 years or 15,000 hours. These estimates were prepared by an experienced equipment dealer.

No information was found on the life expectancy and cost of upkeep on electric motors. However, it is generally accepted by dealers and engineers that electric motors will last approximately 20 years with little or no repairs necessary. At the end of this time a complete overhaul and rewind job could be expected or replace the old motor with a new one. The overhaul and rewind job would cost approximately three-fourths the price of a new motor.

The sum of the fuel cost, oil cost, and estimated cost of repairs gives the total annual operating costs. The operating cost per acre foot of water was found by dividing the annual operating costs by the number of acre feet of water pumped. This cost ranged from $1.45 to $6.42 or an average of $3.11 per acre foot.

It should be noted that this does not represent an actual cash outlay for operating this particular year because the expense of future repairs have been estimated and prorated.

The average lift for the 25 wells was 79 feet. The cost per acre foot per foot of lift was 3.9 cents, (Table IV). This was obtained by dividing average operating cost per foot of water ($3.11) by the average lift of the 25 wells or 79 feet. (Table IV).

A similar study in New Mexico with similar pump and power plants shows an operating cost of $2.71 per acre foot of water pumped. The average lift was 77 feet and operating cost per foot of lift was 3.5 cents.[1]

TABLE IV

COMPARATIVE COST OF OPERATING IRRIGATION SYSTEMS IN HARMON COUNTY, OKLAHOMA WITH OPERATING COSTS IN NEW MEXICO AND TEXAS

State	Average Operating Cost Per Acre Foot	Average Lift	Operating Cost Per Foot of Lift
New Mexico*	$2.71	77	$.0251
Texas**	6.69	332	.0201
Oklahoma	3.11	79	.0394

*Stephens, William P., Cost of Pumping Irrigation Water, Lea County, 1952 Bul. 383 Agricultural Experiment Station, New Mexico A. & M. College

**Hughes, William F., Pumping Costs, Selected Pumping Plants in Moore and Hansford Counties, Texas; Bureau of Agri. Economics USDA. Plants H8, H9A and H9B are used to illustrate the cost of operatings because they were using butane as fuel. Many of the plants in this study used natural gas for fuel with a rate varying from nothing to 17.5 cents per thousand.

Expense Other Than the Cost of Water When Irrigating

It is a mistaken idea that changing from dry farming to irrigation

[1]William P. Stephens, Cost of Pumping Irrigation Water, Lea County, 1952 (Agricultural Experiment Station, Bulletin 383, New Mexico A & M College) p. 11.

farming is merely adding water to dry farming methods. Eventually, with the adoption of irrigation the whole farm program is changed. The old cultural practices are changed and new practices will be adopted to make the most efficient use of the water. Many farmers commented that the only thing different in his pattern of operations was applying water. This may have been the practice the first year or two but it soon became evident that additional precaution in seedbed preparation was essential to secure increased output. Extra cultivations and chopping may or may not have been necessary depending upon the nature of the soil. Many farmers reported fewer cultivations and choppings because the rapid growth and development of the crop helped to shade out weeds.

There are some jobs and practices that are necessary with the introductions of irrigation. Ditches and canals are needed to convey the water to the field. Many of these are temporary and must be plowed-in and rebuilt annually. Some ditches, especially elevated, are semi-permanent and require annual maintenance as well as weed control.

The land was leveled to handle the water efficiently. If it is not naturally level it can be leveled to grade or leveled on the contour. Once level it must be kept level by annually floating or proper land preparation. In the case of alfalfa, borders are built. Row crops such as cotton and grain sorghums must have the middles opened to carry the water. This can be either a separate operation or done at the same time the crop is cultivated in the early stages of growth.

The most common method of planting wheat to be irrigated required an additional operation. The seedbed was either onewayed or moldboarded then bedded with a lister. Loosening the tension on the feet that ride the ridges, the wheat was drilled parallel with the beds. Seeded in this fashion, the wheat can be irrigated by running the water in the furrows.

A list of common practices is presented giving the custom rates for the various jobs (Appendix tables 1 and 2). The custom rates were applied to the various practices that were added as a result of irrigation to obtain the increase in expense due to irrigation.

Custom rates were used to evaluate this alternative. It is not necessary that custom rates be used. If a farmer has adequate equipment to do these additional jobs, and the fixed cost has already been recovered he may elect to charge only the necessary operating costs plus a charge for the additional man-hours of labor required. Where this is the situation, the operator has two alternatives: (1) use the machinery for these added practices, or (2) sell their services at custom rates paid in the local area.

If, however, the equipment owned for dry farming is used to capacity then with the advent of irrigation, the operator will need to hire these additional jobs done at custom rates or buy additional equipment.

It was realized that when these custom rates were used that operators performing these added practices with his own equipment is receiving returns enough to cover fixed and operating costs plus returns for his added labor.

No charge was made for the added labor required in the irrigation operation. The time required for this will depend on the capacity of the well. For example, it would require 2.26 hours to apply 5 acre inches of water from a well yielding 1000 gallons per minute (Table VII). For 5 irrigations during a season 11.3 hours of attendance per acre would be required (5 x 2.26).

The value of this labor will depend on the circumstances. For the purpose of this study it was assumed that these were family type farms with a fixed amount of labor, a part of which was unused during the summer months before irrigation was adopted.

Each operator will need to evaluate his own situation. This requirement for additional labor can be met by either employing family labor, or hiring additional labor. The family labor may be un-employed or it may be under-employed. The value of the added labor will depend on which of the situations that exists. Where there is under-employed labor without other alternatives an arbitary minimum value could be used. If irrigation provided a more attractive alternative use for labor already employed its value will be determined by the next best alternative. Where it is necessary to hire the additional labor, it will be valued at the going rate for farm labor in the community.

CHAPTER V

HOW MUCH DOES IRRIGATION INCREASE YIELDS?

Cotton

The 21 farms studied reported 1,370.62 acres of cotton grown under irrigation in 1954 (Table V). The average yield per acre was 731 pounds of lint. These 21 farms reported 1,336 acres of cotton in 1955 with an average yield of 603 pounds of lint per acre. The average for the two year period was 667 pounds of lint cotton per acre (Table VI).

Nine of the 21 farms reported a total of 621 acres in dry-farmed cotton in 1954 and 3 reported a total of 269 acres dry-farmed in 1955. The two year average (1954-55) yield on the dryland cotton acreage on the farms surveyed was 168 pounds of lint per acre (Table V). This yield was slightly higher than the 10 year county average of 153 pounds of lint per acre but less than the 1954-55 county average of 240 pounds of lint per acre. The 1954 county average was 190 pounds of lint per acre and the 1955 county average was 300 pounds of lint per acre. The higher yield in 1955 was influenced, primarily, by two factors; (1) the favorable growing season with approximately 11 inches of precipitation and (2) an estimated 10,600 acres of irrigated cotton in the county that averaged 608 pounds of lint per acre.

The 1955 Agricultural census reported 50,000 acres of cotton harvested in Harmon County in 1955 with a total production of 30,000 bales of cotton. The Oklahoma Planning and Resource Board estimated there were 10,600 acres of irrigated cotton in the county with a total production of 12,889 bales. The irrigated cotton acreage in the county was only 21 percent of the total acres harvested; but irrigated production was 43 percent of the total.

Because of the influence of these two factors on the two year (1954-55) county average yield of 240 pounds and because of the small difference in yield between the 10 year (1945-54) county average of 153 pounds of lint and the 2 year (1954-55) average yield of 168 pounds of lint on the farms studied the latter yield was used to determine the response that can be attributed directly or indirectly to irrigation. The response to irrigation on the farms studied was 499 pounds of lint per acre (667-168) or an increase of 297 percent (Table VI).

If the comparison were made with the county average for the two year period, irrigation increased output per acre 427 pounds (667-240) or 178 percent.

Wheat

The average dry farmed wheat yield for the two years, (1954-1955) on the 8 farms from 339 acres was 9 bushels per acre. The county average for the 10 year period (1945-54) was 11 bushels per acre and the county average for the two year period (1954-1955), was 8 bushels per acre (Table VI). The average yield from 195 acres of irrigated wheat on 7 farms reporting wheat in the study was 38 bushels per acre for the two year period (1954-55). The higher average of 11 bushels per acre was used as the normal yield to measure the increase in yield due to irrigation. Yield on farms studied was increased over the 10 year (1945-54) county average by 27 bushels (38-11) or an increase of 245 percent.

TABLE V

YIELDS OF MAJOR CROPS GROWN UNDER IRRIGATION AND WITHOUT IRRIGATION IN HARMON COUNTY, OKLAHOMA FOR YEARS 1954 AND 1955 AS SHOWN BY SURVEY DATA

Crop	No. Farms Reporting		Number of Acres		Total Production		Average Yield		Average Yield for Period
	1954	1955	1954	1955	1954	1955	1954	1955	1954-1955
					Irrigated				
Cotton[1]	21	21	1,371	1,336	1,001,990 lbs.	802,749 lbs.	73 lbs.	603 lbs.	667 lbs.
Wheat	4	7	90	195	3,453 bu.	7,517 bu.	38 bu.	38 bu.	38 bu.
Grain Sorghum	6	15	199	461	444,450 lbs.	1,120,502 lbs.	2,293 lbs.	2,427 lbs.	2,371 lbs.
Alfalfa									
Hay	5	6	257	297	951 T	924 T	3.7 T	3.11 T	3.38 T.
Seed	5	6	257	297	94,576 lbs.	77,814 lbs.	368 lbs.	262 lbs.	311 lbs.
					Non-Irrigated				
Cotton[1]	9	3	621	269	91,468 lbs.	58,178 lbs.	147 lbs.	216 lbs.	168 lbs.
Wheat	8	1	339	200	3,638 bu.	1,200 bu.	11 bu.	6 bu.	9 bu.
Grain Sorghum	7	7	285	268	173,144 lbs.	33,200 lbs.	608 lbs.	1,251 lbs.	919 lbs.
Alfalfa									
Hay	1	0	45	0	45 T	0	1 T	0	
Seed	1	0	45	0	7,155 lbs.	0	159 lbs.	0	

[1]Cotton is expressed in pounds of lint.

Grain Sorghums

Six farms surveyed reported irrigating grain sorghums in 1954 and 15 reported irrigating grain sorghums in 1955. The average irrigated yield for the two year period was 2,371 pounds of grain per acre (Table V). Of the 21 farms studied, seven farms reported growing grain sorghums without irrigation in 1954 and seven in 1955. The average two year dry land yield on these seven farms was 919 pounds of grain per acre. The average for this two year period was 952 pounds per acre. The county average for the ten year period (1945-54) was 762 pounds per acre. The survey data two-year average yield of 919 pounds was used to determine the increase in yield due to irrigation. The difference in yield of irrigated and non-irrigated grain sorghum was 1,452 pounds per acre (2,371-919) an increase of 158 percent (Table VI).

Alfalfa Hay

Six farms in the survey reported a total of 297 acres of alfalfa under irrigation. These produced an average of 3.38 tons of hay and 311 pounds of seed per acre for the two year period (1954-55) (Table V). Only one reported dry farmed alfalfa that produced 1 ton of hay and 159 pounds of seed per acre in 1954. No production was reported in 1955. The limited number of observations of dry farmed alfalfa in the survey was inadequate and the average yield for the agricultural census years was used to estimate increased yield due to irrigation. The county average reported by the U. S. Census of Agriculture for the years 1939, 1944, 1949, 1954 was 1.14 tons of hay and 118 pounds of seed per acre. The average yield of alfalfa hay under irrigation (3.38 tons) less the county average of 1.14 tons per acre gave an estimated 2.24 tons per acre increase, an increase of 196 percent (Table VI). The average yield of seed per acre under irrigation (311 pounds) less the county average (118 pounds) gave 193 pounds of seed attributed to irrigation, an increase of 164 percent (Table VI).

TABLE VI

INCREASED YIELDS OF MAJOR CROPS IN HARMON COUNTY, OKLAHOMA DUE TO IRRIGATION

Crop	County Average		Survey Data		Increased Yield	
	1945-54	1954-55	Irrigated 1954-55	Dry Farmed 1954-55	Amount	Percent*
Cotton lbs. lint	153	240	667	168**	499	297
Wheat bu.	11**	8	38	9	27	245
Grain Sorghum lbs. grain	762	952	2,371	919**	1,452	158
Alfalfa						
Hay T	1.14**[1]	0[2]	3.38	0[3]	2.24	196
Seed lbs.	118**	0[2]	311	0[3]	193	164

*Increased yield expressed as a percentage of dryland survey data yield, or ten year county average.
**Used as a basis to calculate percentage increase.

In the above analysis increased yields were attributed directly to irrigation. It is recognized that water alone was not responsible for all the increase in yield but with the water present and available it is possible to have greater control over many of the improved cultural practices, such as the use of commercial fertilizer and insecticides

[1] Average Census year yields reported by USDA census for the years 1939, 1945, 1949, and 1954.

[2] Census data incomplete.

[3] One of the 21 farms surveyed reported growing alfalfa without irrigation in 1954 and none in 1955.

which are considered as essential for maximum yields. It would appear that irrigation has reduced the elements of risk and uncertainty. Farmers were inclined to improve all cultural practices in their farming operations.

In Table VII it is assumed that 5 acre inches of water is required for optimum irrigation conditions. The number of acres that can be irrigated by wells of different capacities has been calculated. If it were necessary to apply 5 acre inches at 10 day intervals to maintain the desired soil moisture level for a crop and if the yield of the well were limited to 800 gallons per minute, only 81 acres could be irrigated (Table VII). More acres irrigated would increase the interval between irrigations if 14 day intervals maintain the desired soil moisture level[1] the acreage irrigated could be increased to 113 compared with 81 when 10 day intervals were used (Table VII).

TABLE VII

NUMBER OF ACRES THAT CAN BE IRRIGATED AT 10 AND 14 DAY INTERVALS AT DIFFERENT RATES OF PUMPING

Gallons Per Minute	Acre Inches Per Hour	No. Hours Required to Apply 5 Acre Inches*	No. Acres that can be Irrigated in 230 Hour Period	No. Acres that can be Irrigated in 322 Hour Period
400	.88384	5.66	41	57
600	1.3256	3.77	61	85
800	1.76768	2.83	81	113
1000	2.20961	2.26	101	142
1200	2.65153	1.89	122	170
1400	3.09345	1.62	142	198

*Assuming 60 percent efficiency this would be equivalent to a 3 inch rain.

[1]This was found to be a judgment factor of the operator. No objective measures were employed by the farmers, such as moisture meters and oven tests. The "squeezed ball" test was reported used by a few individuals.

An estimate of the amount of irrigation water required for the major crops grown on 3 general soil types in Harmon County was prepared by Garton and Criddle (Table VIII). According to this study, 22 inches of irrigation water would be required for cotton on medium loam soil during a normal season. This was figured on a 60% overall plant efficiency that allowed for loss of water due to run off, percolation, evaporation, and pumping plant performance (Table VIII).

TABLE VIII

COMPUTED NORMAL WATER REQUIREMENTS OF CROPS FOR HARMON COUNTY, OKLAHOMA*

Crop	Net Irrigation Requirements (Inches)	Total Irrigation Water Required on Various Soil Types (Inches)		
		Open Porous 35% Efficiency	Medium Loam 60% Efficiency	Heavy Clay 60% Efficiency
Alfalfa	22.0	73	37	37
Pasture	19.5	65	33	33
Cotton	13.1	44	22	22
Sorghum	11.2	37	19	19
Corn	13.0	43	22	22
Early Truck	2.3	8	4	4

*James E. Garton, Wayne D. Criddle, Estimates of Consumptive-Use and Irrigation Water Requirements of Crops in Oklahoma, Oklahoma Experiment Station, Technical Bulletin No. T-57, pp. 8-9.

Water Management

The irrigation farmer is faced with a number of very important problems concerning water management. How much water should be used? How often should he irrigate? How much fertilizer should be used? At what stage of plant development should he apply the first irrigation? These are some of the most pressing and perplexing problems. Experimental work is being done on these and other problems but the information available at the present is quite limited. A frequency summary of the number of irrigations on cotton, milo, alfalfa and wheat on the farms interviewed in Harmon County is indicative of the size of the problem (Tables IX, X XI and XII).

The number of irrigations and total amount of water applied to cotton varied among the farms studied (Table IX). Forty percent of the 20 farms irrigating cotton made one application of water before planting and three summer applications and applied a total of 22 acre inches of water per acre. The average yield for these 8 farms was 624 pounds of lint. This yield is 171 pounds greater than the yield on 4 of the farms that made one irrigation before planting and one less summer irrigations, applying a total of 23 acre inches of water.

TABLE IX

RESPONSE OF COTTON TO INPUTS OF WATER ON 20 FARMS IN HARMON COUNTY, 1955

Practices	Number of Irrigations				
	2	3	4	5	6
Farms Reporting	1	4	8	4	3
Farms Pre-Irrigating	0	4	8	3	3
Total Ac. In. of Water	13	23	22	36	47
Farms Using Fertilizer	0	2	3	1	2
Average Yield Lbs. Lint	519	453	624	643	814

This would seem to indicate that approximately the same amount of water applied in 4 applications instead of three resulted in an increase in yield of 171 pounds of lint. However, it can not be concluded that 4 applications of water would be, in all cases, more profitable than three. In each case the number of applications of water will have to be determined by the capacity of the well, the nature of the soil, the crop to be irrigated, and the acreage to be covered. It is expected that yields can be varied, other things being equal, by maintaining available soil moisture at various levels.

There is an indication that moisture is a very influential factor, and many times a limiting factor of production, but has its limitations if used as the only variable (Table IX). The principle of diminishing physical output, however, provides the framework for the assumption that; if all other factors of production are held constant and, only the amount of water and number of associated irrigations are increased the yield will increase but at a decreasing rate. Although this study was not designed to determine the marginal productivity of various increments, these data do indicate diminishing rates of productivity.

Four of the 20 farms included in the study made one application before planting and 4 summer applications, applying a total of 36 acre inches of water per acre. Increasing the number of irrigations from 4 to 5 and the total acre inches of water per acre from 22 to 36 increased yields only 19 pounds of lint per acre.

Three of the 20 farms made 6 applications of water, one of which was a pre-irrigation and used a total of 47 acre inches of water per acre. The average yield was 814 pounds of lint on these three farms. One of these farms reported an average yield of 1,188 pounds of lint per acre on 47 acres, with the use of fertilizer and insecticides. Another farm in this group reported an average yield of 923 pounds of lint on 52 acres when both fertilizer and insecticides were applied. The third farm in this group used neither fertilizer nor insecticide and averaged only 600 pounds on 109 acres. This indicates that the use of fertilizer and insecticides are complements to moisture.

The yields of grain sorghum under irrigation on the farms studied were very erratic. The correlation between yield and number of irrigations and amount of water used were inconsistent. This can be attributed to the fact that grain sorghum was considered a supplementary land use crop and was used to help reduce the over-head costs of irrigation. Very little attention, according to comments of operators, was given to moisture requirements for grain sorghums, and applications of water were made when the high cash crops were not being irrigated. A yield of 4,500 pounds of grain with three applications of water and no fertilizer illustrates the economic possibilities of the crop under irrigation (Table X). Compared with the survey data dry land yield of 919 pounds this would be a increase of about 3,600 pounds.

TABLE X

RESPONSE OF GRAIN SORGHUMS TO INPUTS OF WATER ON 10 FARMS IN HARMON COUNTY, 1955

Practices	Number of Irrigations					
	1	2	3	4	5	6
Farms Reporting	1	1	1	2	4	2
Farms Pre-Irrigating	1	1	0	2	3	2
Total Ac. in. Water	5	32	11	20	42	28
Farms Using Fertilizer	0	0	0	0	0	0
Average Yield Lbs.	2,500	2,400	4,500	1,682	2,703	3,298

Water requirements for alfalfa are relatively high and the crop was used as a supplementary cash crop with either cotton or a wheat enterprise. None of the farms irrigating alfalfa were producing the crop for hay alone but attempted to take a seed crop after two cuttings of hay. Alfalfa for hay alone was not considered profitable enough by the operators, to compete with cotton for water when it was limited in supply. A partial budget supports their judgments.

TABLE XI

RESPONSE OF ALFALFA TO INPUTS OF WATER ON 6 FARMS
IN HARMON COUNTY, 1955

Practices	Number of Irrigations			
	5	6	7	9
Farms Reporting	1	2	1	2
Total Ac. in. Water	47	47	53	43
Farms Using Fertilizer	0	0	1	2
Average Yields:				
Hay Tons	4	2.6	3	3
Seed Lbs.	168	140	200	328

The response of wheat to irrigation on 7 farms in Harmon County indicates the feasible supplementary use of water (Table XII). The 3 farms that irrigated 3 times had a 15 bushel increase in yield over the 3 farms that irrigated only 2 times. The one farm that irrigated 4 times showed an increase of 11 bushels over the farms that irrigated 3 times. If a dry land yield of 11 bushels is considered normal then two irrigations has increased the yield by 14 bushels per acre. A third irrigation boosted the yield by another 15 bushels and the fourth irrigation gave an increase of 11 bushels.

The use of water to irrigate wheat could be competitive with cotton in the early spring where pre-irrigation is practiced on the cotton land. The third application only may conflict hence, requiring a comparison of the value of the third wheat irrigation with the value of pre-irrigating cotton.

TABLE XII

RESPONSE OF WHEAT TO INPUTS OF WATER ON 7 FARMS
IN HARMON COUNTY, 1955

Practices	Number of Irrigations		
	2	3	4
Farms Reporting	3	3	1
Farms Pre-Irrigating	2	1	1
Total Ac. in. Water	11	14	20
Farms Using Fertilizer	0	1	1
Average Yield Bus.	25	40	51

CHAPTER VI

LONG AND SHORT-RUN DECISIONS

The decision to establish an irrigation system is the beginning of a long series of decisions relative to numerous resource combination possibilities, therefore, requires considered judgment. Even though an irrigation system has been established a farmer may choose not to irrigate in a given year. Affirmation then necessitates decisions relative to: what crops are most profitable under irrigation, how much fertilizer to use, and how much water to allocate to different crops. It was hoped that the cost and yield data presented would be helpful in making these decisions; however, the method of making the decision is perhaps of more importance than the data presented. The question to be resolved by each farmer is: Will net income from irrigation be increased enough over a period of years to justify the added investment? A sample budget is presented to illustrate an objective method of making a long run decision (Example A).

It was assumed that a farmer has 50 acres that can be irrigated by gravity flow irrigation. He has a 15 acre cotton allotment and can plant 15 acres of wheat. He wants to determine if it will be profitable for him to establish an irrigation system. Test drilling reveals that he can develop a well with a 90 foot lift yielding 650 to 1,000 GPM. A total investment of $5,975 will be required to develop a well of this capacity and lift (Table III). This investment spread over an 8 year period would require an annual overhead of $913.00.

For this to be a profitable venture, irrigation must increase annual net income by an amount equal to or greater than the fixed cost of $913.00 plus operating expenses incurred because of irrigation.

Cotton, wheat, and milo in this order gave the greatest returns as well as the greatest increase in net returns per acre in this area (Table VI). The budget method was used to calculate expected returns from irrigation (Figure 3). Returns above variable cost for each crop were calculated and the residual applied against the annual overhead. Irrigation cannot be profitable unless returns are greater than the combined fixed and variable cost during the productive life of the irrigation plant although returns during a particular productive season could be less than total cost. Farmers are aware that the variable or current operating cost each season must be met before any payment on fixed cost could be made. Costs of added cultural practices for cotton were estimated at $82.00 by charging custom rates (Appendix Tables 1 and 2). Cost of operating the irrigation plant was estimated to be $3.50 per acre foot of water applied. This was found by multiplying 3.9 cents times the amount of lift (3.9 cents x 90 feet = $3.50). Approximately 22 acre inches of water is required to maintain soil moisture at a desirable level.[1] This requires a total plant operation cost of $6.38 per acre per year (1.8 acre ft. x $3.50). The cost of water plus the cost of added practices gives a total variable cost per acre of $88.38 ($6.38 + $82.00 = $88.38). The increase yield of 499 pounds of lint

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[1]James E. Garton and Wayne Criddle, Estimates of Consumptive - Use and Irrigation Water Requirements of Crops in Oklahoma, (Oklahoma Agricultural Experiment Station, Technical Bulletin No. T-57 October 1955) pp. 6-9.

above a normal yield of 168 pounds (667 - 168) would be the product obtained by the added cost. At a price of 27.5 cents per pound (Appendix Table 3) the added income per acre above variable cost was $48.84 (499 lbs. x .275 = $137.22) ($137.22 - $88.38 = $48.84).

Acres of irrigated cotton, given the above performance and costs, needed to break-even, can be found by dividing the annual fixed cost by the net income above variable cost ($913.00 ÷ $48.84 = 19 acres) It would require 19 acres of cotton to make this a profitable venture, however, this farm was alloted only 15 acres. The total net income above variable costs was $732.60 (15 x $48.84 = $732.60) that can be applied on the annual fixed cost of $913.60. Therefore, it was necessary to recover the remainder of the annual fixed cost or overhead of $180.40 by irrigating other crops.

The same procedure was followed to determine the increase in net income that can be obtained by irrigating wheat. The expected normal yield per acre is 11 bushels and it was estimated that 38 bushels can be produced by applying 18 inches of water for an increase of 27 bushels per acre (Table VI). A price of $1.70 per bushel was anticipated (Appendix Table 3) for an added income of $45.90 per acre. The difference between added expenses and added income is estimated to be $24.30 ($45.90 - $21.60 = $24.30).

Acres of wheat required to pay the unrecovered fixed costs was found by dividing the unrecovered fixed costs by the added income per acre. This was 7 acres ($180.40 ÷ $24.30 = 7). It was concluded that only 15 acres of cotton and 7 acres of wheat under irrigation would be necessary to meet all variable and fixed cost. Any income obtained from subsequent acres of wheat or other crops irrigated after paying only the variable cost can be treated as profit.

The analysis further reveals a return of $184.10 from the 15 acres of wheat after deducting added cost and the unrecovered fixed cost. Hence the budget study indicates the profitableness of irrigation may be dependent upon the use of water by a supplementary enterprise.

The added income from irrigating 20 acres of milo was also determined in the same manner. All fixed costs had been recovered, thus, only variable cost should be considered in preparing the budget. The expected value of the increased yield less the estimated costs of production gave a net increase in income of $11.82 per acre ($37.02 - $25.20 = $11.82). A total net return of $236.40 was added to farm income from milo ($11.82 x 20 a. = $236.40).[2]

The budget summary reveals that the income above variable costs from the major cash crop, 15 acres of cotton, lacked $180.40 covering the annual fixed costs of the plant. The added income above variable costs from the 15 acres of wheat was enough to add $184.10 above the annual fixed cost. To this was added the income above variable cost from milo for a total annual return of $420.50 that results from irrigation. Also, to this could be added that proportion of the cost of added practices attributed to family labor if the family labor had no other opportunity to be employed. This wculd increase the labor-management wage of either the farm operator or the farm family.

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[2]It was estimated that 36 inches of water would be required to give this increased yield.

BUDGET FORMS FOR CALCULATING INCREASE OR
DECREASE IN INCOME DUE TO IRRIGATION

Farm Identification John Doe   Major Cash Crop Cotton

Expected increase in yield 499 # lint
(lbs., bu., or tons)

Acres that can be irrigated 15
(acres)

Costs of Added Practices Due to Irrigation

Operation	Times Over or Quantity	X	Rate	=	Cost
Stalk Shredding	1		1.00		1.00
Breaking	1		3.00		3.00
Floating	2		1.50		3.00
Harrowing	3		.75		2.25
Cultivation	2		1.50		3.00
Ditches	.2 hours		3.00		.60
Fertilizer	200-10-20-0		4.20		8.40
Hoeing	4.5 hours		1.00		4.50
Spraying & Materials	3		4.50		13.50
Pulling	1900		2.00		38.00
Weighing & Hauling	1900		.25		4.75

Total Cost per acre for additional practices . . . . .$ 82.00

Cost of water for irrigation of major crop plus the cost for added practices.

Annual fixed cost of irrigation $ 913.00

Operating cost per acre foot of water $ 3.50
(3.9 cents X feet of lift)

Acre feet of water to be used on major crop 22 inches

Operating cost per acre of major crop $ 6.38

Cost per acre for additional practices $ 82.00

Total added cost due to irrigation (variable costs) $ 88.38

Figure 3. Suggested Budget Form Filled Out for Example A.

Figure 3 (Continued)

Added Income per acre of Major Crop

Expected normal yield per acre without irrigation	168	
Expected yield per acre with irrigation	666	
Added yield due to irrigation	499	
Expected price per unit of crop	$.275	
Value of added yield per acre		$ 137.22
Added expenses due to irrigation (variable costs)		$ 88.38
Change in per acre income above variable costs		$ 48.84

Break-even acres:[3] $ 913.00 (annual fixed cost) ÷ $ 48.84 (change in per ac. income) = 19 (acres)

Total added income above variable costs:

$ 48.84 (change in per ac. income) x 15 (no. of acres) = $ 732.60 (Total added income)

Difference between annual fixed costs and added income:

$ 913.00 (annual fixed costs) - $ 732.60 (added income) = $ 180.40 (unrecovered fixed costs)[4]

$ ______ (added income) - $ ______ (annual fixed costs) = $ ______ (added profit from irrigation)[5]

---

[3]If the break-even acres are equal to or less than the acres available for growing this crop under irrigation then irrigation will be a profitable venture. If, however, the break-even acres are greater than the acres available for growing this crop under irrigation then it will be necessary to supplement the income by irrigating a competitive crop such as milo or alfalfa or a non-competitive crop (supplementary) such as wheat.

[4]This unrecovered balance must be recovered by irrigating another crop. Carry this balance forward to the budget for a competitive or supplementary crop.

[5]If the added income is equal to or greater than the annual fixed costs then no fixed costs will be charged to other crops that might be irrigated with this plant.

Figure 3 (Continued)

Supplementary crop wheat Expected increase in yield 28 (lbs., bu., or tons)

Acres that can be irrigated 15 (acres)

Cost of Added Practices Due to Irrigation

Operation	Times over or Quantity	X	Rate	=	Cost
Breaking	1		3.00		3.00
Floating	2		1.50		3.00
Harrowing	3		.75		2.25
List	1		1.75		1.75
Fertilizer	100(13-39-0)		5.00		5.00
Hauling	27 bu.		.05		1.35

Total cost per acre for additional practices. . . . . . $ 16.35

Cost of water for irrigation of supplementary crop plus the cost for added practices.

Operating cost per acre foot of water	$ 3.50	
Acre feet of water to be used on supplementary crop	1.5 ft.	
Operating cost per acre of supplementary crop		$ 5.25
Cost per acre for additional practices		$ 16.35
Total added cost due to irrigation (variable costs)		$ 21.60

Figure 3 (Continued)

Added Income per acre of supplementary crop

Expected normal yield per acre without irrigation	11	
Expected yield per acre with irrigation	38	
Added yield due to irrigation	27	
Expected price per unit of crop	$1.70	
Value of added yield per acre		$ 45.90
Added expenses due to irrigation (variable costs)		$ 21.60
Change in per acre income above variable costs		$ 24.30

Break-even acres: $ 180.40 (unrecovered fixed costs) ÷ $ 24.30 (change in per ac. income) = 7 (acres)

Total added income above variable costs:

$ 24.30 (change in per ac. income) X 15 (no. of acres) = $ 364.50 (total added income)

Difference between unrecovered annual fixed costs and added income:

$ ________ (unrecovered fixed costs) - $ ________ (added income) = $ ________ (unrecovered fixed costs)[6]

$ 364.50 (added income) - $ 80.40 (unrecovered fixed costs) $ 184.10 (added profit from irrigation)[7]

---

[6]Carry forward to budget for competitive crop.

[7]Carry forward to summary sheet.

Figure 3 (Continued)

Competitive crop Milo Expected increase in yield 1851
(lbs., bu., or tons)

Acres that can be irrigated 20
(acres)

Cost of Added Practices Due to Irrigation

Operation	Times over or Quantity	X	Rate	=	Cost
Stalk Shredding	1		1.00		1.00
Breaking	1		3.00		3.00
Floating	2		1.50		3.00
Harrowing	3		.75		2.25
Cultivation	2		1.50		3.00
Ditches	.20 hrs.		3.00		.60
Hauling	1851		.10		1.85

Total cost per acre for additional practices. . . . . . $ 14.70

Cost of water irrigation of competitive crop plus the cost for added practices.

Operating cost per acre foot of water $ 3.50

Acre feet of water to be used on competitive crop 3 ft.

Operating cost per acre of competitive crop $ 10.50

Cost per acre for additional practices $ 14.70

Total added cost due to irrigation (variable costs) $ 25.20

Figure 3 (Continued)

Added Income per acre of competitive crop

Expected normal yield per acre without irrigation	919 #	
Expected yield per acre with irrigation	2770 #	
Added yield due to irrigation	1851	
Expected price per unit of crop	$ 2.00 cwt.	
Value of added yield per acre		$ 37.02
Added expenses due to irrigation (variable costs)		$ 25.20
Change in per acre income above variable costs		$ 11.82

Break-even acres: $ 0 (unrecovered fixed costs) ÷ $ 11.82 (change in per ac. income) = 0 (acres)

Total added income above variable costs:

$ 11.82 (change in per acre income) X 20 (no. of acres) = $ 236.40 (total added income)

Difference between unrecovered annual fixed costs and added income:

$ 0 (unrecovered fixed costs) - $ 236.40 (added income) = $ 0 (unrecovered fixed costs)

$ 236.40 (added income) - $ 0 (unrecovered fixed costs) = $ 236.40 (added profit from irrigation)[8]

SUMMARY OF ADDED EXPENSES AND ADDED INCOME

Added profit from irrigation of major crop (s)	$ 0
Added profit from irrigation of supplementary crop (s)	$ 184.10
Added profit from irrigation of competitive crop (s)	$ 236.40
Total added profit from irrigation	$ 420.50

[8]Carry forward to summary sheet.

A limited amount of land and an unlimited amount of water was assumed in the budget model. However, inputs of the various resources used in the budget were at the modal level established from survey data. This was comparable to estimates of consumption use and irrigation water requirements. It was reasonable to assume that yield could have been increased above the level obtained by applying more water. The question is: would the value of the added yield exceed the added cost associated with applying more water? Answering this question was beyond the scope of this study. This would have required a thorough knowledge of the physical relationships between the various levels of available soil moisture and yields on different types of soils. When these physical relationships are determined it will be possible to estimate, within a narrow range, the amount of water to apply to secure maximum profits. The rule will be to keep adding water as long as the added return is greater than the value of added increments of input.

However, if two crops are competing for water such as cotton and milo, additional water should be applied to the crop that will give the greatest return for the use of the scarce resource. Since water was not limited in the above model but land was scarce, it would be profitable to make additional applications to each crop as long as added output was greater in value than the added cost incurred.

The most common short-run decision confronting farmers in this area was the reverse of the above situation. They had an unlimited amount of land and a scarce supply of water. Maximizing returns in this situation requires equi-marginal returns from each enterprise in the use of water. From a well yielding 400 gallons per minute successive applications of 5 acre inches at 10 day intervals can be made on a total of 41 acres of cotton. The irrigation interval can be changed to 14 days and 57 acres irrigated at the rate of 5 inches per irrigation. Other alternative uses of the scarce resource may exist. The operator could elect to apply only 2.5 acre inches at 10 day intervals on 82 acres or apply 2.5 acre inches on 104 acres at 14 day intervals. These alternative uses would require additional outlay for conveyances and would likely decrease the water efficiency compared with the smaller acreage where applications were more intense.

The manager can make the decision objectively provided he can determine the maximum average production per unit of water applied. The semi-arid climate with the seasonal deviations in precipitation makes the problem even more complex. This can only be solved through years of experiment.

Tables XIII and XIV were prepared to assist in estimating the number of acres of cotton or wheat required to break even - - that is, to pay for the added variable and fixed costs - - when the average increase in yields is obtained.

The following assumptions are made and an individual may wish to adjust these estimates to more nearly fit his particular situation.

Costs are based on 8 and 10 inch pumps with the bowls set approximately 5 feet below the operating water level. The pumping range used for 8 inch pumps was 650 to 1,000 gallons per minute and the range for 10 inch pumps was 850 to 1,800 gallons per minute. For this estimate a total of 22 acre inches of water per acre was used for cotton and 18 acre inches per acre for wheat. Cost of pumping water increases as the amount of lift increases, other operating costs remain unchanged. Yield of cotton is estimated to increase by 499 pounds of lint per acre and wheat by 27 bushels per acre. An estimated price of 27.5 cents per pound was used for cotton and $1.70 per bushel for wheat.

Net returns for each acre in excess of the break even acres is the difference in total operating costs and the added income per acre. The number of acres that can be irrigated is limited by the capacity of the well and the interval between irrigations.

The blank budget form in Figure 4 can be used to make an estimate of an actual or an assumed situation. The results should provide the basis for deciding objectively, whether or not to invest in irrigation farming.

TABLE XIII

ESTIMATED COSTS OF IRRIGATING COTTON WITH 8 AND 10 INCH PUMPS FROM VARIOUS DEPTHS AND RETURNS BASED ON AVERAGE YIELDS PER ACRE, HARMON COUNTY, 1954-55

8 inch pump

Feet of lift	(ft)	50	60	70	80	90	100	110	120	135	180
Annual overhead	($)	687.	762.	806.	837.	913.	987	1017.	1032.	1062.	1137.
Cost of pumping 1 acre foot of water	($)	1.95	2.35	2.75	3.10	3.50	3.90	4.30	4.70	5.25	7.00
Cost of pumping 22 acre inches of water	($)	3.90	4.30	5.00	5.70	6.40	7.15	7.90	8.60	9.60	12.85
Cost per acre for added practices	($)	82.00	82.00	82.00	82.00	82.00	82.00	82.00	82.00	82.00	82.00
Total operating costs	($)	85.90	86.30	87.00	87.70	88.40	89.15	89.90	90.60	91.60	94.85
Added income per acre	($)	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00
Added income above operating costs	($)	51.10	50.70	50.00	49.30	48.60	47.85	47.10	46.40	45.40	42.15
Acres required to cover overhead and operating costs	(ac)	13	15	16	17	19	21	22	22+	23	27

TABLE XIII (Continued)

		10 inch pump								
Feet of lift	(ft)	50	60	70	80	90	100	110	120	135
Annual overhead	($)	890	920	965	1010	1055	1100	1115	1145	1220
Cost of pumping 1 acre foot of water	($)	1.95	2.35	2.75	3.10	3.50	3.90	4.30	4.70	5.25
Cost of pumping 22 acre inches of water	($)	3.90	4.30	5.00	5.70	6.40	7.15	7.90	8.00	9.60
Cost per acre for added practices	($)	82.00	82.00	82.00	82.00	82.00	82.00	82.00	82.00	82.00
Total operating costs	($)	85.90	86.30	87.00	87.70	88.40	89.15	89.90	90.60	91.60
Added income per acre	($)	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00
Added income above operating costs	($)	51.10	50.70	50.00	49.30	48.60	47.85	47.10	46.40	45.40
Acres required to cover overhead and operating costs	(ac)	15	18	19	20	21	23	24	25	27

TABLE XIV

ESTIMATED COSTS OF IRRIGATING WHEAT WITH 8 AND 10 INCH PUMPS FROM VARIOUS DEPTHS AND RETURNS BASED ON AVERAGE YIELDS PER ACRE, HARMON COUNTY, 1954-55

					8 inch pump					
Feet of lift	(ft)	50	60	70	80	90	100	110	120	135
Annual overhead	($)	687	762	806	837	193	987	1017	1032	1062
Cost of pumping 1 acre foot of water	($)	1.95	2.35	2.75	3.10	3.50	3.90	4.30	4.70	5.25
Cost of pumping 18 acre inches of water	($)	2.90	3.50	4.10	4.70	5.25	5.85	6.45	7.00	7.90
Cost per acre for added practices	($)	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40
Total operating costs	($)	19.30	19.90	20.50	21.10	21.65	22.25	22.85	23.40	24.30
Added income per acre	($)	47.60	47.60	47.60	47.60	47.60	47.60	47.60	47.60	47.60
Added income above operating costs	($)	28.30	27.70	27.10	26.50	25.95	25.35	24.75	24.20	23.30
Acres required to cover overhead and operating costs	(ac)	24	28	30	32	35	39	41	43	46

TABLE XIV (Continued)

		10 inch pump								
Feet of lift	(ft)	50	60	70	80	90	100	110	120	135
Annual overhead	($)	890	920	965	1010	1055	1100	1115	1145	1220
Cost of pumping 1 acre foot of water	($)	1.95	2.35	2.75	3.10	3.50	3.90	4.30	4.70	5.25
Cost of pumping 18 acre inches of water	($)	2.90	3.50	4.10	4.65	5.25	5.85	6.45	7.05	7.85
Cost per acre for added practices	($)	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40
Total operating costs	($)	19.30	19.90	20.50	21.15	21.65	22.25	22.85	23.45	24.25
Acres required to cover overhead and operating costs	(ac)	46	46	47	48	49	49	49	49	50

BUDGET FORMS FOR CALCULATING INCREASE OR DECREASE IN INCOME DUE TO IRRIGATION

Farm Identification__________ Major Cash Crop__________

Expected increase in yield__________________
(lbs., bu., or tons)

Acres that can be irrigated__________________
(acres)

Costs of Added Practices Due to Irrigation

Operation	Times Over or Quantity	X	Rate	=	Cost
____________	________		________		________
____________	________		________		________
____________	________		________		________
____________	________		________		________
____________	________		________		________
____________	________		________		________
____________	________		________		________
____________	________		________		________
____________	________		________		________

Total cost per acre for additional practices . . . . . .$__________

Cost of water for irrigation of major crop plus the cost for added practices.

Annual fixed cost of irrigation $__________

Operating cost per acre foot of water (3.9 cents X feet of lift) $__________

Acre feet of water to be used on major crop __________

Operating cost per acre of major crop $__________

Cost per acre for additional practices $__________

Total added cost due to irrigation (variable costs) $__________

Figure 4. Suggested Budget Form, for your own Example.

Figure 4 (Continued)

Added Income per acre of Major Crop

Expected normal yield per acre without irrigation ________

Expected yield per acre with irrigation ________

Added yield due to irrigation ________

Expected price per unit of crop $________

Value of added yield per acre $________

Added expenses due to irrigation (variable costs) $________

Change in per acre income above variable costs $________

Break-even acres:[9] $________ (annual fixed cost) ÷ $________ (change in per ac. income) = ________ (acres)

Total added income above variable costs:

$________ (change in per ac. income) x ________ (no. of acres) = $________ (total added income)

Difference between annual fixed costs and added income:

$________ (annual fixed costs) - $________ (added income) = $________ (unrecovered fixed costs)[10]

$________ (added income) - $________ (annual fixed costs) = $________ (added profit from irrigation)[11]

---

[9]If the break-even acres are equal to or less than the acres available for growing this crop under irrigation then irrigation will be a profitable venture. If, however, the break-even acres are greater than the acres available for growing this crop under irrigation then it will be necessary to supplement the income by irrigation of a competitive crop such as milo or alfalfa or a non-competitive crop (supplementary) such as wheat.

[10]This unrecovered balance must be recovered by irrigation of another crop. Carry this balance forward to the budget for a competitive or supplementary crop.

[11]If the added income is equal to or greater than the annual fixed costs then no fixed costs will be charged to other crops that might be irrigated with this plant.

Figure 4 (Continued)

Supplementary crop________Expected increase in yield______________
(lbs., bu., or tons)

Acres that can be irrigated__________
(acres)

Cost of Added Practices Due to Irrigation

Operation	Times Over or Quantity	X	Rate	=	Cost
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________

Total cost per acre for additional practices . . . . . .$________

Cost of water for irrigation of supplementary crop plus the cost for added practices.

Operating cost per acre foot of water $________

Acre feet of water to be used on supplementary crop ________

Operating cost per acre of supplementary crop $________

Cost per acre for additional practices $________

Total added cost due to irrigation (variable costs) $________

Figure 4 (Continued)

Added Income per acre of supplementary crop

Expected normal yield per acre without irrigation ________

Expected yield per acre with irrigation ________

Added yield due to irrigation ________

Expected price per unit of crop ________

Value of added yield per acre $________

Added expenses due to irrigation (variable costs) $________

Change in per acre income above variable costs $________

Break-even acres: $________ (unrecovered fixed costs) ÷ $________ (change in per ac. income ________ (acres)

Total added income above variable costs:

$________ (change in per ac. income) x ________ (no. of acres) = $________ (total added income)

Difference between unrecovered annual fixed costs and added income:

$________ (unrecovered fixed costs) - $________ (added income) = $________ (unrecovered fixed costs)[12]

$________ (added income) - $________ (unrecovered fixed costs) = $________ (added profit from irrigation)[13]

---

[12]Carry forward to budget for competitive crop.

[13]Carry forward to summary sheet.

Figure 4 (Continued)

Competitive crop_________Expected increase in yield____________________
(lbs., bu., or tons)

Acres that can be irrigated___________
(acres)

Cost of Added Practices Due to Irrigation

Operation	Times Over or Quantity	X	Rate	=	Cost
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________
__________	________		________		________

Total cost per acre for additional practices . . . . . .$________

Cost of water irrigation of competitive crop plus the cost for added practices.

Operating cost per acre foot of water $________

Acre feet of water to be used on competitive crop ________

Operating cost per acre of competitive crop $________

Cost per acre for additional practices $________

Total added cost due to irrigation (variable costs) $________

Figure 4 (Continued)

Added Income per acre of competitive crop

Expected normal yield per acre without irrigation ________

Expected yield per acre with irrigation ________

Added yield due to irrigation ________

Expected price per unit of crop $________

Value of added yield per acre $________

Added expenses due to irrigation (variable costs) $________

Change in per acre income above variable costs $________

Break-even acres: ________ (unrecovered fixed costs) ÷ ________ (change in per ac. income) ________ (acres)

Total added income above variable costs:

$________ (change in per acre income) X ________ (no. of acres) = $________ (total added income)

Difference between unrecovered annual fixed costs and added income:

$________ (unrecovered fixed costs) - $________ (added income) = $________ (unrecovered fixed costs)

$________ (added income) - $________ (unrecovered fixed costs) = $________ (added profit from irrigation)[14]

SUMMARY OF ADDED EXPENSES AND ADDED INCOME

Added profit from irrigation of major crop (s) $________

Added profit from irrigation of supplementary crop (s) $________

Added profit from irrigation of competitive crop (s) $________

Total added profit from irrigation $________

---

[14]Carry forward to summary sheet.

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APPENDIX TABLE 1

Custom Rates Used to Determine the Costs of Added Practices in Irrigation*

Operation	Unit	Usual	Range
Mold Board Plow	acre	3.00	2.50-3.50
List	acre	1.75	1.25-2.50
Oneway	acre	1.25	1.25-2.00
Spike Tooth Harrow	acre	.75	.50-1.00
Spring Tooth Harrow	acre	1.00	.75-1.25
Tandem Disc	acre	1.50	1.25-1.50
Hoeme	acre	1.50	1.50-2.50
Row Cultivator	acre	1.50	.75-1.50
Combining	acre		
Wheat and Oats	acre	3.00	2.50-3.25
Grain Sorghum	acre	3.00	2.50-3.25
Alfalfa	acre	5.00	3.00-6.00
Hay	acre		
Mow	acre	1.00	1.00-1.25
Rake	acre	1.75	.50-1.00
Bale	bale	.15	.15- .18
Load, Haul, Store	bale	.06	.06- .09
Complete Job	bale	.36	.36- .40

*Custom Rates for Farm Operation in Oklahoma, Tucker, E. A.; Walker, Odell L.; and Jeffrey, D. B., Experiment Station Bul. No. B-473, July, 1956, Oklahoma A. & M. College.

APPENDIX TABLE 2

Charges Made for Practices that were Added Because of Irrigation*

Operation	Unit	Rate
Hoeing	acre	$4.50
Snapping Cotton	cwt.	2.00
Plane Spraying or Dusting (Includes Material)	acre	4.50
Weighing and Hauling Cotton	cwt.	.25
Stalk Shredding	acre	1.00
Floating	acre	1.50
Alfalfa Ridges	acre	2.25
Ditches	per acre irrigated	.60

*These are operations not given in Custom Rates for Farm Operations in Oklahoma.

APPENDIX TABLE 3

Seasonal Average of Prices Received by Oklahoma Farmers and Projected Long-term Prices*

Commodity	1951-55 Average*	Projected long-term**
	Dollars	Dollars
Wheat	2.12	1.70
Oats	.87	.75
Barley	1.21	1.04
Grain Sorghum	1.30	1.12
Alfalfa Hay	30.55	26.27
Alfalfa Seed	18.76	16.13
Cotton Lint	.32	.275
Soybeans	2.55	2.19
Peanuts	.106	.09
Sweet Potatoes	3.01	2.59

*Current Farm Economics; Vol. 29, No. 4, August, 1956, Vol. 27, No. 2, April, 1954, and Vol. 25, No. 6, December, 1952.

**Projected long-term prices were estimated by adjusting the 1951-55 average by 86 percent of parity. Wheat prices were estimated by adjusting the 1951-55 average price by 80 percent of parity.

APPENDIX TABLE 4

Precipitation by Months for Period 1940-55 as Reported by Hollis Weather Station

Month	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
Jan.	.30	.64	.05	.04	1.57	1.30	1.86	.62	.53	4.14	.36	.19	.93	T	.07	.60
Feb.	2.00	2.09	.42	.27	1.07	1.83	1.04	.06	2.38	.44	1.73	.90	.37	.45	T	.69
Mar.	T	.76	1.52	.63	.85	1.31	1.81	.65	.99	1.55	T	.78	.44	.97	.11	.71
Apr.	3.35	4.59	8.86	.60	1.48	1.76	2.18	4.07	.13	2.07	1.30	1.33	6.20	1.64	2.03	.18
May	5.28	12.70	3.00	6.01	2.64	.27	1.51	10.75	4.47	11.85	1.77	6.32	1.84	1.23	6.34	7.23
June	1.30	9.65	2.64	1.09	5.62	3.33	1.27	3.44	1.02	3.42	5.17	1.68	.40	.32	.92	6.08
July	1.33	1.13	.32	.39	2.41	2.39	1.17	.64	3.43	.75	8.14	2.32	3.69	3.69	.86	2.58
Aug.	1.73	2.62	1.16	T	2.85	.32	2.65	3.87	.50	1.24	3.52	.34	T	1.64	2.11	.51
Sept.	3.42	3.16	4.93	1.57	2.75	3.32	2.63	0	.06	4.76	3.81	2.19	.52	.03	T	1.74
Oct.	1.64	6.45	4.53	.44	1.09	1.14	2.73	.45	.29	2.20	T	.71	T	6.05	1.87	4.86
Nov.	2.97	.34	.47	.65	1.12	0	1.31	1.66	.32	0	.03	.38	1.08	1.17	T	0
Dec.	.21	1.02	2.07	1.78	1.93	.25	.50	1.01	.03	1.43	T	T	1.20	T	.66	0
Annual Total	23.53	45.15	29.97	13.47	25.38	17.22	20.66	27.22	14.15	33.85	25.83	17.14	16.67	17.19	14.97	25.18
Total for June, July, Aug., Sept.	7.78	16.56	9.05	12.10	13.63	9.37	7.72	7.95	5.01	10.17	20.64	6.53	4.61	5.68	3.89	10.91

Climatic summary of the United States - supplement for 1931 through 1952 and subsequent publications, U. S. Department of Commerce, Weather Bureau.

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