ECONOMIC IMPACT OF IRRIGATION DEVELOPMENT:
SUGAR CREEK WATERSHED, OKLAHOMA

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TABLE OF CONTENTS

Chapter	Page

LIST OF TABLES

Table | Page

Table | Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Water was treated as a free good in the classical and neoclassical literature. It was given no particular attention by the early economists, and is scarcely mentioned in their writings. In recent years however, the expanding demands for water of suitable quality and in sufficient quantities have attracted attention to this resource. Increasing demands upon available water supplies stem from two basic factors: (1) the rapid growth of population (increasing 1.5 per cent per annum) and (2) the increase in per capita consumption (which is twice as rapid as the rate of population growth).[1]

Due to increased competition for limited water supplies in many areas, water is becoming more important as a limiting constraint on regional economic growth.[2] Renne indicated that the economic growth of a community or area may depend largely on the increased efficiency with which this resource is used.[3] The problem of inadequate water supplies

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[1]Earl O. Heady and John F. Timmons, "Economic Framework for Planning Efficient Use of Water Resources," Iowa's Water Resources, ed. John F. Timmons, John C. O'Byrne, and Richard K. Frevert (Ames, 1956), p. 48.

[2]L. M. Hartman and R. L. Anderson, Estimating Irrigation Water Values: A Regression Analysis of Farm Sales Data From Northeastern Colorado. Colorado Agricultural Experiment Station Technical Bulletin 81 (Fort Collins, November, 1963), p. 1.

[3]Roland R. Renne, Impact of Water Resource Development on Economic Growth. Presented at the Fourteenth Annual Farm Business Training Conference on Resource and Community Development, Oklahoma State University (Stillwater, June 22, 1966), p. 3.

faced by farmers in some areas is aggravated by uncertainties posed by weather variations. Irrigated agriculture usually permits greater control of moisture availability than dryland farming. Thus, it has become clear that more research is necessary to find means of increasing the supplies of water for irrigation and of utilizing the existing supplies more efficiently.

Watershed development programs provide one means of developing or increasing the supply of water for irrigation. The watershed protection and flood prevention programs authorized in 1954 by Public Law 566 (and subsequent amendments thereto) permits locally organized watershed organizations to sponsor the construction of improvements for flood prevention, drainage, irrigation, recreation, wildlife, and providing water for municipal and industrial uses.

Farmers with flood plain land are generally willing to provide the easements and sign agreements required to build structures for flood prevention purposes because planning and construction costs are financed largely by the Federal Government. Structures built for flood prevention only contain a relatively small part of their total capacity as sediment pool. Rights to the use of water held in this permanent pool can be obtained by farmers if they put the water to a beneficial use. Irrigation is one beneficial use frequently made of the water contained in the sediment pool of flood water retention structures in Oklahoma. Property owners could have larger structures built that would contain storage capacity for water for irrigation or other uses by paying the additional costs. Farmers have generally not made this investment. Apparently they have not had sufficient cost-return information at the time a project is being planned, indicating such an investment would be profitable, to decide in favor of paying for the additional capacity. This study investigates the potential economic impact of using the water stored in the floodwater retention structures of the Sugar Creed Watershed for irrigation. It also investigates the potential economic impact of larger amounts of storage.

The Area of Study

This study is concerned with the Sugar Creek Watershed area. As shown by Figure 1, it is located in the west central part of Oklahoma. Sugar Creek rises three miles west of Hinton in Caddo County, and flows in a southeasterly direction for approximately 30 miles, entering the Washita River four miles east of Anadarko. The watershed is roughly rectangular in shape, averaging ten miles in width. It has a drainage area of 189,076 acres, which comprises Sugar Creek proper and several Washita River laterals. The drainage area of Sugar Creek proper is 152,704 acres.[4]

The soils of the watershed are dominantly sandy and range from silty clay loam to loamy sand and are permeable to freely permeable. The climate of the watershed is mild, although some years it experiences wide ranges of rainfall and temperature. Table I shows the fifteen-year average monthly temperature and rainfall for Anadarko, located three miles south of the watershed. The annual precipitation at the Anadarko station has ranged from 17.15 inches to 43.98 inches during the last fifteen years, with an annual average of 29.13 inches. The average temperature for the same period is 61.87 degrees Fahrenheit.

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[4]United States Department of Agriculture, Soil Conservation Service, Work Plan Sugar Creek Watershed (Stillwater, 1959), p. 3.

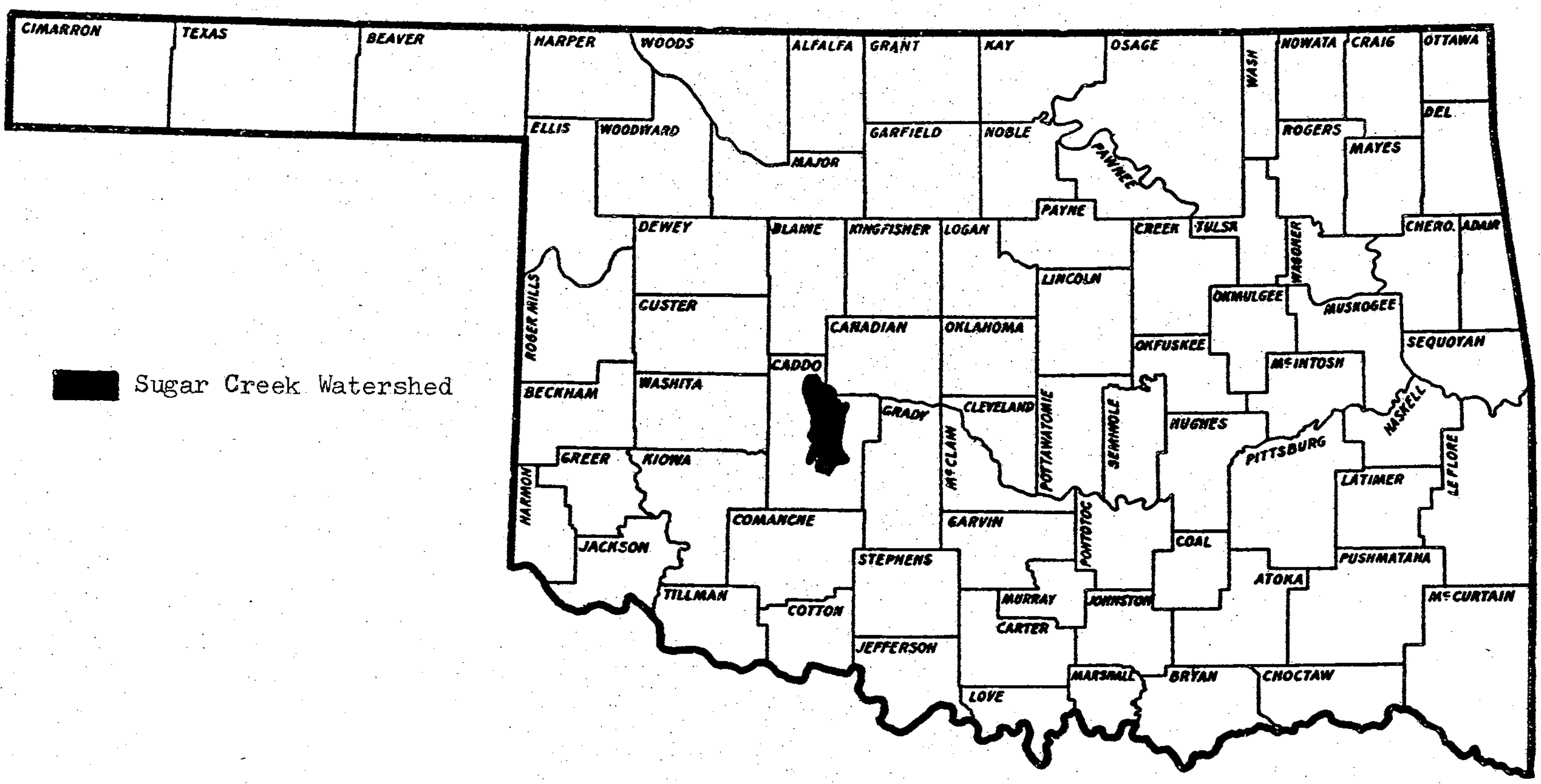

Figure 1. Location of Sugar Creek Watershed

TABLE I

MONTHLY TEMPERATURES AND PRECIPITATION: ANADARKO[1]

Month	Temperature	Precipitation
January	38.36	.721
February	43.36	1.078
March	50.86	1.784
April	62.70	2.753
May	70.80	4.414
June	78.68	3.432
July	83.25	2.593
August	81.92	3.781
September	74.58	3.704
October	63.66	3.058
November	50.62	1.598
December	41.07	1.304

[1]Averages computed for the fifteen-year period January 1953 through December 1967.

Source: U. S. Department of Commerce, Weather Bureau, Climatological Data: Oklahoma (Ashville, 1953-1968).

The economy of the watershed is dependent largely on its farms and ranches. Livestock production, especially beef cattle, is an important source of income. The dominant crops are alfalfa, cotton, peanuts, small grain, and grain sorghum. Approximately 24 per cent of the watershed is Indian land and most farm operators lease some Indian land in addition to farming their own holdings.[5] The major towns within the watershed are Gracemont, Binger, and Lookeba. Anadarko, the county seat of Caddo County, is situated three miles south of the watershed.

The Watershed Program and Objectives of This Study

The Sugar Creek Watershed works of improvement include two types of measures: (1) land treatment measures and (2) structural measures. The land treatment measures are intended to decrease erosion damage and sediment yields by providing improved soil cover conditions. These measures comprise cover cropping, conservation crop rotation, use of rotation hay and pasture, crop residue utilization for croplands, brush control, range seeding, and pasture planting. They also include the construction of farm ponds, and proper use of range and pasture to provide improvement, protection, and good maintenance of grass stands. The structural measures consist of construction of a system of 43 floodwater retarding structures, drop inlets, vegetative stabilization of major gullies, and channel improvement. The average annual cost of all structural measures, composed of a portion of the original construction cost plus operation and maintenance, is estimated to be $114,783. The total flood prevention benefits, including reduction of

[5] Ibid., p. 5.

flood damages, reduction of flood plain scour damages, benefits from restoration of flood plain lands, and reduction of indirect damages are estimated to average $455,148 annually, $390,587 of which are to result from structural measures. Thus, the structural measures are expected to produce, when the project is completely installed, $3.40 of benefits for each dollar of cost.[6] There are other benefits which result from the works of improvement that have not been considered by the Soil Conservation Service in the comparison of benefits and cost for project justification. The secondary effects accruing from the above mentioned measures; the primary and secondary effects that would result from using the water stored in the retention structures for irrigation or recreation purposes; improved wildlife conditions; and some intangible benefits such as better living conditions and a sense of security have not been considered. This study attempts to measure the primary and secondary effects that would result from using the water stored in the sediment pools of the retention structures for irrigation development.

The construction of the floodwater retarding structures in Sugar Creek Watershed, offers potential to the farmers of the area of increasing their profits by using the water stored in the structures for irrigation purposes. This economic potential is not restricted to the farm sector though. Since irrigation development stimulates off-farm economic activity in the area where it takes place, other local economic groups benefit from it to a certain degree. The extent of this potential is of interest to local groups and regional planners, as well as

[6] Ibid., pp. 21-22.

to those who are concerned about water resource development on a national scale.

The general purpose of this study is to present estimates of the importance of irrigation development to the various groups of the local economy. The major objective is to investigate the nature and extent of the primary and secondary impact of irrigation development using the water of the floodwater retention structures. The specific objectives are: (1) to develop optimum farm organizations for representative farms in the watershed, under alternative levels of water supply; (2) to determine the value of irrigation water to the individual farms; (3) to estimate the changes in farm income and resource use arising from irrigation development; (4) to develop a model that will estimate the effect of the irrigation development on employment, population and business activity in the community; (5) to estimate the secondary benefits of irrigation development for the water supply currently available; and (6) to estimate the primary and secondary impact of developing larger quantities of water.

The remainder of this thesis is organized in the following manner. Chapter II presents the relevant theory used in the analysis, and describes the theoretical models to be used in estimating the primary and secondary effects of irrigation development. Chapter III deals with the empirical procedures followed in developing the linear programming model used to: program the optimum farm organizations, determine the value of irrigation water to the individual farms, and estimate the changes in income and resource use arising from irrigation development. These results are used to allocate the available supply of water among farms in the watershed and to estimate the aggregate primary effects of irrigation development. Chapter IV is devoted to the estimation of the interdependence model used in projecting the changes in employment, population, and business activity originating from irrigation development, and presents the numerical results for this phase of the study. Chapter V ties the previous two chapters together, presents estimates of primary and secondary benefits of irrigation development, and considers the potential economic impact of allocating alternative levels of water among farms in the watershed. Chapter VI summarizes the study and presents the relevant conclusions.

CHAPTER II

ANALYTICAL FRAMEWORK

Economic impact studies purport to analyze the changes in economic activity which result from the occurrence of an event in the economy of a region. The effort of this study is not to estimate the total impact resulting from the watershed project, but rather to investigate the changes in economic activity that irrigation development will impose on the farm sector and on other segements of the local economy. The purpose of this chapter is to discuss the concepts involved and present the procedures to be used in the present study. The following section presents some concepts and procedures generally used by the federal agencies in the evaluation of water resource development programs, and is intended to provide a background for the operational techniques introduced in the succeeding sections.

Water Resource Analysis

The economic analysis of water development projects fits into the general area of welfare economics. As a part of economic theory, welfare economics is concerned with the efficient use of resources by an economic system. Henderson and Quandt state that "the objective of welfare economics is the evaluation of the social desirability of alternative economic states."[1] The generally recognized dominant goal in water resource development is to maximize the long run social welfare of the community, which means that in evaluating public programs the federal agencies should use some postulates of welfare economics in their analysis. The concept usually applied by these agencies is known as benefit-cost analysis which is based upon the measurement of benefits and costs of a given project.

Usually, the benefits assigned to a project are the difference in the national income with and without the project. The increase in national income is then broken down into two groups, primary and secondary benefits. Primary benefits are defined as "the value of the products or services resulting directly from the project; net of all associated costs incurred in their realization".[2]

Primary benefits are then the value of the immediate products or services of the project net of associated costs which are all costs other than project costs required for the realization of the benefits. In an irrigation project, for example, the primary benefits would be the value of the additional farm crops which result from the increase in the moisture content of the soil through the application of water or reduction in damages from drought. Associated costs would be those

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[1]James M. Henderson and Richard E. Quandt, _Microeconomic Theory_ (New York, 1958), p. 201.

[2]Subcommittee on Evaluation Standards of the Federal Inter-Agency Committee on Water Resources, _Proposed Practices for Economic Analysis of River Basin Projects: Report to the Inter-Agency Committee on Water Resources_ (Rev., Washington, D. C., May, 1958), p. 8. This report is referred to in the literature as the _Green Book_. Further references to this report will be made in this manner.

incurred by farmers in introducing irrigated farming: additional fertilizer and labor, cost of irrigation system, and higher harvesting costs. Project costs would be those of making water available to the farmers.

Secondary benefits are also referred to as indirect benefits. Secondary benefits attributable to a project are defined in the Green Book as "the value added over and above the value of primary benefits after taking account of expected conditions throughout the economy with and without the project."[3] Secondary benefits are then, the increase in net incomes or other beneficial effects as a result of the project in activities stemming from or induced by the project. The "stemming from" effects are attributed to the industries that process the immediate products of the project. The "induced by" effects are those that result because expenditures by the producers of the immediate products stimulate other economic activity.[4]

Benefits "stemming from" the project arise from increased production of goods (primary benefits) afforded by the project. With this increased supply of goods, new demands result for the transporting, processing and marketing industries of the project area. Profits realized by the industries from handling these new goods are "stemming from" benefits. The "induced by" benefits result from increased expenditures by people of the project area. These benefits arise from the

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[3]Ibid.

[4]S. V. Ciriacy-Wantrup, "The Role of Benefit-Cost Analysis in Public Resource Development," Water Resources and Economic Development of the West, Report No. 3 of the Western Agricultural Economics Research Council (Berkeley, 1954), p. 23.

supplying of additional materials and services required to make possible the increased net returns which stem from the installation of the project facilities. These increased expenditures need not be limited to the primary producers for these are consumers of other goods produced in the economy.

The primary benefits are intended to be an estimate of the primary impact and the secondary benefits are intended to be an estimate of the secondary impact of a water resource development project. Although benefit-cost analysis has become the generally accepted criterion for project evaluation, considerable controversy still centers around the theoretical and empirical problems associated with the measurement of benefits. Fairly standard procedures have been developed to make satisfactory estimates of the increase in net farm incomes or primary benefits that result from these projects. Secondary benefits result in an almost infinite variety of ways and it is difficult to clarify the concepts enough to measure them. For these reasons, methods to measure secondary benefits have not been perfected and their prediction is somewhat uncertain.

General agreement exists among the federal agencies, and among economists about the existence of secondary benefits. Substantial disagreement exists, however, in relation to the appropriateness of inclusion and manner of measurement of secondary benefits in the justification of water resource development projects.[5] Each of the several federal agencies engaged in evaluating water resource projects follows its own methods and standards in making its evaluation. The

[5] A. V. Kneese, "Economic Analysis of Water Resource Development Projects," Monthly Review (Kansas City, October, 1958), p. 10.

Soil Conservation Service and the Corps of Engineers do not include secondary benefits in their justification of projects, but the computation of secondary benefits does play an important role in estimating benefit-cost ratios by the Bureau of Reclamation.[6]

Some economists argue that secondary benefits should not be included in the analysis of benefits and costs as a justification for public investment. For instance, it is said that "from the point of view of the nation as a whole, many of the benefits alleged to accrue in secondary activities merely constitute diversions of income from one region or activity to another."[7] This means that, under the assumption of "no unused capacity", increases in one region or activity are offset by decreases elsewhere in the economy.[8] It is evident, however, that from the national point of view, if in the absence of the project some resources would be unemployed or underemployed then secondary benefits are real and constitute a net increase in national income. Whether or not these benefits are relevant at the national level, no one questions their existence at the local level.

Margolis mentions three types of arguments which can be used in defense of the inclusion of secondary benefits in benefit-cost analysis: (1) that supply creates its own demand; (2) that there exists a large volume of unemployed resources for which the opportunity costs are zero;

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[6] Ibid., p. 11.

[7] Edward F. Renshaw, Toward Responsible Government: An Economic Appraisal of Federal Investment in Water Resource Programs (Chicago, 1957), p. 25.

[8] Ciriacy-Wantrup, p. 25.

and (3) the existence of external economies.[9] The third argument, Margolis maintains, is defensible but cannot be used to defend the measurements used by the Bureau of Reclamation. There are two major sources of external economies: (1) the growth of the market and (2) the use or expansion of social overhead capital. In some cases, roads, schools, and community centers may be used more efficiently.[10]

Different procedures and criteria have been used by the several federal agencies in evaluating benefits. Several attempts have been made to develop a systematic and consistent framework for the economic evaluation of river basin projects and programs. In 1950 a Subcommittee on Benefits and Costs of the Federal Inter-Agency River Basin Committee, submitted a report which was adopted by this Committee as a basis for consideration by the participating agencies for application in their respective fields of activity in water resource development. Later in 1954, the Subcommittee on Evaluation Standards was formed to succeed the Subcommittee on Benefits and Costs, and a revision was made of the original report to include matters in which there was general agreement.[11] This report focuses attention on effects attributable to projects, the nature of benefits, and the effects of alternative opportunities on evaluation and project formulation.[12]

In 1962, a report of the President's Water Resource Council was

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[9]Julius Margolis, "Secondary Benefits, External Economies, and the Justification of Public Investment," The Review of Economies and Statistics, XXIX (August, 1957), pp. 284-9.

[10]Ibid., pp. 287-91.

[11]Green Book, p. 1.

[12]Ibid., p. 2.

issued with the purpose of establishing

> ... executive policies, standards, and procedures for uniform application in the formulation, evaluation, and review of comprehensive river basin plans and individual project plans for use and development of water and related land resources.[13]

The Soil Conservation Service has adjusted its procedures to take into account the recommendations contained in Senate Document 97 and some amendments to Public Law 566.[14]

There are no major differences in regard to the measurement of primary benefits among the different Federal Agencies. The generally accepted basis is the "with" and "without" approach. That is, the benefits to be measured comprise the difference in the future between net returns to the watershed resources with the project and without the project.

The primary benefits to be credited to the project are the total primary benefits as previously defined, less the cost of goods and services that are not otherwise taken into account. These goods and services should be priced at their expected market prices. The types of primary benefits considered include: (1) domestic, municipal, and industrial water supply; (2) irrigation; (3) water quality control; (4) flood control and prevention; (5) land stabilization; (6) electric power; (7) drainage; (8) navigation; (9) recreation development; (10) fish and wildlife development; and (11) other benefits, including area

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[13]President's Water Resource Council, Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, Senate Document No. 97, 87th Congress, 2d session (Washington, D. C., 1962), p. 1.

[14]United States Department of Agriculture, Soil Conservation Service, Economics Guide for Watershed Protection and Flood Prevention (Washington, D. C., March, 1964).

redevelopment and the servicing of international treaties and national defense under specific conditions.

Several formulations exist among the federal agencies in regard to the appropriate operational meaning of secondary benefits and their measurement. It is recognized that through the multiplier effect, a water resource development project frequently does trigger utilization of additional resources and provides a wider base for economic activity, but these agencies differ in respect to the treatment that should be given to these secondary benefits. The Green Book states that although these benefits may be significant at the local or regional level, from the national public point of view such benefits usually have little significance in project formulation and economic justification.[15] No specific procedures for estimating secondary benefits are suggested in this report.

Senate Document No. 97 states that secondary benefits attributable to a project from the local, regional, or state standpoint should be evaluated, and an additional benefit-cost ratio computed. Secondary benefits attributable to the project from a national point of view, shall be included in the computation of the benefit-cost ratio.[16] Again, no specific guidelines are provided for the determination of secondary benefits.

The "Economic Guide" of the Soil Conservation Service suggests some factors that can be used in estimating net secondary benefits: (1) The value of local secondary benefits "stemming from" the project

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[15] Green Book, p. 10.

[16] President's Water Resource Council, p. 6.

can be considered to be equal to ten per cent of the direct primary benefits; (2) The value of local secondary benefits "induced by" the project can be considered to equal ten per cent of the increased costs that primary producers will incur in connection with increased or sustained production.[17]

The Bureau of Reclamation follows a different procedure in the estimation of secondary benefits. In the case of irrigation benefits, the Bureau of Reclamation measures two types of secondary benefits: increased profits to some business of the area and increased property value.[18] Of course, the methodology used by the Bureau of Reclamation and techniques used by other agencies can be questioned, but no single technique has been commonly accepted either by the federal agencies or by economists working on resource development. The estimation of indirect benefits remains one of the most complex and controversial problems in water and related resources development.

Some have pointed out that government decisions are often based largely on political rather than economic considerations, and that instead of benefit-cost analysis the willingness to repay a portion of the costs should be made the criterion for public resource development.[19] It has also been suggested that since the government objectives go beyond the achievement of economic efficiency, projects should be

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[17] U.S.D.A., Soil Conservation Service, Chapter 11, p. 3.

[18] U.S. Department of Interior, Bureau of Reclamation Manual, Vol. XIII-Benefits and Costs (March, 1952), quoted in Roland N. McKean, Efficiency in Government Through Systems Analysis (New York, 1958), p. 154.

[19] See S. V. Ciriacy-Wantrup, "Benefit Cost Analysis and Public Resource Development," Journal of Farm Economics, XXXVII (November, 1955), p. 676.

approved if they help to attain government determined national objectives. This implies that some goals which are not expressable in economic terms should also be considered when evaluating water resource projects.

Primary Impact of Irrigation Development

The first phase of this study analyzes the effects of irrigation development on the farm sector of the study area. This is the primary or direct impact of irrigation. Linear programming techniques are used to determine the farming systems required for maximum income on typical or representative farms operating under dryland and irrigated conditions. Determining the changes in income and resource use "with" or "without" irrigation for the particular farms, and then aggregating for the whole area, a measure of the primary impact of irrigation development is obtained.

The first step in analyzing the importance of irrigation for an area is to consider how valuable an additional unit of water is for the individual farm. Marginal analysis provides the necessary framework for determining the most profitable allocation of a given supply of water among alternative uses. It also permits estimating how valuable a resource is at the margin. Profit maximization is assumed to be the primary objective of the firm (farm). It is also assumed that the markets for factors and products are sufficiently competitive, so that the individual firm faces a perfectly elastic demand curve for its products, and a perfectly elastic resource supply curve. This implies that both product and factor prices are given parameters to the firm.

Under these conditions, the conventional marginal analysis model indicates that the farmer should allocate his available supply of water in such a manner that the marginal value product of the water applied is the same in all of its uses and greater than (in the case of a limited water supply) or equal to (in the case of an ineffective limit) the marginal cost of obtaining the water. This is the necessary condition for profit maximization. The second order condition is that the marginal value product of water in each use decline as additional water is applied. This principle constitutes the basic theoretical framework used in this study in estimating the value of water for irrigation. The operational procedure used is linear programming, which essentially provides the same analytical framework as marginal analysis. There are some differences between the marginal analysis approach to the theory of the firm and the linear programming approach. The principal differences stem from the different assumptions in relation to the production function.[20] Marginal analysis is concerned with the process of making choices from alternative factor product combinations considering infinitesimal changes in these combinations; that is, it involves continuous production functions. Linear programming is concerned with problems involving the optimization of linear relationships subject to certain linear constraints. Linear programming encompasses problems in which the quantity to be maximized (or minimized) is stated as a linear function of the independent variables and is subject to a system of linear inequalities stated in terms of these variables.

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[20]For a detailed discussion of the basic differences between marginal analysis and linear programming, see Thomas H. Naylor, "The Theory of the Firm: A Comparison of Marginal Analysis and Linear Programming," The Southern Economic Journal, XXXII (January, 1966), pp. 263-273.

The general static maximizing linear programming model can be stated in the following manner. Define c_j as unit net revenue above variable costs resulting from one unit increase in the j^{th} activity. Let x_j represent the j^{th} activity, where an activity is a particular way of combining certain factors to produce a unit of output. Let b_i denote the j^{th} limitational resource, and the coefficients a_{ij} specify the amount of the i^{th} resource required per unit increase in the j^{th} activity. The objective is to maximize:

$$P = c_1 x_1 + c_2 x_2 + \ldots + c_n x_n$$

subject to the inequality restrictions of the production possibilities matrix

$$\begin{array}{l} a_{11} x_1 + a_{12} x_2 + \ldots + a_{1n} x_n \leq b_1 \\ a_{21} x_1 + a_{22} x_2 + \ldots + a_{2n} x_n \leq b_2 \\ \cdot \qquad\qquad\qquad\qquad\qquad\quad \cdot \\ \cdot \qquad\qquad\qquad\qquad\qquad\quad \cdot \\ \cdot \qquad\qquad\qquad\qquad\qquad\quad \cdot \\ a_{m1} x_1 + a_{m2} x_2 + \ldots + a_{mn} x_n \leq b_m \end{array}$$

and $x_j \geq 0$.

P is total profits or the returns to the fixed factors. The purpose of the linear programming model is to determine the values of the x_j (activity levels) that will satisfy the restrictions of the production possibilities matrix and at the same time maximize profits.

Linear programming is well suited for the kind of data available and for the nature of the problem to be considered in the first phase of this study. Thus, linear programming is used to determine the optimal allocation of resources among several enterprises, and to obtain the optimum enterprise combinations. The simplex procedure of solving a linear programming problem also provides estimates of the marginal value products of limiting resources, or the amount by which total revenue would increase if one more unit of the resource were available.[21] The marginal value product of a scarce resource is the amount of increase or reduction that would occur in P from increasing or decreasing the availability of the resource by one unit, with all other conditions remaining equal. A complete marginal value product schedule (demand schedule) for irrigation water can be obtained using variable resource programming. The supply of water available may be allowed to change from zero, or a small amount, to an unlimiting amount and the resulting marginal value products can be used to determine the demand schedule for irrigation water. This approach will be used to estimate the value of irrigation water to the farmers of the watershed.

Secondary Impact of Irrigation Development

The broad objective of this study is to provide an insight into the importance of irrigation development, not only to the farmers who are directly affected, but also to other economic groups of the community which are indirectly affected by the development. The various sectors of a local economy contain a degree of interdependence whereby a change in one sector results, indirectly, in changes to the other sectors. Multiplier analysis provides the best available technique to

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[21] See Earl O. Heady and Wilfred Candler, Linear Programming Methods (Ames, 1958) for a complete exposition of the linear programming techniques. Chapter 7 treats the resource valuation problem.

analyze the economic impact or change in economic activity resulting from changes in certain economic variables under given assumptions. The secondary impact of irrigation development is expected to take the form of increases in the trade activity of the area, increases in non-farm employment, increases in population, and increases in income. The development of irrigation brings about an increase in demand for agricultural productive inputs and an increase in farm incomes. This in turn leads to an increase in employment opportunities in other businesses in the local area which produce goods and services for the farm sector. These industries in turn increase their demand for goods and services from other economic groups of the community. This process results in an increase in income for the various economic groups of the local area. The increase in employment tends to result in increases in population. Other less tangible secondary effects have to do with recreation, sense of security, and esthetic values.

The input-output model may provide the most comprehensive mathematical technique available to quantify the secondary effects of irrigation development. However, conceptual and empirical difficulties limit its usefulness at the regional level.

The input-output model was introduced by Wassily Leontief, who used it to study the United States economy.[22] The input-output model is based upon two fundamental assumptions. To be able to make predictions with the model, it is assumed that the input-output coefficients are constant. This implies that technology remains constant over the time period involved. This assumption is criticized as being unrealistic

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[22] Wassily Leontief, The Structure of the American Economy, 1919-1939. 2nd edition (New Yor, 1951).

for long run predictions.[23] The other assumption of the model is that there are no errors of aggregation in combining industries into sectors. This assumption implies that the coefficients for a sector are representative of the industries within the sector.[24] Hatanaka indicates that in order to aggregate without affecting the predictive power of the model, the industries that are combined to form an aggregated sector must have identical cost structures and must not purchase inputs from themselves.[25] There seems to be no way of fulfilling this condition in the real world. Another conceptual shortcoming of the model is that the multipliers obtained from input-output analysis predict the total impact of the initial change in economic conditions, exclusive of any leakage. Leakage is defined as the change in economic activity in other regions due to the change in a particular region.[26] The amount of leakage depends on the imports of goods and services from other regions to the region receiving the initial stimuli. In a low income, predominantly rural area, this leakage has been estimated to be as high as 88 per cent.[27]

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[23]Hollis B. Chenery and Paul G. Clark, Interindustry Economics (New York, 1959), p. 16.

[24]Gerald A. Doeksen, "An Input-Output Analysis of the Structure of the Economy of Oklahoma" (unpub. M.S. thesis, Oklahoma State University, 1967), p. 16.

[25]W. Hatanaka, "Note on Consolidation Within a Leontief System," Econometrica, XX (1952), pp. 301-303.

[26]Gerald A. Doeksen and Charles H. Little, Estimation of the Leakage of Output and Income from a Regional Economy Using Input-Output Analysis. Oklahoma State University Agricultural Economics Paper AE6718 (Stillwater, 1968), p. 2.

[27]H. A. Wadsworth and J. M. Conrad, "Leakages Reducing Employment and Income Multipliers in Labor-Surplus Rural Areas," Journal of Farm Economics, XLVII (December, 1965), pp. 1197-1202.

Empirical difficulties arise in the construction of the input-output model because the statistical data requirements are extensive. These requirements make the development of a regional input-output model time-consuming and costly, especially if local data are to be used. In many areas, the detailed data required (such as purchases and sales of each sector from each other sector) are not available, and the cost of collecting them is prohibitive.

It has been argued recently that in terms of design, the input-output accounting system usually focuses attention on the technical rather than the trade relationships for the region, and that "In order to quantify the secondary effects that are confined to a region, we need purely regional linkages."[28] An operational model which describes the linkages or interdependence of the various sectors and subsectors of southwestern Oklahoma has been developed by Olson.[29] This model is less restrictive in terms of data requirements than the input-output approach and has been designed to reflect the particular or regional economic characteristics of areas such as southwestern Oklahoma. A model similar to the one developed by Olson is used in this study in attempting to evaluate the secondary impact resulting from irrigation development. The procedure followed involves the use of economic base multipliers and regression multipliers.

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[28]Robert J. Kalter and William B. Lord, "Measurement of the Impact of Recreation Investment on a Local Economy," American Journal of Agricultural Economics, L (May, 1968), pp. 243-256.

[29]Carl E. Olson, "The Impact of Agricultural Resource Adjustment on the Economy of Southwestern Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University, 1967).

Economic Base Multipliers

The concept of a multiplier effect in economics was first developed by R. F. Kahn in 1931.[30] Kahn's employment multiplier is a coefficient relating an increment of primary employment to the resulting increment of total employment.[31] From the work of Kahn, Keynes developed an investment multiplier which relates an increment of investment to an increase of income.[32] Like the investment multiplier, economic base multipliers purport to quantify the economic impact which a change in one sector of a local economy will impose on other sectors. Although statements appear in earlier literature to indicate that researchers were using the idea of basic and service activities, it was Hoyt who in 1936 developed the essential outlines of the concept as it is known today.[33] Essentially, the economic base concept asserts that a region or local area can economically exist and expand only because of its specialization in product output, part or all of which is exported and sold to other regions. This premise states that the goods and services a community sells beyond its borders provide the foundation on which nonexport activities can thrive. An increase in exports, *ceteris paribus*, leads to an increase in employment in those industries producing for external markets; this increase in employment leads to an

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[30] R. F. Kahn, "The Relation of Home Investment to Unemployment," *The Economic Journal*, XLI (June, 1931), pp. 179-198.

[31] Alvin H. Hansen, *A Guide to Keynes* (New York, 1953), p. 86.

[32] John Maynard Keynes, *The General Theory of Employment, Interest, and Money* (New York, 1964), pp. 113-131.

[33] Richard B. Andrews, "Historical Development of the Base Concept," *Land Economics*, XXIX (May, 1953), p. 163.

increase in local income, which spent induces a derived and estimable increase in employment in those industries producing for the local consumers. Further, the increase in exports increases the earnings of locally owned factors used in producing goods and services for the external markets. This also leads to an increase in local disposable income and hence to an increase in employment in the industries producing for the local market.[34]

Industries which produce goods all or part of which are sold in external markets are classified as basic. The remaining industries which produce goods and services primarily for the local consumers are referred to as nonbasic, internal, secondary, service, residential, derivative, and by other names by various authors. In this study, they are called derivative, following Olson's notation.

The methodology involved in economic base analysis consists of an estimation of a ratio of some quantifying measure of the derivative industries to the basic industries. From the data used to compute this basic-derivative ratio, a regional multiplier is calculated. Several units of measure could be used to estimate the basic-derivative ratio, however most economic base studies have relied on employment as their unit of measurement, since employment data are more easily obtainable, and because employment levels are considered to be good indicators of economic activity. Other units of measurement that could be used are income flows, payrolls, and value added. Tiebout points out that, although income may be the best unit of measure, measuring income of a

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[34] George H. Hildebrand and Arthur Mace Jr. "The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47," Review of Economics and Statistics, XXXII (August, 1950), p. 242.

community is a tricky problem both conceptually and statistically.[35] Other units of measure present similar problems or are difficult to obtain with the desirable reliability. For the purposes of this study, employment data will be used in estimating the economic base multipliers.

The first step in estimating an employment multiplier using economic base analysis is to group total employment into those employed in basic activities and those employed in derivative activities. The second step is the calculation of the ratio of total derivative employment to total basic employment. This ratio is called the basic-derivative multiplier. A ratio of 1:1.50, for example, indicates that for every individual employed in basic activities there are 1.50 individuals employed in derivative activities. If used for forecasting purposes, this basic-derivative multiplier would indicate that for every 100 new persons employed in basic activities there would be 150 new jobs in derivative activities. A basic-total employment multipler (generally referred to in the literature simply as the employment multiplier) can also be obtained by adding one to the basic-derivative ratio. The actual derivation of this last multiplier is total employment (basic plus derivative) divided by total basic employment.[36] The basic-total employment multiplier indicates

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[35] Charles M. Tiebout, "The Urban Economic Base Reconsidered," The Techniques of Urban Economic Analysis, ed. Ralph W. Pfouts (West Trenton, 1960), p. 288.

[36] This is exactly the same, since:

$$\frac{\text{Derivative Employment}}{\text{Basic Employment}} + 1 = \frac{\text{Derivative Employment} + \text{Basic Employment}}{\text{Basic Employment}} = \frac{\text{Total Employment}}{\text{Basic Employment}}.$$

how a change in basic employment affects total employment.

Another multiplier which is obtained using economic base theory is the basic employment-population multiplier. This particular multiplier indicates how a change in basic employment affects total population. This multiplier is obtained by dividing total population by total basic employment, and is based upon the assumption that there is a somewhat constant relationship between the labor force of a community and the size of the population which it supports.[37] By the same token, a total population to total employment ratio could be estimated that would indicate how many persons, including himself, a given individual employed in any activity could support.

Each of these economic base multipliers are useful in forecasting the future growth of a region. First, the change in basic employment is estimated. Then, the change in basic employment is multiplied by the respective economic base mutliplier to find out the future change in derivative employment, total employment, or total population. The basic assumption of the procedure is that exports are basic to the growth of a region.

Economic Interdependence Model Specification

The economic interdependence model is designed to represent the intersectoral linkages of the local economy. The model is used to predict the effects that the initial changes in the agricultural sector, arising from irrigation development, will impose on the rest of

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[37] Richard B. Andrews, "Mechanics of the Urban Economic Base: The Concept of Base Ratios," The Techniques of Urban Economic Analysis, ed. Ralph W. Pfouts (West Trenton, 1960), p. 142.

the economy. For this purpose, the local economy is divided into two broad sectors, the agricultural sector and the nonagricultural sector. In order to isolate the specific effects of the original change in the farm sector on certain subsectors, the nonagricultural sector is subdivided into four subsectors: (1) the wholesale, retail and service sales subsector, which is expected to be the most affected by the changes in the agricultural sector; (2) the mining and manufacturing subsector, which is assumed to be unaffected by the changes in the agricultural sector; (3) the government subsector; and (4) the retired population subsector.

The model consists of the five following basic equations and their estimating forms:

$$\Delta E_d = k_1 \Delta E_b \tag{1.0}$$

$$\Delta P = k_2 \Delta E_b \tag{2.0}$$

$$E = E_a + E_{na} \tag{3.0}$$

$$E = E_a + E_{mm} + E_{wrs} + E_g \tag{3.1}$$

$$\hat{E} = E_a + E_{mm} + \hat{E}_{wrs} + \hat{E}_g \tag{3.2}$$

$$\hat{E} = E_a + E_{mm} + (E_{wrs} + k_3 \Delta C_{wrs}) + (E_g + k_4 \Delta P) \tag{3.3}$$

$$Y = Y_a + Y_{na} \tag{4.0}$$

$$Y = Y_a + Y_{wrs} + Y_{mm} + Y_g + Y_r \tag{4.1}$$

$$\hat{Y} = \hat{Y}_a + \hat{Y}_{wrs} + \hat{Y}_g + Y_{mm} + Y_r \tag{4.2}$$

$$\hat{Y} = (Y_a + k_5 \Delta E) + (Y_{wrs} + k_6 \Delta C_{wrs}) + (Y_g + k_7 \Delta P) + Y_{mm} + Y_r \tag{4.3}$$

$$C_{rs} = C_{pa} + C_c \tag{5.0}$$

$$\hat{C}_{rs} = C_{pa} + \hat{C}_c \tag{5.1}$$

$$\hat{C}_{rs} = C_{pa} + k_8 P \tag{5.2}$$

where:

E = Total Employment

E_b = Basic Employment

E_d = Derivative Employment

E_a = Agricultural Employment

E_{na} = Nonagricultural Employment

E_{mm} = Mining and Manufacturing Employment

E_{wrs} = Wholesale, Retail, and Service Sales Employment

E_g = Government Employment

P = Total Population

Y = Total Personal Income

Y_a = Agricultural Personal Income

Y_{na} = Nonagricultural Personal Income

Y_r = Personal Income to Retired Population

Y_{wrs} = Personal Income to Wholesale, Retail, and Service Sales

Y_{mm} = Personal Income to Mining and Manufacturing

Y_g = Personal Income to Government

C_{wrs} = Total Volume of Trade in Retail, Wholesale, and Service Sales

C_{rs} = Total Volume of Expenditures in Retail and Service Trade

C_{pa} = Demand for Productive Inputs and Services by Agriculture

C_c = Demand for Consumer Goods and Services

k_1 = Basic-Derivative Employment Multiplier

k_2 = Basic Employment-Population Multiplier

k_3 = Consumption Expenditures-Employment Multiplier

k_4 = Population-Government Employment Multiplier

k_5 = Employment-Agricultural Personal Income Multiplier

k_6 = Consumption Expenditures-Personal Income Multiplier

k_7 = Population-Governmental Personal Income Multiplier

k_8 = Per Capita Consumption.

Equations (1.0) and (2.0) are functional relationships, the former indicating how a change in basic employment affects derivative employment and the latter showing how a change in basic employment affects total population. The coefficient k_1, of Equation (1.0), is a basic-derivative employment multiplier that is used to estimate the extent to which additional employment in the agricultural sector leads to increased employment in the nonagricultural sector. The coefficient k_2, of Equation (2.0), is a basic employment-population multiplier that is used to project the change in total population resulting from a change in agricultural employment. These first two coefficients are the basic elements of the model.

Equations (3.0) and (3.1) describe the composition of total employment in the area of study. The level of agricultural employment, E_a, is a predetermined variable, and the level of employment in the mining and manufacturing subsector, E_{mm}, is assumed to remain unaffected by irrigation development. Equations (3.2) and (3.3), which are used to project the future levels of employment in the area $(\hat{E})$, contain two variables that will be estimated within the model: employment in the wholesale, retail and service sales subsector $(\hat{E}_{wrs})$, and employment in the government subsector $(\hat{E}_g)$. The change in employment in the wholesale, retail and service sales subsector is considered to be influenced by the change in the volume of trade in the same subsector; that is $\Delta E_{wrs} = k_3 \Delta C_{wrs}$. The change in governmental employment is assumed to be influenced by the change in total population;

that is, $\Delta E_g = k_4 \Delta P$.

Equations (4.0) and (4.1) describe the composition of total personal income for the area of study. Personal income is defined as the income received by persons from all sources during the calendar year. It includes cash plus selected payments in kind without deducting personal income taxes and other direct taxes. Equations (4.2) and (4.3) are the estimating equations of total personal income for the area. Personal income for the mining and manufacturing subsector and personal income of the retired population are assumed to remain unchanged as a result of irrigation development. Personal income to agriculture ($\hat{Y}_a$), personal income to the wholesale, retail, and service sales, ($\hat{Y}_{wrs}$), and governmental personal income ($\hat{Y}_g$), are estimated within the model.

The change in personal income to agriculture is considered to be affected by the change in total employment; that is, $\Delta Y_a = k_5 \Delta E$. The increase in personal income to agriculture as a secondary impact includes increments in income from all sources, wages, and salary payments and other forms of income; ΔY_a is only secondary effect on agricultural income. These increases in personal income are produced by the successive rounds of wealth-producing activities which result from the initial changes in the farm sector. The increase in net farm returns obtained in the first part of the study is an estimate of the direct or primary effects in the form of profit accruing to the farmers of the watershed for the additional operator labor and management associated with irrigation development. The change in personal income to the wholesale, retail, and service sales subsector is assumed to be related to the changes in the volume of trade in the same subsector; or $\Delta Y_{wrs} = k_6 \Delta C_{wrs}$. And, the change in governmental personal income is assumed to be determined by the change in population, $\Delta Y_g = k_7 \Delta P$.

Equations (5.0) and (5.1) show that the total volume of expenditures in the retail and service trade is composed of the demand for agricultural productive inputs and services, and the demand for consumer goods and services. Equations (5.1) and (5.2) are used to predict the volume of retail and service trade in the area. In these last two equations, C_{pa} is a predetermined variable. The demand for consumer goods and services, C_c, which includes all kinds of products sold at retail (including manufactured goods or oils and minerals sold at retail), is estimated within the model.

Equations (1.0) and (2.0) are used to estimate the changes in non-agricultural employment and population originating from the initial change in the farm sector. The coefficients k_1 and k_2 appearing in these two equations are estimated using economic base analysis. The first coefficient, k_1, is a basic-derivative employment multiplier. The second coefficient, k_2, is a basic employment-population multiplier.

Equation (3.3) is used to estimate the level of governmental employment, $\hat{E}_g$; the change in the total volume of trade in the wholesale, retail and service sales subsector, ΔC_{wrs}; and also the level of employment in the wholesale retail and service sales subsector, $\hat{E}_{wrs}$. The change in total population ΔP, obtained from Equation (2.0) is used to estimate the level of governmental employment, $\hat{E}_g$. The change in total employment is obtained when the change in derivative employment is estimated from relationship 1.0; then, using the estimated values of E and E_g, Equation (3.3) is solved for ΔC_{wrs}. The value of $\hat{E}_{wrs}$ is obtained by substituting ΔC_{wrs} into $\Delta\hat{E}_{wrs} = k_3 \Delta C_{wrs}$. The coefficient k_3 is a consumption expenditures-employment multiplier that indicates how changes in the volume of trade in the wholesale, retail, and service sales subsector affects employment in the same subsector. The other coefficient appearing in Equation (3.3), k_4, is a population-governmental employment multiplier that shows how governmental employment is influenced by changes in total population. These two multipliers are estimated using regression analysis.

The levels of personal income are estimated using Equation (4.3). There are three multipliers in this equation that are estimated using regression analysis: k_5 is an employment-agricultural personal income multiplier that indicates how personal income to agriculture responds to changes in total employment; k_6 is a consumption expenditures-personal income multiplier that relates changes in personal income in the wholesale, retail, and service sales subsector to changes in consumption expenditures; and, k_7 is a population governmental personal income multiplier that indicates how governmental personal income is affected by changes in total population.

The demand for consumer goods and services, C_c, is obtained by multiplying the projected level of population of the study area by the per capita consumption, k_8. Then, Equation (5.2) is used to project the total volume of expenditures in the retail and service trade, C_{rs}.

Thus, there are five multipliers in the interdependence model which are estimated using regression analysis. Least squares regression techniques, forcing the regression through the origin can be used to compute such multipliers.[38]

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[38] Charles H. Little, Effects of New Investment on a Community. Oklahoma Agricultural Experiment Station Processed Series P-551 (Stillwater, 1966), p. 15. The regression techniques are discussed in

Problems in Applying the Interdependence Model

Two key multipliers in the model presented above are calculated using economic base analysis. However, there are some problems associated with the use of this technique in regional analysis. One of the most important technical problems in the use of this concept is that of identifying basic and derivative industries. To estimate the basic-derivative multipliers, it is necessary to separate the industries of the region under study into basic and derivative categories. Isard points out that differences in methods of basic and service component identification can cause significant variation in the estimated basic-derivative ratio, and hence in any derived multiplier value.[39] There are at least three ways in which the basic derivative classification can be made: (1) an *a priori* classification using the experience or judgement of the researcher, (2) a firm-by-firm determination of the market orientation of each firm's output; that is, an analysis of the marketing areas of each firm, and (3) a comparison of local industry employment shares with those of other areas of the nation.

The first approach above is questionable for obvious reasons, and the second method is replete with difficulties due to the amount of information that is required. The third method is more promising and can be applied by the use of location quotients and specialization ratios.

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any statistics or econometrics book. For example J. Johnston, *Econometric Methods* (New York, 1963), pp. 3-39.

[39] Walter Isard, *Methods of Regional Analysis: An Introduction to Regional Science* (New York, 1960), p. 198. For a detailed discussion of the problem of identification, see also Richard B. Andrews, "The Mechanics of the Urban Economic Base: General Problems of Base Identification," *Land Economics*, XXX (May, 1954), pp. 164-172.

This procedure is used in the present study to classify industries into the basic and derivative categories and is discussed in the final section of this chapter.

Another problem associated with economic base studies revolves around the delimitation of the geographic area for which the study is to be made. However, Isard suggests that the choice of the area should be made based on the purposes of the investigation, the nature of the regional linkages, and the data availability.[40] Secondary data is used to estimate the parameters of the interdependence model. Thus, for the purposes of this study, the delineation of the area to be considered has to be made in terms of counties, since data for smaller geographical areas are not available. The selection of the counties to be included is made using results from previous studies conducted to determine the trade area of the watershed.

Another problem is that using employment figures ignores the differentials in wage levels for alternative occupations. It is evident that the multiplier effect of an increase in employment in a basic industry with high wages will be different from that which would result from an increase in employment in a low-wage industry. An expansion in a high-wage industry will have a greater impact through the multiplier than expansion in a low-wage industry.

This study is concerned with the estimation of the economic impact resulting from original changes in the farm sector. It does not consider the effects that would result from changes in alternative industries. Hence, this problem does not affect the results of this study

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[40] Isard, p. 198.

and can be ignored.

Economic base multipliers measure the effect of an economic change, but not the time required for the total adjustment in the economy to occur. Economic base analysis assumes that subsequent to the occurrence of an economic change in the local area, the economy will gradually settle back to its previous or historical basic-derivative relationship. But, although the round-by-round process which causes the return to the original relationship takes time, in the long run the constant changes in the structure of the economy are likely to alter this basic-derivative relationship. Nourse indicates that, conceptually, the economic base multiplier is a short-run concept that takes time to work out its full effects.[41]

In the case of irrigation development, it is necessary to allow time for farmers to adopt irrigation and to make the investments required by irrigated farming. It is also necessary to keep in mind that in the long run the input-output coefficients, prices, and other variable are bound to change. Thus, the results of this study have to be interpreted considering these factors. The analysis does not indicate how long it will take for the full effect of irrigation development to take place, nor how long it will last.

Location Quotients and Specialization Ratios

The location quotient measures the degree of concentration of employment in a given industry in one area (the "subject economy") as

[41]Hugh O. Nourse, Regional Economics (New York, 1968), pp. 162-163.

compared with another area (the "benchmark economy").[42] More precisely, the location quotient is a ratio of the employment in a given industry as a per cent of total employment in the subject economy to employment in the same industry as a per cent of total employment in the benchmark economy. For example, assume that employment in a given industry of the subject economy is 20 per cent of total employment. Further assume that the benchmark economy has 10 per cent employed in the same industry. The location quotient for the subject economy compared with the benchmark economy would be 2 in this case (20 per cent for the subject economy divided by 10 per cent for the benchmark economy).

A location quotient of 1 for a particular industry indicates no greater specialization in the subject economy relative to the benchmark economy. Where a location quotient in excess of 1 is found, greater specialization is indicated in the subject economy relative to the benchmark economy. If a given industry has a location quotient significantly below 1, this indicates greater specialization in the benchmark economy than in the subject economy. The extent to which a location quotient exceeds 1 indicates the amount of local employment in an industry which can be classified as basic. Hildebrand and Mace list 4 factors that may result in location quotients being significantly above or below unity in a subject economy. They are: (1) differences in factor input coefficients of the same industry in the subject and benchmark economies; (2) differences in the quantity and quality of available productive resources; (3) differences in the demand functions of the two areas, which indicate differences in tastes, income levels, and

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[42] Hildebrand and Mace, pp. 241-249.

income distribution; and (4) differences for certain industries between the two areas-in procurement and/or distribution costs of transfer, which could explain locational concentrations of industries.[43]

Thus, the location quotient can be employed as a usable index of the market orientation of industries in a particular economy. In mixed industries, the location quotient assumes that the local patterns of use and habits of consumption are equal to the national average, and that all local demands for products of these industries are served by local production.[44, 45] There are cases in which these assumptions do not hold; for instance, the local consumption habits may deviate from the national average because of differences in taste patterns, income levels and income distribution or relative price patterns.[46]

In the actual classification of employment into basic and derivative for those industries in the subject economy which reveal a location quotient greater than 1, specialization ratios can be used. The specialization ratio considers the difference between employment in an industry in the subject economy and employment expected in this industry if both the subject economy and the benchmark economy were self-sufficient.[47] Each of the two areas are self-sufficient if the

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[43] Ibid., p. 244.

[44] The term mixed industries is due to Isard, p. 195, and refers to industries which sell in both the local and the external markets.

[45] Ibid.

[46] John M. Mattilla and Wilbur R. Thompson, "The Measurement of the Economic Base of the Metropolitan Area," Land Economics, XXXI (August, 1955), p. 218.

[47] Gerald E. Thompson, "An Investigation of the Local Employment Multiplier," The Review of Economics and Statistics, XLI (February, 1959), p. 64.

industry's level of employment is proportionate to their respective levels of total employment. The difference between the actual level of employment and the estimated self-sufficient level of employment, gives a measure of the extent to which a given industry's employment in the subject economy is sustained by sales outside the subject economy.[48] From this estimation, it is possible to calculate the amount of employment which is basic for a particular industry. The specialization ratio can be expressed arithmetically as follows:

$$\text{Specialization Ratio} = \frac{S_i - \frac{B_i + S_i}{B_t + S_t}(S_t)}{S_i},$$

where S_i and B_i are industry employment in the subject and benchmark economies, respectively, and S_t and B_t are total employment in the subject and benchmark economies, respectively.[49] For example, assume that the values of S_i, S_t, B_i, and B_t are 20, 60, 40, and 240, respectively. Substituting these values into the above formula and solving, results in a specialization ratio of .40. This means that 40 per cent of the employment of this industry in the subject economy may be classed as basic.[50]

Location quotients and specialization ratios are used in this study to classify industries into the basic and derivative categories. These procedures identify the basic and derivative employment of an

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[48]Ibid.

[49]Ibid.

[50]This also implies that to be just self-sufficient the subject economy would need only 12 persons employed in this industry.

industry more objectively than a simple *a priori* classification. Chapter IV describes the specific procedures used to estimate the parameters of the interdependence model. The numerical results are presented in Chapter V. The next chapter deals with the primary effects of irrigation development.

CHAPTER III

PRIMARY IMPACT OF IRRIGATION DEVELOPMENT

The empirical procedures used in estimating the primary impact of irrigation development are explained in the first part of this chapter. The rest of the chapter contains the numerical results for this phase of the study.

Empirical Procedures

Defining Typical Farms

The idea of a typical or representative firm has an historical basis. Alfred Marshall pointed out that "a representative firm is in a sense an average firm."[1] He uses the idea of a representative firm in analyzing the effect of firm size on returns. Other uses of the typical firm approach have been made in farm management and production economics.[2] Although most studies based on the typical farm concept are static in nature and tend to be normative rather than predictive, the technique can be used as an operational tool of farm analysis. As Plaxico and Tweeten put it, "until more is known about how managers

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[1] Alfred Marshall, Principles of Economics (8th ed., London, 1959), p. 318.

[2] The development of this approach is discussed in Harold O. Carter, "Representative Farms-Guides for Decision Making," Journal of Farm Economics, XLV (December, 1963), pp. 1448-1455.

actually make decisions, and how the different variables enter the decision-making framework, a systematic objective predictive model does not appear possible."[3]

The Soil Conservation Service provided detailed soil survey maps and a complete description of the soil units of the watershed. Information on the operator's name, legal description, acreage allotments, and other data on each farm were obtained from the Caddo County Agricultural Stabilization and Conservation Service. This information was utilized to develop typical farms for the programming analysis, in the following manner.

First, using standard sampling procedures, a stratified random sample of the operators in the watershed was obtained. Stratified sampling was used to insure that the total sample would not be improperly weighted by a particular size of holding. Prior knowledge of the prevalence of particular sizes permitted stratifying the population into five groups according to size: The first group was composed of farms of less than 240 acres; the second, farms of 240 to 400 acres; the third, farms of 400 to 560 acres; the fourth, 560 to 800 acres; and the fifth, farms of over 800 acres. Following this sampling procedure, a sample size of 54 was determined with subsamples of sizes 38, 6, 3, 3, and 4 corresponding to the five strata considered.

Second, the soil units of the watershed were combined into classes having relatively equal productivity as determined by comparable yields and physical characteristics. Tables II and III present the definitions

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[3]James Plaxico and Luther G. Tweeten, "Representative Farms for Policy and Projection Research," Journal of Farm Economics, XLV (December, 1963), p. 1464.

TABLE II

DEFINITION OF LAND PRODUCTIVITY CLASSES, SANDY SOILS

S_b	- Land Capability Classes I and II. The soils of this group are deep, level to very gently slopping (0 to 3 per cent slopes). These soils are productive fine sandy loams. The following soils are included in this group: Cyril fine sandy loam, Pulaski and Yahola Soils, and Noble fine sandy loam.
S_c	- Land Capability Class III. This group consists of deep, gently sloping soils (3 to 5 per cent slopes). Included in this group are the sandy upland soils of the Dougherty series.
S_d	- Land Capability Class IV. This group comprises sloping soils (5 to 8 per cent slopes) of the following series: Dougherty and Eufala loamy fine sands, Noble fine sandy loams, Eufala loamy fine sand, and Eufala loamy fine sand hummocky.

TABLE III

DEFINITIONS OF LAND PRODUCTIVITY CLASSES, LOAMY SOILS

L_a - Land Capability Class I bottomland. This group is composed of deep, level soils (0 to 1 per cent slopes) with none to slight erosion. These are highly productive soils. This group includes the following soils: Reinach silt loam, Pond Creek silt loam, and Pond Creek fine sandy loam.

L_b - Land Capability Class I upland and Class II upland or bottomland. This group consists of deep, very gently sloping soils (1 to 3 per cent slopes) with negligible to moderate erosion and high natural fertility. It includes the following soils: Reinach silt loam upland, Pond Creek silt loam, Pond Creek fine sandy loam, Port silt loam, Grant loam, Norge silt loam, Shellabarger fine sandy loam, and Cobb fine sandy loam.

L_c - Land Capability Class III. This group comprises sloping soils (3 to 5 per cent slopes) with negligible to moderately severe erosion. They have moderate to high natural fertility. The following soils are included in this group: Grant loam, Minco silt loam, Norge silt loam, Pond Creek silt loam, Shellabarger fine sandy loam, and Cobb fine sandy loam.

L_d - Land Capability Class IV. This group is made up of sloping soils (5 to 8 per cent slopes), or lesser slopes with severe erosion. This group contains the following soils: Grant loam, Grant-Wing Complex, Minco very fine sandy loam, Cobb fine sandy loam, konawa loamy fine sand, Grant silt loam and Woodward-Quinlan Complex.

of the soil productivity classes. Third, the soil units on each of the 54 farms of the sample were measured and aggregated according to the productivity classes defined in Tables II and III. Finally, the typical farms defined in Table IV were obtained by using the averages of land resources and acreage allotments for each of the above five groups.

It is convenient to keep in mind that the synthesized typical farms described here are not necessarily equal to any particular farm in the watershed. Rather, they reflect physical and institutional farm resource situations common to the area.

Crop Enterprises

The crop enterprises considered in this study are those currently being used in the watershed. Admissible dryland and irrigated crop enterprises for all representative farms are: cotton, grain sorghum, wheat, peanuts, alfalfa, forage sorghum, ensilage, and bermuda grass.

The enterprise budgets used in the linear programming analysis are based on information collected from several sources. The yield estimates and cropping systems were obtained from county extension personnel, and staff members of the Departments of Agronomy and Agricultural Economics of the Oklahoma State University. Machinery costs are based on data developed from other southwestern Oklahoma studies. Machinery costs and typical field operations are shown in Appendix A, Tables XXIV and XXV.

Sprinkler irrigation methods are assumed in this study because surface distribution methods cannot be used effectively on the coarse textured sandy soils and because much of the land of the watershed is undulating to strongly sloping. Extensive land leveling is not

TABLE IV

DESCRIPTION OF TYPICAL FARMS

	Typical Farms				
	I	II	III	IV	V
Cropland (Acres):					
Sb	13	20	11	33	117
Sc				3	2
Sd	25	73	114	121	178
La				6	9
Lb	34	42	96	125	179
Lc	4	7	22	16	12
Ld	18	60	48	86	126
Total Cropland	94	202	291	390	623
Rangeland	38	128	165	256	346
Other Land[1]	7	17	24	34	51
Total Land	139	347	480	680	1020
Acreage Allotments:					
Wheat	9	11	10	6	26
Peanuts	6	29	35	30	47
Cotton	18	47	67	68	140
Conserving Base	10	47	24	54	79
Number of Farms in Watershed	532	113	61	41	14

[1]Farmstead, road, wasteland, etc.

required by sprinkler irrigation and no particular skills are necessary to move the portable lateral lines which makes this system very practical. Although the initial cost of the equipment is high, it usually permits utilizing a limited water supply more efficiently than alternative distribution methods.

Two basic sprinkler irrigation systems are designed based on the amount of water to be pumped (Appendix A, Table XXVI). Other systems can be designed by combining these two systems. The costs of delivering the water to the pump are not considered in this study. Hence, the values of water obtained represent the maximum amount that farmers could afford to pay for water delivered to the pump. Since the average fixed and variable costs per acre-inch are different depending upon the amount of water applied, and since this amount cannot be specified in advance of programming, the programming is carried on considering only variable costs for alternative irrigation systems. After the programming is completed, the appropriate size of irrigation system is assigned to the particular farm and the annual fixed costs subtracted from the marginal value products to obtain the values of irrigation water.

Three irrigation levels are used for each crop. These irrigation levels are supplemental or in addition to the usual distribution of rainfall. The lowest irrigation level is chosen to represent that combination of inputs that would yield the highest physical output per acre-inch of irrigation water applied. The highest level of irrigation is chosen to represent that combination of inputs yielding the greatest net return per acre. The intermediate level of water is chosen to fall between the upper and lower levels. These crop irrigation levels are based on experimental data and experience of personnel of the Soil

Conservation Service, the Agricultural Extension Service, and the Oklahoma Experiment Station. Appendix A, Table XXVII shows the monthly distribution of irrigation water for each crop.

The enterprise budgets for dryland and irrigated conditions prepared for this study are presented in Appendix A, Tables XXVIII-LVI. Wheat, peanuts and cotton enterprises are restricted to the current allotments of the typical farms. The conserving base restriction is also included in the programs.

Livestock Enterprises

Alternative livestock enterprises are limited to cow-calf and feeder systems prevalent in the watershed. Appendix A, Tables LVII-LXII, contains the budgets developed for the alternative livestock enterprises. Two cow-calf enterprises, one assuming spring calving with sale of good-choice feeders October 1, and the other assuming fall calving and selling of good-choice feeders July 20 are included. Two feeder systems, one fall buy, selling one year later, and the second fall buy, selling on March 1 are included. The other feeder system provides for spring buy and fall selling.

Labor, Capital, and Price Assumptions

Two classes of labor are included in the analysis: operator labor and hired labor. The operator labor available for farm work is assumed to decrease as the size of the farm increases. As the size of the farm increases more time is used in management activities. Four labor periods are used in the programming analysis following the typical labor-use time divisions for the crop and livestock enterprises of

Oklahoma. Table V shows the levels of operator labor assumed in this study. The analysis assumes that additional labor can be hired throughout the year at a rate of $1.50 per hour.

It is assumed that the farm operator may borrow all the capital that is necessary for his farming operations at seven per cent simple interest. A capital charge of seven per cent is imposed on the annual capital used by each enterprise.

Price assumptions for this study approximate current prices paid and received by farmers of the study area. These assumed prices are based upon information obtained from extension personnel, retail merchants and earlier surveys made in the area.

Linear Programming Results

Variable resource programming is used to obtain optimum farm organizations at different levels of water supply. The acre inches of water available to the farm are allowed to vary from zero (representing dryland conditions) to the level at which water is no longer a limiting resource.

The parametric programming method is a modification of the standard simplex linear programming model. This procedure permits one to analyze the effect of changes in the water supply on the optimum solution, and to generate the data needed to construct a demand schedule for irrigation water. The following sections give the results of programming optimum farm organizations for the five typical farms at alternative levels of water supply.

TABLE V

ESTIMATED OPERATOR'S TIME AVAILABLE FOR FARM WORK BY TYPICAL FARM

Month	Month	Hours per Day	Hours per Month	Typical Farms				
				I	II[a]	III[b]	IV[c]	V[d]
January	22	8	176	176	165	154	143	132
February	20	8	160	160	150	140	130	120
March	22	8	176	176	165	154	143	132
April	22	9	198	198	187	176	165	154
Subtotal	86		710	710	667	624	581	538
May	22	9	198	198	187	176	165	154
June	22	10	220	220	209	198	187	176
July	22	10	220	220	209	198	187	176
Subtotal	66		638	638	605	572	539	506
August	22	10	220	220	209	198	187	176
Sept.	22	10	220	220	209	198	187	176
Subtotal	44		440	440	418	396	374	352
October	22	10	220	220	209	198	187	176
Nov.	22	9	198	198	187	176	165	154
Dec.	22	8	176	176	165	154	143	132
Subtotal	66		594	594	561	528	495	462
Total	262		2,382	2,382	2,251	2,120	1,989	1,858

[a] Assumes that $\frac{1}{2}$ hour is used daily in management.

[b] Assumes that 1 hour is used daily in management.

[c] Assumes that $1\frac{1}{2}$ hour is used daily in management.

[d] Assumes that 2 hours are used daily in management.

Programmed Optimum Organizations

Tables VI through X show the programmed optimum organizations at alternatives levels of water supply for the five typical or representative farms considered in this study. Of the activities programmed, peanuts and grain sorghum are the only crops to enter all plans. One feeder cattle enterprise based on native range or bermuda pasture, is similarly present in all alternative optimum programs. Of the crop alternatives considered, only forage sorghum and ensilage fail to enter any of the optimum solutions (Tables VI-X).

Under dryland conditions, the optimum plans for all five typical farms include peanuts, cotton, grain sorghum, and steers. All typical farms with the exception of typical farm II, also include alfalfa to satisfy the conserving base acreage restriction, and to utilize the minimum cotton diversion acreage. Typical farm II complies with the conserving base restriction with the inclusion of bermuda grass. Wheat, which is programmed only as a dryland alternative, enters only in some of the optimum plans for typical farms I, III, and V. It is later replaced by grain sorghum.

Irrigation water is initially allocated to peanuts on each of the typical farms. When peanuts are irrigated at the high rate of water application, the water not utilized by peanuts goes to bermuda grass. The higher acreage of bermuda grass permits increases in the number of steers contained in the optimum plans. As irrigation water becomes less limiting, the general pattern is for cotton, alfalfa and wheat to leave the optimum organizations. When water becomes an unlimiting factor, in general five activities remain in the optimum programs: irrigated peanuts, irrigated bermuda grass, irrigated grain sorghum,

TABLE VI

PROGRAMMED OPTIMUM ORGANIZATIONS FOR TYPICAL FARM I, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.		72.00	90.00	108.00	219.00	321.00	567.00	837.00	1,251.00
Net Returns[1]	Dol.	3,841.00	4,680.11	4,780.20	4,850.75	5,202.00	5,468.89	5,883.62	6,036.37	6,112.07
Dryland Crops:										
Alfalfa	Acres	11.00	11.00	11.00	8.00					
Cotton	Acres	17.00	17.00	17.00	17.00	17.00	17.00	29.00	23.00	
Grain Sorghum	Acres	54.00	54.00	54.00	51.00	44.00	36.00			
Peanuts	Acres	6.00								
Wheat	Acres	6.00	6.00	6.00	9.00	9.00				
Irrigated Crops:										
Bermuda Grass	Acres				3.00	11.00	11.00	18.00	18.00	41.00
Grain Sorghum	Acres					7.00	24.00	41.00	47.00	47.00
Peanuts	Acres		6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Livestock:										
Cows	Head									
Steers	Head	9.50	9.50	9.50	14.75	28.75	28.75	41.00	56.75	117.12
Labor Used:										
Operator	Hrs.	259.70	261.18	263.40	289.86	353.94	371.57	426.34	509.69	713.57
Hired	Hrs.									
Annual Capital Used	Dol.	1,492.23	1,576.64	1,589.24	1,955.86	2,973.56	2,991.55	3,901.89	5,118.22	9,473.78
Crop Production:										
Alfalfa	Ton	38.50	38.50	38.50	28.00					
Cotton Lint	Cwt.	76.50	76.50	76.50	76.50	76.50	76.50			
Cotton Seed	Cwt.	122.40	122.40	122.40	122.40	122.40	122.40			
Grain Sorghum	Cwt.	1,272.00	1,272.00	1,272.00	1,218.00	1,482.00	1,990.00	2,782.00	2,998.00	2,446.00
Peanuts	Cwt.	120.00	216.00	228.00	228.00	228.00	228.00	228.00	204.00	
Wheat	Bu.	210.00	210.00	210.00	315.00	315.00				

[1]Returns to land, operator's labor, equipment capital, management, and overhead.

TABLE VII

PROGRAMMED OPTIMUM ORGANIZATIONS FOR TYPICAL FARM II, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.		108.00	348.00	729.00	1,173.00	1,353.00	2,073.00	2,199.00	2,314.73	2,423.00
Net Returns[1]	Dol.	8,143.86	9,581.80	12,404.70	14,307.88	15,141.35	15,403.42	15,848.54	15,903.98	15,949.70	15,957.59
Dryland Crops:											
Bermuda Grass	Acres	49.00	49.00	49.00							
Cotton	Acres	42.00	33.00	33.00	42.00						
Grain Sorghum	Acres	82.00	91.00	91.00	82.00	71.00	51.00	51.00	44.00	37.57	32.00
Peanuts	Acres	29.00	20.00								
Irrigated Crops:											
Bermuda Grass	Acres				49.00	60.00	60.00	60.00	67.00	73.43	79.00
Grain Sorghum	Acres					42.00	62.00	62.00	62.00	62.00	62.00
Peanuts	Acres		9.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00
Livestock:											
Cows	Head										
Steers	Head	61.40	61.40	61.40	117.75	137.00	137.00	189.50	207.87	224.75	240.54
Labor Used:											
Operator	Hrs.	650.71	663.13	692.73	943.48	1,035.11	1,057.31	1,345.92	1,374.06	1,430.22	1,460.27
Hired	Hrs.										22.46
Annual Capital Used	Dol.	6,137.24	6,188.90	6,436.10	10,676.93	12,060.57	12,188.17	16,115.02	17,438.95	18,656.88	19,812.79
Crop Production											
Cotton Lint	Cwt.	189.00	148.50	148.40	189.00						
Cotton Seed	Cwt.	302.40	237.60	237.60	302.40						
Grain Sorghum	Cwt.	1,902.00	2,118.00	2,118.00	1,902.00	3,762.00	4,482.00	4,482.00	4,314.00	4,160.00	4,015.36
Peanuts	Cwt.	552.00	706.00	1,026.00	1,066.00	1,066.00	986.00	986.00	986.00	986.00	986.00

[1] Returns to land, operator's labor, equipment capital, management and overhead

TABLE VIII

PROGRAMMED OPTIMUM ORGANIZATIONS FOR TYPICAL FARM III, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.		216.00	288.00	420.00	477.00	510.00	639.00	687.00	735.00
Net Returns[1]	Dol.	12,115.92	15,036.66	15,942.51	17,511.60	17,859.39	18,050.17	18,650.18	18,846.95	18,978.92
Dryland Crops:										
Alfalfa	Acres	27.00	8.00	8.00	8.00	27.00	27.00	8.00		
Bermuda Grass	Acres		19.00	19.00	19.00					
Cotton	Acres	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00
Grain Sorghum	Acres	160.00	165.00	165.00	165.00	165.00	165.00	165.00	157.00	165.00
Peanuts	Acres	35.00	11.00	11.00						
Wheat	Acres	5.00							8.00	
Irrigated Crops:										
Bermuda Grass	Acres							19.00	27.00	27.00
Grain Sorghum	Acres									
Peanuts	Acres		24.00	24.00	35.00	35.00	35.00	35.00	35.00	35.00
Livestock:										
Cows	Head									
Steers	Head	41.25	52.65	52.65	52.65	41.25	41.25	74.50	88.50	88.50
Labor Used:										
Operator	Hrs.	875.93	946.00	954.88	971.16	937.16	941.23	1,076.84	1,128.68	1,139.08
Hired	Hrs.									
Annual Capital Used	Dol.	5,781.39	6,630.86	6,681.02	6,816.98	6,143.65	6,166.75	8,501.81	9,506.81	9,490.09
Crop Production:										
Alfalfa	Ton	94.50	28.00	28.00	28.00	94.50	94.50	28.00		
Cotton Lint	Cwt.	288.00	288.00	288.00	288.00	288.00	288.00	288.00	288.00	288.00
Cotton Seed	Cwt.	460.80	460.80	460.80	460.80	460.80	460.80	460.80	460.80	460.80
Grain Sorghum	Cwt.	3,552.00	3,786.00	3,786.00	3,786.00	3,672.00	3,672.00	3,786.00	3,642.00	3,994.00
Peanuts	Cwt.	628.00	940.00	1,036.00	1,212.00	1,212.00	1,234.00	1,282.00	1,282.00	1,282.00
Wheat	Bu.	175.00							280.00	

[1]Returns to land, operator's labor, equipment capital, management and overhead.

TABLE VIII (Continued)

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.	879.00	975.00	1,050.93	1,522.55	1,677.00	1,776.00	1,837.19	2,352.00	2,376.00
Net Returns[1]	Dol.	19,316.76	19,508.93	19,654.99	20,539.20	20,827.89	20,972.02	21,009.85	21,240.70	21,243.96
Dryland Crops:										
Alfalfa	Acres									
Bermuda Grass	Acres									
Cotton	Acres	64.00	64.00	64.00	17.16					
Grain Sorghum	Acres	133.00	133.00	120.35	112.00	112.00	101.00	101.00	101.00	100.00
Peanuts	Acres									
Wheat	Acres									
Irrigated Crops:										
Bermuda Grass	Acres	27.00	27.00	39.65	48.00	48.00	48.00	48.00	48.00	49.00
Grain Sorghum	Acres	32.00	32.00	32.00	78.83	96.00	107.00	107.00	107.00	107.00
Peanuts	Acres	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Livestock:										
Cows	Head									
Steers	Head	88.50	88.50	110.65	125.25	125.25	125.25	129.71	167.25	170.69
Labor Used:										
Operator	Hrs.	1,156.84	1,192.86	1,225.30	1,309.93	1,327.47	1,339.48	1,361.20	1,487.65	1,494.51
Hired	Hrs.								56.31	60.90
Annual Capital Used	Dol.	9,518.65	9,584.89	11,150.13	12,208.04	12,217.47	12,287.65	12,621.40	15,471.36	15,722.94
Crop Production:										
Alfalfa	Ton									
Cotton Lint	Cwt.	288.00	288.00	288.00	77.00					
Cotton Seed	Cwt.	460.80	460.80	460.80	123.00					
Grain Sorghum	Cwt.	4,474.00	4,634.00	4,406.20	6,551.08	7,392.00	7,788.00	7,788.00	7,788.00	7,756.51
Peanuts	Cwt.	1,234.00	1,234.00	1,234.00	1,234.00	1,234.00	1,190.00	1,190.00	1,190.00	1,190.00
Wheat	Bu.									

[1]Returns to land, operator's labor, equipment capital, management and overhead.

TABLE IX

PROGRAMMED OPTIMUM ORGANIZATIONS FOR TYPICAL FARM IV, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.		450.00	468.00	792.00	819.00	855.00	1,179.00	1,215.00	1,395.00
Net Returns[1]	Dol.	16,187.80	20,970.21	21,028.58	22,003.41	22,083.89	22,189.75	23,075.55	23,165.86	23,595.10
Dryland Crops:										
Alfalfa	Acres	57.00	57.00	54.00						
Bermuda Grass	Acres									
Cotton	Acres	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00
Grain Sorghum	Acres	235.00	235.00	235.00	232.00	229.00	223.00	169.00	169.00	169.00
Peanuts	Acres	30.00								
Wheat	Acres	3.00	3.00	6.00	6.00	6.00	6.00	6.00		
Irrigated Crops:										
Alfalfa	Acres									
Bermuda Grass	Acres				57.00	57.00	57.00	57.00	57.00	57.00
Grain Sorghum	Acres					3.00	9.00	63.00	69.00	69.00
Peanuts	Acres		30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Livestock:										
Cows	Head									
Steers	Head	64.00	64.00	69.00	164.00	164.00	164.00	164.00	164.00	164.00
Labor Used:										
Operator	Hrs.	1,125.96	1,170.75	1,180.26	1,371.47	1,374.80	1,374.80	1,374.80	1,377.02	1,443.62
Hired	Hrs.	21.61	32.71	42.64	231.58	231.58	236.02	275.98	281.56	237.16
Annual Capital Used	Dol.	7,818.85	8,260.97	8,645.29	15,209.49	15,237.87	15,277.02	15,555.39	15,547.04	15,637.94
Crop Production:										
Alfalfa	Ton	199.50	199.50	189.00						
Cotton Lint	Cwt.	292.50	292.50	292.50	292.50	292.50	292.50	292.50	292.50	292.50
Cotton Seed	Cwt.	468.00	468.00	468.00	468.00	468.00	468.00	468.00	468.00	468.00
Grain Sorghum	Cwt.	5,250.00	5,250.00	5,196.00	5,844.00	5,916.00	6,012.00	6,768.00	7,032.00	7,332.00
Peanuts	Cwt.	600.00	1,140.00	1,140.00	1,140.00	1,140.00	1,140.00	1,140.00	1,140.00	1,140.00
Wheat	Bu.	105.00	105.00	210.00	210.00	210.00	210.00	210.00		

[1]Returns to land, operator's labor, equipment capital, management and overhead.

TABLE IX (Continued)

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.	1,422.00	2,007.00	2,172.73	2,250.00	2,424.00	2,442.00	3,474.00	3,528.00
Net Returns[1]	Dol.	23,652.12	24,784.00	25,026.16	25,123.87	25,231.24	25,296.59	25,494.33	25,503.07
Dryland Crops:									
Alfalfa	Acres								
Bermuda Grass	Acres								
Cotton	Acres	65.00							
Grain Sorghum	Acres	166.00	166.00	147.59	139.00	110.00	110.00	110.00	107.00
Peanuts	Acres								
Wheat	Acres								
Irrigated Crops:									
Alfalfa	Acres								3.00
Bermuda Grass	Acres	57.00	57.00	57.00	57.00	86.00	86.00	86.00	86.00
Grain Sorghum	Acres	72.00	137.00	155.41	164.00	164.00	164.00	164.00	164.00
Peanuts	Acres	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Livestock:									
Cows	Head								
Steers	Head	164.00	164.00	164.00	164.00	215.00	215.00	290.00	290.00
Labor Used:									
Operator	Hrs.	1,446.95	1,580.95	1,601.39	1,601.39	1,616.92	1,616.92	1,656.68	1,654.03
Hired	Hrs.	237.16	211.81	211.81	221.34	335.57	337.79	621.38	622.99
Annual Capital Used	Dol.	15,661.70	15,678.43	15,795.92	15,857.84	19,530.38	19,547.28	25,388.46	25,440.52
Crop Production:									
Alfalfa	Ton								
Cotton Lint	Cwt.	292.50							
Cotton Seed	Cwt.	468.00							
Grain Sorghum	Cwt.	7,422.00	10,607.00	11,269.92	11,579.00	11,057.00	11,081.00	11,081.00	11,009.00
Peanuts	Cwt.	1,134.00	1,134.00	1.060.34	1,026.00	1,026.00	1,026.00	1,026.00	1,020.00
Wheat	Bu.								

[1]Returns to land, operator's labor, equipment capital, management and overhead.

TABLE X

PROGRAMMED OPTIMUM ORGANIZATIONS FOR TYPICAL FARM V, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.		705.00	879.00	1,035.00	1,089.00	1,101.00	1,538.19	1,592.19	1,733.49
Net Returns[1]	Dol.	25,745.41	32,991.09	33,549.63	34,023.63	34,184.78	34,219.12	35,369.31	35,504.70	35,855.45
Dryland Crops:										
Alfalfa	Acres	86.00	86.00	57.00	31.00	22.00	20.00	20.00	20.00	28.58
Bermuda Grass	Acres									
Cotton	Acres	133.00	133.00	133.00	133.00	133.00	133.00	133.00	133.00	133.00
Grain Sorghum	Acres	357.00	357.00	357.00	331.00	331.00	331.00	282.42	273.42	260.58
Peanuts	Acres	47.00								
Wheat	Acres				26.00	26.00	26.00	26.00	26.00	17.42
Irrigated Crops:										
Alfalfa	Acres									
Bermuda Grass	Acres			29.00	55.00	64.00	66.00	66.00	66.00	57.42
Grain Sorghum	Acres							48.58	57.58	79.00
Peanuts	Acres		47.00	47.00	47.00	47.00	47.00	47.00	47.00	47.00
Livestock:										
Cows	Head									
Steers	Head	87.00	87.00	137.00	183.00	198.00	202.00	202.00	202.00	187.00
Labor Used:										
Operator	Hrs.	1,196.41	1,265.97	1,344.63	1,441.67	1,466.09	1,471.51	1,525.43	1,525.43	1,517.17
Hired	Hrs.	599.12	616.61	742.00	813.44	852.39	861.04	861.04	867.70	844.12
Annual Capital	Dol.	12,065.87	12,758.53	16,250.00	19,570.27	20,669.89	20,909.87	21,369.41	21,428.13	20,534.64
Crop Production:										
Alfalfa	Ton	304.50	304.50	203.00	112.00	76.00	70.00	70.00	70.00	100.05
Cotton Lint	Cwt.	598.50	598.50	598.50	598.50	598.50	598.50	598.50	598.50	598.50
Cotton Seed	Cwt.	957.60	957.60	957.60	957.60	957.60	957.60	957.60	957.60	957.60
Grain Sorghum	Cwt.	8,304.00	8,304.00	8,836.00	8,358.00	8,520.00	8,544.00	9,709.84	9,853.84	10,522.53
Peanuts	Cwt.	940.00	1,786.00	1,786.00	1,786.00	1,786.00	1,786.00	1,786.00	1,786.00	1,786.00
Wheat	Bu.				910.00	910.00	910.00	910.00	910.00	609.53

[1] Returns to land, operator's labor, equipment capital, management and overhead.

TABLE X (Continued)

Item	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply	A.-In.	1,785.00	2,025.00	2,181.00	2,199.00	2,337.00	3,534.00	3,939.00	4,179.00	4,206.00
Net Returns[1]	Dol.	35,975.04	36,501.21	36,823.04	36,851.30	37,052.81	38,662.57	39,032.93	39,192.55	39,206.12
Dryland Crops:										
Alfalfa	Acres	20.00								
Bermuda Grass	Acres									
Cotton	Acres	133.00	133.00	133.00	133.00	133.00				
Grain Sorghum	Acres	252.00	232.00	232.00	230.00	230.00	230.00	185.00	145.00	145.00
Peanuts	Acres									
Wheat	Acres	26.00	26.00							
Irrigated Crops:										
Alfalfa	Acres									
Bermuda Grass	Acres	66.00	86.00	86.00	86.00	86.00	86.00	86.00	126.00	126.00
Grain Sorghum	Acres	79.00	99.00	125.00	127.00	127.00	260.00	305.00	305.00	305.00
Peanuts	Acres	47.00	47.00	47.00	47.00	47.00	47.00	47.00	47.00	47.00
Livestock:										
Cows	Head									
Steers	Head	202.00	237.00	237.00	237.00	237.00	237.00	237.00	307.00	307.00
Labor Used:										
Operator	Hrs.	1,525.43	1,544.68	1,544.68	1,544.68	1,544.68	1,544.68	1,544.68	1,583.18	1,583.18
Hired	Hrs.	891.48	1,027.83	1,061.63	1,063.85	1,080.87	1,215.20	1,265.15	1,405.61	1,408.94
Annual Capital	Dol.	21,648.63	24,221.59	24,192.60	24,210.11	24,318.09	24,491.99	24,816.56	29,869.30	29,894.66
Crop Production										
Alfalfa	Ton	70.00								
Cotton Lint	Cwt.	598.50	598.50	598.50	598.50	598.50				
Cotton Seed	Cwt.	957.60	957.60	957.60	957.60	957.60				
Grain Sorghum	Cwt.	10,368.00	10,888.00	12,032.00	12,092.00	12,322.00	18,839.00	20,459.00	19,739.00	19,775.00
Peanuts	Cwt.	1,786.00	1,786.00	1,786.00	1,782.00	1,782.00	1,782.00	1,602.00	1,602.00	1,602.00
Wheat	Bu.	910.00	910.00							

[1]Returns to land, operator's labor, equipment capital, management and overhead.

dryland grain sorghum, and steers on native range and bermuda grass. One exception is that farm I does not have any dryland sorghum. A second exception is that the organization of typical farm IV contains three acres of irrigated alfalfa. When water is no longer in short supply, each of the irrigated crops comes in at the high rate of water application. It is interesting to observe the similarities, in terms of activities contained, between the optimum programs of the various farms. The differences are, of course, dictated by the relative proportions of the basic acreage allotments, and the relative amounts of the different soils which each typical farm has.

Tables XI through XV help to explain why the changes in organization take place at the various water levels. Tables XI through XV present the programmed optimum cropland uses and optimum levels of water use per acre for the five typical farms at alternative levels of water supply. Under dryland conditions cotton and peanuts enter the optimum solution for all five typical farms at the full allotment level. With no irrigation water available, the high producing L_b soils are used to produce primarily cotton, and the S_b soils in producing peanuts. The remaining soils are taken by grain sorghum, bermuda grass, wheat, and alfalfa production. The conserving base acreage is satisfied with production of alfalfa or bermuda grass.

Peanuts is the first crop to be irrigated in all farm situations. Typical farm I uses the initial 72 acre-inches of irrigation water to irrigate the peanut allotment at the intermediate level of water application. Typical farm II utilizes the initial 108 acre-inches of irrigation water to irrigate part of the peanut allotment at the high rate. Typical farm III uses the first 216 acre-inches of water to

TABLE XI

PROGRAMMED OPTIMUM CROPLAND ORGANIZATIONS FOR TYPICAL FARM I, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.		72.00	90.00	108.00	219.00	321.00	567.00	837.00	1,251.00
Crops:												
Alfalfa	Lb	Dryland	Acres	11.00	11.00	11.00	8.00					
Bermuda Grass	Sd	18"	Acres									19.00
Bermuda Grass	Lc	18"	Acres									4.00
Bermuda Grass	Ld	6"	Acres				3.00	11.00	11.00	18.00		
Bermuda Grass	Ld	18"	Acres								18.00	18.00
Cotton	Lb	Dryland	Acres	17.00	17.00	17.00	17.00	17.00	17.00			
Grain Sorghum	Sb	Dryland	Acres	7.00	7.00	7.00	7.00					
Grain Sorghum	Sb	9"	Acres					7.00	7.00	7.00	13.00	13.00
Grain Sorghum	Sd	Dryland	Acres	25.00	25.00	25.00	25.00	25.00	25.00	25.00	19.00	
Grain Sorghum	Lb	Dryland	Acres					8.00				
Grain Sorghum	Lb	6"	Acres						17.00			
Grain Sorghum	Lb	9"	Acres							34.00	34.00	34.00
Grain Sorghum	Lc	Dryland	Acres	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Grain Sorghum	Ld	Dryland	Acres	18.00	18.00	18.00	15.00	7.00	7.00			
Peanuts	Sb	Dryland	Acres	6.00								
Peanuts	Sb	12"	Acres		6.00							
Peanuts	Sb	15"	Acres			6.00	6.00	6.00	6.00	6.00		
Peanuts	Sd	15"	Acres								6.00	6.00
Wheat	Lb	Dryland	Acres	6.00	6.00	6.00	9.00	9.00				

TABLE XII

PROGRAMMED OPTIMUM CROPLAND ORGANIZATIONS FOR TYPICAL FARM II, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.		108	348	729	1,173	1,353	2,073	2,199	2,315	2,423
Crops:													
Bermuda Grass	Sd	18"	Acres									6	12
Bermuda Grass	Lc	18"	Acres								7	7	7
Bermuda Grass	Ld	Dryland	Acres	49	49	49							
Bermuda Grass	Ld	6"	Acres				49	60	60				
Bermuda Grass	Ld	18"	Acres							60	60	60	60
Cotton	Lb	Dryland	Acres	42	33	33	42						
Grain Sorghum	Sb	9"	Acres						20	20	20	20	20
Grain Sorghum	Sd	Dryland	Acres	64	73	73	64	64	44	44	44	38	32
Grain Sorghum	Lb	9"	Acres					42	42	42	42	42	42
Grain Sorghum	Lc	Dryland	Acres	7	7	7	7	7	7	7			
Grain Sorghum	Ld	Dryland	Acres	11	11	11	11						
Peanuts	Sb	Dryland	Acres	20	20								
Peanuts	Sb	12"	Acres			20							
Peanuts	Sb	15"	Acres				20	20					
Peanuts	Sd	Dryland	Acres	9									
Peanuts	Sd	15"	Acres				9	9	29	29	29	29	29
Peanuts	Lb	12"	Acres		9	9							

TABLE XIII

PROGRAMMED OPTIMUM CROPLAND ORGANIZATIONS FOR TYPICAL FARM III, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.		216	288	420	477	510	639	687	735
Crops:												
Alfalfa	Lb	Dryland	Acres	27	8	8	8	27	27	8		
Bermuda Grass	Lc	18"	Acres									
Bermuda Grass	Ld	Dryland	Acres		19	19	19					
Bermuda Grass	Ld	6"	Acres							19	27	27
Bermuda Grass	Ld	18"	Acres									
Cotton	Lb	Dryland	Acres	64	64	64	64	64	64	64	64	64
Grain Sorghum	Sb	9"	Acres									
Grain Sorghum	Sd	Dryland	Acres	90	114	114	114	95	95	114	114	114
Grain Sorghum	Lb	6"	Acres									8
Grain Sorghum	Lb	9"	Acres									
Grain Sorghum	Lc	Dryland	Acres	22	22	22	22	22	22	22	22	22
Grain Sorghum	Ld	Dryland	Acres	48	29	29	29	48	48	29	21	21
Peanuts	Sb	Dryland	Acres	11	11	11						
Peanuts	Sb	12"	Acres				11	11				
Peanuts	Sb	15"	Acres						11	11	11	11
Peanuts	Sd	Dryland	Acres	24								
Peanuts	Sd	15"	Acres					19	19			
Peanuts	Lb	9"	Acres		24							
Peanuts	Lb	12"	Acres			24	24	5	5			
Peanuts	Lb	15"	Acres							24	24	24
Wheat	Lb	Dryland	Acres	5							8	

TABLE XIII (Continued)

Item	Productivity Class	Water Level	Unit	Quan- tity	Quan- tity	Quan- tity	Quan- tity	Quan- tity	Quan- tity	Quan- tity	Quan- tity	Quan- tity
Irrigation Water Supply			A.-In.	879	975	1,051	1,523	1,677	1,776	1,837	2,352	2,376
Crops:												
Alfalfa	Lb	Dryland	Acres									
Bermuda Grass	Lc	18"	Acres									1
Bermuda Grass	Ld	Dryland	Acres									
Bermuda Grass	Ld	6"	Acres	27	27	40	48	48	48	43		
Bermuda Grass	Ld	18"	Acres							5	48	48
Cotton	Lb	Dryland	Acres	64	64	64	17					
Grain Sorghum	Sb	9"	Acres						11	11	11	11
Grain Sorghum	Sd	Dryland	Acres	90	90	90	90	90	79	79	79	79
Grain Sorghum	Lb	6"	Acres	32								
Grain Sorghum	Lb	9"	Acres		32	32	79	96	96	96	96	96
Grain Sorghum	Lc	Dryland	Acres	22	22	22	22	22	22	22	22	21
Grain Sorghum	Ld	Dryland	Acres	21	21	8						
Peanuts	Sb	Dryland	Acres									
Peanuts	Sb	12"	Acres									
Peanuts	Sb	15"	Acres	11	11	11	11	11				
Peanuts	Sd	Dryland	Acres									
Peanuts	Sd	15"	Acres	24	24	24	24	24	35	35	35	35
Peanuts	Lb	9"	Acres									
Peanuts	Lb	12"	Acres									
Peanuts	Lb	15"	Acres									
Wheat	Lb	Dryland	Acres									

TABLE XIV

PROGRAMMED OPTIMUM CROPLAND ORGANIZATION FOR TYPICAL FARM IV, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.		450	468	792	819	855	1,179	1,215	1,395
Crops:												
Alfalfa	Sc	18"	Acres									
Alfalfa	Lb	Dryland	Acres	57	57	54						
Bermuda Grass	Ld	6"	Acres			3	57	57	57	57	57	57
Bermuda Grass	Ld	18"	Acres									
Cotton	Lb	Dryland	Acres	65	65	65	65	65	65	65	65	65
Grain Sorghum	Sb	Dryland	Acres	3	3	3	3					
Grain Sorghum	Sb	9"	Acres					3	3	3	3	3
Grain Sorghum	Sc	Dryland	Acres	3	3	3	3	3	3	3	3	3
Grain Sorghum	Sd	Dryland	Acres	121	121	121	121	121	121	121	121	121
Grain Sorghum	La	Dryland	Acres	6	6	6	6	6				
Grain Sorghum	La	6"	Acres						6	6	6	6
Grain Sorghum	La	9"	Acres									
Grain Sorghum	Lb	Dryland	Acres				54	54	54			
Grain Sorghum	Lb	6"	Acres							54	60	
Grain Sorghum	Lb	9"	Acres									60
Grain Sorghum	Lc	Dryland	Acres	16	16	16	16	16	16	16	16	16
Grain Sorghum	Ld	Dryland	Acres	86	86	83	29	29	29	29	29	29
Peanuts	Sb	Dryland	Acres	30								
Peanuts	Sb	15"	Acres		30	30	30	30	30	30	30	30
Peanuts	Sc	15"	Acres									
Peanuts	Sd	15"	Acres									
Wheat	Lb	Dryland	Acres	3	3	6	6	6	6	6		

TABLE XIV (Continued)

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.	1,422	2,007	2,173	2,250	2,424	2,442	3,474	3,528
Crops:											
Alfalfa	Sc	18"	Acres								3
Alfalfa	Lb	Dryland	Acres								
Bermuda Grass	Ld	6"	Acres	57	57	57	57	86	86		
Bermuda Grass	Ld	18"	Acres							86	86
Cotton	Lb	Dryland	Acres	65							
Grain Sorghum	Sb	Dryland	Acres								
Grain Sorghum	Sb	9"	Acres	6	6	24	33	33	33	33	33
Grain Sorghum	Sc	Dryland	Acres								
Grain Sorghum	Sd	Dryland	Acres	121	121	103	94	94	94	94	91
Grain Sorghum	La	Dryland	Acres								
Grain Sorghum	La	6"	Acres	6	6	6	6	6	6	6	
Grain Sorghum	La	9"	Acres								6
Grain Sorghum	Lb	Dryland	Acres								
Grain Sorghum	Lb	6"	Acres								
Grain Sorghum	Lb	9"	Acres	60	125	125	125	125	125	125	125
Grain Sorghum	Lc	Dryland	Acres	16	16	16	16	16	16	16	16
Grain Sorghum	Ld	Dryland	Acres	29	29	29	29				
Peanuts	Sb	Dryland	Acres								
Peanuts	Sb	15"	Acres	27	27	8.59					
Peanuts	Sc	15"	Acres	3	3	3	3	3	3	3	
Peanuts	Sd	15"	Acres			18.41	27	27	27	27	30
Wheat	Lb	Dryland	Acres								

TABLE XV

PROGRAMMED OPTIMUM CROPLAND ORGANIZATION FOR TYPICAL FARM V, AT ALTERNATIVE LEVELS OF WATER SUPPLY

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.		705	879	1,035	1,089	1,101	1,538	1,592	1,733
Crops:												
Alfalfa	Sb	Dryland	Acres	29	29							
Alfalfa	Sc	Dryland	Acres	2	2	2	2	2	2		2	
Alfalfa	La	Dryland	Acres	9	9	9	9					
Alfalfa	Lb	Dryland	Acres	46	46	46	20	20	20	20	20	29
Bermuda Grass	Ld	6"	Acres			29	55	64	66	66	66	57
Cotton	Lb	Dryland	Acres	133	133	133	133	133	133	133	133	133
Grain Sorghum	Sb	Dryland	Acres	41	41	70	70	70	70	21	21	
Grain Sorghum	Sb	9"	Acres							49	49	70
Grain Sorghum	Sc	Dryland	Acres							2		2
Grain Sorghum	Sd	Dryland	Acres	178	178	178	178	178	178	178	178	178
Grain Sorghum	La	Dryland	Acres					9	9	9		
Grain Sorghum	La	6"	Acres								9	9
Grain Sorghum	La	9"	Acres									
Grain Sorghum	Lb	6"	Acres									
Grain Sorghum	Lb	9"	Acres									
Grain Sorghum	Lc	Dryland	Acres	12	12	12	12	12	12	12	12	12
Grain Sorghum	Ld	Dryland	Acres	126	126	97	71	62	60	60	60	69
Peanuts	Sb	Dryland	Acres	47								
Peanuts	Sb	15"	Acres		47	47	47	47	47	47	47	47
Peanuts	Sc	15"	Acres									
Peanuts	Sd	15"	Acres									
Wheat	Lb	Dryland	Acres				26	26	26	26	26	17

TABLE XV (Continued)

Item	Productivity Class	Water Level	Unit	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Irrigation Water Supply			A.-In.	1,785	2,025	2,181	2,199	2,337	3,534	3,939	4,179	4,206
Crops:												
Alfalfa	Sb	Dryland	Acres									
Alfalfa	Sc	Dryland	Acres									
Alfalfa	La	Dryland	Acres									
Alfalfa	Lb	Dryland	Acres	20								
Bermuda Grass	Ld	6"	Acres	66	86	86	86	86	86	86	126	126
Cotton	Lb	Dryland	Acres	133	133	133	133	133				
Grain Sorghum	Sb	Dryland	Acres									
Grain Sorghum	Sb	9"	Acres	70	70	70	72	72	72	117	117	117
Grain Sorghum	Sc	Dryland	Acres	2	2	2						
Grain Sorghum	Sd	Dryland	Acres	178	178	178	178	178	178	133	133	133
Grain Sorghum	La	Dryland	Acres									
Grain Sorghum	La	6"	Acres	9	9	9	9	9	9	9	9	
Grain Sorghum	La	9"	Acres									9
Grain Sorghum	Lb	6"	Acres		20	46	46					
Grain Sorghum	Lb	9"	Acres					46	179	179	179	179
Grain Sorghum	Lc	Dryland	Acres	12	12	12	12	12	12	12	12	12
Grain Sorghum	Ld	Dryland	Acres	60	40	40	40	40	40	40		
Peanuts	Sb	Dryland	Acres									
Peanuts	Sb	15"	Acres	47	47	47	45	45	45			
Peanuts	Sc	15"	Acres				2	2	2	2	2	2
Peanuts	Sd	15"	Acres							45	45	45
Wheat	Lb	Dryland	Acres	26	26							

irrigate the peanut allotment at the low rate of water application. Typical farm IV uses the initial 450 acre-inches of irrigation water to irrigate the peanut allotment at the high rate. And, typical farm V utilizes the first 705 acre-inches of water to irrigate the peanut allotment at the high rate of water application (Tables XI-XV).

There are three possible adjustments to a change in water supply: a change in total acreage irrigated; a change in acreage of crops with differing water requirements; and a change in rate of application to existing crops. For all five typical farms it is more profitable to irrigate fewer acres at the highest level and plant the remainder of allotment to dryland peanuts than to irrigate more acres at a lower level. Only after the peanut allotment has been irrigated at the high rate of water application, do other crops enter the solutions as irrigated alternatives.

The second crop to be irrigated with the limited amount of water is bermuda grass. When the amount of irrigation water available to typical farm I is increased to 108 acre-inches, irrigated bermuda grass enters the optimum organization (Table XI). With the third increment of irrigation water, typical farm II has more water than is necessary to irrigate the peanut allotment at the high rate and 49 acres of bermuda grass are irrigated at the low rate of water application (Table XII). Typical farm III disposes of enough water to irrigate the peanut allotment at the high rate of application with the sixth increment of water, the extra water is used to irrigate 19 acres of bermuda grass at the low rate of water application (Table XIII). Typical farm IV has enough water to irrigate the peanut allotment with the first increment of water; the second increment is used to irrigate 3 acres of bermuda grass (Table XIV). With the first increment of irrigation water, typical farm V has enough water to irrigate the peanut allotment at the high rate of water application; the second increment is used to irrigate 29 acres of bermuda grass (Table XV).

The third crop to be irrigated is grain sorghum. In general, after the peanut acreage is irrigated at the high rate of water application, the next increments of water are used, first, to increase the irrigated acreage of bermuda grass, up to the minimum level of the conserving base acreage plus the cotton diversion acreage, and then to irrigate grain sorghum at the high rate of water application.

When the supply of water is very limiting, cotton production enters the optimum solutions of all five typical farms at the level of the allotment. When irrigation water is less limiting, cotton is substituted for irrigated grain sorghum production at the high rate of water application.

No general pattern is present with respect to wheat production, which is programmed only as a dryland alternative. When no irrigation water is available, wheat enters the optimum solutions of typical farms I, III, and V. When sufficient irrigation water is available, wheat is replaced by irrigated grain sorghum production in the typical farm organizations which were previously producing wheat. It should be noted that wheat certificate payments were included on 43 per cent of the yield of each acre. The program did not consider the possibility of planting only 43 per cent of the allotment and receiving the full certificate payments for which the farm is eligible. The organizations obtained may have contained some wheat if this option had been considered.

At the high levels of water supply, there is a switch of peanut production from the relatively high producing S_b soils to the less productive S_d soils. Peanuts are replaced by grain sorghum irrigated at the high rate of water application on the S_b soils. In fact, when water is no longer a limiting factor, the entire peanut enterprise is confined to the S_d soils irrigated at the high rate of water application for all typical farms. The programming results indicate that to obtain maximum profits, when water is not a limiting factor, farmers should use the high yielding L_b and S_b soils in producing grain sorghum. However, when water is very limiting the highest returns should be obtained by allocating the best soils to peanut production. These results suggest that, in fact, farmers in the area are doing the right thing because, under very limiting water supplies, they are actually using the best sandy soils for peanut production.

At the high levels of water supply all the L_d soils are used in bermuda grass production at the high rate of water application (Table X-XV). This is especially true when water is not a limiting factor.

The land use pattern is generally determined by the proportions of the different soils which the typical farms have, as well as by the basic acreage allotments of peanuts, cotton, wheat, and conservation base. In general, for any particular farm, under dryland conditions or very limiting supplies of water, the S_b soils would be used primarily in peanut production. The L_b soils would be used on cotton production first, and then on alfalfa or wheat production. The other soils would be taken by grain sorghum or bermuda grass production. As pointed out previously, at the high levels of irrigation water supply, or when water is not a limiting factor, peanut production is confined to the S_d

soils and bermuda grass to the L_d soils. The remaining soils are generally used on grain sorghum production.

When water is less limiting, only three crops remain in the optimum solutions: peanuts, bermuda grass, and grain sorghum at the high rate of water application in all typical farms, and dryland grain sorghum in four of them. The only exception to this occurs when three acres of irrigated alfalfa enter the optimum solution of typical farm IV when water is unlimiting.

Changes in Resource Requirements and Income

Tables VI through X also summarize the levels of labor and annual capital required by the optimum programs at the different levels of farm water supply. Both labor requirements and annual capital used increase for all typical farms with the increase in use of irrigation water. For typical farm I, the use of operator labor more than doubles from no irrigation to irrigation with an unlimited water supply, but it is not necessary to hire labor. For typical farm II, operator labor for full irrigation is more than double the amount required for the optimum dryland organization, and it is necessary to hire 22.46 hours.

Utilizing additional operator labor is sufficient to irrigate typical farm III for most levels of water supply. Only when irrigation water is almost unlimiting or unlimiting is it necessary to hire additional labor. With a supply of irrigation water of 2,352 acre inches, it is necessary to hire 56.31 hours of labor in the August-September period. When water is unlimiting it is necessary to hire 60.90 hours of additional labor in the same months. Typical farms IV and V require hired labor in addition to the available operator labor for all levels of water supply, as well as under dryland conditions, even though the total annual operator labor supply is not completely utilized. Typical farm IV uses 21.61 hours of hired labor under dryland conditions, and 622.99 hours at full irrigation. The optimum organization of typical farm V requires hiring 599.12 hours of labor under dryland conditions and 1,408.94 at full irrigation.

The increase in annual capital used is significant for all five typical farms as the supply of irrigation water increases. Percentage-wise, the increases in annual capital requirements are lower for the larger farms than for the smaller ones. Obviously, the absolute increases are greater for the larger farms (Tables VI-X). This arises because it is relatively more expensive for the smaller farms to introduce irrigation. The programming results also indicate that for greater supplies of irrigation water, there is a higher demand for other productive inputs like seed and fertilizers.

The increases in net returns which result from the changes in the supply of irrigation water are presented in Tables VI through X. Net returns increase with each additional increment of water for all typical farms. These figures show the net returns to land, operator's labor, equipment capital, management and overhead associated with a given level of irrigation development.

Water Values

As discussed in Chapter II, the simplex linear programming model provides estimates of the marginal value products of limiting resources as a by-product of getting an optimum solution. These marginal value products represent the amount by which total revenue would decrease if the availability of the resource were decreased by one unit, or the amount by which total revenue would increase if the availability of the resource were increased by one unit, all other conditions remaining constant. Marginal value products indicate possible gains in income through acquisitions of scarce or limiting resources. These marginal value products represent the maximum price a farmer can afford to pay for an additional acre-inch of irrigation water.

Figure 2 depicts the marginal value products of irrigation water obtained using variable resource programming. These values are shown for all levels of water supply for which an optimum organization is determined. Integration from zero to a given level of water supply indicates the total increase in income that would result from using that particular amount of water. If the value of this integral is greater than the annual fixed costs of the irrigation equipment, it would be profitable to irrigate at that particular level.

The problem handled by linear programming is one of how to maximize income from a given set of resources. The optimum solution that the model chooses is not necessarily one that yields the highest return to any one factor, but one that makes the most efficient use of all the fixed resources and yields the maximum returns subject to the limitations imposed by these resources. As the supply of any of the fixed resources changes, the optimum solution will tend to change. As pointed out previously, the values graphically depicted in Figure 2 indicate how much an additional acre-inch of water, used in combination with the other resources, would increase total returns.

Typical farm I shows a value of $11.67 per acre-inch for the first 72 acre-inches of irrigation water. This amount of water is enough to

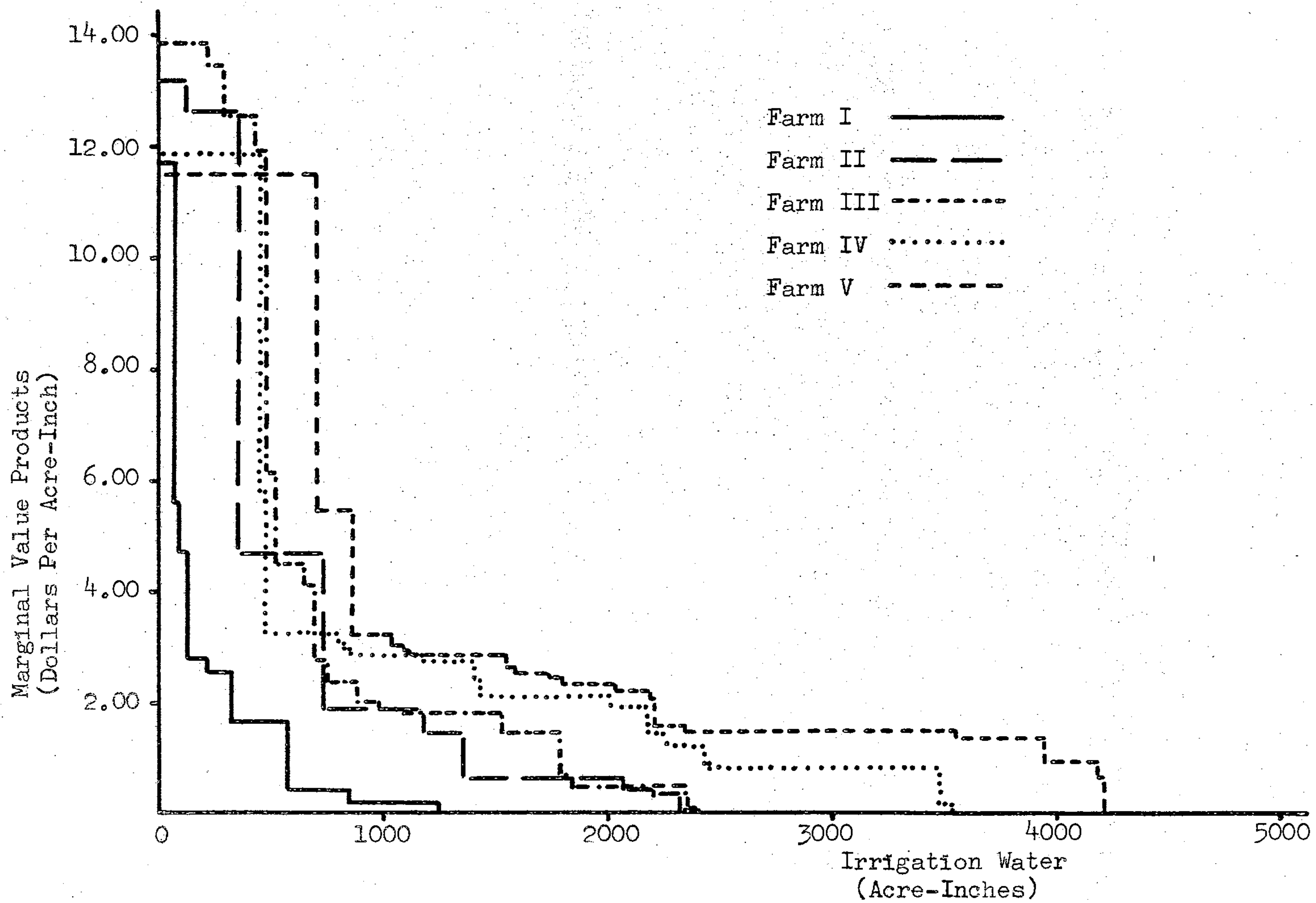

Figure 2. Marginal Value Products of Irrigation Water, Five Typical Farms

irrigate the peanut allotment at the intermediate rate of water application. Beyond this level, the marginal values of water for this farm are much lower. The amount of 1,251 acre-inches of water is all that can be profitably used by typical farm I and the value per acre-inch is zero for additional water. Typical farm II displays higher marginal values for water, at all levels of water supply, than typical farm I. Typical farm II has a marginal value per acre-inch of irrigation water of $13.19 for the first acre-inches of water. When this farm disposes of 729 acre-inches of water, it has as much as is necessary to irrigate the peanut allotment at the high rate of water application and the marginal value of the following acre-inch drops to $4.66. Beyond 2,423 acre-inches, water is no longer limiting for typical farm II and its value declines to zero.

Typical farm III exhibits the highest marginal value per acre-inch for the first increments of water. This indicates that this farm can utilize limited amounts of water more efficiently than any other farm. The value of water for this farm is $13.82 from zero to 216 acre-inches of irrigation water, drops to $11.89 when the peanut allotment has been irrigated at the intermediate level of water application, and falls to $4.50 when the peanut allotment has been irrigated at the high rate. With a water level of 2,375 acre-inches, water is no longer in short supply for this farm, and the marginal value of water drops to zero.

Both typical farms IV and V show smaller initial marginal values per acre-inch than either typical farm II or III. However, for higher levels of water supply, this situation is reversed. The value of water from zero to 450 acre-inches is $11.84 for typical farm IV. This amount of water irrigates the peanut allotment of this farm. Farm IV cannot increase net returns by utilizing more than 3,528 acre-inches per year. From zero to 705 acre-inches, water is worth $11.49 to typical farm V. Beyond this amount, additional water increases net returns by only $5.43 per acre-inch up to 879 acre inches. When typical farm V receives 4,206 acre-inches, all that can be profitably irrigated is being irrigated and the marginal value of irrigation water drops to zero.

The relationships depicted by the curves of Figure 2 are somewhat restrictive, in the sense that they are applicable only to farms of the type considered in this study. Furthermore, these relationships are normative in nature indicating what the farmer should do to maximize profits rather than what he will do. However, it is expected that in the long run farmers will tend to adjust to what the analysis indicates they should do, if they want to remain in business.

Average and Quasi Marginal Returns

Farmers are generally more familiar with the concepts of average and marginal returns than with the marginal value product concept; thus, it is perhaps more practical to analyze the changes in income, at alternative water supplies in terms of average and marginal returns per acre-inch of irrigation water.

Marginal return (or marginal revenue) of a given resource is the change in the firm's total returns resulting from a one-unit change in the use of the resource. For purposes of this study, quasi marginal returns of irrigation water are defined as additional returns per acre-inch resulting from a certain increase in the quantity of irrigation water used. More specifically, the quasi marginal returns are computed by dividing the increase in net returns from one level of irrigation to the next, by the respective increase in irrigation water used.

Table XVI shows the average and quasi marginal returns per acre-inch of water by farm type and levels of water use. Both the average and quasi marginal returns are greater for the first level of irrigation water than for the succeeding levels for all typical farms. For typical farm I, the first level irrigates the six acres of peanut allotment, and increases net income by $11.67 per acre-inch of water. For typical farm II, the first level irrigates nine acres of the peanut allotment and increases net returns by $13.31 per acre inch of water. For typical farm III, the first level irrigates 24 acres of the peanut allotment and increases net returns by $13.52 per acre-inch of water. For typical farm IV, the first level irrigates the 30 acres of peanut allotment and increases net returns by $10.63. And, for typical farm V the first level irrigates the 47 acres of peanut allotment and increases net returns by $10.28 per acre inch of water.

Typical farms II and III have the highest average returns per acre-inch for the second levels of irrigation water. These two are the only farms for which the first level of water is not sufficient to irrigate the full peanut allotment. In general, the relative size of the peanut allotment is the main determinant of the magnitude of the average returns. Typical farms II and III display the highest values of quasi marginal returns for successive increments of water. This is explained by the fact that these two farms have the highest peanut allotments in proportion to farm size.

The average returns indicate the average value of an acre-inch of water to the farm at a given level of irrigation development. The marginal returns and the marginal value product per acre-inch of

TABLE XVI

AVERAGE AND QUASI MARGINAL RETURNS[1] PER ACRE INCH OF WATER BY FARM TYPE AT SPECIFIED LEVELS OF WATER USE

Farm Type and Water Level	Average Returns	Quasi Marginal Returns[2]
Typical Farm I		
72.00	$11.67	$11.67
90.00	10.43	5.60
108.00	9.35	3.92
219.00	6.21	3.16
321.00	5.07	2.62
567.00	3.60	1.68
837.00	2.62	.57
1,251.00	1.81	.18
Typical Farm II		
108.00	13.31	13.31
348.00	12.24	11.76
729.00	8.45	4.99
1,173.00	5.96	1.88
1,353.00	5.36	1.45
2,073.00	3.72	.62
2,199.00	3.52	.44
2,315.00	3.37	.39
2,423.00	3.22	.07
Typical Farm III		
216.00	13.52	13.52
288.00	13.29	12.58
420.00	12.84	11.89
477.00	12.04	6.10
510.00	11.63	5.78
639.00	10.23	4.65
687.00	9.80	4.10
735.00	9.21	2.74
975.00	8.19	2.34
1,059.00	7.17	1.92
1,523.00	5.53	1.87
1,677.00	5.19	1.86
1,766.00	4.99	1.45
1,837.00	4.84	.62
2,352.00	3.88	.45
2,376.00	3.84	.13

TABLE XVI (Continued)

Farm Type and Water Level	Average Returns	Quasi Marginal Returns[2]
Typical Farm IV		
450.00	10.63	10.63
468.00	10.34	3.24
792.00	7.34	3.00
819.00	7.20	2.98
855.00	7.02	2.94
1,179.00	5.84	2.73
1,215.00	5.74	2.51
1,395.00	5.31	2.38
1,422.00	5.25	2.11
2,007.00	4.28	1.93
2,172.00	4.07	1.46
2,250.00	3.97	1.26
2,424.00	3.75	.90
2,442.00	3.73	.85
3,474.00	2.68	.19
3,528.00	2.64	.16
Typical Farm V		
705.00	10.28	10.28
879.00	8.88	3.21
1,035.00	8.00	3.04
1,089.00	7.65	2.98
1,101.00	7.70	2.86
1,538.00	6.26	2.63
1,592.00	6.13	2.51
1,733.00	5.83	2.48
1,785.00	5.73	2.32
2,025.00	5.31	2.19
2,181.00	5.08	2.06
2,199.00	5.05	1.57
2,337.00	4.83	1.46
3,534.00	3.65	1.34
3,939.00	3.37	.91
4,179.00	3.22	.66
4,206.00	3.20	.50

[1]Above variable costs of pumping the water.

[2]The figures in this column are obtained by dividing the increase in net returns from one level of irrigation to the next, by the respective increase in irrigation water used.

irrigation water are conceptually the same and indicate how much an additional acre-inch of irrigation water is worth to the farm. The quasi marginal returns presented in Table XVI are average values over a range or interval. That is, the quasi marginal returns are computed for a wider range than the marginal value products. This explains the slight differences between the marginal value products and the quasi marginal returns at comparable levels of irrigation water use.

Aggregate Primary Impact of Irrigation Development

The first task in attempting to determine the aggregate primary impact of irrigation development is to estimate the potential supply of irrigation water. Second, this aggregate supply of water is allocated to the individual farms. Third, the over-all potential primary effects are determined.

Potential Supply of Irrigation Water

The water stored in the sediment pools of the structures developed in association with the upstream flood protection program, provides a potential source of water which may be used for irrigation. The plan for Sugar Creek Watershed includes 43 retarding structures with an aggregate storage capacity of 5,642 acre-feet in the sediment pools (Table XVII). However, evaporation and seepage losses reduce considerably the amount of this water that actually could be utilized by farms for irrigation. Research conducted by Arnold on the Boggy Creek Watershed indicated that 46 per cent of this water would be lost

TABLE XVII

SEDIMENT POOL STORAGE CAPACITY OF THE FLOODWATER RETARDING STRUCTURES: SUGAR CREEK WATERSHED

Structure Number	Storage Capacity (Acre-feet)	Structure Number	Storage Capacity (Acre-feet)
1	99	22	207
2	118	23	51
3	115	24	272
4	406	25	188
4A	266	26	238
5	58	27	50
6	94	28	139
7	105	29	85
8	63	30	291
9	254	31	92
10	152	32	25
11	85	33	136
12	107	34	30
13	99	35	50
14	121	36	70
15	69	37	55
16	286	38	96
17	54	39	52
18	81	40	211
19	96	41	133
20	200	42	30
21	213		
Total			5,642

Source: Soil Conservation Service, USDA, _Work Plan Sugar Creek Watershed_ (Stillwater, 1959), pp. 41-44.

through evaporation.[4] Arnold's study also assumed that an additional 15 per cent would be lost from other diversions.

Assuming that an evaporation loss of 46 per cent, and other losses of 15 per cent occurred from structures in Sugar Creek Watershed, there would be an aggregate supply of 26,400 acre-inches of water available for irrigation in the combined sediment pool storage of all floodwater retarding structures in Sugar Creek Watershed. Anderson points out that the evaporation losses from the sediment pools would be reduced somewhat if the water was used for irrigation throughout the year rather than remaining in the sediment pools.[5] This would tend to make the estimate of 26,400 acre-inches of water available for irrigation conservative rather than inflated. Another factor making it conservative is that summer rain may refill the pool after some use of the water has been made. This amount of water would be sufficient to irrigate about 28 per cent of the peanut allotment acreage of the watershed at the low rate of water application, or about 17 per cent at the high rate. Hence, irrigation utilizing the water of the sediment pools seems to have a limited economic potential for the watershed.

Allocation of Potential Water Supply

This section deals with the allocation of the estimated supply of irrigation water to the individual farms of the watershed. A later

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[4] Adlai F. Arnold, "Potential Economic Effects of Upstream Flood Control and Irrigation Development: Boggy Creek Watershed, Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University, 1962), p. 89.

[5] Dale O. Anderson, "The Value of Irrigation Water in the Washita River Basin of Roger Mills County, Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University, 1965), p. 74.

section considers the allocation of alternative water supplies. Economic theory indicates that if one wants to maximize returns to a scarce resource, it should be allocated among its alternative uses in such a manner that those uses yielding higher returns are given priority. This principle is utilized in allocating the available water supply among farms and uses on the farm. Time does not permit determining the type of farms on which the floodwater retarding structures are located. Thus, it is assumed that they are randomly distributed among the farms, and that all size farms have access to the water of the detention pools.

Table XVIII is prepared using results from Table XVI, and presents aggregate annual increases in net returns from dryland to certain specified levels of water use by farm type. This table is intended to assist in the allocation of the available water supply to the individual farms. From the information contained in this table, it is evident that the 26,400 acre inches of water from the detention pools should be assigned to the group of farms of which typical farm III is representative. Each farm would use 420 acre-inches of irrigation water, and the aggregate increase in net returns would be $286,773. Any other allocation of the water supply would decrease aggregate total returns to the watershed. Thus, the annual increase in net returns to the watershed attributable to irrigation, using the water stored in the floodwater retarding structures, is $286,773.

Potential Primary Impact of Irrigation Development

The primary impact of irrigation development refers to the changes in income and resource use at the farm level that result from using the

TABLE XVIII

AGGREGATE ANNUAL INCREASE IN NET RETURNS FROM DRYLAND CONDITIONS TO SPECIFIED LEVELS OF WATER USE BY FARM TYPE

Farm Type and Water Level	Aggregate Irrigation Water Use (Acre Inches)	Aggregate Increase in Net Returns[1] (Dollars)
Typical Farm I		
72.00	38,304	147,109
90.00	47,880	200,255
Typical Farm II		
231.00	12,204	99,237
348.00	39,324	417,937
Typical Farm III		
216.00	13,176	135,801
288.00	17,568	191,058
420.00	25,620	286,773
477.00	29,097	307,988
510.00	31,110	319,625
639.00	38,970	356,226
687.00	41,907	368,229
735.00	44,835	376,279
Typical Farm IV		
450.00	18,450	167,605
468.00	19,188	169,998
792.00	32,472	209,966
819.00	33,579	213,266
855.00	35,055	217,606
1,179.00	48,339	253,924
1,215.00	49,815	257,626
Typical Farm V		
705.00	9,870	81,994
879.00	12,306	89,813
1,035.00	14,490	96,449
1,089.00	15,246	98,705
1,101.00	15,414	99,186
1,538.00	21,535	115,289
1,592.00	22,291	117,184
1,733.00	24,269	122,095

TABLE XVIII (Continued)

Farm Type and Water Level	Aggregate Irrigation Water Use (Acre Inches)	Aggregate Increase in Net Returns[1] (Dollars)
1,785.00	24,990	123,740
2,025.00	28,350	131,107
2,181.00	30,534	135,613
2,199.00	30,786	136,008
2,337.00	32,718	138,829
3,534.00	49,476	161,394

[1]Fixed annual costs of irrigation equipment have been deducted. Represents returns to land, operator's labor, management, and overhead.

water stored in the sediment pools for irrigation. The estimates of the primary impact presented in this section are based on the allocation of the available water supply discussed in the previous section. The "with" and "without" approach permits estimation of the magnitude of such changes. That is, an estimate of the change can be obtained by contrasting the aggregate levels of income and demand for productive inputs for the two situations.

Table XIX shows the present and projected demand for agricultural productive inputs. The basic classes of inputs considered are seed, fertilizer materials, feed, machinery, fuel and lubricants, and labor. The data for the present demand for seed, fertilizer materials, feed and fuel and lubricants are taken from the Census of Agriculture.[6] The figure for present demand for machinery was synthesized because no specific data could be found for this input class. The present demand for machinery was estimated assuming that the annual depreciation for a basic set of machinery represents the average annual demand for machinery for a given farm. Appendix B, Table LXIV, presents the calculation of the depreciation for a basic set of farm machinery. The aggregate estimate of demand for machinery is obtained by multiplying the figure for annual depreciation by the number of farms.[7]

The Census of Agriculture provides information on the amount of hired labor by counties, but the figures for expenditures on hired labor include family labor. Thus, the present demand for labor is

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[6]U. S. Department of Commerce, Bureau of the Census, United States Census of Agriculture, 1959 (Washington, 1961).

[7]The estimated present and projected values of this chapter refer to the entire area considered in association with the interdependence model rather than to the watershed.

TABLE XIX

PRESENT AND PROJECTED DEMAND FOR AGRICULTURAL PRODUCTIVE INPUTS

Item	Present Dollars	Projected Dollars	Change Dollars
Seed	1,768,543	1,772,007	3,464
Fertilizer Materials	4,994,186	5,007,896	13,710
Feed	7,188,455	7,188,796	341
Machinery[1]	12,884,400	12,908,517	24,117
Fuel and Lubricants[1]	5,511,868	5,526,709	14,841
Labor[2]	1,679,392	1,689,201	9,809
Totals	34,026,844	34,093,126	66,282

[1]The estimate of the change includes the increase in direct demand and the increase from custom charges.

[2]The amount of the change is a result of the increased amount of custom work required.

estimated using the figures for hired labor from the Census, and assuming that a regular worker worked 44 hours per week and received $1.00 per hour in the census year.

The projected demands for productive inputs are calculated by simply adding the value of the change in demand to the present quantity demanded. The projected demand for seed is estimated to increase by $3,564 annually as a result of using the water from the sediment pools for irrigation. The projected demand for fertilizer materials is estimated to increase by $13,710 annually. The demand for feed will increase by an insignificant $341. The annual machinery demand, including direct demand and demand from custom work, is projected to increase $24,117. The demand for fuel and lubricants is estimated to experience an increase of $14,841 per annum, considering both direct demand and demand from custom work. And, the demand for labor is projected to have an increase of $9,809 from custom work. The direct increase in demand for labor is met with available family labor. Assuming that a regular worker, works 44 hours per week, and is paid $1.50 per hour, the increased labor demand, resulting from using the water stored in the sediment pools for irrigation, is equivalent to three full-time workers. Appendix B, Table LXV, shows the breakdown of custom charges used in estimating the increase in demand for machinery, fuel and lubricants, and labor from custom charges.

In summary, the utilization of the water stored in the sediment pools of the floodwater retarding structures, if used for irrigation purposes, will cause an aggregate net increase in farm incomes of $286,773 annually. There will be an additional net increase in demand for productive inputs of $66,282 per annum (Table XIX). This figure includes an increase in demand for labor equivalent to three full-time workers. These increases are, however, only the primary or direct impact of irrigation development. The direct impact affects primarily the farming sector of the economy in consideration, but the primary impact also generates additional changes in the rest of the economy through multiplier effects. These changes are estimated in the following chapter.

CHAPTER IV

SECONDARY IMPACT OF IRRIGATION DEVELOPMENT

The theoretical interdependence model used in estimating the secondary impact of irrigation development is presented in Chapter II. This chapter describes the procedures used to estimate the parameters of the model and presents the results obtained.

Delimitation of the Geographic Area

The secondary impact of irrigation development is not confined to the specific area where it occurs, but is also felt in surrounding areas with which the producing and consuming units of the irrigated area have economic ties. It is necessary to consider this fact in attempting to delineate the area over which the secondary impact of irrigation development is felt. Economic linkages are particularly important between small agricultural areas and relatively large trade centers. The area considered in estimating the secondary impact of irrigation development includes the following counties: Blaine, Caddo, Canadian, Custer, Grady, Kiowa, and Washita. The selection of these counties is supported by previous work carried on by the Agricultural Extension Service of Oklahoma State University to determine community boundaries and neighborhoods. This investigation determined the extent of farmer's travel to obtain agricultural inputs and consumer goods and services. Since secondary data are used in this phase of the study, it is necessary to delineate the area in terms of counties instead of more specific geographic boundaries. All the counties included contain cities that may be considered important trade centers in the vicinity of the watershed. The city of Lawton in Comanche County is an important trade center for the area. However, this county is not included because much of its economic activity originates from a military base.

Basic-Derivative Multiplier Estimation

The data used in estimating the basic-derivative multipliers are obtained from the 1960 United States Census of Population.[1] The procedure used in developing the basic-derivative multipliers, involves calculation of location quotients and specialization ratios. The location quotients indicate the primary market orientation of industries in a given subject economy. The specialization ratios permit separating total employment into basic and derivative employment.

Location quotients are estimated for each of the 38 industries in the 1960 Census, in order to determine the probable market areas which industries in the subject economy might be serving. Two location quotients (LQ) are calculated for each industry. First, the area included in the second phase of this study (Blaine, Caddo, Canadian, Custer, Grady, Kiowa, and Washita Counties) is considered as the subject economy and the United States as a benchmark economy. Second, with the same subject economy, Oklahoma is taken as the benchmark economy.

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[1] United States Department of Commerce, Bureau of the Census, U. S. Census of Population: 1960. Vol. I, Part 38, Oklahoma (Washington, 1961).

Table XX presents the location quotients obtained as a result of these comparisons. LQ_1 corresponds to the comparison between the subject economy and Oklahoma, LQ_2 refers to the comparison between the subject economy and the United States. A location quotient greater than one for a particular industry indicates that the subject economy has specialized in this industry, in the sense that it exports part of this industry's product or service.

The values of the location quotients are also assumed to reveal the economy or market area which supports any specialization occurring in the subject economy.[2] For example, the two location quotients calculated for agriculture in Table XX are greater than one. This suggests that part of the employment in agriculture in the subject economy must be classified as basic. Some of the agricultural production is exported from the subject area. It can also be observed that the location quotient obtained with the United States as the benchmark economy is greater than the location quotient obtained when Oklahoma is considered as the benchmark economy (3.6874 and 2.5961, respectively). This indicates that the agricultural products exported from the subject area are more oriented to the United States market than to the Oklahoma market. In this case, the United States is selected as the benchmark economy with which the subject area should be compared to estimate the specialization ratio for agriculture, or the proportion of employment in agriculture which is supported by receipts with a source external to the subject economy. The same criterion is used in evaluating each of the other industrial classifications.

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[2]Thompson, pp. 61-62.

TABLE XX

EMPLOYMENT BY INDUSTRY GROUPS, LOCATION QUOTIENTS, SPECIALIZATION RATIOS, AND BASIC AND DERIVATE EMPLOYMENT

Industry Classification	Subject Area[1] Number (1)	Subject Area[1] % of Total (2)	Oklahoma Number (3)	Oklahoma % of Total (4)	U. S. Number (5)	U. S. % of Total (6)	LQ_1 (2)/(4)	LQ_2 (2)/(6)	Specialization Ratio %	Basic Employment	Derivative Employment
Agricultural	11,807	24.30	73,539	9.36	4,256,734	6.59	2.5961	3.6874	72.85	8,601	3206
Forestry and Fisheries	4	.01	319	.04	93,150	.14	.2500	.0714	.00	0	4
Mining	1,183	2.43	35,129	4.47	654,006	1.01	.5436	2.4059	58.41	691	492
Construction	3,625	7.46	56,693	7.21	3,815,937	5.90	1.0347	1.2644	20.87	757	2868
Manufacturing											
Furniture, and Lumber and Wood Products	66	.14	6,049	.77	1,067,252	1.65	.1818	.0848	.00	0	66
Primary Metal Industries	32	.07	3,938	.50	1,224,922	1.89	.1400	.5000	.00	0	32
Fabricated Metal Industries	62	.13	6,704	.85	1,291,709	2.00	.1529	.0650	.00	0	62
Machinery, except Electrical	192	.40	12,060	1.54	1,568,035	2.43	.2597	.1646	.00	0	192
Electrical Machinery, Equipment and Supplies	147	.30	4,367	.55	1,487,412	2.30	.5454	.1304	.00	0	147
Motor Vehicles and Motor Vehicle Equipment	39	.08	785	.10	841,861	1.30	.8000	.0615	.00	0	39
Transportation Equipment, except Motor Vehicle	304	.63	7,604	.97	976,837	1.50	.6495	.4200	.00	0	304
Other Durable Goods	636	1.31	9,710	1.24	1,370,661	2.12	1.0564	.6179	5.30	34	602
Food and Kindred Products	1,109	2.28	17,056	2.17	1,822,477	2.82	1.0507	.8085	4.65	52	1057
Textile Mill Products	7	.01	1,205	.15	954,036	1.48	.0667	.0067	.00	0	7
Apparel and Other Fabricated Textile Products	42	.09	4,122	.52	1,159,163	1.79	.1731	.0503	.00	0	42
Printing, Publishing, and Allied Products	386	.79	9,639	1.23	1,141,192	1.77	.6423	.4463	.00	0	386
Chemical and Allied Products	22	.05	2,371	.30	864,542	1.34	.1667	.0373	.00	0	22
Other Nondurable Goods (including not specified manufacturing)	240	.49	18,524	2.35	1,742,987	2.70	.2085	.1814	.00	0	240
Railroad and Railway Express Service	934	1.92	6,878	.88	941,214	1.46	2.1818	1.3151	51.31	479	455
Trucking Service and Warehousing	693	1.43	12,380	1.58	911,454	1.41	.9051	1.0142	1.15	8	685
Other Transportation	330	.68	12,996	1.65	887,245	1.37	.4121	.4964	.00	0	330
Communications	496	1.02	9,899	1.26	819,649	1.27	.8095	.8031	.00	0	496
Utilities and Sanitary Service	822	1.69	13,775	1.75	898,585	1.39	.9657	1.2158	17.83	147	675
Wholesale Trade	1,186	2.44	29,765	3.79	2,212,984	3.42	.6438	.7134	.00	0	1186
Food and Dairy Products Stores	1,271	2.62	21,422	2.73	1,689,688	2.61	.9597	1.0038	.01	0	1271
Eating and Drinking Places	1,961	4.04	25,253	3.21	1,801,667	2.79	1.2586	1.4480	30.92	606	1355
Other Retail Trade	5,493	11.31	88,724	11.29	6,088,296	9.42	1.0018	1.2006	16.68	916	4577
Finance, Insurance and Real State	1,180	2.43	29,133	3.71	2,694,630	4.17	.6550	.5827	.00	0	1180
Business Services	154	.32	5,976	.76	761,430	1.18	.4210	.2712	.00	0	154
Repair Services	845	1.74	13,858	1.76	849,298	1.31	.9886	1.3282	24.44	207	638
Private Households	1,423	2.93	21,911	2.79	1,916,964	2.97	1.0502	.9865	4.54	65	1358
Other Personal Services	1,637	3.37	28,346	3.61	1,941,530	3.00	.9335	1.1233	10.85	178	1459
Entertainment and Recreation Services	287	.59	5,574	.71	502,879	.78	.8310	.7564	.00	0	287
Educational Services, Government	2,609	5.37	40,885	5.20	2,537,388	3.93	1.0327	1.3664	26.88	701	1908
Educational Services, Private	439	.90	7,492	.95	856,545	1.33	.9474	.6767	.00	0	439
Other Professional and Related Services	2,601	5.35	51,197	6.52	4,183,913	6.47	.8205	.8269	.00	0	2601
Public Administration	2,931	6.03	55,432	7.05	3,202,890	4.96	.8553	1.2157	17.86	523	2408
Industry not Reported	1,386	2.85	35,238	4.48	2,608,085	4.03	.6362	.7072	.00	0	1386
TOTAL	48,581	100.00	785,948	100.00	64,639,247	100.00				13,965	34,616

[1] Includes Blaine, Caddo, Canadian, Custer, Grady, Kiowa and Washita Counties

Table XX contains the specialization ratios estimated for each of the industries using the formula given in Chapter II, page 41. The specialization ratio assumes that the combined employment of the subject and the benchmark economies in an industry is adequate to make both areas self-sufficient. For each area to be self-sufficient, each should have an employment level in the industry proportionate to its total employment. The difference between the actual level of employment and the estimated self-sufficient level of employment provides an estimate of the amount of employment in the particular industry, which is sustained by sales outside the subject economy.

For explanatory purposes, consider the following example. Assume that agricultural employment is 80 in the benchmark economy and 40 in the subject economy. Further, suppose that total employment is 400 in the benchmark economy and 100 in the subject economy. This means that agricultural employment represents 20 per cent and 40 per cent of total employment in the benchmark and subject economies, respectively. The location quotient for agriculture in the subject economy compared with the benchmark economy would be 2.00 (.40 divided by .20). If both economies had the same level of employment in agriculture as a per cent of total employment, the location quotient for agriculture in the subject economy would be 1.00, and this would imply that agriculture showed no greater concentration in the subject economy than in the benchmark economy. The location quotient of 2.00 for agriculture in the subject economy indicates specialization by agriculture in the subject economy. Were the two areas self-sufficient, the expected employment in agriculture would be 24 per cent in both economies, or 24 in the subject economy, and 96 in the benchmark economy.[3] It follows that the employment in agriculture, in the subject economy, supported by exports outside the region is equal to 16 (40 minus 24). The specialization ratio may be obtained directly from the formula introduced in Chapter II:

$$\text{Specialization Ratio} = \frac{S_1 - \frac{S_1 + B_1}{S_t + B_t}(S_t)}{S_1}$$

$$= \frac{40 - \frac{40 + 80}{100 + 400}(100)}{40}$$

$$= \frac{40 - 24}{40} = .40$$

which indicates that 40 per cent of agricultural employment in the subject economy is basic. This procedure was used to estimate the specialization ratios presented in Table XX.

From the specialization ratios calculated in Table XX, total employment in the different industry categories can be separated into basic and derivative. The specialization ratio for agriculture, for example, is 72.85 per cent, which implies that of the total employment in agriculture 72.85 per cent is basic and 27.15 per cent is derivative. Applying these percentages to total employment in agriculture, it is found that 8,601 persons employed in agriculture may be considered as

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[3] $\frac{80 + 40}{400 + 100} = \frac{120}{500} = .24.$

being in basic or export activities, and 3,206 may be considered as being in derivative activities. Following this procedure, the amount of basic and derivative employment in the rest of the industry groups is estimated (Table XX). Aggregating over all industry categories a total basic employment of 13,965, and a total derivative employment of 34,616 are estimated. Using these estimates, a basic derivative employment ratio or basic derivative multiplier of 2.48 is obtained. This ratio indicates that 248 persons employed in derivative industries are supported by 100 jobs in basic activities, according to 1960 data. This also implies that if the ratio of basic to derivative employment has remained constant since 1960, an increase of 100 jobs in agriculture will lead to an increase of 248 jobs in derivative activities.

The basic-derivative ratio might have changed during the last eight years, but more recent employment data to compute the ratio are not available. From 1950 to 1960 there was a reduction in agricultural employment in the area considered, and nonagricultural employment remained more or less stable. Thus, the ratio based on 1960 data is greater than the same ratio based on 1950 data. If the trend that existed during the 1950's persisted through the last eight years, it is probable that the basic-derivative ratio based on current data would be greater than the ratio computed for 1960. Consequently, it is expected that any error induced by the use of 1960 data is on the conservative side, i.e., it may tend to underestimate the amount of derivative employment resulting from an increase in basic employment.

A basic-total employment multiplier is computed by adding one to the basic-derivative ratio previously estimated, resulting in a basic-total employment multiplier of 3.48 for the subject economy. This multiplier indicates that for each 100 jobs created in basic activities, total employment increases by 348 jobs. This multiplier can be computed directly, dividing total employment by basic employment; i.e., 48,581 divided by 13,965, which yields 3.48. The basic employment-population multiplier is estimated by simply dividing total population by basic employment. This multiplier rests upon the assumption that there is a constant relationship between the labor force of a community and the size of the population which it supports. Using population data from the 1960 Census of Population and the level of basic employment estimated formerly, a basic employment-population multiplier of 10.67 is obtained.[4] This multiplier indicates that every 100 persons employed in basic industries support 1,067 persons, including themselves. Another ratio that can be estimated is the total employment-population ratio, which shows how many persons are supported by each job holder, regardless of which job he has. This ratio is estimated as 3.06 for the subject area, which indicates that each employed person supports 3.06 persons.

Regression Multipliers

Five of the multipliers included in the interdependence model discussed in Chapter II are estimated using regression analysis. Several sources of information are used in this part of the study. The main sources, however, are the United States Census of Population of 1950 and 1960, the United States Census of Business of 1948, 1954, 1958, and 1963, and

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[4] $\frac{\text{Total Population}}{\text{Basic Employment}} = \frac{149{,}001}{13{,}965} = 10.67.$

information compiled by the Research Foundation of Oklahoma State University.[5] Appendix B, Table LXIII, contains the data used in computing the regression multipliers. Both cross sectional data and time series data are used in estimating the regression coefficients. Fourteen observations, one for each of the seven counties included in the subject area for the years 1950 and 1960 are used. The coefficients obtained using least-squares regression are discussed in the following five sections.

Expenditure-Employment Multiplier

This multiplier relates employment in the wholesale, retail and services firms of the economy to the total volume of sales of these same firms. The functional relationship assumed in the model between these two variables is of the following form:

$$E_{wrs} = k_3 C_{wrs}$$

where E_{wrs} refers to employment in the wholesale, retail and service firms of the area, C_{wrs} is the volume of sales of these same firms, and k_3 is the coefficient that shows how changes in the volume of trade in the wholesale, retail and service firms affect employment in the same subsector. The estimated value of k_3 is $\hat{k}_3 = 0.1095$. Hence, the estimating form of the relationship is:

$$E_{wrs} = 0.1095\, C_{wrs} \;. \qquad R^2 = .965$$

$$(19.03\,{*}\,{*})$$

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[5] W. Nelson Peach, Richard W. Poole, and James D. Tarver. County Building Block Data for Regional Analysis: Oklahoma (Stillwater, 1965).

The number in parentheses is the t-value. The two asterisks indicate that the estimated coefficient is significantly different from zero at the 99 per cent confidence level. The R^2 value is the coefficient of determination which is equal to the proportion of the dependent variable variance "explained" by the linear influence of the independent variable. In this case, the R^2 value of .965 indicates that the least square regression of E_{wrs} on C_{wrs} accounts for 96.5 per cent of the variance in E_{wrs}. These interpretations are applicable to the t-values and R^2 values found in connection with each of the regression multipliers.

The estimated value of k_3, $\hat{k}_3$ = .1095, indicates that for every change of ten million dollars in the volume of trade in the wholesale, retail, and service firms, the level of employment in this subsector will change by 1,095 jobs in the same direction.

Population-Government Employment Multiplier

This multiplier indicates how changes in population influence the level of government employment. The functional relationship between these two variables is assumed to be as follows:

$$E_g = k_4 P$$

where E_g is government employment, including public administration at all levels, school teachers, and public service workers. P is total population, and k_4 is a population-government employment multiplier. The estimate of k_4 is $\hat{k}_4$ = 0.036. Thus, the estimating form of the equation is:

$$\hat{E}_g = 0.036\ P \qquad R^2 = .947$$

$$(15.28 * *)$$

The estimate of k_4 indicates that a change of 1000 in total population results in a change of 36 in government employment in the same direction.

Employment-Personal Income Multiplier

This multiplier shows how agricultural personal income is affected by changes in the total level of employment. The assumed functional relationship between these two variables is:

$$Y_a = k_5 E.$$

Where y_a represents agricultural personal income, E is total level of employment and k_5 is an employment-personal income multiplier. The estimate of k_5 is $\hat{k}_5 = 0.92$. The estimating form of the relationship is:

$$\hat{Y}_a = 0.92E \qquad R^2 = .916$$

$$(11.92 * *)$$

This suggests that for every change in total employment of 100, personal income to agriculture changes by $92,000 in the same direction.

Expenditure-Personal Income Multiplier

This multiplier indicates how personal income to employees and proprietors in the wholesale, retail, and service firms responds to changes in the volume of sales in these same firms. The functional relationship between these two variables is:

$$Y_{wrs} = k_6 C_{wrs}$$

where Y_{wrs} is personal income to wholesale, retail and service firms, C_{wrs} is total volume of trade in these firms, and k_6 is an expenditure-personal income multiplier. The estimate of k_6 is $\hat{k}_6 = 0.3045$. Hence, the estimating form of the equation is:

$$\hat{Y}_{wrs} = 0.3045\, C_{wrs} . \qquad R^2 = .98$$

$$(26.19 **)$$

This indicates that for every change of $1,000 in the volume of sales in the wholesale, retail and service firms, the level of personal income to the same subsector will change by $304.50 in the same direction.

Population-Government Personal Income Multiplier

This multiplier relates changes in governmental personal income to changes in population. The functional relationship assumed between these variables is the following:

$$Y_g = k_7 P$$

where Y_g is governmental personal income, P is total population and k_7 is a population-governmental personal income multiplier. The estimated value of k_7 is $\hat{k} = 0.1401$, and the estimating form of the equation is:

$$\hat{Y}_g = 0.1401\, P . \qquad R^2 = .519$$

$$(3.75 **)$$

The coefficient in this relationship indicates that a change of 1,000 in the level of population results in a change of $140,100 in governmental personal income.

Per Capita Consumption Expenditures

The last coefficient appearing in the interdependence model discussed in Chapter II is the per capita consumption of goods and services by the consumers of the study area. Olson estimates per capita consumption for southwestern Oklahoma based on information from the Bureau of Labor Statistics on nonfarm consumption expenditures.[6, 7] His estimate of k_8, $\hat{k}_8 = 1{,}260$, is used in this study. The area considered in Olson's study overlaps the area of the present study and no more recent statistical data exist that can be used to estimate this variable.

Empirical Interdependence Model

The theoretical interdependence model discussed in Chapter II is presented below with the estimates of its parameters.

$$\Delta E_d = 2.48\, \Delta E_b \qquad (1.0)$$

$$\Delta P = 10.67\, \Delta E_b \qquad (2.0)$$

$$E = E_a + E_{na} \qquad (3.0)$$

$$E = E_a + E_{mm} + E_{wrs} + E_g \qquad (3.1)$$

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[6] Olson, p. 64, and Appendix E.

[7] United States Department of Labor, Bureau of Labor Statistics. Consumer Expenditures and Income, Small Cities in the Southern Region, B.L.S. Report No. 237-75 (Washington, April, 1964).

$$\hat{E} = E_a + E_{mm} + \hat{E}_{wrs} + \hat{E}_g \qquad (3.2)$$

$$\hat{E} = E_a + E_{mm} + (E_{wrs} + .1095\,\Delta C_{wrs}) + (E_g + .036\,\Delta P) \qquad (3.3)$$

$$Y = Y_a + Y_{na} \qquad (4.0)$$

$$Y = Y_a + Y_{wrs} + Y_g + Y_{mm} + Y_r \qquad (4.1)$$

$$\hat{Y} = \hat{Y}_a + \hat{Y}_{wrs} + \hat{Y}_g + Y_{mm} + Y_r \qquad (4.2)$$

$$\hat{Y} = (Y_a + .92\,\Delta E) + (Y_{wrs} + .3045\,\Delta C_{wrs}) + (Y_g + .1401\,\Delta P) + Y_{mm} + Y_r \qquad (4.3)$$

$$C_{rs} = C_{pa} + C_c \qquad (5.0)$$

$$\hat{C}_{rs} = C_{pa} + \hat{C}_c \qquad (5.1)$$

$$\hat{C}_{rs} = C_{pa} + 1{,}260P\,. \qquad (5.2)$$

This model is used to project the secondary impact of irrigation development on employment, population, income, and expenditures within the area of influence of the development. The estimates made using this model are presented in the following section.

Projection of Secondary Impact of Irrigation Development

The secondary impact is based upon the primary adjustments in the agricultural sector, and the magnitude of the basic changes in the agricultural sector determines the proportion of the secondary impact. The estimates of the primary and secondary impact correspond to a maximum potential which could be realized only if the assumptions on which the study is based are met. That is, if profit maximization is actually the goal which determines farmers behavior, and if the allocation of the available water supply takes place in the manner described in Chapter III. Considering the size of the watershed and the limited amount of water available for irrigation from the detention pools, it is reasonable to expect that the total economic impact will actually be somewhat less than the numerical estimates presented.

Changes in Employment and Population

The increase in demand for labor, resulting from the utilization of the available water supply, was estimated in the previous chapter to be equivalent to three full-time workers. It is possible that part of this increase in labor use will produce products for consumption in the study area. However, it is reasonable to expect that for a basically agricultural area like this, any increase in agricultural production will be primarily oriented to the export market. Thus, the increase in farm employment is classified as increase in basic employment.

The first equation in the interdependence model introduced in Chapter II and estimated in Chapter IV is used to project the change in derivative employment that will result from the initial change in basic employment. The second equation serves to project the change in population resulting from the change in basic employment. Basic employment was estimated to increase by three farm workers, and the values of k_1 and k_2 were estimated as 2.48 and 10.67, respectively. Plugging these values into Equations (1.0) and (2.0), the following is obtained:

$$\Delta \hat{E}_d = k_1 \, \Delta E_b \qquad (1.0)$$

$$= 2.48\ (3)$$

$$= 7$$

and

$$\Delta \hat{P} = k_2 \Delta E_b \tag{2.0}$$

$$= 10.67\ (3)$$

$$= 32\ .$$

The coefficients k_1 and k_2 appearing in these two equations were estimated using economic base analysis. Again, the economic base approach to regional multiplier analysis has as its basic assumption the notion that a region or local area can economically exist and expand only because of its specialization in product output, part or all of which is exported and sold to other areas. Activities which produce primarily for the local economy (derivative activities) are dependent upon the basic activities. Changes in basic employment generate adjustments in the same direction in derivative employment and total population.

The total employment multiplier, which is equal to the basic-derivative multiplier plus one (or $k_1 + 1 = 3.48$), can be used to estimate directly the total change in employment (basic and derivative) resulting from an initial change in basic employment. Or,

$$\Delta \hat{E} = 3.48\ (3)$$

$$= 10\ .$$

These results indicate that the total impact on employment and population generated by the utilization of the water of the detention pools for irrigation, will be a net gain of ten full-time jobs (three in agriculture and seven in nonfarm activities), and an increase in population of 32 persons.

Equations (3.0) and (3.1) describe the composition of total employment in the study area. Equations (3.2) and (3.3) are used to project the future levels of employment. The change in employment in the wholesale, retail, and service subsector is assumed to be determined by the change in the volume of trade in the same subsector. The change in government employment is dictated by the change in population. The level of agricultural employment is a pre-determined variable in this part of the study, and the level of employment in the mining and manufacturing subsector is considered to remain constant. Equation (3.3) is also used to estimate the change in the volume of trade in the wholesale, retail, and service sales subsector. Thus, the variables ΔC_{wrs}, ΔE_{wrs}, and ΔE_g are estimated in the following manner where[8]:

$$E_a = 11,810 \text{ (pre-determined variable)}$$

$$E_{mm} = 4,475$$

$$E_{wrs} = 25,941$$

$$E_g = 6,362$$

$$\hat{E}_{wrs} = E_{wrs} + .1095\,\Delta C_{wrs} = 25,941 + .1095\,\Delta C_{wrs}$$

$$\hat{E}_g = E_g + .036\,\Delta P = 6,362 + .036\,(32)$$

$$= 6,362 + 1 = 6,363$$

And, $$\hat{E}_{na} = E_{na} + \Delta E_d$$

$$= 36,788 + 7 = 36,795.$$

Thus, $$E = E_a + E_{na} \qquad (3.0)$$

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[8]Appendix B, Table LXIII, contains information on the present values (1960) of the variables included in the interdependence model.

$$E = E_a + E_{mm} + E_{wrs} + E_g \quad (3.1)$$

$$\hat{E} = E_a + E_{mm} + (E_{wrs} + k_3 \Delta C_{wrs}) + (E_g + k_4 \Delta P) \quad (3.2)$$

$$= 11,810 + 4,475 + (25,941 + .1095 \Delta C_{wrs}) +$$

$$[6,362 + .036 (32)]$$

$$= 48,589 + .1095 \Delta C_{wrs}.$$

Since

$$\hat{E} = E_a + \hat{E}_{na}$$

$$= 11,810 + 36,785 = 48,595$$

then,

$$48,595 = 48,589 + .1095 \Delta C_{wrs}$$

$$.1095 \Delta C_{wrs} = 6$$

$$\Delta C_{wrs} = \$54,795$$

$$\Delta E_{wrs} = .1095 (54.795)$$

$$= 6.$$

Hence, government employment is estimated to increase by 1, and wholesale, retail, and service sales employment by six as a result of the initial changes in the farm sector. The total change in both the wholesale and retail trade is estimated to increase by $54,795 per year. In summary, the utilization of the water stored in the detention pools of the floodwater retarding structures for irrigation, is estimated to cause a total increase in population of 32 persons, a total increase in employment of ten jobs (three in agriculture; one in government; and six in wholesale, retail, and service sales activities), and an increase in the volume of trade (retail and wholesale) of $54,795.

Changes in Personal Income

Equations (4.0) and (4.1) describe the composition of total personal incomes of the study area. Personal income is defined as the income received by persons from all sources during the calendar year. It includes cash plus selected payments in kind without deducting personal income taxes and other direct taxes. Equation (4.3) is used to project the total level of personal income of the area. Personal income to mining and manufacturing and personal income to retired population are assumed to remain unchanged for purposes of this study. The change in personal income to agriculture is assumed to be influenced by the change in total employment ($\Delta Y_a = k_5 \Delta E$); the change in personal income to the wholesale, retail, and service sales subsector is assumed to be affected by the change in the volume of trade in the same subsector ($\Delta Y_{wrs} = k_6 \Delta C_{wrs}$); and the change in personal income to government is assumed to be determined by the change in total population ($\Delta Y_g = k_7 \Delta P$). The changes in total employment, total volume of trade, and total population were estimated above to be 10, \$54,795, and 32, respectively. Thus, total personal income can be estimated as follows:

$$Y = Y_a + Y_{na} \tag{4.0}$$

$$Y = Y_a + Y_{wrs} + Y_{mm} + Y_g + Y_r \tag{4.1}$$

$$\hat{Y} = \hat{Y}_a + \hat{Y}_{wrs} + Y_{mm} + \hat{Y}_g + Y_r \tag{4.2}$$

$$\hat{Y} = (Y_a + k_5 \Delta E) + (Y_{wrs} + k_6 \Delta C_{wrs}) + (Y_g + k_7 \Delta P) + Y_{mm} + Y_r \tag{4.3}$$

$$= [52,325,000 + 920(10)] + [83,207,000 + .3045\ (54,795)]$$

$$+ [35,064,000 + 140.1\ (32)] + 18,379,000 + 24,402,000$$

$$= (52,325,000 + 9,200) + (83,207,000 + 16,865) + (35,064,000$$

$$+ 4,483) + 18,379,000 + 24,402,000$$

$$= 213,407,368.$$

Total personal income, exclusive of the initial change in net farm incomes, is estimated to be \$213,407,368, which represents an increase of \$30,368 above the present level. Personal incomes to agriculture; to wholesale, retail, and service sales; and to government employees are projected to increase by \$9,200; \$16,685; and \$4,483, respectively, per year, as a result of using the water of the detention pools for irrigation.

Changes in Expenditures

Equations (5.0) and (5.1) indicate that the total level of expenditures in retail and service trade is composed of the demand for agricultural productive inputs and the demand for consumer goods and services. The demand for agricultural productive inputs was estimated to increase by \$66,282 in Chapter III and total population was estimated to increase by 32 persons in a previous section of this chapter. Using Equation (5.3), the projected level of expenditures is obtained:

$$C_{rs} = C_{pa} + C_{c} \tag{5.0}$$

$$\hat{C}_{rs} = C_{pa} + \hat{C}_{c} \tag{5.1}$$

$$\hat{C}_{rs} = C_{pa} + k_{8}P \tag{5.2}$$

$$\hat{C}_{rs} = 34,093,126 + 1260\ (149,033) \tag{5.3}$$

$$= 221,874,706.$$

The level of total expenditures in retail and service trade is expected to increase by \$106,602 annually. Of this, \$66,282 corresponds to the increase in demand for agricultural productive inputs, and \$40,320 to the increase in personal consumption expenditures in consumer goods and services.

The estimate of the change in the volume of trade in the wholesale, retail, and service sales in Equation (3.3) ($\Delta\hat{C}_{wrs}$ = 54,795) represents the increase in the volume of trade in the wholesale, retail, and service sales subsector of the study area. The estimate of the change in the volume of expenditures in the retail and service trade obtained from Equation (5.3), (\$106,602), corresponds to the increase in demand for agricultural productive inputs and the increase in demand for consumer goods and services. This last estimate includes only expenditures at retail and service establishments. Thus, one would expect the first estimate to be greater than the second. However, part of the retail and service establishments from which farmers and consumers buy may be located outside the study area. This leakage explains the nature of the discrepancy between the two estimates.

This chapter has dealt with the estimation of the interdependence model and the projection of the secondary impact of using the current supply of water for irrigation. The following chapter discusses the potential economic impact of irrigation development.

CHAPTER V

POTENTIAL ECONOMIC IMPACT OF IRRIGATION DEVELOPMENT

The basic objective of this study is to assess the potential economic impact of irrigation development. Chapter III presents the optimum organizations for typical farms of the study area under dryland and irrigated conditions, and shows the estimates of the primary effects of irrigation development. Chapter IV contains the estimates of the interdependence model parameters required to determine the secondary impact of irrigation development, and presents the numerical results. This chapter utilizes information developed in the two previous chapters to: (1) summarize the aggregate economic impact resulting from the utilization of water stored in the retention structures of Sugar Creek Watershed for irrigation purposes; (2) present estimates of primary and secondary benefits of irrigation development; and (3) consider alternative levels of irrigation water supply and analyze the potential economic impact of using them for irrigation.

Economic Potential of Irrigation Development

It was estimated in Chapter III that the primary impact would consist of an increase in aggregate net farm income of $286,773 per year, and an increase in aggregate demand for agricultural productive inputs of $66,282 annually. This increase in demand for productive inputs comprises an increase in demand for labor equivalent to three full-time jobs per year.

By using the interdependence model estimated in Chapter IV, it is possible to trace the secondary effects or secondary impact of irrigation development. It was found in Chapter IV that the initial increase in employment in the farm sector would create seven additional jobs in the nonfarm economy. One more person would be employed in governmental activities, and six additional workers would be working in wholesale, retail, and service sales activities. Population was estimated to increase by 32 persons. Total personal income of the study area is projected to increase by $30,368 as a result of the secondary effects. And, the total volume of expenditures in retail outlets and service firms is estimated to increase by $106,602 per year. Table XXI summarizes these results.

Estimates of Primary and Secondary Benefits

The change in aggregate net farm income obtained in Chapter III is equivalent to what is referred to in the literature on water resource development projects as primary benefits; i.e., the value of the products or services directly resulting from the project, net of all non-project costs incurred in their realization (See Chapter II). Thus, the primary or direct benefits of utilizing the water of the detention pools of the floodwater retarding structures of Sugar Creek Watershed are estimated to be $286,773 annually.

Secondary benefits of watershed development were defined in Chapter II as the increase in net incomes or other beneficial effects resulting from activities stemming from or induced by the project. In spite of the controversy which exists with respect to the procedures

TABLE XXI

PRESENT AND PROJECTED LEVELS OF AGGREGATE ECONOMIC ACTIVITY[1]

Item	Unit	Present[2]	Projected	Change
Total Population	No.	149,001	149,033	32
Total Employment	No.	48,585	48,595	10
Agricultural	No.	11,807	11,810	3
Nonagricultural	No.	36,778	36,785	7
W. R. and S.	No.	25,941	25,947	6
Mining and Mfg.	No.	4,475	4,475	0
Government	No.	6,362	6,363	1
Total Personal Income	$000	213,377	213,724	317
Agricultural	$000	52,325	52,621	296
Nonagricultural	$000	161,052	161,073	21
W. R. and S.	$000	83,207	83,224	17
Mining and Mfg.	$000	18,379	18,379	0
Government	$000	35,064	35,068	4
Retired Population	$000	24,402	24,402	0
Total Volume of Expenditures in Retail and Service Trade	$000	221,769	221,875	106
Ag. Prod. Inputs	$000	34,027	34,093	66
Consum. Expendit.	$000	187,742	187,782	40

[1]Present and projected levels of aggregate population, employment, personal income, and expenditures; and changes resulting from using the water of the detention pools of the floodwater retarding structures of Sugar Creek Watershed for irrigation.

[2]1960.

that should be used in estimating secondary benefits, and with the current diversity of opinion on the legitimacy of the inclusion of secondary benefits in project justification, the Bureau of Reclamation has continued to include indirect benefits in its analyses of irrigation projects. The indirect benefits are calculated from summaries of farm budget data representing future conditions with and without the project. These benefits are computed using percentage factors to selected items of gross farm income and expenses.

The secondary or indirect benefits calculated in this manner, are an estimate of the impact of an irrigation project on the nonagricultural sector of the economy. It has been argued that since indirect benefits will accrue from one of several possible reclamation projects from a national point of view secondary benefits normally have very little significance in economically justifying a resource development project. However, from the local point of view, such benefits are real and contribute to the growth of the local economy.

Personal income constitutes the principal measure for assessing secondary benefits because it shows how economic activity pays off, and because it is a good index of the economic welfare of the people. The estimate of the change in total personal income provides a measure of the change in wages and salary payments and other forms of income, associated with irrigation development, to the residents of the area. This may be considered to be the monetary value of the local indirect benefits of irrigation development. Thus, the local secondary benefits, resulting from the use of the water stored in the detention pools of the floodwater retarding structures of Sugar Creek Watershed for irrigation, are estimated to be $30,368 per year. Hence, the total benefits of irrigation development (primary and secondary) are estimated to be $317,141 annually.

Allocation of Alternative Water Supplies

The above analysis has been concerned with allocating the actual supply of water available in the watershed, and estimating the primary and secondary effects that would result from its use in irrigation. The analysis has shown that the economic potential of irrigation development in Sugar Creek Watershed is limited by the quantity of water stored in the floodwater retarding structures. Although cost estimates of increasing the water storage capacity of the structures were not available, some of these structures do have potential for this kind of development. This section discusses the primary and secondary economic impact of utilizing somewhat larger quantities of water than are currently available. The purpose of this analysis is to examine the economic potential to farmers of developing additional storage for irrigation by entering into cost-sharing agreements with the Federal Government to develop the additional storage capacity.

Three alternative levels of water supply are considered: 33,000; 39,600; and 52,800 acre inches, which correspond to 125 per cent, 150 per cent, and 200 per cent of the supply presently available. The following estimates of primary and secondary benefits are made for these three water levels using the procedures discussed previously.

Benefits From Increasing the Water Supply 25 Per Cent

A supply of 33,000 acre inches of water would be allocated to the group of farms of which typical farm III is representative. Each farm would use 510 acre-inches of irrigation water, and the aggregate increase in net farm returns would be $319,625 (Table XVIII). This increase in net farm income, together with an increase in demand for agricultural productive inputs of $66,937 (Table XXII) gives an estimate of the primary effects of using this supply of water for irrigation. The increase in demand for agricultural productive inputs comprises an increase in demand for labor equivalent to four full-time workers. Using the interdependence model results in the following estimates of the secondary impact. Derivative employment is estimated to increase by 10 workers (2.48 x 4), and total employment increases by 14 full-time jobs (3.48 x 4). Population is estimated to increase by 43 persons (10.67 x 4). The changes in employment in the nonfarm sector caused by the projected changes in the farm sector are estimated using Equation (3.3) of the interdependence model. The level of employment in the wholesale, retail, and service sales subsector is projected to increase by eight, and the level of employment in the government subsector is estimated to increase by two. Similarly, the volume of trade in the wholesale, retail, and service sales subsector is projected to increase by $73,059.[1]

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[1]
$$\hat{E} = E_a + E_{mm} (E_{wrs} + .1095 \Delta C_{wrs}) + (E_g + .036 \Delta P) \qquad (3.3)$$
$$= 11,811 + 4,475 + (25,941 + .1095 \Delta C_{wrs}) + [6,362 + .036 (43)]$$
$$= 48,591 + .1095 \Delta C_{wrs}$$
$$\hat{E} = E_a + \hat{E}_{na}$$
$$= 11,811 + (36,778 + 10)$$
$$= 48,599$$
$$48,599 = 48,591 + .1095 \Delta C_{wrs}$$
$$\Delta C_{wrs} = 73,059$$
$$\Delta \hat{E}_{wrs} = .1095 (73.059)$$

TABLE XXII

PRESENT AND PROJECTED DEMAND FOR AGRICULTURAL PRODUCTIVE INPUTS AT ALTERNATIVE LEVELS OF AGGREGATE WATER SUPPLY

	Present	33,000 Acre-Inches		39,600 Acre-Inches		52,800 Acre-Inches	
Item	Demand	Projected	Change	Projected	Change	Projected	Change
				Dollars			
Seed	1,768,543	1,761,764	3,221	1,772,771	4,228	1,775,129	6,586
Fertilizer Materials	4,994,186	5,001,298	7,112	5,009,649	15,463	5,020,662	26,476
Feed	7,188,455	7,188,455	0	7,188,455	0	7,188,796	341
Machinery[1]	12,884,400	12,910,519	26,119	12,935,253	50,853	12,953,239	68,839
Fuel and Lubricants[1]	5,511,868	5,530,944	19,076	5,525,599	13,731	5,538,086	26,218
Labor[2]	1,679,392	1,690,801	11,409	1,691,141	11,749	1,694,436	15,044
Totals	34,026,844	34,093,781	66,937	34,122,868	96,024	34,170,348	143,504

[1]The estimate of the change includes the increase in direct demand and the increase from custom charges.

[2]The amount of the change is a result of the increased amount of custom work required.

Equation (4.3) is used to project the personal income of the area. Total personal income is projected to increase by $41,150. Personal incomes to agriculture; to wholesale, retail, and service sales; and to government are projected to increase by $12,880; $22,246; and $6,024, respectively. Total personal income is estimated to reach a level of $213,418,150 exclusive of the initial increase in net farm incomes.[2]

Equation (5.3) permits projecting the level of expenditures of the area. The demand for agricultural productive inputs was estimated to increase by $66,937 per year. Using Equation (5.3), the demand for consumer goods and services is projected to increase $54,180 annually. Thus, the volume of expenditures in retail and service trade is estimated to increase by $121,117 per year.

$= 8$

Thus, $\Delta E_g = 2$

$\Delta E_{wrs} = 8$

$\Delta C_{wrs} = \$73,059.$

[2] $$\hat{Y} = (Y_a + k_5\,\Delta E) + (Y_{wrs} + k_6\,\Delta C_{wrs}) + (Y_g + k_7\,\Delta P) + Y_{mm} + Y_r \qquad (4.3)$$

$$= [52,325,000 + 920\ (14)] + [83,207,000 + .3045\ (73,059)] + [35,064,000 + 140.1\ (43)] + 18,379,000 + 24,402,000$$

$$= 213,418,150$$

Thus, $\Delta Y = 41,150$

$\Delta Y_a = 12,880$

$\Delta Y_{wrs} = 22,246$

$\Delta Y_g = 6,024.$

Benefits From Increasing the Water Supply 50 Per Cent

A supply of irrigation water of 39,600 acre-inches would be allocated to the group of farms from which typical farm II was selected as representative. This allocation would increase aggregate net farm returns by $417,937 (Table XVIII). The aggregate increase in demand for agricultural productive inputs would be $96,024 per year (Table XXII), of which the increase in demand for labor is equivalent to four full-time workers. Since the basic changes in employment and population are the same for the supplies of 33,000 and 39,600 acre-inches of water, the secondary effects are also equivalent.

Benefits From Increasing the Water Supply 100 Per Cent

A supply of 52,800 acre-inches of water would be allocated in the following manner to maximize aggregate net farm income for the area: the typical farm II group would receive 39,324 acre-inches, and the typical farm III group would get 13,176 acre-inches. Each of the farms in group II would use 348 acre-inches. This allocation would increase aggregate net farm returns to the watershed by $553,739 per year (Table XVIII). The aggregate demand for agricultural productive inputs is estimated to increase by $143,504 annually (Table XXII). This increase in demand comprises an increase in demand for farm labor equivalent to five full-time jobs.

The secondary effects are projected using the flow or interdependence model. The original change in labor causes an increase in derivative employment of 12 (2.48 x 5). Thus, total employment is projected to increase by 17 jobs (or 3.48 x 5), and total population by 53 persons (10.67 x 5). The change in employment in wholesale, retail, and service sales, and the change in government employment are projected using Equation (3.3). This equation also permits one to estimate the change in the total volume of trade (retail and wholesale) in the area. Wholesale, retail, and service sales employment is expected to increase by 10; government employment is projected to increase by two; and the total volume of trade in the wholesale, retail, and service sales subsector is estimated to increase by $91,324 per year.[3]

Equation (4.3) is used to project the changes in personal income. The changes in total personal income; personal income to agriculture; personal income to wholesale, retail, and service sales; and personal income to government are estimated to increase by $50,873; $15,640; $27,808; and $7,425, respectively, per year. The total level of personal income is estimated to be $213,427,873, exclusive of the original

---

[3]
$$
\begin{aligned}
\hat{E} &= E_a + E_{mm} + (E'_{wrs} + .1095\Delta C_{wrs}) + [E_g + .036\ (53)] \qquad (3.3)\\
&= 11,812 + 4,475 + (25,941 + .1095\Delta C_{wrs}) + (6,362 + 2)\\
&= 48,592 + .1095\Delta C_{wrs}\\
\hat{E} &= E_a + \hat{E}_{na}\\
&= 11,812 + 36,790\\
&= 48,602\\
48,602 &= 48,592 + .1095\ \Delta C_{wrs}\\
\Delta C_{wrs} &= 91,324\\
\Delta E_{wrs} &= .1095\ (91.324)\\
&= 10
\end{aligned}
$$

Thus,

$$
\begin{aligned}
\Delta E_{wrs} &= 10\\
\Delta E_g &= 2\\
\Delta C_{wrs} &= \$91,324.
\end{aligned}
$$

increase in net farm incomes.[4]

The demand for agricultural productive inputs was estimated to increase by \$143,504. From Equation (5.3), the total level of expenditures in consumer goods and services is projected to increase by \$66,780 (1,260ΔP), and the total volume of retail and service trade is projected to be \$221,978,388 (an increase of \$210,284 per year). Table XXIII summarizes the results for the three alternative water levels considered.

Economics of Increasing the Water Supply

The increase in net returns resulting from incrementing the supply of water for irrigation from the amount currently available to 33,000 acre-inches would be \$32,852 per year. This indicates that farmers could pay up to \$4.98 per acre-inch of water used per year. The present value of the stream of net returns per acre-inch, discounted for 12 years (the assumed life of the irrigation system) at seven per cent is \$39.55. Thus, the maximum amount farmers could pay for developing this additional storage capacity would be \$39.55 per acre-inch of water

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[4]
$$\hat{Y} = [52,325,000 + 920(\Delta E)] + [83,207,000 + .3045\,(\Delta C_{wrs})] + [35,064,000 + 140.1\,(\Delta P)] + 18,379,000 + 24,402,000 \quad (4.3)$$

$$= [52,325,000 + 920\,(17)] + [83,207,000 + .3045\,(91,324)] + [35,064,000 + 140.1\,(53)] + 18,379,000 + 24,402,000$$

$$= 213,427,873$$

Thus,

$$\Delta Y = \$50,873$$
$$\Delta Y_a = 15,640$$
$$\Delta Y_{wrs} = 27,808$$
$$\Delta Y_g = 7,425.$$

TABLE XXIII

PRESENT AND PROJECTED LEVELS OF AGGREGATE ECONOMIC ACTIVITY AT ALTERNATIVE LEVELS OF AGGREGATE WATER SUPPLY[1]

Item	Unit	Present[2]	33,000 Acre Inches		39,600 Acre Inches		52,800 Acre Inches	
			Projected	Change	Projected	Change	Projected	Change
Total Population	No.	149,001	149,044	43	149,044	43	149,054	53
Total Employment	No.	48,585	48,599	14	48,599	14	48,602	17
Agricultural	No.	11,807	11,811	4	11,811	4	11,812	5
Nonagricultural	No.	36,778	36,788	10	36,788	10	36,790	12
W.R. & S.	No.	25,941	25,949	8	25,949	8	25,951	10
Mining & Mfg.	No.	4,475	4,475	0	4,475	0	4,475	0
Government	No.	6,362	6,364	2	6,364	2	6,362	2
Total Personal Income	$000	213,377	213,738	361	213,836	459	213,981	604
Agricultural	$000	52,325	52,658	333	52,756	431	52,894	569
Nonagricultural	$000	161,052	161,080	28	161,080	28	161,087	35
W.R. & S.	$000	83,207	83,229	22	83,229	22	83,235	28
Mining & Mfg.	$000	18,379	18,379	0	18,379	0	18,379	0
Government	$000	35,064	35,070	6	35,070	6	35,071	7
Retired Population	$000	24,402	24,402	0	24,402	0	24,402	0
Total Volume of Expenditures in Retail and Service Trade	$000	221,769	221,890	121	221,919	150	221,978	209
Ag. Prod. Inputs	$000	34,027	34,094	67	34,123	96	34,170	143
Consum. Expenditures	$000	187,742	187,796	54	187,796	54	187,808	66

[1]Present and projected levels of aggregate population, employment, personal income and expenditures; and changes resulting from using alternative levels of aggregate water supply for irrigation.

[2]1960.

available at the pump.

If the supply of water for irrigation is increased, from the amount currently available to 39,600 acre-inches, net returns would increase by $131,164 annually. This implies that farmers could pay up to $9.94 per acre-inch of water used per year. The present value of the stream of net returns per acre-inch, discounted for 12 years at seven per cent, would be $78.95. Hence, farmers could pay a maximum of $78.95 per acre-inch of water available at the pump, for developing this additional capacity. Farmers can pay more per acre-inch of water for developing the second level of additional capacity because the increased amount of water available per farm permits utilizing the irrigation systems more efficiently. That is, the surplus above the lump sum of annual fixed costs is greater for the second level of water used per year than for the first.

Increasing the supply of irrigation water from the quantity presently available to 52,800 acre-inches would result in an increase of net farm returns of $266,966. This means that farmers could pay up to $10.11 per acre-inch of water used per year. The present value of the stream of net returns per acre-inch, discounted for 12 years at seven per cent, would be $80.30. Thus, the maximum amount farmers could pay for developing this additional storage capacity would be $80.30 per acre-inch of water available at the pump.

This section has dealt with the estimation of the potential economic effects of using alternative supplies of water for irrigation. The costs of adding to the aggregate storage capacity would have to be compared with the potential economic benefits in order to assess the true economic impact of such developments. The Soil Conservation

Service could provide cost estimates of adding to the water storage capacity, and furnish information about which structures offer the best possibilities. With these estimates and the kind of analysis presented in this section, a decision could be reached about the profitability of such an endeavor, and about the most desirable aggregate storage capacity to develop. Farmers could use the procedures followed in the three examples above to determine how much they could afford to pay for any additional capacity. Of course, this kind of project could be undertaken only if institutional arrangements permit, and if the farmers are willing to share not only the interest and the benefits, but also the costs.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Using the water stored in the floodwater retarding structures in Sugar Creek Watershed for irrigation offers area farmers a potential to increase their net returns. Since irrigation development stimulates off-farm economic activity, this economic potential is not restricted to the farm sector. The over-all purpose of this study was to present estimates of the importance of irrigation development to the various groups of the local economy. This chapter is divided into three parts: objectives and procedures, findings and conclusions, and implications. The first part restates the objectives of the study and describes the procedures used to fulfill the objectives. The second section presents the numerical results and draws some conclusions based on these results. The last portion discusses the implications of the study.

Objectives and Procedures

The major objective of this study was to determine the primary and secondary impact resulting from the use of water in the Sugar Creek Watershed floodwater retention structure sediment pools for irrigation. The specific objectives were to: (1) develop optimum farm organizations for representative farms in the watershed, under alternative levels of water supply; (2) determine the value of irrigation water to the individual farms; (3) estimate the changes in farm income and resource use arising from irrigation development; (4) develop a model that would estimate the effect of the irrigation development on employment, population, and business activity in the community; (5) estimate the secondary benefits of irrigation development for the water supply currently available; and (6) estimate the primary and secondary impact of developing larger quantities of water.

Five typical farms were defined using information from a sample of farms in the watershed. These farms were designed to reflect physical and institutional farm resource situations common to the area. A description of the typical farms is presented in Chapter III, Table IV.

Linear programming was used as the operational technique for estimating the net returns and allocation of resources for the representative farms. Variable resource programming, allowing the supply of water available per farm to vary from zero to an unlimiting amount, was used to determine the optimum farm organizations at alternative levels of water supply, the value of irrigation water to the individual farms, and the changes in income and resource use arising from irrigation development.

Input-output data for the programming analysis were obtained from several sources. The yield estimates and cropping systems were obtained from county extension personnel, and staff members of the Departments of Agricultural Economics and Agronomy. Machinery costs were based on data developed from other southwestern Oklahoma studies, and price assumptions approximate current prices paid and received by farmers of the study area. The crop and livestock enterprises considered were those currently being used in the watershed. Appendix A contains the crop and livestock budgets prepared for this study.

The allocation of the available water supply among farms and uses on the farm was based on the economic principle which states that if one wants to maximize returns to a scarce resource, it should be allocated among its alternative uses in such a manner that those uses yielding higher returns are given priority.

The aggregate primary impact of irrigation development was estimated by determining the changes in income and resource use with and without irrigation for the particular farms, and then aggregating for the whole area. The change in income calculated in this manner may be considered an estimate of the primary benefits of irrigation development.

An economic interdependence model was designed to represent the intersectoral linkages of the local economy. This model was used to predict the effects that the initial changes in the farm sector, arising from irrigation development, would impose on the rest of the economy. The model consists of a set of five basic equations and their estimating forms. The first two equations of the model are functional relationships indicating how changes in basic employment affect derivative employment and population. The other equations describe the composition of total employment, total personal income and expenditures in the area of study. Two of the coefficients in the model are estimated using economic base analysis and five of the coefficients are estimated using regression analysis. These seven coefficients represent multipliers of different kinds indicating how changes in one variable affect another variable. The last coefficient in the model is the per capita consumption of goods and services in the study area. The methodology involved in economic base analysis consists of an estimation of a ratio of some quantifying measure of the derivative to basic industries. Basic industries are those which produce goods all or part of which are sold in external markets. Derivative industries are those which produce goods and services primarily for the local consumers.

The interdependence model was used to project the secondary impact of irrigation development on employment, population, personal income, and expenditures within the area of influence of the development. The estimate of the change in total personal income provides a measure of the change in wages and salary payments and other forms of income accruing to the residents of the area as a result of irrigation development. This may be considered to be the monetary value of the local indirect or secondary benefits of irrigation development.

The procedures outlined above were used to estimate the primary and secondary impact of using the water currently available in the sediment pools of the floodwater retarding structures for irrigation. They were also used to estimate the primary and secondary impact of developing larger quantities of water.

Findings and Conclusions

The relative amounts of land on the five typical farms used in the programming analysis were as follows: typical farm I, 139 acres of total land, 94 acres of cropland and 38 acres of rangeland; typical farm II, 347 acres of total land, 202 acres of cropland, and 128 acres of rangeland; typical farm III, 480 acres of total land, 291 acres of cropland, and 165 acres of rangeland; typical farm IV, 680 acres of total land, 390 acres of cropland, and 256 acres of rangeland; and typical farm V, 1,020 acres of total land, 623 acres of cropland, and 346 acres of rangeland.

Linear Programming Results

Of all the activities programmed, peanuts and grain sorghum were the only crops to enter all optimum farm organizations. One feeder cattle enterprise based on native range or bermuda pasture also entered all plans. Under dryland conditions, the optimum plans for each of the typical farms included peanuts, cotton, grain sorghum, and steers. All typical farms with the exception of typical farm II, also included alfalfa to satisfy the conserving base acreage restriction, and to utilize the minimum cotton diversion acreage. Typical farm II complied with the conserving base restriction with the inclusion of bermuda grass. Irrigation water was initially allocated to peanuts on each of the typical farms. It was more profitable to irrigate fewer acres at the high level of water application and plant the remainder of allotment to dryland peanuts than to irrigate more acres at a lower level. Only after the peanut allotment had been irrigated at the high rate did other crops enter the solutions as irrigated alternatives.

The second crop to be irrigated with the limited amount of water was bermuda grass. The higher acreage of bermuda grass was utilized by an increased number of steers. As water became less limiting, irrigated grain sorghum entered each of the solutions. When water was no longer a limiting factor, five activities remained in the optimum plans: irrigated peanuts, irrigated bermuda grass, irrigated grain sorghum, dryland grain sorghum, and steers on native range and bermuda grass. One exception was that farm I did not have any dryland sorghum.

A second exception was that the organization of typical farm IV contained three acres of irrigated alfalfa. All the irrigated activities came in at the high rate of water application.

The land use pattern was generally determined by the proportions of the different soils which the typical farms had, as well as by the basic acreage allotments of peanuts, cotton, wheat, and conserving base. The analysis indicated that to obtain maximum profits, when water is not a limiting factor, farmers should use the high yielding L_b and S_b soils in producing grain sorghum. However, when water is very limiting the highest returns should be obtained by allocating the best sandy soils to peanut production and the best loamy soils to cotton production.

The marginal value products of irrigation water declined with increases in water availability. Typical farm III showed the highest values of water for very limiting levels of water supply. However, typical farm V had higher values than any other farm for high levels of water supply. This indicates that typical farm III can use limited amounts of water more efficiently than the other farms considered, while typical farm V utilizes large amounts of water more efficiently.

Both labor requirements and the use of annual capital increased for all typical farms with the increase in use of irrigation water. However, utilizing additional operator labor was sufficient to irrigate typical farms I and II at all levels of water supply, and for most levels of irrigation of typical farm III. Typical farms IV and V required hired labor in addition to the available operator labor for all levels of water supply as well as under dryland conditions.

Primary Impact of Irrigation Development

The aggregate primary impact of irrigation development refers to the changes in aggregate farm income and demand for agricultural productive inputs that result from using the water of the sediment pools for irrigation. The combined sediment pool storage capacity of all floodwater retarding structures in Sugar Creek Watershed is 67,704 acre-inches. Of this amount, it was estimated that 26,400 acre-inches would be available for irrigation after deduction for evaporation and other losses. This supply of water was allocated among the farms of the watershed resulting in an aggregate increase in net returns to the watershed of $286,773, and an aggregate increase in demand for agricultural productive inputs of $66,282 per year. The increase in aggregate farm income may be considered a measure of the primary benefits of irrigation development.

Secondary Impact of Irrigation Development

The results of this study indicated that using the water stored in the sediment pools of the floodwater retarding structures for irrigation would result in a net increase of 10 full-time jobs per year (three in agriculture; one in government; and six in wholesale, retail, and service sales activities), and an increase in population of 32 persons. The volume of trade in the wholesale, retail, and service sales activities would increase by $54,795 per year. Total personal incomes to agriculture; to wholesale, retail, and service sales; and to government employees were projected to increase by $9,200; $16,685; and $4,483, respectively, per year. The level of total expenditures in retail and service trade was expected to increase by $106,602 annually (of which $66,282 corresponded to the increase in demand for agricultural productive inputs and $40,320 to the increase in personal consumption expenditures).

Secondary benefits of watershed development were defined in Chapter II as the increase in net incomes or other beneficial effects resulting from activities stemming from or induced by the project. Personal income constitutes a good measure for assessing secondary benefits, because it shows how economic activity pays off. Thus, the estimate of the increase in total personal income, $30,368 per year, may be considered to be the monetary value of the local indirect benefits of irrigation development.

Allocation of Alternative Water Supplies

The economic potential of irrigation development in Sugar Creek Watershed is limited by the amount of water presently available. Although no data were available to estimate the cost of increasing the storage capacity of the structures, some of these structures offer potential for this kind of development. Three alternative levels of water supply were considered to examine the economic potential to farmers of developing additional storage capacity for irrigation water. The three levels considered were: 33,000; 39,600; and 52,800 acre-inches, which correspond to 125, 150, and 200 per cent of the supply currently available.

Using the procedures discussed above, the following results were obtained. Utilizing a net supply of 33,000 acre-inches would increase net farm returns $319,625, and the demand for agricultural productive inputs $66,937 per year. The estimate of the increase in demand for agricultural productive inputs includes an increase in demand for labor equivalent to four full-time workers. Using the interdependence model to project the secondary impact resulted in the following estimates. Nonfarm employment was projected to increase by 10 (wholesale, retail, and service employment 8 and governmental employment 2). Total population was projected to increase by 43 persons, and total personal income by $41,150 (agriculture $12,880; wholesale, retail, and service sales $22,246; and government $6,024). The volume of expenditures in retail and service trade was projected to increase by $121,117.

A supply of water of 39,600 acre-inches, used for irrigation, would increase aggregate net farm incomes $417,937, and the aggregate demand for agricultural productive inputs $96,024. The increase in demand for agricultural productive inputs includes an increase in demand for labor equivalent to four full-time jobs. Since the basic changes in employment and population were the same for the supplies of 33,000 and 39,600 acre-inches of water, the secondary effects were also equivalent.

Utilizing a supply of 52,800 acre-inches of water would increase aggregate net farm incomes by $553,739 and the demand for agricultural productive inputs by $143,504 per year. This increase in demand comprises an increase in demand for labor equivalent to five full-time jobs. The secondary effects were projected using the interdependence model. Total population was projected to increase by 53 persons; wholesale, retail, and service sales employment was projected to increase by 10; and governmental employment was projected to increase by two. Total personal income was projected to increase by $50,873 annually (agriculture $15,640; wholesale, retail, and service sales $27,808; and government $7,425), and the volume of retail and service trade was projected to increase by $210,284 per year.

The results indicated that farmers using a payoff period of twelve years and an interest rate of seven per cent could invest a maximum of $39.55 per acre-inch of water used per year for increasing the storage capacity from the present level to 33,000 acre-inches. Similarly, farmers could invest up to $78.95 and $80.30 per acre-inch of water used per year for increasing the storage capacity to 39,600 and 52,800 acre-inches, respectively. Farmers can invest more per acre-inch of water used for the larger levels, because the increased amounts of water available per farm permit utilizing the irrigation systems more efficiently.

Implications

The results of this study have indicated that using the water stored in the detention pools of the floodwater retarding structures of Sugar Creek Watershed for irrigation purposes is economically desirable. From the point of view of welfare economics, if the principles discussed in Chapter II in relation to the justification of water resource development projects are kept in mind, such utilization is socially and economically justified. Irrigation development offers possibilities to the farmers of the watershed of increasing net returns. Through multiplier effects, the initial changes in the farm sector originating from irrigation development, produce net increases in the aggregate levels of employment, population, personal income, and expenditures.

The results of this study are useful for several purposes. First, the programmed optimum farm organizations can be used by farmers and extension personnel as guides for planning optimum farm plans. Second, the marginal value products of water can be used by farmers in deciding between dryland and irrigated farming, and also to what level they should go if they do want to irrigate. Third, the estimates of primary and secondary impacts provide an insight into the importance of irrigation development to the local economy. Fourth, farmers can use the procedures and results presented in Chapter IV to determine how much they could afford to pay for developing additional water storage capacity.

The procedure used in this study to investigate the nature and extent of the economic impact of irrigation development can be applied by the federal, state, or local agencies for the evaluation of water resource development projects. The procedure used to analyze the secondary impact of irrigation development is based upon the recognition that because of intersectoral linkages, the different sectors of the economy are interdependent. This implies that changes in one sector are diffused throughout the rest of the economy in harmonious movements. The diffusion of changes can be traced by means of multiplier analysis. This procedure permits estimating the changes in employment, population, income, and expenditures generated by the initial changes in the agricultural sector, as well as to quantify the secondary benefits of irrigation development.

This study has shown that irrigation development can exert a significant impact on economic growth and community development. The increase in economic activity stimulated by irrigation development is important because it represents gains in incomes not only for the farmers but for other local groups as well. The creation of new jobs, which usually provides incentive for increases in population, has a tremendous importance for areas such as the one considered in this study, which has experienced out-migration and declines in employment in recent years. Irrigation development can be an important factor in reversing or mitigating these trends.

Limitations

The optimum farm organizations presented in this study apply only to assumed price-cost, technical, and institutional relationships assumed for Sugar Creek Watershed. The synthesized typical farms used in the programming analysis are not necessarily equal to any particular farm in the watershed; rather, they reflect physical and institutional farm resource situations common to the area. The crop and livestock enterprises considered were those currently being used in the watershed. It is possible that enterprises not programmed may yield greater net returns.

The linear programming results obtained are based on the assumption of perfect knowledge about input-output coefficients, prices, and decision maker's objectives. Additionally, the linear programming analysis indicates what the farmer should do to maximize profits rather than what he will do. Thus, these results could be attained only if farmers are able to achieve the efficiency implied by the profit maximizing static linear programming framework.

The actual quantity of water available in the structures for any given year is subject to variability. The actual supply of water available for irrigation depends on the amount of runoff in the watershed, evaporation, seepage and the use of the water.

The estimates of the primary and secondary impact of irrigation development should be understood as a maximum potential which could be attained only if the assumptions underlying this study are met. The model used to project the economic impact assumed that the water available would be allocated among farms and uses such as to maximize returns for the watershed. The actual magnitude of the estimates depends on the number of farmers adopting irrigation and on how efficiently the water is used. Another assumption of the model was that any farm would have access to the water of the structures. However, this may not be the case.

Delivery costs from the structures to the farm irrigation pumps were not included in the analysis. They would need to be included in order to assess the true economic benefits of irrigation development.

Need for Further Research

The methodological procedures utilized in this study could be refined to incorporate uncertainty in the analysis. Using a range of prices rather than single values would permit one to evaluate the effect of different prices on the farm organizations and on the demand schedules for irrigation water. Variability of water supply could be incorporated by estimating the probability distribution of runoff which adds to the water supply available for irrigation. This would permit one to predict the amount of water available for irrigation for any particular year more accurately.

Research is needed to incorporate the costs of delivering the water from the structures to the farm irrigation pumps. Determining the type of farms on which the structures are located, the distance from the structures to the pumps, and other factors would permit estimation of the appropriate costs for a given representative farm.

Additional research is also needed on reasonable methods of controlling the use of the water from the structures. Only if the available water supply is allocated among alternative uses in such a manner that those uses yielding higher returns are given priority, will it be possible to maximize aggregate net returns for the watershed.

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APPENDIX A

ENTERPRISE BUDGETS

APPENDIX A

ENTERPRISE BUDGETS

The enterprise budgets used in the linear programming analysis of this study are based on information collected from the Caddo County Extension Director, staff members of the Departments of Agronomy and Agricultural Economics of the Oklahoma State University, and personnel of the Soil Conservation Service. Data obtained from secondary sources were also extremely useful.[1]

The machinery costs used in developing the budgets are based on four-row equipment, and are tabulated in Table XXIV of this Appendix. Custom harvesting is assumed in developing these budgets. Table XXV presents the typical field operations, usual times, times over, machine hours, tractor hours, and nonirrigation labor for the crops included in the linear programming analysis. Table XXVI shows the estimated total

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[1]Charles O. Hopkins and Vernon R. Eidman, Alternative Irrigated Crop Enterprises on Clay, Loam and Sandy Soils of Southwestern Oklahoma: Resource Requirements, Costs and Returns, Oklahoma Agricultural Experiment Station Processed Series P-600 (Stillwater, 1969); P. Leo Strickland and Terry Dunn, Crop Enterprise Budgets for Dryland Production, Southwestern Oklahoma, Oklahoma Agricultural Experiment Station and Farm Production Economics Division, ERS, USDA, Processed Series P-599 (Stillwater, 1969); Harry H. Hall, Larry J. Connor, Odell L. Walker, and William F. Lagrone, Resource Requirements, Costs, and Expected Returns; Alternative Crop and Livestock Enterprises; Oklahoma Panhandle, Oklahoma Agricultural Experiment Station Processed Series P-459 (Stillwater, 1963); and William L. Brant, "Analysis of the Representative Farm Concept as a Tool in Area Supply Response Research and Farm Management Education" (unpub. Ph.D. dissertation, Oklahoma State University, 1967).

investment and annual fixed costs of irrigation systems used in the programming analysis. Table XXVII presents the estimated acre-inches of water applied per month for the different crops. The rest of this Appendix (Tablex XXVIII to LXII) contains the crop and livestock budgets.

TABLE XXIV

ESTIMATED COST PER HOUR OF USE FOR SPECIFIED MACHINERY

Item	Size	Ownership Costs		Operating Costs
		Depre- ciation	Interest, Taxes and Insurance	
Tractor	90 H.P.	.90	.61	1.441[a]
Cultivator	4 row	.26	.23	.448
Planter	4 row	.66	.588	.623
Spring Harrow	4 section	.17	.149	.288
Moldboard	4-16	.32	.282	.639
Disc	14 feet	.36	.363	.750
Float	10 feet	.18	.17	.151
Rotary Hoe	14 feet	.21	.20	.242
Grain Drill	16-8	.76	.683	.829
Stalk Cutter	4 row	.29	.267	.246
Chisel	12 feet	.23	.202	.331
Lister	4 row	.66	.589	.633
One way	12 feet	.64	.468	.620

[a]Fuel .627, lube and filter .094, and repair and maintenance .72 per hour. The remaining operating costs in this column are for the implement itself. One must add the operating cost of the tractor and implement to obtain the operating cost of a given field operation.

Source: P. Leo Strickland and Terry Dunn, Crop Enterprise Budgets for Dryland Production, Southwestern Oklahoma, Oklahoma Agricultural Experiment Station and Farm Production Economics Division, ERS, USDA, Processed Series P-599 (Stillwater, 1969).

TABLE XXV

TYPICAL FIELD OPERATIONS, USUAL TIMES, TIMES OVER, MACHINE HOURS, TRACTOR HOURS, AND NONIRRIGATION LABOR REQUIRED FOR SPECIFIED CROPS

Crop and Operation	Usual Time	Times Over	Machine Hours	Tractor Hours[1]	Nonirrigation Labor[2]
Alfalfa Establishment					
Moldboard	July	1	.444	.488	.532
Disc	Aug.-Sept.	2	.34	.374	.410
Apply Fertilizer	September	1	.042	.046	.050
Springtooth	Sept.-Oct.	2	.28	.308	.336
Spike-tooth	Sept.-Oct.	3	.21	.231	.252
Drill	Sept.-Oct.	1	.285	.313	.342
Total			1.601	1.761	1.922
Alfalfa					
Apply Fertilizer	March	1	.42	.046	.050
Spike Tooth	March	1	.07	.077	.084
Total			.112	.123	134
Bermuda Grass Establishment					
Disc	March	1	.17	.187	.204
Moldboard	April	1	.444	.488	.532
Apply Fertilizer	May	1	.042	.046	.050
Spike-tooth	June	2	.14	.154	.168
Total			.796	.875	.955
Bermuda Grass					
Apply Fertilizer	May	1	.042	.046	.05
Chip	June	1	.07	.077	.084
Total			.112	.123	.134
Cotton					
Shred Stalks	Februray	1	.17	.187	.204
Moldboard	March-April	1	.444	.488	.532
Disc	March-May	2	.34	.374	.410
Apply Fertilizer	April-May	3	.126	.139	.151
Springtooth	April-May	1	.14	.154	.168
Plant	May-June	2	.42	.462	.504
Rotary Hoe	June-July	2	.19	.209	.228

TABLE XXV (Continued)

Crop and Operation	Usual Time	Times Over	Machine Hours	Tractor Hours[1]	Nonirrigation Labor[2]
Cultivate	June-July	2	.50	.550	.600
Total			2.33	2.563	2.796
<u>Ensilage</u>					
Shred Stalks	February	1	.17	.187	.204
Moldboard	March-April	1	.444	.488	.532
Disc	March-May	2	.34	.374	.410
Apply Fertilizer	April-May	1	.042	.046	.051
Springtooth	April	1	.14	.154	.168
Plant	April-May	2	.42	.462	.504
Rotary Hoe	May-June	2	.19	.209	.228
Cultivate	June-July	2	.50	.550	.600
Total			2.246	2.471	2.696
<u>Forage Sorghum</u>					
Shred Stalks	February	1	.17	.187	.204
Moldboard	March-April	1	.444	.488	.532
Disc	March-May	2	.34	.374	.410
Apply Fertilizer	April-May	1	.042	.046	.050
Springtooth	April-May	1	.14	.154	.168
Plant	May-June	2	.42	.462	.504
Rotary Hoe	June-July	2	.19	.209	.228
Cultivate	July-Aug.	2	.50	.550	.600
Total			2.246	2.470	2.696
<u>Grain Sorghum</u>					
Shred Stalks	Februray	1	.17	.187	.204
Moldboard	March-April	1	.444	.488	.532
Disc	March-May	2	.34	.374	.410
Apply Fertilizer	April-May	1	.042	.046	.051
Springtooth	April	1	.14	.154	.168
Plant	April-May	2	.42	.462	.504
Rotary Hoe	May-June	2	.19	.209	.228
Cultivate	June-July	2	.50	.550	.600
Total			2.246	2.471	2.696
<u>Peanuts</u>					
Apply Fertilizer	Apr.-May-Nov.	3	.126	.138	.151
Disc	April-May	2	.34	.374	.408
Moldboard	March-April	1	.444	.488	.533
Springtooth	April-May	2	.28	.308	.336
Plant	April-May	1	.21	.231	.252
Rotary Hoe	May-June	2.5	.237	.261	.284
Cultivate	May-June	2	.50	.55	.600
Drill	Nov.	1	.285	.313	.342
Total			2.422	2.664	2.906

TABLE XXV (Continued)

Crop and Operation	Usual Time	Times Over	Machine Hours	Tractor Hours[1]	Nonirrigation Labor[2]
<u>Wheat</u>					
Disc	June-Aug.	2	.34	.374	.408
Moldboard	June-July	3	.133	.146	.159
Chisel	June-July	2	.42	.462	.504
Sweep	July-Aug.	2	.42	.462	.504
Apply Fertilizer	Aug.	1	.042	.046	.050
Springtooth	Aug.	1	.14	.154	.168
Drill	Aug.-Sep.	1	.285	.313	.342
Total			1.780	1.958	2.135

[1]Tractor time is 1.1 times the machine time to allow for field changing, etc.

[2]Total labor is 1.2 times machine time to allow for adjusting equipment, lubrication, maintenance, etc.

TABLE XXVI

ESTIMATED TOTAL INVESTMENT AND ANNUAL FIXED COSTS OF IRRIGATION SYSTEMS USED IN PROGRAMMING ANALYSIS

Item	Size of Irrigation System		
	Small	Medium	Large
Investment:			
Pump and Motor	1,375.00	1,475.00	2,950.00
Mainline	2,032.80	2,032.80	4,065.60
Laterals	1,000.00	2,000.00	4,000.00
Total	4,407.80	5,507.80	11,015.60
Costs:			
Depreciation	339.69	416.35	832.70
Taxes	55.10	68.85	137.70
Insurance	13.22	16.52	33.04
Interest	154.27	192.77	385.54
Total	562.28	694.49	1,388.98

TABLE XXVII

ESTIMATED ACRE-INCHES OF WATER APPLIED PER MONTH FOR SPECIFIED CROPS

Crop	Total Acre-Inches	Monthly Water Applied (Acre-Inches)					
		March	May	June	July	Aug.	Sept.
Alfalfa	12	3		3	3	3	
	15	3		3	3	3	3
	18	3	3	3	3	3	3
Bermuda Grass	6			3	3		
	18			3	6	6	3
Cotton	6				3	3	
	9				3	6	
	15				6	9	
Forage Sorghum	3				3		
	6			3	3		
	9			3	3	3	
Grain Sorghum	3				3		
	6				6		
	9				6	3	
Peanuts	9				3	6	
	12				3	6	3
	15				3	9	3
Ensilage	3				3		
	6			3	3		
	9			3	3	3	

TABLE XXVIII

COTTON: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class Sb Quantity	Sb Value	Sc Quantity	Sc Value	Sd Quantity	Sd Value
Production:								
Lint	Lb.	.205	325	66.63	275	56.38	200	41.00
Seed	Lb.	.024	520	12.48	440	10.56	320	7.68
Total Receipts	Dol.			79.11		66.94		48.68
Inputs:								
Seed (50% replant)	Lb.	.14	16	2.24	16	2.24	16	2.24
Rye Cover Crop	Lb.	.041	60	2.46	60	2.46	60	2.46
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	60	6.00
P	Lb.	.08	20	1.60	20	1.60	20	1.60
K	Lb.	.05	20	1.00	20	1.00	20	1.00
Rye Fertilizer: N	Lb.	.10	20	2.00	20	2.00	20	2.00
P	Lb.	.08	20	1.60	20	1.60	20	1.60
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45
Insecticides	Acre	2.00	3	6.00	3	6.00	3	6.00
Herbicide	Lb.	8.25	.5	4.12	.5	4.12	.5	4.12
Power & Machinery Oper. Costs	Acre			4.85		4.85		4.85
Defoliants	Acre	3.00	1	3.00	1	3.00	1	3.00
Picking Lint	Lb.	.05	325	16.25	275	13.75	200	10.00
Ginning, Bag & Tie (lint)	Lb.	.021	325	6.83	275	5.78	200	4.20
Hauling (seed)	Cwt.	.25	5.20	1.30	4.40	1.10	3.20	.80
Interest on Annual Capital	Dol.	.07	15.86	1.11	15.86	1.11	15.86	1.11
Total Specified Costs	Dol.			60.81		57.06		51.43
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			18.30		9.88		- 2.75
Labor Required	Hr.	1.50	2.80	4.20	2.80	4.20	2.80	4.20
Fixed Costs:								
Power & Machinery	Acre			5.40		5.40		5.40
Return to Land, Management & Overhead	Dol.			8.70		.28		-12.35

TABLE XXIX

COTTON: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

			Productivity Class							
			La		Lb		Lc		Ld	
Item	Unit	Price or Cost per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:										
Lint	Lb.	.205	475	97.38	450	92.25	275	56.38	200	41.00
Seed	Lb.	.024	760	18.24	720	17.28	440	10.56	320	7.68
Total Receipts	Dol.			115.62		109.53		66.94		48.68
Inputs:										
Seed (50% replant)	Lb.	.14	14	1.96	14	1.96	14	1.96	14	1.96
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	40	4.00	40	4.00
P	Lb.	.08	20	1.60	20	1.60	20	1.60	20	1.60
K	Lb.	.05	10	.50	10	.50	0	---	0	---
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45	3	.45
Insecticides	Acre	2.00	5	10.00	3	6.00	3	6.00	3	6.00
Herbicide	Lb.	8.25	.5	4.12	.5	4.12	.5	4.12	.5	4.12
Power & Machinery Oper. Costs	Acre			4.85		4.85		4.85		4.85
Defoliants	Acre	3.00	1	3.00	1	3.00	1	3.00	1	3.00
Picking Lint	Lb.	.05	475	23.75	450	22.50	275	13.75	200	10.00
Ginning, Bag & Tie (lint)	Lb.	.021	475	9.98	450	9.45	275	5.78	200	4.20
Hauling (seed)	Cwt.	.25	7.60	1.90	7.20	1.80	4.40	1.10	3.20	.80
Interest on Annual Capital	Dol.	.07	11.66	.82	11.66	.82	9.19	.64	9.19	.64
Total Specified Costs	Dol.			68.93		63.05		47.25		41.62
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			46.69		46.48		19.69		7.06
Labor Required	Hr.	1.50	2.80	4.20	2.80	4.20	2.18	4.20	2.80	4.20
Fixed Costs:										
Power & Machinery	Acre			5.40		5.40		5.40		5.40
Return to Land, Management & Overhead	Dol.			37.09		36.88		10.09		- 2.54

TABLE XXX

PEANUTS: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

		Price or	Productivity Class					
		Cost per	Sb		Sc		Sd	
Item	Unit	Unit	Quantity	Value	Quantity	Value	Quantity	Value
Production:	Cwt.	11.00	20	220.00	17	187.00	15	165.00
Total Receipts	Dol.			220.00		187.00		165.00
Inputs:								
Seed	Lb.	.33	75	24.75	75	24.75	75	24.75
Rye Cover	Lb.	.041	65	2.67	65	2.67	65	2.67
Fertilizer: N	Lb.	.10	10	1.00	10	1.00	10	1.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20
K	Lb.	.05	20	1.00	20	1.00	20	1.00
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45
Lime (custom applied)	Ton	6.00	1	6.00	1	6.00	1	6.00
Herbicide	Acre	6.75	1	6.75	1	6.75	1	6.75
Insecticides & Fungicides	Lb.	.45	30	13.50	30	13.50	30	13.50
Power & Machinery Oper. Costs	Acre			5.11		5.11		5.11
Dig & Shake	Acre	3.50	2	7.00	2	7.00	2	7.00
Combine	Acre	15.00	1	15.00	1	15.00	1	15.00
Haul, Clean & Dry	Ton	16.00	1.00	16.00	.85	13.60	.75	12.00
Interest on Annual Capital	Dol.	.07	33.03	2.31	33.03	2.31	33.03	2.31
Total Specified Costs				104.74		102.34		100.74
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			115.26		84.66		64.26
Labor Required	Hr.	1.50	2.91	4.36	2.91	4.36	2.91	4.36
Fixed Costs:								
Power & Machinery	Acre			5.67		5.67		5.67
Return to Land, Management & Overhead	Dol.			105.23		74.63		54.23

TABLE XXXI

PEANUTS: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

			Productivity Class			
		Price or	Lb		Lc	
Item	Unit	Cost per Unit	Quantity	Value	Quantity	Value
Production:	Cwt.	11.00	15	165.00	12	132.00
Total Receipts	Dol.			165.00		132.00
Inputs:						
Seed	Lb.	.33	75	24.75	75	24.75
Rye Cover	Lb.	.041	65	2.67	65	2.67
Fertilizer: N	Lb.	.10	10	1.00	10	1.00
P	Lb.	.08	40	3.20	40	3.20
K	Lb.	.05	20	1.00	20	1.00
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45
Lime (custom applied)	Ton	6.00	1	6.00	1	6.00
Herbicide	Acre	6.45	1	6.45	1	6.45
Insecticides & Fungicides	Lb.	.45	30	13.50	30	13.50
Power & Machinery Oper. Costs	Acre			5.11		5.11
Dig & Shake	Acre	3.50	2	7.00	2	7.00
Combine	Acre	15.00	1	15.00	1	15.00
Haul, Clean & Dry	Ton	16.00	.75	12.00	.60	9.60
Interest on Annual Capital	Dol.	.07	33.03	2.31	33.03	2.31
Total Specified Costs	Dol.			100.44		98.04
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			64.56		33.96
Labor Required	Hr.	1.50	2.91	4.36	2.91	4.36
Fixed Costs:						
Power & Machinery	Acre			5.67		5.67
Return to Land, Management, & Overhead	Dol.			54.53		23.93

TABLE XXXII

FORAGE SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Production:								
Hay	Ton	18.00	4.5	81.00	4.0	72.00	3.0	54.00
Total Receipts	Dol.			81.00		72.00		54.00
Inputs:								
Seed	Lb.	.20	15	3.00	15	3.00	15	3.00
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	40	4.00
P	Lb.	.08	40	3.20	40	3.20	20	1.60
K	Lb.	.05	30	1.50	20	1.00	10	.50
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			4.71		4.71		4.71
Swathing	Acre	2.50	1	2.50	1	2.50	1	2.50
Baling	Bale	.17	135	22.95	120	20.40	90	15.30
Hauling	Bale	.15	135	20.25	120	18.00	90	13.50
Interest on Annual Capital	Dol.	.07	12.35	.86	12.03	.84	8.05	.56
Total Specified Costs	Dol.			65.12		59.80		45.82
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			15.88		12.20		8.18
Labor Required	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:								
Power & Machinery	Acre			5.26		5.26		5.26
Return to Land, Management & Overhead	Dol.			6.57		2.89		- 1.13

TABLE XXXIII

FORAGE SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

Item	Unit	Price or Cost per Unit	La Quantity	La Value	Lb Quantity	Lb Value	Lc Quantity	Lc Value	Ld Quantity	Ld Value
Production:										
Hay	Ton	18.00	5.0	90.00	4.5	81.00	4.0	72.00	2.5	45.00
Total Receipts										
Inputs:										
Seed	Lb.	.20	14	2.80	14	2.80	14	2.80	14	2.80
Fertilizer: N	Lb.	.10	40	4.00	40	4.00	30	3.00	30	3.00
P	Lb.	.08	20	1.60	20	1.60	20	1.60	20	1.60
K	Lb.	.05	0	---	0	---	10	.50	10	.50
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			4.71		4.71		4.71		4.71
Swathing	Acre	2.50	1	2.50	1	2.50	1	2.50	1	2.50
Baling	Bale	.17	150	25.50	135	22.95	120	20.40	90	15.30
Hauling	Bale	.15	150	22.50	135	20.25	120	18.00	90	13.50
Interest on Annual Capital	Dol.	.07	7.66	.54	7.66	.54	7.41	.52	7.41	.52
Total Specified Costs	Dol.			64.30		53.50		55.18		44.58
Return to Land, Labor, Equipment Capital, Management & Overhead				25.70		21.50		17.82		.42
Labor Required	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:										
Power & Machinery	Acre			5.26		5.26		5.26		5.26
Return to Land, Management & Overhead	Dol.			16.39		12.19		8.51		- 8.89

TABLE XXXIV

GRAIN SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Production:								
Grain	Cwt.	1.93	36	69.48	30	57.90	24	46.32
Total Receipts				69.48		57.90		46.32
Inputs:								
Seed	Lb.	.21	7	1.47	7	1.47	7	1.47
Fertilizer: N	Lb.	.10	40	4.00	30	3.00	20	2.00
P	Lb.	.08	20	1.60	20	1.60	20	1.60
K	Lb.	.05	10	.50	10	.50	10	.50
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			4.71		4.71		4.71
Combining	Acre	3.50	1	3.50	1	3.50	1	3.50
Hauling	Cwt.	.09	36	3.24	30	2.70	24	2.16
Interest on Annual Capital	Dol.	.07	5.87	.41	5.45	.38	5.04	.35
Total Specified Costs				19.58		18.01		16.44
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			49.90		39.89		29.88
Labor Required	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:								
Power & Machinery	Acre			5.26		5.26		5.26
Return to Land, Management & Overhead	Dol.			40.59		30.58		20.57

TABLE XXXV

GRAIN SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

			Productivity Class							
		Price or	La		Lb		Lc		Ld	
Item	Unit	Cost per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:										
Grain	Cwt.	1.93	36	69.48	30	57.90	24	46.32	18	34.74
Grain Sorghum Stubble	AUM		.4		.4		.4		.4	
Total Receipts	Dol.			69.48		57.90		46.32		34.74
Inputs:										
Seed	Lb.	.21	6	1.26	6	1.26	6	1.26	6	1.26
Fertilizer: N	Lb.	.10	40	4.00	40	4.00	30	3.00	30	3.00
P	Lb.	.08	20	1.60	20	1.60	20	1.60	20	1.60
K	Lb.	.05	0	---	0	---	10	.50	10	.50
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			4.71		4.71		4.71		4.71
Combining	Acre	3.50	1	3.50	1	3.50	1	3.50	1	3.50
Hauling	Cwt.	.09	36	3.24	30	2.70	24	2.16	18	1.62
Interest on Annual Capital	Dol.	.07	5.54	.39	5.54	.39	5.33	.37	5.33	.37
Total Specified Costs	Dol.			18.85		18.31		17.25		16.71
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			50.63		39.69		29.07		18.03
Labor Required	Hr.	1.50	2.70	4.26	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:										
Power & Machinery	Acre			5.26		5.26		5.26		5.26
Return to Land, Management & Overhead	Dol.			41.32		30.28		19.76		8.72

TABLE XXXVI

ENSILAGE: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class Sb Quantity	Sb Value	Sc Quantity	Sc Value	Sd Quantity	Sd Value
Production:								
Ensilage	Ton	6.00	13.50	81.00	12.00	72.00	9.00	54.00
Total Receipts	Dol.			81.00		72.00		54.00
Inputs:								
Seed	Lb.	.17	15	2.55	15	2.55	15	2.55
Fertilizer: N	Lb.	.10	80	8.00	80	8.00	80	8.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20
K	Lb.	.05	10	.50	10	.50	10	.50
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			4.71		4.71		4.71
Chop & Haul	Ton	2.00	13.50	27.00	12.00	24.00	9	18.00
Interest on Annual Capital	Dol.	.07	12.14	.85	12.14	.85	12.14	.85
Total Specified Costs	Dol.			46.81		43.81		37.81
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			34.19		28.19		16.19
Labor Required	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:								
Power & Machinery	Acre			5.26		5.26		5.26
Return to Land, Management & Overhead	Dol.			24.88		18.88		6.88

TABLE XXXVII

ENSILAGE: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

			Productivity Class							
		Price or	La		Lb		Lc		Ld	
Item	Unit	Cost per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production										
Ensilage	Ton	6.00	12.50	75.00	11.25	67.50	10.00	62.50	6.25	37.50
Total Receipts	Dol.			75.00		67.50		62.50		37.50
Inputs:										
Seed	Lb.	.17	15	2.55	15	2.55	15	2.55	15	2.55
Fertilizer: N	Lb.	.10	80	8.00	80	8.00	80	8.00	80	8.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20	40	3.20
K	Lb.	.05	20	1.00	20	1.00	20	1.00	20	1.00
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			4.71		4.71	10.00	4.71		4.71
Chop & Haul	Ton	2.00	12.50	25.00	11.25	22.50	12.50	20.00	6.25	12.50
Interest on Annual Capital	Dol.	.07	12.50	.87	12.50	.87		.87	12.50	.87
Total Specified Costs	Dol.			45.48		42.98		40.48		32.98
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			29.52		24.52		22.02		4.52
Labor Required	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:										
Power & Machinery	Acre			5.26		5.26		5.26		5.26
Return to Land, Management & Overhead	Dol.			20.21		15.21		12.71		- 6.79

TABLE XXXVIII

ALFALFA ESTABLISHMENT: PRODUCTION COSTS PER ACRE ON DRYLAND SANDY AND LOAMY SOILS

Item	Unit	Price or Cost Per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Inputs:								
Seed	Lb.	.39	20	7.80	20	7.80	20	7.80
Fertilizer: N	Lb.	.10	10	1.00	10	1.00	10	1.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20
K	Lb.	.05	20	1.00	20	1.00	20	1.00
Lime (custom applied)	Ton	6.00	2	12.00	2	12.00	2	12.00
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Power & Machinery Oper. Costs	Acre			3.42		3.42		3.42
Interest on Annual Capital	Dol.	.07	28.57	2.00	28.57	2.00	28.57	2.00
Total Specified Costs Above Land, Labor, Equipment Cap., Management & Overhead	Dol.			30.57		30.57		30.57
Labor Required	Hr.	1.50	1.922	2.88	1.922	2.88	1.922	2.88
Fixed Costs:								
Power & Machinery	Acre			3.73		3.73		3.73
Total Specified Costs Above Land, Management & Overhead	Dol.			37.18		37.18		37.18

TABLE XXXIX

ALFALFA: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Production:								
Hay	Ton	25.00	3.5	87.50	3.0	75.00	2.0	50.00
Grazing	AUM		.7		.7		.7	
Total Receipts				87.50		75.00		50.00
Inputs:								
Fertilizer: N	Lb.	.10	0	---	0	---	0	---
P	Lb.	.08	80	6.40	80	6.40	80	6.40
K	Lb.	.05	40	2.00	40	2.00	40	2.00
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Insecticides	Acre	3.65	1	3.65	1	3.65	1	3.65
Power and Machinery Oper. Costs	Acre			.19		.19		.19
Swathing	Acre	2.50	3	7.50	3	7.50	3	7.50
Baling	Bale	.17	105	17.85	90	15.30	60	10.20
Hauling	Bale	.15	105	15.75	90	13.50	60	9.00
¼ of Establishment Costs	Dol.		30.57	7.64	30.57	7.64	30.57	7.64
Interest on Annual Capital	Dol.	.07	12.39	.22	12.39	.22	12.39	.22
Total Specified Costs	Dol.			53.49		48.91		39.31
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			34.01		26.09		10.69
Labor Required	Hr.	1.50	.13	.19	.13	.19	.13	.19
Fixed Costs:								
Power and Machinery	Acre			.20		.20		.20
¼ of Establishment Labor	Dol.		3.73	.93		.93		.93
Return to Land, Management & Overhead	Dol.			32.69		24.77		9.37

TABLE XL

ALFALFA: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class La Quantity	La Value	Lb Quantity	Lb Value	Lc Quantity	Lc Value
Production:								
Hay	Ton	25.00	4.0	100.00	3.5	87.50	2.0	50.00
Grazing	AUM		.7		.7		.7	
Total Receipts				100.00		87.50		50.00
Inputs:								
Fertilizer: N	Lb.	.10	0	---	0	---	0	---
P	Lb.	.08	60	4.80	60	4.80	60	4.80
K	Lb.	.05	30	1.50	30	1.50	30	1.50
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Insecticides	Acre	3.65	1	3.65	1	3.65	1	3.65
Power and Machinery Oper. Costs	Acre			.19		.19		.19
Swathing	Acre	2.50	3	7.50	3	7.50	3	7.50
Baling	Bale	.17	120	20.40	105	17.85	60	10.20
Hauling	Bale	.15	120	18.00	105	15.75	60	9.00
¼ of Establishment Costs	Dol.		30.57	7.64	30.57	7.64	30.57	7.64
Interest on Annual Capital	Dol.	.07	10.29	.18	10.29	.18	10.29	.18
Total Specified Costs	Dol.			64.01		59.21		44.81
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			35.99		28.29		5.19
Labor Required	Hr.	1.50	.13	.19	.13	.19	.13	.19
Fixed Costs:								
Power and Machinery	Acre			.20		.20		.20
¼ of Establishment Labor	Dol.		3.73	.93	3.73	.93	3.73	.93
Return to Land, Management & Overhead	Dol.			34.67		26.97		3.87

TABLE XLI

WHEAT: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Production:								
Grain	Bu.	1.60	30	48.00	26	41.60	20	32.00
Grazing	AUM		.4		.3		.2	
Total Receipts	Dol.			48.00		41.60		32.00
Inputs:								
Seed	Lb.	.041	60	2.46	60	2.46	60	2.46
Topdress	Acre	1.00	2	2.00	2	2.00	2	2.00
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	60	6.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20
K	Lb.	.05	20	1.00	20	1.00	20	1.00
Insecticides	Acre	2.00	1	2.00	1	2.00	1	2.00
Power and Machinery Oper. Costs	Acre			3.71		3.71		3.71
Combining[1]	Acre	3.00	1	3.50	1	3.30	1	3.00
Hauling	Bu.	.055	30	1.65	26	1.43	20	1.10
Interest on Annual Capital	Dol.	.07	13.77	.96	13.77	.96	13.77	.96
Total Specified Costs	Dol.			26.48		26.06		25.43
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			21.52		18.54		6.57
Labor Required	Hr.	1.50	2.14	3.21	2.14	3.21	2.14	3.21
Fixed Costs:								
Power and Machinery	Acre			4.10		4.10		4.10
Return to Land, Management & Overhead	Dol.			14.21		11.23		- .74

[1] $3.00 per acre plus $.05 per bushel of yield over 20 bushels per acre.

TABLE XLII

WHEAT: PRODUCTION COSTS AND RETURNS PER ACRE ON DRYLAND LOAMY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class							
			La		Lb		Lc		Ld	
			Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:										
Grain	Bu.	1.60	33	52.80	35	56.00	26	41.60	20	32.00
Grazing	AUM		.6		.5		.4		.3	
Total Receipts	Dol.			52.80		56.00		41.60		32.00
Inputs:										
Seed	Lb.	.041	60	2.46	60	2.46	60	2.46	60	2.46
Topdress	Acre	1.00	2	2.00	2	2.00	2	2.00	2	2.00
Fertilizer: N	Lb.	.10	50	5.00	50	5.00	50	5.00	50	5.00
P	Lb.	.08	30	2.40	30	2.40	30	2.40	30	2.40
K	Lb.	.05	10	.50	10	.50	10	.50	10	.50
Insecticides	Acre	2.00	1	2.00	1	2.00	1	2.00	1	2.00
Power & Machinery Oper. Costs	Acre			3.71		3.71	3.71	3.71		3.71
Combining[1/]	Acre	3.00	1	3.65	1	3.75	1	3.30	1	3.00
Hauling	Bu.	.055	33	1.82	35	1.93	26	1.43	20	1.10
Interest on Annual Capital	Dol.	.07	12.23	.86	12.23	.86	12.23	.86	12.23	.86
Total Specified Costs	Dol.			24.40		24.61		23.66		23.03
Return to Land, Labor, Equipment Capital, Management & Overhead	Dol.			28.40		31.39		17.94		8.97
Labor Required	Hr.	1.50	2.14	3.21	2.14	3.21	2.14	3.21	2.14	3.21
Fixed Costs:										
Power & Machinery	Acre			4.10		4.10		4.10		4.10
Return to Land, Management & Overhead	Dol.			21.09		24.08		10.63		1.66

1/ $3.00 per acre plus $.05 per bushel of yield over 20 bushels per acre.

TABLE XLIII

BERMUDA GRASS ESTABLISHMENT: PRODUCTION COSTS PER ACRE ON DRYLAND SANDY AND LOAMY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Inputs:								
Contract Sprigging[1/]	Acre	24.00	1	24.00	1	24.00	1	24.00
Fertilizer: N	Lb.	.10	20	2.00	20	2.00	20	2.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20
K	Lb.	.05	20	1.00	20	1.00	20	1.00
Lime (custom applied)	Ton	6.00	1	6.00	1	6.00	1	6.00
Power & Machinery Oper. Costs	Acre			1.61		1.61		1.61
Interest on Annual Capital	Dol.	.07	9.45	.66	9.45	.66	9.45	.66
Total Specified Costs Above Land, Labor, Equipment Cap., Management & Overhead	Dol.			38.46		38.46		38.46
Labor Required	Hr.	1.50	.96	1.44	.96	1.44	.96	1.44
Fixed Costs:								
Power & Machinery	Acre			1.73		1.73		1.73
Total Specified Costs Above Land, Management & Overhead	Dol.			41.63		41.63		41.63

1/Sprigs are furnished.

TABLE XLIV

BERMUDA GRASS: PRODUCTION COSTS AND YIELDS PER ACRE ON DRYLAND SANDY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class					
			Sb		Sc		Sd	
			Quantity	Value	Quantity	Value	Quantity	Value
Production:								
Pasture	AUM		3.50		3.25		3.0	
Inputs:								
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	60	6.00
P	Lb.	.08	30	2.40	30	2.40	30	2.40
K	Lb.	.05	15	.75	15	.75	15	.75
Power and Machinery Oper. Costs	Acre			.19		.19		.19
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
1/10 of Establishment Costs	Dol.		38.46	3.84	38.46	3.84	38.46	3.84
Interest on Annual Capital	Dol.	.07	4.74	.33	4.74	.33	4.74	.33
Total Specified Costs Above Land, Labor, Equipment Cap., Management & Overhead	Dol.			15.66		15.66		15.66
Labor Required:								
Regular	Hr.	1.50	.13	.19	.13	.19	.13	.19
1/10 of Establishment Labor	Dol.		1.44	.14	1.44	.14	1.44	.14
Fixed Costs:								
Power & Machinery	Acre			.30		.30		.30
1/10 of Establishment Costs	Dol.		1.73	.17	1.73	.17	1.73	.17
Total Specified Costs Above Land, Management & Overhead	Dol.			20.31		20.31		20.31

TABLE XLV

BERMUDA GRASS: PRODUCTION COSTS AND YIELDS PER ACRE ON DRYLAND LOAMY SOILS

Item	Unit	Price or Cost per Unit	Productivity Class La Quantity	La Value	Lb Quantity	Lb Value	Lc Quantity	Lc Value	Ld Quantity	Ld Value
Production:										
Pasture	AUM		3.5		3.5		3.0		2.4	
Inputs:										
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	60	6.00	60	6.00
P	Lb.	.08	30	2.40	30	2.40	30	2.40	30	2.40
K	Lb.	.05	15	.75	15	.75	15	.75	15	.75
Power & Machinery Oper. Costs	Acre			.19		.19		.19		.19
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15
1/10 of Establishment Cost	Dol.		38.46	3.84	38.46	3.84	38.46	3.84	38.46	3.84
Interest on Annual Capital	Dol.	.07	4.74	.33	4.74	.33	4.74	.33	4.74	.33
Total Specified Costs Above Land, Labor, Equipment Cap., Management & Overhead	Dol.			15.66		15.66		15.66		15.66
Labor Required:										
Regular	Hr.	1.50	.13	.19	.13	.19	.13	.19	.13	.19
1/10 of Establishment Labor	Dol.		1.44	.14	1.44	.14	1.44	.14	1.44	.14
Fixed Costs:										
Power & Machinery	Acre			.30		.30		.30		.30
1/10 of Establishment Costs	Dol.		1.73	.17	1.73	.17	1.73	.17	1.73	.17
Total Specified Costs Above Land, Management & Overhead	Dol.			20.31		20.31		20.31		20.31

TABLE XLVI

COTTON: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED SANDY SOILS

			Inches of Irrigation											
			Sb						Sc					
		Price or	6"		9"		15"		6"		9"		15"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Lint	Lb.	.205	625	128.12	725	148.62	850	174.25	525	107.62	625	128.12	750	153.75
Seed	Lb.	.024	1,000	24.00	1,160	27.84	1,360	32.64	840	20.16	1,000	24.00	1,200	28.80
Total Receipts	Dol.			152.12		176.46		206.89		127.78		152.12		182.55
Inputs:														
Seed	Lb.	.14	37.5	5.25	37.5	5.25	37.5	5.25	37.5	5.25	37.5	5.25	37.5	5.25
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	80	8.00	60	6.00	60	6.00	80	8.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20	40	3.20	40	3.20	40	3.20
K	Lb.	.05	50	2.50	50	2.50	50	2.50	50	2.50	50	2.50	50	2.50
Herbicide	Acre	8.88	1	8.88	1	8.88	1	8.88	1	8.88	1	8.88	1	8.88
Insecticide	Acre	3.00	10	30.00	10	30.00	15	45.00	10	30.00	10	30.00	15	45.00
Crop Insurance	$100	5.65	1.5	8.47	1.5	8.47	1.5	8.47	1.5	8.47	1	8.47	1	8.47
Power and Machinery Oper. Costs	Acre			4.80		4.80		4.80		4.80		4.80		4.80
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45	3	.45	3	.45	3	.45
Irrigation Oper. Costs	A.-In.	.57	6	3.42	9	5.13	15	8.55	6	3.42	9	5.13	15	8.55
Picking Lint	Lb.	.05	625	31.25	725	36.25	850	42.50	525	26.25	625	31.25	750	37.50
Ginning, Bag and Tie	Lb.	.021	625	13.12	725	15.22	850	17.85	525	11.02	625	13.12	750	15.75
Interest on Annual Capital	Dol.	.07	41.04	2.87	41.04	2.87	50.79	3.55	41.04	2.87	41.04	2.87	50.79	3.55
Total Specified Costs	Dol.			120.21		129.02		159.00		113.11		121.92		151.90
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			31.91		47.44		47.89		14.67		30.20		30.65
Labor Required:														
Irrigation	Hr.	1.50	.74	1.11	1.11	1.67	1.85	2.78	.74	1.11	1.11	1.67	1.85	2.78
Non Irrigation	Hr.	1.50	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20
Fixed Costs:														
Power and Machinery	Acre			5.40		5.40		5.40		5.40		5.40		5.40
Irrigation	A.-In.	.27	6	1.62	9	2.43	15	4.05	6	1.62	9	2.43	15	4.05
Return to Land, Management and Overhead	Dol.			19.58		33.74		31.46		2.34		16.50		14.22

TABLE XLVII

COTTON: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED LOAMY SOILS

			Inches of Irrigation											
			La						Lb					
		Price or	6"		9"		15"		6"		9"		15"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Lint	Lb.	.205	600	123.00	725	148.62	850	174.25	575	117.87	700	143.50	825	169.12
Seed	Lb.	.024	960	23.04	1,160	27.84	1,360	32.64	920	22.08	1,120	26.88	1,320	31.68
Total Receipts	Dol.			156.04		176.46		206.89		139.95		170.38		200.80
Inputs:														
Seed	Lb.	.14	37.5	5.25	37.5	5.25	37.5	5.25	37.5	5.25	37.5	5.25	37.5	5.25
Fertilizer: N	Lb.	.10	60	6.00	60	6.00	80	8.00	60	6.00	60	6.00	80	8.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20	40	3.20	40	3.20	40	3.20
K	Lb.	.05	10	.50	10	.50	10	.50	10	.50	10	.50	10	.50
Herbicide	Acre	8.88	1	8.88	1	8.88	1	8.88	1	8.88	1	8.88	1	8.88
Insecticide	Acre	3.00	3	45.00	3	45.00	3	45.00	3	45.00	3	45.00	3	45.00
Crop Insurance	$100	5.65	2	11.30	2	11.30	2	11.30	2	11.30	2	11.30	2	11.30
Power and Machinery Oper. Costs	Acre			4.80		4.80		4.80		4.80		4.80		4.80
Irrigation Oper. Costs	A.-In.	.57	6	3.42	9	5.13	15	8.55	6	3.42	9	5.13	15	8.55
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45	3	.45	3	.45	3	.45
Picking Lint	Lb.	.05	600	30.00	725	36.25	850	42.50	575	28.75	700	35.00	825	41.25
Ginning, Bag and Tie	Lb.	.021	600	12.60	725	15.22	850	17.85	575	12.07	700	14.70	825	17.32
Interest on Annual Capital	Dol.	.07	43.89	3.07	43.89	3.07	45.14	3.16	43.89	3.07	43.89	3.07	45.14	3.16
Total Specified Costs	Dol.			134.47		145.05		159.44		132.69		143.28		157.66
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			21.57		31.41		47.45		7.26		27.10		43.14
Labor Required:														
Irrigation	Hr.	1.50	.74	1.11	1.11	1.67	1.85	2.78	.74	1.11	1.11	1.67	1.85	2.78
Non Irrigation	Hr.	1.50	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20
Fixed Costs:														
Power and Machinery	Acre			5.40		5.40		5.40		5.40		5.40		5.40
Irrigation	A.-In.	.27	6	1.62	9	2.43	15	4.05	6	1.62	9	2.43	15	4.05
Return to Land, Management and Overhead	Dol.			9.24		17.71		31.02		-5.07		13.40		26.71

TABLE XLVII (Continued)

Item	Unit	Price or Cost Per Unit	Lc Inches of Irrigation 6" Quantity	6" Value	9" Quantity	9" Value	15" Quantity	15" Value
Production:								
Lint	Lb.	.205	475	97.37	600	123.00	725	148.62
Seed	Lb.	.024	760	18.24	960	23.04	1,160	27.84
Total Receipts	Dol.			115.61		156.04		176.46
Inputs:								
Seed	Lb.	.14	37.5	5.25	37.5	5.25	37.5	5.25
Fertilizer: N	Lb.	.10	60	6.00	80	8.00	80	8.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20
K	Lb.	.05	10	.50	10	.50	10	.50
Herbicide	Acre	8.88	1	8.88	1	8.88	1	8.88
Insecticide	Acre	3.00	3	45.00	3	45.00	3	45.00
Crop Insurance	$ 100	5.65	2	11.30	2	11.30	2	11.30
Power and Machinery Oper. Costs	Acre			4.80		4.80		4.80
Irrigation Oper. Costs	A.-In.	.57	6	3.42	9	5.13	15	8.55
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45
Picking Lint	Lb.	.05	475	23.75	600	30.00	725	36.25
Ginning, Bag and Tie	Lb.	.021	475	9.97	600	12.60	725	15.22
Interest on Annual Capital	Dol.	.07	43.89	3.07	45.14	3.16	45.14	3.16
Total Specified Costs	Dol.			125.59		138.27		150.56
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			-9.98		17.77		25.90
Labor Required:								
Irrigation	Hr.	1.50	.74	1.11	1.11	1.67	1.85	2.78
Non Irrigation	Hr.	1.50	2.80	4.20	2.80	4.20	2.80	4.20
Fixed Costs:								
Power and Machinery	Acre			5.40		5.40		5.40
Irrigation	A.-In.	.27	6	1.62	9	2.43	15	4.05
Return to Land, Management and Overhead	Dol.			-22.31		4.07		9.47

TABLE XLVIII

PEANUTS: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED SANDY SOILS

			Inches of Irrigation											
			Sb						Sc					
		Price or	9"		12"		15"		9"		12"		15"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Peanuts	Cwt.	11.00	32	352.00	36	396.00	38	418.00	30	330.00	34	374.00	36	396.00
Total Receipts	Dol.			352.00		396.00		418.00		330.00		374.00		396.00
Inputs:														
Rye Seed	Lb.	.05	65	3.25	65	3.25	65	3.25	65	3.25	65	3.25	65	3.25
Peanut Seed	Lb.	.33	80	26.40	80	26.40	80	26.40	80	26.40	80	26.40	80	26.40
Fertilizer: N	Lb.	.10	15	1.50	18	1.80	21	2.10	15	1.50	18	1.80	21	2.10
P	Lb.	.08	60	4.80	72	5.76	84	6.72	60	4.80	72	5.76	84	6.72
K	Lb.	.05	60	3.00	72	3.60	84	4.20	30	1.50	36	1.80	42	2.10
Herbicide	Acre	6.75	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75
Insecticide	Lb.	.45	60	27.00	60	27.00	60	27.00	60	27.00	60	27.00	60	27.00
Power and Machinery Oper. Costs	Acre			5.11		5.11		5.11		5.11		5.11		5.11
Irrigation Oper Costs	A.-In.	.57	9	5.13	12	6.84	15	8.55	9	5.13	12	6.84	15	8.55
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45	3	.45	3	.45	3	.45
Dig and Shake	Acre	3.50	2	7.00	2	7.00	2	7.00	2	7.00	2	7.00	2	7.00
Combine	Acre	15.00	1	15.00	1	15.00	1	15.00	1	15.00	1	15.00	1	15.00
Hauling, Clean and Dry	Ton	16.00	1.6	25.60	1.8	28.80	1.9	30.40	1.5	24.00	1.7	27.20	1.8	28.80
Interest on Annual Capital	Dol.	.07	43.30	3.03	45.39	3.18	47.49	3.32	41.90	2.93	43.71	3.06	45.53	3.19
Total Specified Costs	Dol.			134.02		140.94		146.25		130.82		137.42		142.09
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			217.98		255.06		271.75		199.18		236.58		253.91
Labor Required:														
Irrigation	Hr.	1.50	1.11	1.67	1.48	2.22	1.85	2.78	1.11	1.67	1.48	2.22	1.85	2.78
Non Irrigation	Hr.	1.50	2.91	4.36	2.91	4.36	2.91	4.36	2.91	4.36	2.91	4.36	2.91	4.36
Fixed Costs:														
Power and Machinery	Acre			5.67		5.67		5.67		5.67		5.67		5.67
Irrigation	A.-In.	.27	9	2.43	12	3.24	15	4.05	9	2.43	12	3.24	15	4.05
Return to Land, Management and Overhead	Dol.			203.85		239.57		254.89		185.05		221.09		237.05

TABLE XLVIII (Continued)

Item	Unit	Price or Cost Per Unit	Sd Inches of Irrigation 9" Quantity	Value	12" Quantity	Value	15" Quantity	Value
Production:								
Peanuts	Cwt.	11.00	28	308.00	32	352.00	34	374.00
Total Receipts	Dol.			308.00		352.00		374.00
Inputs:								
Rye Seed	Lb.	.05	65	3.25	65	3.25	65	3.25
Peanut Seed	Lb.	.33	80	26.40	80	26.40	80	26.40
Fertilizer: N	Lb.	.10	12	1.20	12	1.20	12	1.20
P	Lb.	.08	48	3.84	48	3.84	48	3.84
K	Lb.	.05	24	1.20	24	1.20	24	1.20
Herbicide	Acre	6.75	1	6.75	1	6.75	1	6.75
Insecticide	Lb.	.45	60	27.00	60	27.00	60	27.00
Power and Machinery Oper. Costs	Acre			5.11		5.11		5.11
Irrigation Oper Costs	A.-In.	.57	9	5.13	12	6.84	15	8.55
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45
Dig and Shake	Acre	3.50	2	7.00	2	7.00	2	7.00
Combine	Acre	15.00	1	15.00	1	15.00	1	15.00
Hauling, Clean and Dry	Ton	16.00	1.4	22.40	1.6	25.60	1.7	27.20
Interest on Annual Capital	Dol.	.07	41.25	2.89	42.41	2.97	43.58	3.05
Total Specified Costs	Dol.			127.62		132.61		136.00
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			180.38		192.39		238.00
Labor Required:								
Irrigation	Hr.	1.50	1.11	1.67	1.48	2.22	1.85	2.78
Non Irrigation	Hr.	1.50	2.91	4.36	2.91	4.36	2.91	4.36
Fixed Costs:								
Power and Machinery	Acre			5.67		5.67		5.67
Irrigation	A.-In.	.27	9	2.43	12	3.24	15	4.05
Return to Land, Management and Overhead	Dol.			166.25		176.90		221.14

TABLE XLIX

PEANUTS: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED LOAMY SOILS

			Inches of Irrigation											
			Lb						Lc					
		Price or	9"		12"		15"		9"		12"		15"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Peanuts	Cwt.	11.00	30	330.00	34	374.00	36	396.00	24	264.00	27	297.00	30	330.00
Total Receipts	Dol.			330.00		374.00		396.00		264.00		297.00		330.00
Inputs:														
Rye Seed	Lb.	.05	65	3.25	65	3.25	65	3.25	65	3.25	65	3.25	65	3.25
Peanut Seed	Lb.	.33	80	26.40	80	26.40	80	26.40	80	26.40	80	26.40	80	26.40
Fertilizer: N	Lb.	.10	15	1.50	18	1.80	21	2.10	15	1.50	18	1.80	21	2.10
P	Lb.	.08	60	4.80	72	5.76	84	6.72	60	4.80	72	5.76	84	6.72
K	Lb.	.05	60	3.00	72	3.60	84	4.20	30	1.50	36	1.80	42	2.10
Herbicide	Acre	6.75	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75
Insecticide	Lb.	.45	60	27.00	60	27.00	60	27.00	60	27.00	60	27.00	60	27.00
Power and Machinery Oper. Costs	Acre			5.11		5.11		5.11		5.11		5.11		5.11
Irrigation Oper Costs	A.-In.	.57	9	5.13	12	6.84	15	8.55	9	5.13	12	6.84	15	8.55
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45	3	.45	3	.45	3	.45
Dig and Shake	Acre	3.50	2	7.00	2	7.00	2	7.00	2	7.00	2	7.00	2	7.00
Combine	Acre	15.00	1	15.00	1	15.00	1	15.00	1	15.00	1	15.00	1	15.00
Hauling, Clean & Dry	Ton	16.00	1.5	24.00	1.7	27.20	1.8	28.80	1.2	19.20	1.35	21.60	1.5	24.00
Interest on Annual Capital	Dol.	.07	43.30	3.03	45.39	3.18	47.49	3.32	41.90	2.93	43.71	3.06	45.53	3.19
Total Specified Costs	Dol.			132.42		139.34		144.65		126.02		131.82		137.62
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			197.58		234.66		251.35		137.98		165.18		192.38
Labor Required:														
Irrigation	Hr.	1.50	1.11	1.67	1.48	2.22	1.85	2.78	1.11	1.67	1.48	2.22	1.85	2.78
Non Irrigation	Hr.	1.50	2.91	4.36	2.91	4.36	2.91	4.36	2.91	4.36	2.91	4.36	2.91	4.36
Fixed Costs:														
Power and Machinery	Acre			5.67		5.67		5.67		5.67		5.67		5.67
Irrigation	A.-In.	.27	9	2.43	12	3.24	15	4.05	9	2.43	12	3.24	15	4.05
Return to Land, Management and Overhead	Dol.			183.45		219.17		234.49		123.85		149.69		175.52

TABLE XLIX (Continued)

			Ld Inches of Irrigation					
			9"		12"		15"	
Item	Unit	Price or Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value
Production:								
Peanuts	Cwt.	11.00	24	266.00	27	297.00	30	330.00
Total Receipts	Dol.			266.00		297.00		330.00
Inputs:								
Rye Seed	Lb.	.05	65	3.25	65	3.25	65	3.25
Peanut Seed	Lb.	.33	80	26.40	80	26.40	80	26.40
Fertilizer: N	Lb.	.10	12	1.20	12	1.20	12	1.20
P	Lb.	.08	48	3.84	48	3.84	48	3.84
K	Lb.	.05	24	1.20	24	1.20	24	1.20
Herbicide	Acre	6.75	1	6.75	1	6.75	1	6.75
Insecticide	Lb.	.45	60	27.00	60	27.00	60	27.00
Power and Machinery Oper. Costs	Acre			5.11		5.11		5.11
Irrigation Oper. Costs	A.-In.	.57	9	5.13	12	6.84	15	8.55
Fertilizer Spreader Rental	Acre	.15	3	.45	3	.45	3	.45
Dig and Shake	Acre	3.50	2	7.00	2	7.00	2	7.00
Combine	Acre	15.00	1	15.00	1	15.00	1	15.00
Hauling, Clean & Dry	Ton	16.00	1.2	19.20	1.35	21.60	1.5	24.00
Interest on Annual Capital	Dol.	.07	41.25	2.89	42.41	2.97	43.58	3.05
Total Specified Costs	Dol.			124.42		128.61		132.80
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			141.58		168.39		197.20
Labor Required:								
Irrigation	Hr.	1.50	1.11	1.67	1.48	2.22	1.85	2.78
Non Irrigation	Hr.	1.50	2.91	4.36	2.91	4.36	2.91	4.36
Fixed Costs:								
Power and Machinery	Acre			5.67		5.67		5.67
Irrigation	A.-In.	.27	9	2.43	12	3.24	15	4.05
Return to Land, Management and Overhead	Dol.			127.45		152.90		180.34

TABLE L

ALFALFA: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED SANDY SOILS

			Sb						Sc					
							Inches of Irrigation							
		Price or	12"		15"		18"		12"		15"		18"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Hay	Ton	25.00	5.0	125.00	6.0	150.00	7.0	175.00	4.5	112.50	5.5	137.50	6.5	162.50
Grazing	AUM		.8	125.00	.9	150.00	1.0	175.00	.8	112.50	.9	137.50	1.0	162.50
Total Receipts	Dol.													
Inputs:														
Fertilizer: N	Lb.	.10	20	2.00	25	2.50	30	3.00	20	2.00	25	2.50	30	3.00
P	Lb.	.08	80	6.40	100	8.00	120	9.60	80	6.40	100	8.00	120	9.60
K	Lb.	.05	40	2.00	50	2.50	60	3.00	40	2.00	50	2.50	60	3.00
Insecticide	Acre	2.00	2	4.00	2	4.00	2	4.00	2	4.00	2	4.00	2	4.00
Power and Machinery Oper. Costs	Acre			.19		.19		.19		.19		.19		.19
Irrigation Oper. Costs	A.-In.	.57	12	6.84	15	8.55	18	10.26	12	6.84	15	8.55	18	10.26
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Swathing	Acre	2.50	4	10.00	5	12.50	6	15.00	4	10.00	5	12.50	6	15.00
Baling	Bale	.17	150	22.50	180	30.60	210	35.70	135	22.95	165	28.05	195	33.15
Hauling	Bale	.15	150	25.50	180	27.00	210	31.50	135	20.25	165	24.75	195	29.25
1/4 of Establishment Costs	Dol.		30.57	7.64	30.57	7.64	30.57	7.64	30.57	7.64	30.57	7.64	30.57	7.64
Interest on Annual Capital	Dol.	.07	16.66	1.16	20.31	1.42	23.94	1.67	14.66	1.16	20.31	1.42	23.94	1.67
Total Specified Costs	Dol.			88.38		105.05		121.71		83.58		100.25		116.91
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			36.62		44.95		53.29		28.92		37.25		45.59
Labor Required:														
Irrigation	Hr.	1.50	1.48	2.22	1.85	2.78	2.22	3.33	1.48	2.22	1.85	2.78	2.28	3.33
Non Irrigation	Hr.	1.50	.13	.19	.13	.19	.13	.19	.13	.19	.13	.19	.13	.19
1/4 of Establishment Labor	Dol.		2.88	.72		.72		.72		.72		.72		.72
Fixed Costs:														
Power and Machinery	Acre			.20		.20		.20		.20		.20		.20
Irrigation	A.-In.	.27	12	3.24	15	4.05	18	4.86	12	3.24	15	4.05	18	4.86
1/4 of Establishment Costs	Dol.		3.73	.93	3.73	.93	3.73	.93	3.73	.93	3.73	.93	3.73	.93
Return to Land, Management and Overhead	Dol.			30.26		36.08		43.06		21.42		28.38		35.36

TABLE LI

ALFALFA: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED LOAMY SOILS

			Inches of Irrigation											
			La						Lb					
		Price or	12"		15"		18"		12"		15"		18"	
Item	Unit	Cost Per Unit	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value
Production:														
Hay	Ton	25.00	5.0	125.00	6.0	150.00	7.0	175.00	5.0	125.00	6.0	150.00	7.0	175.00
Grazing	AUM		.8	125.00	.9	150.00	1.0	175.00	.8	125.00	.9	150.00	1.0	175.00
Total Receipts	Dol.													
Inputs:														
Fertilizer: N	Lb.	.10	10	1.00	10	1.00	20	2.00	10	1.00	20	2.00	30	3.00
P	Lb.	.08	60	4.80	60	4.80	80	6.40	60	4.80	80	6.40	100	8.00
K	Lb.	.05	30	1.50	30	1.50	40	2.00	30	1.50	40	2.00	60	3.00
Insecticide	Acre	2.00	2	4.00	2	4.00	2	4.00	2	4.00	2	4.00	2	4.00
Power and Machinery Oper. Costs	Acre			.19		.19		.19		.19		.19		.19
Irrigation Oper. Costs	A.-In.	.57	12	6.84	15	8.55	18	10.26	12	6.84	15	8.55	18	10.26
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Swathing	Acre	2.50	4	10.00	5	12.50	6	15.00	4	10.00	5	12.50	6	15.00
Baling	Bale	.17	150	22.50	180	30.60	210	35.70	150	22.50	180	30.60	210	35.70
Hauling	Bale	.15	150	25.50	180	27.00	210	31.50	150	25.50	180	27.00	210	31.50
1/4 of Establishment Costs	Dol.		30.57	7.64	30.57	7.64	30.57	7.64	30.57	7.64	30.57	7.64	30.57	7.64
Interest on Annual Capital	Dol.	.07	15.13	1.06	17.46	1.22	19.79	1.38	15.13	1.06	18.93	1.32	23.14	1.62
Total Specified Costs	Dol.			85.18		99.15		116.22		85.18		102.35		120.06
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			39.82		50.85		58.78		39.82		47.65		54.94
Labor Required:														
Irrigation	Hr.	1.50	1.48	2.22	1.85	2.78	2.22	3.33	1.48	2.22	1.85	2.78	2.22	3.33
Non Irrigation	Hr.	1.50	.13	.19	.13	.19	.13	.19	.13	.19	.13	.19	.13	.19
1/4 of Establishment Labor	Dol.		2.88	.72	2.80	.72	2.80	.72	2.80	.72	2.80	.72	2.80	.72
Fixed Costs:														
Power and Machinery	Acre			.20		.20		.20		.20		.20		.20
Irrigation	A.-In.	.27	12	3.24	15	4.05	18	4.86	12	3.24	15	4.05	18	4.86
1/4 of Establishment Costs	Dol.		3.73	.93	3.73	.93	3.73	.93	3.73	.93	3.73	.93	3.73	.93
Return to Land, Management and Overhead	Dol.			32.32		41.98		48.55		32.32		38.78		44.71

TABLE LII

FORAGE SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED SANDY SOILS

			Inches of Irrigation											
			Sb						Sc					
		Price or	3"		6"		9"		3"		6"		9"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Hay	Ton	18.00	5.5	99.00	6.3	113.40	7.0	126.00	5.0	90.00	5.8	104.40	6.5	117.00
Total Receipts	Dol.			99.00		113.40		126.00		90.00		104.40		117.00
Inputs:														
Seed	Lb.	.20	25	5.00	25	5.00	25	5.00	25	5.00	25	5.00	25	5.00
Fertilizer: N	Lb.	.10	60	6.00	80	8.00	100	10.00	60	6.00	80	8.00	100	10.00
P	Lb.	.08	40	3.20	50	4.00	60	4.80	40	3.20	50	4.00	60	4.80
K	Lb.	.05	30	1.50	30	1.50	40	2.00	30	1.50	30	1.50	40	2.00
Power and Machinery Oper. Costs	Acre			4.71		4.71		4.71		4.71		4.71		4.71
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Swathing	Acre	2.50	1	2.50	2	5.00	3	7.50	1	2.50	2	5.00	3	7.50
Baling	Bale	.17	165	28.05	189	32.13	210	35.70	150	25.50	174	29.58	195	33.15
Hauling	Bale	.15	165	24.75	189	28.35	210	31.50	150	22.50	174	26.10	195	29.25
Interest on Annual Capital	Dol.	.07	10.91	.76	11.02	.77	14.28	1.00	10.91	.76	11.02	.77	14.28	1.00
Total Specified Costs	Dol.			78.33		93.03		107.49		73.53		88.23		102.69
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			20.67		20.37		18.51		16.47		16.17		14.31
Labor Required:														
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:														
Power and Machinery	Acre			5.26		5.26		5.26		5.26		5.26		5.26
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			10.27		8.33		5.10		5.79		4.13		.90

TABLE LII (Continued)

Item	Unit	Price or Cost Per Unit	Sd Inches of Irrigation 3" Quan-tity	Value	6" Quan-tity	Value	9" Quan-tity	Value
Production:								
Hay	Ton	18.00	4.0	72.00	4.8	86.40	5.5	99.00
Total Receipts	Dol.			72.00		86.40		99.00
Inputs:								
Seed	Lb.	.20	25	5.00	25	5.00	25	5.00
Fertilizer: N	Lb.	.10	60	6.00	80	8.00	100	10.00
P	Lb.	.08	40	3.20	50	4.00	60	4.80
K	Lb.	.05	30	1.50	30	1.50	40	2.00
Power and Machinery Oper. Costs	Acre			4.71		4.71		4.71
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Swathing	Acre	2.50	1	2.50	2	5.00	3	7.50
Baling	Bale	.17	120	20.40	144	24.48	165	28.05
Hauling	Bale	.15	120	18.00	144	21.60	165	24.75
Interest on Annual Capital	Dol.	.07	10.91	.76	11.02	.77	14.28	1.00
Total Specified Costs	Dol.			63.93		81.63		93.09
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			8.07		4.77		5.91
Labor Required:								
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:								
Power and Machinery	Acre			5.26		5.26		5.26
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			-2.61		-7.27		-7.50

TABLE LIII

FORAGE SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED LOAMY SOILS

			Inches of Irrigation											
			La						Lb					
		Price or	3"		6"		9"		3"		6"		9"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Hay	Ton	18.00	6.0	108.00	6.8	122.40	7.5	135.00	5.5	99.00	6.3	113.40	7.0	126.00
Total Receipts	Dol.			108.00		122.40		135.00		99.00		113.40		126.00
Inputs:														
Seed	Lb.	.20	25	5.00	25	5.00	25	5.00	25	5.00	25	5.00	25	5.00
Fertilizer: N	Lb.	.10	60	6.00	80	8.00	80	8.00	60	6.00	80	8.00	80	8.00
P	Lb.	.08	40	3.20	50	4.00	60	4.80	40	3.20	50	4.00	60	4.80
K	Lb.	.05	30	1.50	30	1.50	40	2.00	30	1.50	30	1.50	40	2.00
Power and Machinery Oper. Costs	Acre			4.71		4.71		4.71		4.71		4.71		4.71
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Swathing	Acre	2.50	1	2.50	2	5.00	3	7.50	1	2.50	2	5.00	3	7.50
Baling	Bale	.17	180	30.60	204	34.68	225	38.25	165	28.05	189	32.13	210	35.70
Hauling	Bale	.15	180	27.00	204	30.60	225	33.75	165	24.75	189	28.35	210	31.50
Interest on Annual Capital	Dol.	.07	10.91	.76	11.02	.77	12.77	.89	10.91	.76	11.02	.77	12.77	.89
Total Specified Costs	Dol.			83.13		97.83		110.18		78.33		93.03		105.38
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			24.87		24.57		24.82		20.67		20.37		20.62
Labor Required:														
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:														
Power and Machinery	Acre			5.26		5.26		5.26		5.26		5.26		5.26
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			14.47		12.53		11.41		9.99		8.33		7.21

TABLE LIII (Continued)

			Inches of Irrigation											
			Lc						Ld					
		Price or	3"		6"		9"		3"		6"		9"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Hay	Ton	18.00	5.0	90.00	5.8	104.40	6.5	117.00	4.0	72.00	4.8	86.40	5.5	99.00
Total Receipts	Dol.			90.00		104.40		117.00		72.00		86.40		99.00
Inputs:														
Seed	Lb.	.20	25	5.00	25	5.00	25	5.00	25	5.00	25	5.00	25	5.00
Fertilizer: N	Lb.	.10	60	6.00	80	8.00	80	8.00	60	6.00	80	8.00	80	8.00
P	Lb.	.08	40	3.20	50	4.00	60	4.80	40	3.20	50	4.00	60	4.80
K	Lb.	.05	30	1.50	30	1.50	40	2.00	30	1.50	30	1.50	40	2.00
Power and Machinery Oper. Costs	Acre			4.71		4.71		4.71		4.71		4.71		4.71
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Swathing	Acre	2.50	1	2.50	2	5.00	3	7.50	1	2.50	2	5.00	3	7.50
Baling	Bale	.17	150	25.50	174	29.58	195	33.15	120	20.40	144	24.48	165	28.05
Hauling	Bale	.15	150	22.50	174	26.10	195	29.25	120	18.00	144	21.60	165	24.75
Interest on Annual Capital	Dol.	.07	10.91	.76	11.02	.77	12.77	.89	10.91	.76	11.02	.77	12.77	.89
Total Specified Costs	Dol.			73.53		88.23		100.58		63.93		78.63		90.98
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			16.47		16.17		16.42		8.07		7.77		8.02
Labor Required:														
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:														
Power and Machinery	Acre			5.26		5.26		5.26		5.26		5.26		5.26
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			5.79		4.13		3.01		-2.61		-4.27		-5.39

TABLE LIV

ENSILAGE: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED SANDY AND LOAMY SOILS

Item	Unit	Price or Cost Per Unit	La 3" Quantity	La 3" Value	La 6" Quantity	La 6" Value	La 9" Quantity	La 9" Value	Sb 3" Quantity	Sb 3" Value	Sb 6" Quantity	Sb 6" Value	Sb 9" Quantity	Sb 9" Value
Production:														
Ensilage	Ton	6.00	17	102.00	20	120.00	22	132.00	15	90.00	18	108.00	20	120.00
Total Receipts	Dol.			102.00		120.00		132.00		90.00		108.00		120.00
Inputs:														
Seed	Lb.	.17	20	3.40	20	3.40	20	3.40	20	3.40	20	3.40	20	3.40
Fertilizer: N	Lb.	.10	80	8.00	100	10.00	120	12.00	80	8.00	100	10.00	120	12.00
P	Lb.	.08	40	3.20	50	4.00	60	4.80	40	3.20	50	4.00	60	4.80
K	Lb.	.05	30	1.50	30	1.50	40	2.00	30	1.50	30	1.50	40	2.00
Power and Machinery Oper. Costs	Acre			4.71		4.71		4.71		4.71		4.71		4.71
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Chop and Haul	Ton	2.00	17	34.00	20	40.00	22	44.00	15	30.00	18	36.00	20	40.00
Interest on Annual Capital	Dol.	.07	11.71	.82	13.84	.97	15.93	1.12	11.71	.82	13.84	.97	15.93	1.12
Total Specified Costs	Dol.			57.49		68.15		77.31		53.49		64.15		73.31
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			44.51		51.85		54.69		36.51		43.85		46.69
Labor Required:														
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05	2.70	4.05
Fixed Costs:														
Power and Machinery	Acre			5.26		5.26		5.26		5.26		5.26		5.26
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			33.83		39.81		41.28		25.83		31.81		33.28

TABLE LV

GRAIN SORGHUM: PRODUCTION COSTS AND RETURNS PER ACRE ON IRRIGATED SANDY AND LOAMY SOILS

			Inches of Irrigation											
			La						Lb					
		Price or	3"		6"		9"		3"		6"		9"	
Item	Unit	Cost Per Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production:														
Grain	Cwt.	1.93	42	81.06	52	100.36	56	108.08	34	65.62	44	84.92	49	94.57
Aftermath	AUM		.35		.40		.45		.30		.35		.40	
Total Receipts	Dol.			81.06		100.36		108.08		65.62		84.92		94.57
Inputs:														
Seed	Lb.	.21	15	3.15	15	3.15	15	3.15	15	3.15	15	3.15	15	3.15
Fertilizer: N	Lb.	.10	70	7.00	90	9.00	120	12.00	60	6.00	60	6.00	80	8.00
P	Lb.	.08	40	3.20	40	3.20	40	3.20	40	3.20	40	3.20	40	3.20
K	Lb.	.05	0	-	0	-	0	-	0	-	0	0	0	-
Power and Machinery Oper. Costs	Acre			4.85		4.85		4.85		4.85		4.85		4.85
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
Combining	Acre	3.50	1	3.50	1	3.50	1	3.50	1	3.50	1	3.50	1	3.50
Hauling	Cwt.	.09	42	3.78	52	4.68	56	5.04	34	3.06	44	3.96	49	4.41
Interest on Annual Capital	Dol.	.07	9.42	.66	11.51	.80	14.05	.98	8.97	.63	10.14	.71	12.21	.85
Total Specified Costs	Dol.			28.00		32.75		38.00		26.25		28.94		33.24
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			53.06		67.61		70.08		39.37		55.98		61.33
Labor Required:														
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20	2.80	4.20
Fixed Costs:														
Power and Machinery	Acre			5.40		5.40		5.40		5.40		5.40		5.40
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			42.37		55.28		56.38		28.40		43.65		47.63

TABLE LV (Continued)

Item	Unit	Price or Cost Per Unit	Sb Inches of Irrigation 3" Quan-tity	Value	6" Quan-tity	Value	9" Quan-tity	Value
Production:								
Grain	Cwt.	1.93	44	84.92	52	100.36	60	115.80
Aftermath	AUM		.40		.45		.50	
Total Receipts	Dol.			84.92		100.36		115.80
Inputs:								
Seed	Lb.	.21	15	3.15	15	3.15	15	3.15
Fertilizer: N	Lb.	.10	70	7.00	90	9.00	120	12.00
P	Lb.	.08	40	3.20	40	3.20	60	4.80
K	Lb.	.05	20	1.00	20	1.00	20	1.00
Power and Machinery Oper. Costs	Acre			4.85		4.85		4.85
Irrigation Oper. Costs	A.-In.	.57	3	1.71	6	3.42	9	5.13
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15
Combining	Acre	3.50	1	3.50	1	3.50	1	3.50
Hauling	Cwt.	.09	44	3.96	52	4.68	60	5.40
Interest on Annual Capital	Dol.	.07	9.88	.69	12.07	.84	15.33	1.07
Total Specified Costs	Dol.			29.21		33.79		41.05
Return to Land, Labor, Equipment, Capital, Management & Overhead	Dol.			55.71		66.57		74.75
Labor Required:								
Irrigation	Hr.	1.50	.37	.56	.74	1.11	1.11	1.67
Non Irrigation	Hr.	1.50	2.80	4.20	2.80	4.20	2.80	4.20
Fixed Costs:								
Power and Machinery	Acre			5.40		5.40		5.40
Irrigation	A.-In.	.27	3	.81	6	1.62	9	2.43
Return to Land, Management and Overhead	Dol.			45.02		54.24		61.05

TABLE LVI

BERMUDA GRASS: PRODUCTION COSTS AND YIELDS PER ACRE ON IRRIGATED SANDY AND LOAMY SOILS

			Sb & Lb				Sc & Lc				Sd & Ld			
			Inches of Irrigation											
		Price or	6"		18"		6"		18"		6"		18"	
Item	Unit	Cost Per Unit	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value	Quan-tity	Value
Production:														
Pasture	AUM		7.0		10.5		7.0		10.5		7.0		10.5	
Inputs:														
Fertilizer: N	Lb.	.10	60	6.00	90	9.00	60	6.00	90	9.00	60	6.00	90	9.00
P	Lb.	.08	30	2.40	60	4.80	30	2.40	60	4.80	30	2.40	60	4.80
K	Lb.	.05	15	.75	30	1.50	15	.75	30	1.50	15	.75	30	1.50
Power and Machinery Oper. Costs	Acre			.19		.19		.19		.19		.19		.19
Irrigation Oper. Costs	A.-In.	.57	6	3.42	18	10.26	6	3.42	18	10.26	6	3.42	18	10.26
Fertilizer Spreader Rental	Acre	.15	1	.15	1	.15	1	.15	1	.15	1	.15	1	.15
1/10 of Establishment Costs	Dol.		47.77	4.77	47.77	4.77	47.77	4.77	47.77	4.77	47.77	4.77	47.77	4.77
Interest on Annual Capital	Dol.	.07	13.90	.97	21.79	1.52	13.90	.97	21.79	1.52	13.90	.97	21.79	1.52
Total Specified Costs Above Land, Labor, Equipment, Capital, Management & Overhead	Dol.			18.65		32.19		18.65		32.19		18.65		32.19
Labor Required:														
Irrigation	Hr.	1.50	.74	1.11	2.22	3.33	.74	1.11	2.22	3.33	.74	1.11	2.22	3.33
Non Irrigation	Hr.	1.50	.13	.19	.13	.19	.13	.19	.13	.19	.13	.19	.13	.19
1/10 of Establishment Labor	Dol.		3.12	.31	4.80	.48	3.12	.31	4.80	.48	3.12	.31	4.80	.48
Fixed Costs:														
Power and Machinery	Acre			1.73		1.73		1.73		1.73		1.73		1.73
Irrigation	A.-In.	.27	6	1.62	18	4.86	6	1.62	18	4.86	6	1.62	18	4.86
1/10 of Establishment Costs	Dol.		5.70	.57	13.74	1.37	5.70	.57	13.74	1.37	5.70	.57	13.74	1.37
Total Specified Costs Above Land, Management and Overhead	Dol.			24.18		44.15		24.18		44.15		24.18		44.15

TABLE LVII

PRODUCTION COSTS AND RETURNS PER STEER FOR GOOD FEEDER CATTLE ENTERPRISE; ROUGHED THROUGH WINTER ON RANGE AND COTTON SEED CAKE[1]

Item	Unit	Price or Cost per Unit	Quantity	Value or Cost
Production:				
Feeder	Cwt	21.98	7.75	170.34
Less one percent Death Loss				168.64
Inputs:				
Calf	Cwt	25.46	4.50	114.57
Range	AUM		7.30	
C.S.C. (15 #/day, 150 days)	Cwt	3.49	2.25	7.85
Veterinary and Medicine	Dol.		2.66	2.66
Salt	Lbs.	.03	16.30	.49
Hauling and Marketing Costs	Cwt	.48	12.25	5.88
Property Tax	Dol.	.04	22.91	.92
Int. on Annual Capital	Dol.	.07	125.73	8.80
Total Specified Costs	Dol.			141.17
Returns to Land, Labor, Fixed Capital, Mgmt. and Overhead	Dol.			27.47
Labor Required	Hr.	1.50	7.60	11.40
Returns to Land, Fixed Capital, Mgmt. and Overhead	Dol.			16.07

Labor Requirements (Man Hours Per Steer)

Jan. - April	May - July	Aug. - Sept.	Oct. - Dec.	Total
2.80	1.50	1.00	2.30	7.60

[1]Fall buy - October 15, and sold off grass October 15.

TABLE LVIII

PRODUCTION COSTS AND RETURNS PER STEER FOR GOOD FEEDER CATTLE ENTERPRISE; WINTER RATION OF SMALL GRAIN PASTURE WITH FORAGE SORGHUM AND COTTONSEED CAKE WHILE OFF SMALL GRAIN[1]

Item	Unit	Price or Cost per Unit	Quantity	Value or Cost
Production:				
Feeder	Cwt	23.77	6.00	142.62
Less One Percent Death Loss				141.19
Inputs:				
Calf	Cwt	25.46	4.50	114.57
Range	AUM		.50	
Small Grain Grazing	AUM		1.20	
Forage Sorghum	Ton	18.00	.33	5.94
C.S.C. (1.5 #/day)	Cwt	3.49	.24	.84
Veterinary and Medicine	Dol.		1.51	1.51
Salt	Lbs.	.03	6.50	.19
Hauling and Marketing Cost	Cwt	.48	10.50	5.04
Property Tax	Dol.	.04	22.91	.92
Int. on Annual Capital	Dol.	.07	51.21	3.58
Total Specified Costs	Dol.			132.59
Returns to Land, Labor Fixed Capital, Mgmt. and Overhead	Dol.			8.60
Labor Required	Hr.	1.50	2.76	4.14
Returns to Land, Fixed Capital, Mgmt. and Overhead	Dol.			4.46

Labor Requirements (Man Hours Per Steer)

Jan. - April	May - July	Aug. - Sept.	Oct. - Dec.	Total
1.62	.00	.00	1.14	2.76

[1]Fall buy - October 15, and sold off small grain March 1.

TABLE LIX

PRODUCTION COSTS AND RETURNS PER STEER FOR GOOD FEEDER CATTLE ENTERPRISE; GRAZED THROUGH SUMMER ON NATIVE RANGE OR BERMUDA PASTURE[1]

Item	Unit	Price or Cost per Unit	Quantity	Value or Cost
Production				
Feeder	Cwt	21.98	7.75	170.34
Less One Percent Death Loss				168.64
Inputs:				
Calf	Cwt	25.54	5.00	127.70
Range	AUM		4.00	
Veterinary and Medicine	Dol.		.97	.97
Salt		.03	16.30	.49
Hauling and Marketing Cost	Cwt	.48	12.75	6.12
Int. on Annual Capital	Dol.	.07	65.78	4.60
Total Specified Costs	Dol.			139.88
Returns to Land, Labor, Fixed Capital, Mgmt., and Overhead	Dol.			28.76
Labor Required	Hr.	1.50	3.60	5.40
Returns to Land, Fixed Capital, Mgmt. and Overhead	Dol.			23.36

Labor Requirements (Man Hours Per Steer)

Jan. - April	May - July	Aug. - Sept.	Oct. - Dec.	Total
.55	1.50	1.00	.55	3.60

[1]Spring buy - April 15, and sold off native pasture October 15.

TABLE LX

PRODUCTION COSTS AND RETURNS FOR BEEF COW HERD (25 COW UNIT); SPRING CALVING; COWS WINTERED ON COTTONSEED CAKE AND NATIVE RANGE OR BERMUDA PASTURE[1]

Item	Unit	Price or Cost per Unit	Quantity	Value or Cost	Value or Cost per Cow
Production:					
Cull Cows (3 head)	Cwt	10.57	29.50	311.81	12.47
Heifer Calves (7 head)	Cwt	22.70	30.00	681.00	27.24
Steer Calves (11 head)	Cwt	25.46	49.50	1,260.27	50.41
Total Receipts	Dol.			2,253.08	90.12
Inputs:					
Range	AUM		336.00		
Forage Sorghum	Ton	18.00	.75	13.50	.54
C.S.C. (1.5 #/day; 150 days)	Cwt	3.49	63.00	219.87	8.79
Salt	Lbs.	.03	840.00	25.20	1.01
Veterinary and Medicine	Dol.			101.50	4.06
Bull Depreciation	Dol.			35.00	1.40
Hauling and Marketing Costs	Cwt	.48	109.00	52.32	2.09
Property Tax	Dol.	.04	972.00	38.88	1.56
Int. on Annual Capital	Dol.	.07	5,104.00	357.28	14.29
Total Specified Costs	Dol.			843.55	33.74
Returns to Land, Labor, Fixed Capital, Mgmt., and Overhead	Dol.			1,409.53	56.48
Labor Required	Hr.	1.50	279.00	418.50	16.74
Returns to Land, Fixed Capital, Mgmt., and Overhead	Dol.			991.03	39.64

Labor Requirements (Man Hours Per Cow)

Jan. - April	May - July	Aug. - Sept.	Oct. - Dec.	Total
8.10	1.12	.36	1.58	11.16

[1]Calves born March 1; non-creep fed; sold off native range October 1 as good-choice feeders.

TABLE LXI

PRODUCTION COSTS AND RETURNS FOR BEEF COW HERD (25 COW UNIT); SPRING CALVING; COWS WINTERED ON NATIVE RANGE, FORAGE SORGHUM AND SMALL GRAIN PASTURE (WINTER ONLY)[1]

Item	Unit	Price or Cost per Unit	Quantity	Value or Cost	Value or Cost per Cow
Production:					
Cull Cows (3 head)	Cwt	10.57	29.50	311.81	12.47
Heifer Calves (7 head)	Cwt	22.70	30.00	681.00	27.24
Steer Calves (11 head)	Cwt	25.46	49.50	1,260.27	50.41
Total Receipts	Dol.			2,253.08	90.12
Inputs:					
Range	AUM		251.00		
Small Grain Pasture	AUM		70.00		
Forage Sorghum	Ton	18.00	7.00	126.00	5.04
C.S.C. (1.5 #/day; 75 days)	Cwt	3.49	31.25	109.06	4.36
Salt	Lbs.	.03	840.00	25.20	1.01
Veterinary and Medicine	Dol.			101.50	4.06
Bull Depreciation	Dol.			35.00	1.40
Hauling and Marketing Costs	Cwt	.48	109.00	52.32	2.09
Property Tax	Dol.	.04	972.00	38.88	1.56
Int. on Annual Capital	Dol.	.07	5,068.25	354.78	14.19
Total Specified Costs	Dol.			842.74	33.71
Returns to Land, Labor, Fixed Capital, Mgmt., and Overhead	Dol.			1,410.34	56.41
Labor Required	Hr.	1.50	279.00	418.50	16.74
Returns to Land, Fixed Capital Mgmt., and Overhead	Dol.			991.00	39.67

Labor Requirements (Man Hours Per Cow)

Jan. - April	May - July	Aug. - Sept.	Oct. - Dec.	Total
8.10	1.12	.36	1.58	11.16

[1]Calves born March 1; non-creep fed; sold off native range October 1 as good-choice feeders.

TABLE LXII

PRODUCTION COSTS AND RETURNS FOR BEEF COW HERD (25 COW UNIT); FALL CALVING; COWS WINTERED ON NATIVE RANGE, SMALL GRAIN PASTURE (WINTER ONLY), AND GRAIN SORGHUM STUBBLE WITH FORAGE SORGHUM AND COTTONSEED CAKE[1]

Item	Unit	Price or Cost per Unit	Quantity	Value or Cost	Value or Cost per Cow
Production:					
Cull Cows (3 head)	Cwt.	10.57	29.50	311.81	12.47
Heifer Calves (7 head)	Cwt.	23.14	30.75	711.55	28.46
Steer Calves (11 head)	Cwt.	25.96	46.50	1,207.14	48.28
Total Receipts	Dol.			2,230.50	89.21
Inputs					
Range	AUM		214.00		
Small Grain Pasture	AUM		70.00		
Grain Sorghum Stubble	AUM		42.00		
Forage Sorghum	Ton	18.00	5.25	94.50	3.78
C.S.C. (1.5 #/day; 75 days)	Cwt.	3.49	31.25	109.06	4.36
Salt	Lbs.	.03	840.00	25.20	1.01
Veterinary and Medicine	Dol.			101.50	4.06
Bull Depreciation	Dol.			35.00	1.40
Hauling and Marketing Cost	Cwt.	.48	107.00	51.36	2.05
Property Tax	Dol.	.04	1,182.00	47.28	1.89
Int. on Annual Capital	Dol.	.07	5,112.25	357.86	14.31
Total Specified Costs	Dol.			821.76	32.86
Returns to Land, Labor, Fixed Capital, Mgmt., and Overhead	Dol.			1,408.74	56.35
Labor Required	Hr.	1.50	319.00	478.50	19.14
Returns to Land, Fixed Cap., Mgmt., and Overhead	Dol.			930.24	37.21

Labor Requirements (Man Hours per Cow)

Jan.-April	May-July	Aug.-Sept	Oct.-Dec.	Total
4.94	1.04	1.00	5.78	12.76

[1]Calves born November 1; non-creep fed; sold off native range July 20 as good-choice feeders.

APPENDIX B

INFORMATION USED IN THE ESTIMATION OF THE INTERDEPENDENCE MODEL

TABLE LXIII

DATA USED IN ESTIMATES OF INTERDEPENDENCE MODEL AND SOURCES

Year and County	Population[1] (No.)	Total Employment (No.)	Employment W.R., & S.[1,2] (No.)	Employment Mining and Manufacturing[1] (No.)	Government Employment[1] (No.)	Agricultural Employment[1] (No.)	Volume of Trade In W.R., & S.[2,3] ($1,000)	Personal Income to W.R., & S.[2,4,5] ($1,000)
1950:								
Blaine	15,049	5,261	2,079	428	473	2,281	18,335	3,685
Caddo	34,913	10,085	3,974	826	942	4,343	31,910	8,682
Canadian	25,644	8,806	4,710	552	981	2,563	26,120	9,284
Custer	21,097	7,576	3,979	455	779	2,363	35,071	7,466
Grady	34,872	11,037	5,159	1,251	1,060	3,567	38,020	12,005
Kiowa	18,926	6,111	2,918	329	520	2,344	26,025	6,420
Washita	17,657	6,226	2,200	120	429	3,477	14,691	4,116
Total	168,158	55,102	25,019	3,961	5,184	20,938	190,172	51,658
1960:								
Blaine	12,077	4,167	1,890	543	414	1,320	22,027	5,788
Caddo	28,621	8,734	4,206	768	1,243	2,517	42,993	13,881
Canadian	24,727	8,139	4,788	744	1,155	1,452	48,407	15,756
Custer	21,040	8,006	4,781	483	1,162	1,580	51,224	15,358
Grady	29,590	10,048	5,490	1,502	1,326	1,730	49,917	17,830
Kiowa	14,825	4,875	2,659	349	544	1,323	31,019	8,951
Washita	18,121	4,616	2,127	86	518	1,885	17,075	5,643
Total	149,001	48,585	25,941	4,475	6,362	11,807	262,662	83,207

[1]Source: U.S. Census of Population for 1950 and 1960.

[2]Wholesale, Retail and Service Sales Subsector.

[3]Source: U.S. Census of Business for 1948, 1954, and 1963. Volumes dealing with Retail, Wholesale, Trade and Selected Services. Projected to 1950 and 1960.

[4]Source: County Building Block Data for Regional Analysis, Oklahoma.

[5]Sum of wages paid in Wholesale and Retail Trade Services, Services, Finance, Insurance and Real Estates, Contract Construction, Public Utilities, and 87.5% of Proprietor and Property Incomes.

[6]Sum of wages paid in Mining and Manufacturing and 12.5% of Proprietor and Property Incomes.

[7]Transfer Payments.

TABLE LXIII (Continued)

Year and County	Personal Income to Agriculture[4] ($1,000)	Personal Income to Government[4] ($1,000)	Personal Income to Mining and Manufacturing[4,6] ($1,000)	Personal Income to Retired Population[4,7] ($1,000)
1950:				
Blaine	5,209	927	1,137	1,348
Caddo	9,123	3,466	2,769	3,197
Canadian	6,597	2,796	2,589	2,712
Custer	5,429	1,914	1,491	1,755
Grady	6,558	1,576	3,074	3,532
Kiowa	6,702	1,508	1,152	1,565
Washita	9,395	845	466	1,157
Total	49,013	13,032	12,678	15,266
1960:				
Blaine	5,371	1,365	2,256	2,087
Caddo	10,249	5,128	3,392	4,760
Canadian	7,450	4,799	2,824	4,421
Custer	7,217	5,070	2,318	3,149
Grady	7,734	3,716	5,430	5,319
Kiowa	5,393	1,645	1,459	2,791
Washita	8,911	13,341	700	1,875
Total	52,325	35,064	18,379	24,402

[1]Source: U.S. Census of Population for 1950 and 1960.

[2]Wholesale, Retail and Service Sales Subsector.

[3]Source: U.S. Census of Business for 1948, 1954, and 1963. Volumes dealing with Retail, Wholesale, Trade and Selected Services. Projected to 1950 and 1960.

[4]Source: County Building Block Data for Regional Analysis, Oklahoma.

[5]Sum of wages paid in Wholesale and Retail Trade Services, Services, Finance, Insurance and Real Estates, Contract Construction, Public Utilities, and 87.5% of Proprietor and Property Incomes.

[6]Sum of wages paid in Mining and Manufacturing and 12.5% of Proprietor and Property Incomes.

[7]Transfer Payments.

TABLE LXIV

CALCULATION OF ANNUAL DEPRECIATION FOR BASIC FARM MACHINERY

Machine	New Cost	Salvage Value	Years of Life	Annual Depreciation
Tractor	7,200	2,160	8	630
Cultivator	750	90	12	55
Planter	900	108	15	52
Spring Harrow	488	59	15	28
Moldboard	910	109	15	53
Disc	1,135	136	15	66
Float	500	60	15	29
Rotary Hoe	600	528	15	35
Grain Drill	1,033	124	15	60
Stalk Cutter	400	48	15	23
Chisel	650	78	15	38
Lister	900	108	15	52
One Way	1,100	145	12	79
Total				1,200

TABLE LXV

BREAKDOWN OF CUSTOM CHARGES INTO LABOR, FUEL AND LUBRICANTS, REPAIRS AND DEPRECIATION, INTEREST AND RETURNS TO MACHINE OWNER'S RISK AND OVERHEAD[1]

Item	% of Total Charge
Total charges	100.00
Labor	21.9
Fuel and Lubricants	6.7
Repairs and Depreciation	30.0
Interest	8.0
Returns to owner's Risk and Overhead	33.4

[1]Source: Carl E. Olson, "The Impact of Agricultural Resource Adjustments on the Economy of Southwestern Oklahoma," (Unpublished Ph.D. dissertation, Oklahoma State University, 1967), p. 123.

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