Economics of

Ground Water Development

on Farms in Southwest Oklahoma

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Introduction

The purpose of the study reported in this bulletin was to provide a basis for determining net returns that can be expected from an investment in irrigation under conditions existing in Harmon County, Oklahoma. To make this evaluation, information was needed on (1) cost of developing an irrigation system, (2) cost of operating an irrigation system, (3) costs of added cultural practices due to irrigation. (4) increased yields that result from irrigation, and (5) value of the commodies produced.

Twenty-one farms in Harmon County, suggested by businessmen and agricultural workers of the area, were chosen as typical situations. This 21-farm 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 claims filed for water rights with the Oklahoma Planning and Resources Board. Twenty-five wells were located on this 21-farm sample.

Data relating to installation and operating costs of wells on the 21-farm sample in Harmon County were obtained for 1955 and 1956 by interviews with operators. Experiences of these 21 farmers were analyzed to provide a basis 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 operators. Data relative to cost of fuel oil and energy were obtained from farm records and reflect actual cash outlays for these purposes.

Estimated increases in yields were computed from yields obtained under irrigation by the 21 farmers compared with yields obtained without irrigation.

Economic studies of irrigation in the sub-humid regions were first conducted by Hughes and Motheral in Texas in 1949.[1] The objectives of this study were to determine the trends in types of water used for irrigation (surface or ground water) and the acreage, yield and farm value of various irrigated crops. This study was supplemented later by

[1]Hughes, William F., Motheral, Joe "Irrigated Agriculture in Texas." Miscellaneous Publication No. 59, Texas Agricultural Experiment Station, College Station. Texas, 1950.

a study in which factors influencing costs were analyzed.[2] Cost of pumping irrigation water, Lea County, New Mexico, 1952 was studied by Stephens to determine costs associated with various well depths, volume of water pumped, lift, type of power and fuel used.[3] These studies did not attempt to relate costs and returns from irrigation in the sub-humid and semi-arid regions.

Description of Situation

Location

Harmon County is in the extreme southwest corner of Oklahoma, bordered on the west and south by Texas. The irrigated area of the county is located 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. This area is drained by Lebos Creek and its tributaries. A large section of the area ranges from level to gently undulating slopes and much of the irrigation is practiced on these soils.

Climate

Climate of the district is classified as sub-humid. According to Weather Bureau records, the average annual precipitation is 24.42 inches, with a range of 13.47 to 45.15 inches. The annual average for the critical growing months of June, July, August and September for the years 1949-1955 was 9 inches, ranging from 5.01 inches to 20.64 inches.

The last killing frost in the spring is usually around March 10 and the first in the fall around October 10, for a frost-free growing season of some 225 days.

Soil Classification

The soils in Harmon County have been classified by the Soil Conservation Service into eight land-use groups for the purpose of applying farm practices and land-conservation measures.

Soil Group I consisted of deep. moderately permeable, sandy or loamy soils located on the uplands or on terraces along the streams. This group contained much of the best farming land in the area. Productivity was moderate to high and the soils were well suited for growing row crops, small grains, and alfalfa. Group I soils absorbed water readily and held moisture for a relatively long time. Slopes were for the most part less than 1½ percent. The soil technician considered these soils ideal for irrigation when water was available.

Group II soils were fine textured and did not absorb water as readily nor give up water to the plants as readily as Group I soils. These soils

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[2]Hughes, William F., "Pumping Costs, Selected Pumping Plants in Morre and Hansford Counties, Texas," Report of the Texas Board of Water Engineers, Austin, Texas. March, 1950.

[3]Stephens, William P. "Cost of Pumping Irrigation Water. Lea County, 1952" New Mexico Experiment Station Bulletin 383, 1952.

were productive but required more care in applying irrigation water.

Group III contained shallow permeable to coarse soils that absorbed water readily but had a sub-soil that would catch and hold the moisture in the plant-root zone of the plants. These soils were not as fertile as Groups 1 and II but responded well to irrigation. Because of the water absorbing and holding qualities of these soils, they produced 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 were considered to be more productive.

Group IV included shallow, fine-textured, sandy or clay loam soils with rather low productivity.

Group V was composed of mixed soils ranging from fine to medium fine texture. These were productive soils which responded well to irrigation because of their water-holding capacity.

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

Crops

According to the 1954 census, the principal crops grown in the county were cotton, wheat, grain sorghums, barley, and alfalfa for hay and seed. Table 1 shows acreage devoted to principal crops in Harmon County in earlier years.

Cotton yields varied considerably from year to year, depending largely upon the amount of rainfall. Yields also varied within the district according to type of soil. Acreage has decreased greatly since 1950 as a result of the agricultural program and drought.

Wheat culture was easily adapted to the nearly level, fine-textured and fertile soils in the district. Following mechanization in the latter

Table 1.—Acreage devoted to the principal crops in Harmon County, Oklahoma, in stated years

Crop	1909	1919	1929	1939	1949	1954
Cropland, total harvested acres*			197,399	136,081	151,046	163,140
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

*Census does not give Cropland, total harvested acres for years 1909 and 1919.

1920's and an increase in size of units, wheat has increased in importance.

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 were moderate.

Cost of Developing an Irrigation System

To calculate the net income from irrigation, it was necessary to determine the resource costs per unit of input. To determine the cost per acre foot of water, it was necessary to consider the capital outlay involved in establishing an irrigation system and the cost of operating the plant. These cost data were obtained from 21 farmers in Harmon County by personal interviews. These 21 farmers had a total of 25 wells.

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.

Total annual operating costs include cost of fuel, cost of oil, repair of motor and repair of pump. No charge was made for attendants. The "operating cost per acre foot" of water was determined by dividing the total annual operating costs by the estimated number of acre feet of water pumped.

Development costs were classified into two divisions, primary and adjunct costs. Primary costs included all capital outlay involved in locating the water supply, drilling and developing the well, and installing the pump and power plant. Adjunct costs included cost of leveling the land to grade for flood irrigation, cost of conveyance structures, and sprinkler systems if used.

Primary Development Cost

Test Drilling: To locate the supply of water and determine the amount of water available, four-inch test holes were usually drilled. The most desirable location, in terms of land utilization and water distribution, was tested. If unsuccessful, a move was made to less desirable locations in the field. Costs of drilling these test wells varied but were usually from 60 cents to $1 per foot. Cost of the test hole selected for development was applied against the cost of the well.

Well Drilling: The test hole selected as showing the greatest possibilities was 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 meant casing the well the entire depth in an

*This corresponds to the rate of depreciation used by local certified public accountant for income tax purposes.

unconsolidated aquifier. Many drillers improvised by slitting the lower section of steel well casing with an acetylene torch. In most instances this was a part of the contractual services provided by drillers.

The casing and screen installed were usually 12 to 16 inches in diameter, depending on the capacity of the aquifer, size of pump and diameter of bowls installed. After the casing and screen were centered in the hole, washed pea gravel was packed around the casing.

After the casing was set properly, wells were tested to determine well capacity and size of pump to be installed. The driller usually had a test pump to use in making the test. An additional charge, which was seldom less than $50, was made for this service.

Pumps: Deep-well, turbine pumps were used exclusively in the wells studied. The average total cost of pump and gearhead was about $25 per foot of setting for these wells.

Power Plant: The type of power plant used depended somewhat on the type of energy available. Three general classifications of motors were used by the Harmon County farmers: electric, automotive, and industrial. Electric motors had a cheaper first cost and were 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 industrial motors. Cost of overhauling was about the same, but the automotive type motor did not run as long between overhaul jobs.

Of the 25 plants studied, 11 were using automotive motors; 13, industrial motors; and 1, electric motor. The 13 plants powered by industrial type motors had costs which ranged from $850 to $1400 for an average cost per plant of $1,001.23. The 11 plants powered by automotive motors had an average cost of $694.09, ranging 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 and 32 cents per hour for those on propane. Operating cost records on the electric motor were considered inadequate to make an estimate.

Additional Equipment: An average of $691.74 per farm was spent on additional equipment. Such items as shovels, siphons, canvas dams and ditchers were bought the first year, indicating they were essential. It was evident that investment in additional equipment increased over time. One-way plows were traded for two-way plows, and conventional stalkcutters were traded for rotary, power-driven, stalk shredders. Investment in equipment adapted to irrigation farming naurally 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 Development Costs

Adjunct costs depend more or less upon individual situations. Such costs include land leveling and conveyance structure.

Land leveling cost is considered in this study as the expense involved in moving dirt by the yard with heavy equipment. Only about 50 per cent of the farmers interviewed indicated expenditures for land leveling. These expenditures ranged from $100 to $4,000 for an average of $1,410.-27 per farm reporting land leveling as an expense.

Conveyance structures included flumes across ditches and creeks, elevated ditches, plastic pipe, steel and concrete underground pipe, aluminum gated pipe, and clay lined ditches. If it were 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. When water had to be moved a long distance over sandy soil, structures were necessary which would lessen loss by evaporation and percolation.

A total of $12,364 was spent for conveyance structures by 11 of the 21 farmers, or an average of $1,124 per farm purchasing conveyances. Others indicated they were considering some type of prefabricated ditch, either to conserve and make better use of water or to minimize labor involved in conveying water from the well to the field.

Total Investment

A total of $151,810.56 was invested by 21 farmers in 25 wells to get established in irrigation farming. Investments ranged from $2.973.50 to $12,976.55 with an average investment per installation of $6,072.42.

To study more closely the investments made, wells were grouped according to depth, as this factor had more influence on development cost than any other item. 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. 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 2 shows average cost of developing irrigation systems by depth of wells and acres irrigated in Harmon County.

Fixed Costs

Fixed costs consisted of annual investment charges (depreciation).

Table 2.—Average cost of developing irrigation systems by depth of wells and acres irrigated in Harmon County, Oklahoma

Depth of Well feet	No. of Wells	Av. No. of Acres Irrigated per Well	Primary Development Cost: Per Well	Primary Development Cost: Per acre Irrigated In 1955	Adjunct Cost Per Well	Total Cost Per Well	Av. Investment per acre 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,[illegible].16	49.[illegible]8	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			$4,361.53	$44.62	$1,663.27	$6,924.81	$61.63

interest on investment, and taxes.

Annual Investment Charges. For purposes of this study, an annual investment charge was calculated at 12½ percent 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, but this corresponded to the rate used for income tax purposes by the local certified public accountant.

Interest. Interest on investment was calculated at 5 percent on one-half the total initial investment.

Taxes. Irrigation wells were assessed in Harmon County according to the size of the pump. A 10-inch pump added $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 added $600, a 6-inch pump added $400, and a 4-inch pump added $200 to the value of personal property. The amount of taxes on each irrigation installation reflected the tax levy for the school district in which the well was located.

Although fixed costs must be recovered in the long-run, they were not considered in deciding whether to apply water in a season. Only the operating or variable costs were 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 were considered supplementary crops and carried only variable costs. 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.

Estimated fixed costs of developing irrigation plants of different capacities and to different depths in Harmon County, Oklahoma are shown in Table 3.

Cost of Operating an Irrigation System

Operating costs include the cost of fuel or energy, cost of oil for lubrication of the power plant, and cost of repairs for the power plant and pump. In this study no charge was made for attendants as most farms were considered family operations with a fixed supply of labor and no additional labor was hired. (For labor requirements see Table 12).

Fuel Cost

Liquid petroleum gas was used by 21 of the 25 plants, natural gas by three, and electricity by one. A comparative study of different types of fuel was not made, but it was evident that natural gas was the most economical fuel to use if the irrigation plant were located near a natural gas line. 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 cubic feet or more were used. Higher rates

Table 3.—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 (12½ 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.)

were charged if less than this was used. The electric rate was 1.2 cents per kilowatt hour plus a $10 per month stand-by charge.

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

Oil Cost

Oil was figured at 30 cents per quart. Estimates given by operators indicated the pattern was to change oil every 100 hours using 5 quarts to change and one to two quarts between changes.

Cost of Repairs

Most of the plants in Harmon County have been established only a short time. One of the plants studied was established in 1950 and the remainder were begun in 1952, 1953, 1954 and 1955. Therefore, little repair work has been necessary.

For purposes of this study, an estimate was made of the cost of removing, overhauling and resetting both the pump and motors after a period of ten years or 15,000 hours. These estimates were prepared by an experienced equipment dealer.

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

Other Operating Costs

Operating cost per acre foot of water was found by dividing the annual operating cost (cost of fuel plus cost of oil plus estimated cost of repairs) 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. This did not represent an actual cash outlay for operating for the particular year because the expense of future repairs was 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. This was obtained by dividing the average operating cost per acre foot of water ($3.11) by the average lift of the 25 wells or 79 feet.

There are some jobs and practices necessary with the introduction 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.

Many farmers commented that the only primary difference in their patterns of operations was application of water. This may have been the case the first year or two, but it soon became evident that additional precaution in seedbed preparation was essential to secure increased output. Extra cultivation and choppings 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 irrigated crop helped to shade out weeds.

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

The most common method of sowing wheat to be irrigated required an additional operation. The seedbed was either plowed with a oneway or broken with a moldboard then bedded with a lister. The wheat was drilled parallel with the beds loosening the tension on the feet that ride the ridges. Wheat sowed in this manner was irrigated by running water in the furrows.

Custom rates were applied to cultural practices added as a result of irrigation to obtain the increase in expense due to irrigation. A list of common practices with the custom rates is given in Appendix Table 1.

Increase in Yields as a Result of Irrigation

Cotton

The 21 farms studied reported 1,370.62 acres of cotton grown under irrigation in 1954. 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. (Tables 4 and 5).

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 yield on the dryland cotton acreage on the farms surveyed was 168 pounds of lint per acre. 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 higher yield in 1955 was influenced 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 Resources Board estimated 10,600 acres of irrigated cotton in the county with a total production of

Table 4.—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.

Table 5.—Increased yields of major crops in Harmon County, Oklahoma, due to irrigation

Crop	County Average		Survey Data Irrigated	Survey Data Non-Irrigated	Increased Yield	
	1954-55	1954-55	1954-55	1954-55	Amount	Percent[4]
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]	[2]	3.38	[3]	2.24	196
Seed lbs.	118**	[2]	311	[3]	193	164

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

12,889 bales. The irrigated cotton acreage represented 21 percent of the total acres harvested but produced 43 percent of the total for Harmon County.

Because of the influence of the favorable growing season and inclusion of irrigated acreage on the two-year (1954 and 1955) county average yield of 240 pounds and because of the small difference in yield between the 10-year (1945 to 1954) county average of 153 pounds of lint and the two-year (1954 and 1955) average yield of 168 pounds of lint on the farms studied, the latter yield was used to determine the response that can be attributed 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.

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.

Table 6, gives a summary of the number of irrigations on cotton on the farms in Harmon County which were included in the survey.

The number of irrigations and total amount of water applied to cotton varied among the farms studied (Table 6). 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, which is 171 pounds greater than the yield on 4 of the farms that made one irrigation before planting and one less summer irrigation, applying a total of 23 acre inches of water.

This seems to indicate that approximately the same amount of water applied in four applications instead of three resulted in an increase in yield of 171 pounds of lint. However, the number of applications of water had to be determined by the capacity of the well, the nature of

Table 6.—Response of cotton to inputs of water on 20 farms in Harmon County, Oklahoma, 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

the soil, the crop to be irrigated, and the acreage to be covered.

Moisture was a very influential factor and many times a limiting factor of production. If all other factors of production were held constant and only the amount of water and number of irrigations increased, yield increased but at a decreasing rate. Although this study was not designed to determine the marginal productivity at various increments, these data do indicate diminishing rates of productivity.

Four of the 20 farms reporting irrigated cotton 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 four to five and the total acre inches of water (per acre) from 22 to 36 increased yields only 19 pounds of cotton lint per acre.

Three of the 20 farms raising cotton 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 with the use of both fertilizer and insecticides. The third farm in this group used neither fertilizer nor insecticides and averaged only 600 pounds on 109 acres. This indicates that the use of fertilizer and insecticides is a complement to moisture.

The estimated number of acres of irrigated cotton required to cover overhead and operating costs with wells pumping from various lifts is given in Table 7. These 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 1000 gallons per minute and the range for 10-inch pumps was 850 to 1800 gallons per minute. For this estimate a total of 22 acre inches of water per acre was used. Cost of pumping water increased as the amount of lift increased and other operating costs remained unchanged. Yield of cotton was estimated to increase by 499 pounds of lint per acre. An estimated price of 27.5 cents per pound was used for cotton.

Table 7.—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

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

Wheat

Average dry-farmed wheat yield for the two years 1954 and 1955 on the 8 farms in the study reporting 339 acres was 9 bushels per acre. The county average for the two-year period was 8 bushels per acre and for the 10-year period 1945 to 1954 was 11 bushels per acre.

The average yield from 195 acres of irrigated wheat on 7 farms in the study was 38 bushels per acre for the two-year period 1954 and 1955.

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 to 1954) county average by 27 bushels (38—11) or an increase of 245 percent.

Table 8 shows results of irrigating wheat on seven farms in Harmon County. The three farms that irrigated three times had a 15 bushel increase in yield over the three farms that irrigated only two times. The one farm that irrigated four times showed an increase of 11 bushels over the farms that irrigated three times. If the average county dry-farmed yield of 11 bushels per acre for the 10-year period 1945 to 1954 were normal then two irrigations 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.

Table 8.—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
Fa:ms Pre-Irrigating	2	1	1
Total Ac. in. Water	11	14	20
Farms using Fertilizer	0	1	1
Average yields bu.	25	40	51

The estimated number of acres of irrigated wheat required to cover overhead and operating costs with wells pumping from various lifts is given in Table 9. For this estimate a total of 18 acre inches of water per acre was used for wheat. Yield of wheat was estimated to increase by 28 bushels per acre, and an estimated price of $1.70 per bushel was used.

Grain Sorghums

Of the 21 farms studied, six farms reported irrigating grain sorghums in 1954 and 15 reported irrigating grain sorghums in 1955. Seven of the farms surveyed reported growing grain sorghums without irrigation in 1954 and seven in 1955.

The average irrigated yield for the two-year period was 2,371 pounds of grain per acre. The average two-year, dry-land yield on the seven

Table 9.—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	180
Annual overhead	($)	687	762	806	837	913	987	1017	1032	1062	1137
Cost of pumping 1 acre ft. of water	($)	1.95	2.35	2.75	3.10	3.50	3.90	4.30	4.70	5.25	7.00
Cost of pumping 18 acre in. of water	($)	2.90	3.50	4.10	4.70	5.25	5.85	6.45	7.00	7.90	10.55
Cost per acre for added practices	($)	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40	16.40
Total operating costs	($)	19.30	19.90	20.50	21.10	21.65	22.25	22.85	23.40	24.30	26.95
Added income per acre	($)	47.60	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	20.65
Acres required to cover overhead and operating costs	(ac)	24	28	30	32	35	39	41	43	46	55

10 inch Pump										
Feet of lift	(ft)	50	60	70	80	90	100	110	120	135
Annual overhead	($)	890	920	965	1010	1055	1100	1115	1145	1220
Cost of pumping 1 acre ft. of water	($)	1.95	2.35	2.75	3.10	3.50	3.90	4.30	4.70	5.25
Cost of pumping 18 in. 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

farms surveyed was 919 pounds of grain per acre.

The county average for the two-year period 1954-1955 was 952 pounds per acre and for the ten-year period 1945 to 1954 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 sorghums was 1,452 pounds per acre (2,371—919) an increase of 158 percent.

Table 10 gives response of grain sorghums to inputs of water on 10 farms in Harmon County in 1955. 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 was 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 overhead costs of irrigation. According to comments of operators, very little attention was given to moisture requirements for grain sorghums. 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. Compared with the survey data dry-land yield of 919 pounds, this would be an increase of about 3,600 pounds.

Table 10.—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

Alfalfa

Six farms in the survey reported a total of 297 acres of alfalfa under irrigation for the two-year period 1954-1955. Only one farm surveyed reported dry-farmed alfalfa.

Table 11 gives response of alfalfa to inputs of water on six farms in Harmon County. The six irrigated farms produced an average of 3.38 tons of hay and 311 pounds of seed per acre for the two-year period 1954 and 1955.

The farm reporting dry-farmed alfalfa produced 1 ton of hay and 159 pounds of seed per acre in 1954 and reported no production in 1955.

Because of the inadequacy of the observations of dry-farmed alfalfa in the survey, the average yield of the agricultural census was used to estimate increased yield due to irrigation. The county average reported

Table 11.—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

by the U. S. Census of Agriculture for the years 1939, 1944, 1949 and 1954 was 1.14 tons of hay and 118 pounds of seed per acre. The difference in yield of irrigated and non-irrigated alfalfa was 2.24 tons of hay (3.38—1.14), an increase of 196 percent, and 193 pounds of seed (311—118), an increase of 164 perecent.

Water requirements for alfalfa are relatively high. The crop was used as a supplementary cash crop with either cotton or wheat. None of the farms irrigating alfalfa was producing the crop for hay alone but attempted to take a seed crop after two cuttings of hay. The operators did not consider alfalfa for hay alone profitable enough to compete with cotton for water when the supply of water was limited.

Management Decisions

In these analyses, increased yields were attributed directly to irrigation. Water alone was not responsible for all the increase in yield, but did reduce the elements of risk and uncertainty and encourage improved cultural practices.

In Table 12, it is assumed that 5 acre inches of water are required per application 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

Table 12.—Number of acres that can be irrigated at 10 and 14 day intervals at different rates of pumping

GPM	Acre Inches Per Hour	No. Hours Required To apply 5 Acre Inches*	No. Acres that can be Irrigated	
			in 230 hour period	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.

the desired soil moisture level for a crop and the yield of the well were limited to 800 gallons per minute, only 81 acres could be irrigated. Increasing the interval between irrigations would increase the number of acres that might be irrigated.

The desired soil moisture level was found to be an individual judgment. No objective measures such as moisture meters and oven tests were employed by the farmers. A few operators reported use of the "squeezed ball" test.

An estimate of the amount of irrigation water required for the major crops grown on three general soil types in Harmon county was prepared by Garton and Criddle and is presented in Table 13. According to their estimate, 22 inches of irrigation water are required for cotton on medium loam soil during a normal season. This was figured on a 60 percent overall plant efficiency allowing for loss of water due to runoff, percolation, evaporation, and pumping plant performance.

Table 13.—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.

The decision to establish an irrigation system was the beginning of a long series of decisions relative to numerous resource combination possibilities. Even though an irrigation system had been established, a farmer might choose not to irrigate in a given year. Decision to irrigate originated such problems as what crops to produce, how much fertilizer to use, and how much water to allocate to different crops.

A sample budget was designed to illustrate an objective method of deciding whether the net income from irrigation would be increased enough over a period of years to justify the added investment. The sample budget is shown in Figure 1.

It was assumed that a farmer had 50 acres that could be irrigated by gravity flow irrigation. He had a 15-acre cotton allotment and could plant 15 acres of wheat. He needed to determine whether it would be profitable for him to establish an irrigation system.

Test drilling revealed that he could develop a well with a 90-foot lift yielding 650 to 1,000 gallons per minute. A total investment of $5,975 was required to develop a well of this capacity and lift, and annual fixed costs of $913.00 were required plus operating expenses incurred because of irrigation. (See Table 3.)

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. The budget method was used to calculate expected returns from irrigation. Returns against variable cost for each crop were calculated and the residual applied against the annual overhead. Farmers were aware that the variable or current operating cost each season must be met before any payment on fixed cost could be made.

Figure 1.—Suggested Budget Form Filled Out for Example A.

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	
Acre foot 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

*3.9 cents x feet of lift.

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* $ 913 00 (annual fixed cost) ÷ 48 84 (change in per ac. income) = 19 (acres)

*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.

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)*

$ (added income) — $ (annual fixed costs) = $ (added profit from irrigation)**

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

**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.

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

Acres that can be irrigater 15 (acres)

Costs 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
Listing	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

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)*

$364.50 (added income) — $180.40 (unrecovered fixed costs) = $184.10 (added profit from irrigation)**

*Carry forward to budget for competitive crop.
**Carry forward to summary sheet.

Competitive crop—milo   Expected increase in yield 1851 lbs. (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

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) ÷ 11.89 (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)*

*Carry forward to summary sheet

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

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 were required to maintain soil moisture at a desirable level.*

This required 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 gave a total variable cost per acre of $88.38 ($6.38 + $82.00 = $88.38). The increased yield of 499 pounds of lint above a normal yield of 168 pounds (667—168) was 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

*Jams 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.

needed to break even were found by dividing the annual fixed cost by the net income above variable cost (913.00 ÷ $48.84 = 19 acres). Nineteen acres of cotton were required to make this a profitable venture; however, this farm was allotted only 15 acres. The total net income above variable costs was $732.60 (15 x $48.84 = $732.60) that could be applied on the annual fixed cost of $913.00. 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 obtainable by irrigating wheat. The expected normal yield per acre was 11 bushels. It was estimated that 38 bushels could be produced by applying 18 inches of water, or an increase of 27 bushels per acre (See Table 6). A price of $1.70 per bushel was anticipated (See Appendix Table 3) for an added income of $45.90 per acre. The difference between added expenses and added income was estimated to be $24.30 ($45.90 — $21.65 = $24.25).

Number of acres of wheat required to pay the unrecovered fixed costs was found by dividing the unrecovered fixed costs by the added income per acre. ($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 costs. Any income obtained from subsequent acres of wheat or other crops irrigated after paying only the variable cost could be treated as profit.

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

Added income from irrigating 20 acres of milo was determined in the same manner. All fixed costs had been recovered so only variable costs were considered in preparing the budget. The expected value of the increased yieled less the estimated costs of production gave a net increase in income of $11.82 per acre (37.03 — $25.20 = $11.82). A total net return of $236.40 was added to farm income from milo ($11.82 x 20 acres = $236.40). It was estimated that 36 inches of water would be required to give this increased yield.

The budget summary revealed 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 profit of $420.50.

Summary

The purpose of this study was to provide a basis for determining net returns that may be expected from an investment in irrigation.

Experiences of 21 farmers in Harmon County, Oklahoma, were analyzed to provide a basis 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 operators. Operating costs were obtained from farm records. Estimated increases in yields were computed from yields obtained under irrigation by these 21 farmers compared with yields obtained without irrigation.

A limited amount of land and an unlimited amount of water were assumed in the budget model. Inputs of the various resources used in the budget were at the modal level established from survey data. If two crops were competing for water such as cotton and milo, additional water was applied to the crop that would 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 was profitable to make additional applications to each crop as long as added output was greater in value than the added cost incurred.

Most farmers in this area had the reverse of this situation, an unlimited amount of land and a scarce supply of water. Maximizing returns in this situation required 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 could be made on a total of 41 acres of cotton. The irrigation interval could be changed to 14 days and 57 acres irrigated at the rate of 5 inches per irrigation. The operator could apply only 2.5 acre inches at 10-day intervals on 82 acres or 2.5 acre inches on 104 acres at 14-day intervals. These alternative uses required additional outlay for conveyances and decreased the water efficiency compared with the smaller acreage where applications were more intense.

Appendix Table 1.—Custom rates used to determine the cost of added practices in irrigation*

Operation	Unit	Usual	Range
Mold Board plow	acre	3.00	2.50-3.50
List		1.75	1.25-2.50
Oneway		1.25	1.25-2 00
Spike tooth harrow		.75	.50-1.00
Spring tooth harrow		1.00	.75-1.25
Tandem disc		1.50	1.25-1.50
Hoeme		1.50	1.50-2.50
Row cultivator		1.50	.75-1.50
Combining			
Wheat and oats	acre	3.00	2.50-3.25
Grain sorghums	acre	3 00	2 50-3.25
Alfalfa	acre	5.00	3.00-6.00
Hay			
Mow	acre	1.00	1.00-1.25
Rake	acre	.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	
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.