ECONOMICS OF RESOURCE USE IN IRRIGATED AGRICULTURE: A CASE STUDY OF PUMP SYSTEMS IN THE WESTERN ZONE OF THE BAUCHI STATE AGRICULTURAL DEVELOPMENT PROGRAMME, NIGERIA

BY

KPOTUN MOHAMMAD BABA

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Department of Agricultural Economies and Rural
Sociology, Faculty of Agriculture,
Ahmadu Bello University, Zaria

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DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work. It has not been presented before in any previous application for a higher degree. References made to published literature have been duly acknowledged.

28/8/89

Kpotun Mohammed Baba

The above declaration is confirmed.

Dr. E.C. Etuk
Chairman, Supervisory Committee

CERTIFICATION

This thesis entitled "Economics of Resource Use in Irrigated Agriculture: A Case Study of Pump Systems in the Western Zone of the Bauchi State Agricultural Development Programme" by Kpotun Mohammed Baba meets the regulations governing the award of the degree of Master of Science (Agricultural Economics) of Ahmadu Bello University, and is approved for its contribution to scientific knowledge of literary presentation.

Dr. E.G. Etuk
Chairman, Supervisory Committee

Dr. C.I. Agbo
Member, Supervisory Committee

Dr. Y.A. Abdullahi
Head, Department of Agric. Econs. & Rural Sociology.

Professor D. Saror
Dean, Postgraduate School

Date 4-6-90

DEDICATION

This work is dedicated to my parents: Mallam Yisa Baba and Madam Aishetu Rokan Baba, for putting me on this path which they were never opportuned to tread.

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Kpotun Mohammad Baba

ABSTRACT

Government thrust on irrigation development in Nigeria seems to have focused on the establishment of large-scale irrigation schemes, which for various reasons have been unable to yield the desired increase in agricultural production. Available evidences tend to suggest that small-scale irrigation systems have greater potential of increasing agricultural production in the country than the large-scale schemes. Despite their potentials, irrigation development planners, in Nigeria, have continuously neglected the small-scale irrigation systems. The neglect is probably due to lack of adequate research information on crop production under the system This study was therefore designed to provide empirical information on the economics of crop production under small-scale irrigation, with particular reference to pump systems in the Western Zone of the Bauchi State Agricultural Development Programme (BSADP).

To achieve the objectives of the study, input-output data were collected, through the "Cost route" method, from forty-five farmers purposively sampled from four villages in the Western Zone of the BSADP. She data collection was undertaken between December 1987 and June 1988. The collected data were analysed using the Farm Budget and Cobb-Douglas (Power) production function models. The farm budget analysis revealed that most of the farmers were making profits from crop production under pump irrigation systems. In fact, the analysis revealed that the farmers realised an average profit of N2,558.46 per hectare. On the other hand, the Cobb-Douglas production function analysis revealed that inputs were being inefficiently allocated under the systems. While labour and plant population were being used above their economic optimum levels, fertilizer and irrigation water were being used below their economic optima. This implies that there is still, opportunity for increasing profits through resource adjustments under the systems. Efforts should be made towards increased provision of irrigation water and fertilizer. Farmers would also need a downward adjustment of their plant population.

On the basis of the findings of the study, it was concluded that tho promotion of pump irrigation systems should be seriously considered by policy makers in Nigeria.

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CHAPTER ONE

INTRODUCTION

1.1 Problem Setting

Prior to the early 1970's, the Nigerian economy depended mainly on agriculture for food and raw materials supply, revenue generation, and foreign exchange earnings. About the mid seventies, petroleum became prominent in the economy and agriculture began to lose her relative position as the country's leading foreign exchange and revenue earner. Gradually, the agricultural sector was neglected by policy makers and development planners, in favour of the non-agricultural sector. The evidence of this neglect can be seen in the decline of the percentage capital expenditures earmarked for agriculture from 11.74 percent in the Second National Development Plan (1970-1974) to 8.99 percent in the Third National Development Plan (1976-1980) (Federal Republic of Nigeria, 1970). As a result of this neglect, the growth in agricultural output has been unable to keep pace with increases in the demand for food and raw materials accompanying the rapid growth in population and industrialization which the country has experienced over the years. This has led to the diversion of a substantial share of the foreign exchange accruing from oil exports to the importation of food items and raw materials in which the country was formerly self-sufficient, or even an exporter. The food import bills and the value of agricultural export for Nigeria from 1960 to 1964 are presented in Table 1.1. As can be seen from the Table, the value of food imports increased from 43.8 million Naira in 1963 to over 1 billion Naira in 1984, while the percentage share of agriculture in total exports has decreased from over 85 percent in 1960 to a mere 3.2 percent in 1984. It appears that the policy makers

Table 1.1: Growth in domestic food production: agricultural exports and imports in Nigeria, 1960–1984 (₦ million, except otherwise stated).

Year	Food Imports	Value of Total Exports	Agric. Exports	Share of Agric. in Total Exports (%)
1960	n.a	330.0	282.5	85.6
1961	-	346.0	283.0	81.8
1962	-	334.2	260.0	77.8
1963	43.8	378.0	285.9	75.6
1964	23.3	429.4	339.0	69.6
1965	46.1	536.8	332.4	60.1
1966	51.6	566.2	285.8	50.5
1967	42.6	483.6	257.2	53.1
1968	28.4	422.2	274.4	65.0
1969	41.7	636.4	288.2	45.3
1970	57.7	885.4	265.2	30.0
1971	87.9	1,293.4	242.8	18.8
1972	95.1	1,434.2	172.0	12.0
1973	126.3	2,278.4	250.1	10.9
1974	155.0	5,794.8	276.0	4.7
1975	297.9	4,925.5	230.6	4.7
1976	440.9	6,751.1	274.1	4.1
1977	736.4	7,630.7	375.7	4.9
1978	1,027.1	6,064.4	412.8	6.8
1979	766.5	10,836.8	468.0	4.5
1980	1,437.5	14,186.7	340.5	2.4
1981	2,111.5	10,876.7	180.8	1.1
1982	1,755.6	8,192.1	178.9	2.2
1983	1,377.9	7,494.5	293.3	3.9
1984	1,052.1	8,717.1	276.0	3.2

Source: Balogun (1986).

were under the illusion that the economy could be adequately supported by the non-agricultural sector alone.

However, recent developments in the macro-economy have disillusioned the government. Faced with huge food import bills, as well as dwindling and uncertain oil revenues, the government has been forced to realise the fact that the development of agriculture must form the basis for dependable economic development in Nigeria. Consequently, a number of remedial measures have been taken to revive the agricultural sector. Such measures include the establishment of the National Accelerated Food Production Programme, the Agricultural Development Projects, the Operation Feed the Nation, the Green Revolution Programme, the Agricultural Credit Guarantee Scheme Fund, the Directorate for Food, Roads and Rural Infrastructure, the Agricultural Insurance Scheme, and the development of water resources for irrigation. The overall aim of these programmes is to achieve rapid increases in agricultural production in the country.

Perhaps, the most important of the strategies, adopted to revive the nation's agriculture, is the development of water resources for irrigation. Policy statements by Federal and State governments, as well as the huge financial allocations to water resources development in the national development plans, tend to portray irrigation as the connerstone of the nation's agricultural development programme. For example, in the Fourth National Development Plan, it was stated that "..........the full agricultural potential of this country cannot be realised until the abundant water resources are developed and brought to bear on agricultural production" (Federal Ministry of National Planning, 1981). In the same plan, the sums of 2,000 million naira (or 37 percent of total allocation to agriculture) and 58.5 million naira (or 26 percent of total allocation to agriculture), were earmarked for irrigation development by Federal and Bauchi State governments, respectively. As can be seen from Table 1.2 the allocation to irrigation by both governments, far exceeded the allocations to any other subsector of agriculture, with the exception of "crops".

The need for irrigation in Nigerian agriculture arises from the fact that rainfall, the most important source of agricultural water is inadequate and highly variable in supply. Nwa (1976) reports that the annual rainfall in Nigeria is less than 500 mm in some parts of the North and greater than 2,300 mm in some parts of the South. It is also reported that about three-fourths of the North, receive less than five months of rainfall in a year (F.A.O., 1966; Federal Republic of Nigeria, 1976; Nwa, 1980; Nwuba and Onwuyi, 1982).

The implication of these rainfall characteristics is that large areas of land are left uncultivated, especially in the Sahel region of the North. In addition, the intensity of land use is low because cropping of the cultivated land is restricted to the short rainy period. Furthermore, only crops that are quick-maturing and/or drought-tolerant are grown - a situation that prevents diversification into the production of new and high value crops. Also, poor harvests are recorded in years of late arrival, early cessation, and/or frequent breaks of the rains. All these constitute major constraints on increased agricultural production in Nigeria. Irrigation is therefore, considered necessary to alleviate these problems, in order to increase agricultural production in the country. It is estimated that the full development of available water resources for irrigation will add as much as 1.4 to 2 million hectares to the existing arable land (Federal Ministry of National Planning, 1981).

Table 1.2: Federal and Bauchi State Governments' Allocation to the Sub-sectors of Agriculture in the Fourth National Development Plan, 1981-85 (₦ million).

Government	Sub-Sectors of Agriculture					Total	Allocation to Irrigation as per-cent of Total
	Crops	Irrigation	Livestock	Forestry	Fisheries		
Federal	2,962.66	2,000	252.78	97.23	87.33	5,400	37
Bauchi	147.87	59.50	11.60	2.13	0.95	222.05	26

Source: Compiled from the Fourth National Development Plan (1981-85), pp. 89

Government involvement in the development of irrigation in Nigeria, has a relatively long history. The first recorded attempt at irrigation development dates back to 1918 when flood waters were impounded from Sokoto and Rima Rivers, following a study conducted by Colonel Collins, a military engineer (Erhabor, 1982; Nwa and Martins, 1982). Following this, other small scale irrigation schemes such as the Daya, Abadan, Gamboru, Kano, Wurno, and Edozhigi projects were established by the Northern Nigeria Ministry of Agriculture. The year 1973 marked the beginning of organised Federal government involvement in irrigation development. In this year, the Chad-Basin and the Sokoto-Rima Basin Development Authorities were established by the Federal government of Nigeria. In 1976, nine additional River Basin Development Authorities were created and the existing two reconstituted. The idea of river basin development in Nigeria was motivated by the abundance of river systems. The annual surface water in Nigeria is estimated to be 193×10^9 cubic metres (N.E.D.E.C O,1959).

The eleven River Basin Development Authorities are still in existence today and are charged with a range of responsibilities including the harnessing, management, and exploitation of the country's water resources for agricultural production and other purposes. They therefore, appear to be the vehicle through which the government's objective, of increasing agricultural production through irrigation, is expected to be achieved. Nwa and Martins (1982) have adequately documented the various irrigation schemes established by the Authorities in their respective areas of operation.

The irrigation projects established by the River Basin Authorities and other government agencies are mostly large-scale schemes which involve the spending of huge sums of money and the employment of alien and capital-intensive technology. Reports on some of the schemes, however, tend to indicate that the prospects of achieving the desired objectives, through large-scale schemes, are slim. For instance, Etuk and Abalu (1982) reported very high non-participation by farmers and low productivity (yields less than half of potentials), for the Bakolori Irrigation Project. A study of the South Chad Irrigation Project also revealed local farmer participation to be as low as 10.23 percent (Kolawole, 1982). It has also been reported that the benefits of large-scale schemes go mostly to the wealthy and locally powerful people (Palmer-Jones, 1980), and that the intended beneficiaries, the small-scale farmers, gradually get marginalised from participating in the schemes (Makarfi, 1987). The feasibility study of some of the large-scale irrigation schemes estimated the potential internal rate of return to capital to be as low as 2.6 percent, for the Hadejia River Basin Development Authority (Schultz, 1976) and 5.18 percent for the Western Area of the Chad Irrigation Scheme (MRT, 1974). These rates were far lower than the prevailing opportunity cost of capital. Also commenting on the disadvantages of large-scale irrigation schemes, Wallace (1979) maintained that the decision to irrigate through large-scale irrigation schemes has forced Nigeria to turn to expatriates who help to design, construct and manage the schemes. Idachaba et al. (1980) have summarised the other shortcomings of the large-scale irrigation schemes as follows:

(a) they are capital-intensive, expensive and constitute a heavy drain on scarce foreign exchange;

(b) they typically use heavy equipment for levelling, a procedure that seriously disturbs the soil;

(c) they make heavy demand on management, already a very scarce resource;

(d) they have adverse effects on farming and fishing below the dams, and

(e) they often involve large-scale displacement of human settlements with potentials for social upheaval.

Available evidences tend to indicate that small-scale irrigation schemes have greater potential of increasing agricultural production, than the large-scale schemes. Wickramasuriya (1975) made a case for small-scale irrigation schemes when he noted that the overall cost of production under the schemes and the foreign exchange requirements are lower than in the large-scale schemes. He further noted that the investigations, designs and constructions required for the small-scale schemes are relatively simple. Also, the feasibility study for Tomas and Kangimi small-scale irrigation schemes estimated their internal rates of return to capital, to be as high as 14.2 percent and 10 percent, respectively.

1.2 The Research Problem

While Government thrust on irrigation development in Nigeria has focused on the establishment of large-scale irrigation schemes, many farmers in the north of Nigeria privately irrigate their fadama land with water from streams, ponds, and wells, using pump and shadoof water lift devices. The capital requirement of these lift systems is low and the technologies, while being simple, allow the farmer the best control over the time and rate of water application. Also, high returns to crop production have been reported under the systems (Erhabor, 1982). The systems have, therefore, found acceptance and popularity among traditional small-scale farmers in this area. Since the small-scale farmers play a dominant role in the country's agricultural sector, it is expected that the promotion and improvement of any technology (such as the pump and shadoof systems) acceptable to them, would have high potentials of increasing aggregate agricultural production in the country.

Despite their potentials, irrigation development planners in Nigeria have continuously neglected the small-scale irrigation systems. The neglect is probably due to the lack of adequate research information on crop production under the systems. Research work on small-scale irrigation systems have, so far, covered only few crops and small geographical areas (Orewa, 1978; Erhabor, 1982; Ofojekwu, 1982; Makarfi, 1985). The result is that there is a dearth of data on the economics of crop production under small-scale irrigation systems. Since production characteristics in agriculture are variable, depending on the type of crop and the nature of the environment, there is need for research information to be generated on small-scale irrigation systems in different locations in the country. Specifically, answers must be provided to a number of questions relating to the economics of crop production under the systems, including:

(1) What are the resource requirements and constraints associated with the systems?

(2) How profitable is crop production under the systems?

(3) Are resources being efficiently allocated under the systems?

Answers to these questions should reveal the potentials and constraints of the systems. The appropriate magnitude and direction of resource adjustments under the systems would also be indicated. Policy makers, irrigation development planners, as well as research and extension workers would then recognise the specific aspects of small-scale irrigation systems on which to focus their attention. This study is designed to provide answers to these questions with particular reference to pump lift systems in the area covered by the Western Zone of the Bauchi State Agricultural Development Programme (BSADP).

1.3 Objectives of the Study

This study is aimed at providing empirical information on the economics of resource use under pump irrigation systems. The specific objectives of the study are:

(1) to describe farming practices under pump irrigation systems in the study area;

(2) to determine the costs, returns and profitability of crop production under the systems;

(3) to estimate the productivities of the resources employed under the systems;

(4) to determine the efficiency of resource-use and the nature of returns to scale that prevail under the systems; and

(5) to derive from the results of the above analysis, implications for research and extension work, and for government policy on irrigation development.

1.4 Organization of the Thesis

Chapter two of this thesis provides a theoretical background to the study and reviews previous studies on the economics of small-scale irrigation. In chapter three, the methods of data collection and analysis are presented. Chapter four describes the characteristics of irrigated farming in the study area, while chapter five discusses the results of the farm budget and production function analysis.

The last and final chapter presents the summary and conclusion of the thesis.

CHAPTER TWO

LITERATURE REVIEW

2.1 Irrigation and Agricultural Development

Basically, irrigation is the artificial application of water to the soil for the purpose of crop production. It supplements rainfall which, although unpredictable both in time and quantity, is nevertheless, received at little or no expense to the farmer. The benefits of irrigation development are numerous. Hedges (1963) listed the benefits of irrigated agriculture as[1]:

(1) increasing the range of choice of crops and livestock, thus providing flexibility in decision-making;

(2) lessening the danger of crop failure and the range of yield fluctuations, hence reducing uncertainty;

(3) favouring more complete and efficient resource use;

(4) increasing the capacity of the land for input of other factors;

(5) shifting the factor-product curves toward higher inputs and greater production, thus increasing gross receipts per acre and for the total farm operations;

(6) increasing the size of the total farm business.

Nwa (1976) also noted that irrigation permits multiple cropping and ensures job security for farm workers. In a study in Taiwan, Jones (1971) found that days required "per acre" per annum had doubled where multiple cropping was widely practised. The all-year-round production implied by multiple cropping also results in the stability

1. Cited in Mulga (1983)

of output, as against the seasonal pattern of supply characteristic of single cropping. Furthermore, crops like rice, which has been described as the crop that is most dependent on irrigation (Clark, 1964), produce higher yields under irrigation than under rainfed conditions. Best yields of rice of approximately 4,000 kilograms per hectare under upland conditions, and 7,000 kilograms per hectare under irrigated conditions have been reported (Abifarin, 1974). Irrigation also makes possible, the growth of such crops as wheat whose climatic requirements are best approximated during the harmattan season in the north of Nigeria.

Wood (1980) noted that consumers of agricultural commodities benefit from irrigated agriculture through reduced food prices (due to yield increases), increased economic activities from both increased capital investment and increased production, as well as through increased variety of food supply. Two kinds of indirect income effects or secondary impacts have also been identified with irrigation development (Young, 1980). The first is the forward-linked ("stemming from") activities which involve processing, marketing, and transportation of increased production resulting from irrigation. The second is the backward-linked ("induced") effects which include increased supply of inputs (seed, fertilizer, machinery, etc) to the farm sector. In addition, irrigation can be used specifically to settle human population for the purposes of development.

In view of these benefits, it could be concluded that the development of irrigated agriculture has high potentials of increasing the farm income of farmers and farm workers, as well as the aggregate agricultural production of the country. It must, however, be cautioned that the mere application of irrigation water will not give maximum increases in crop yields unless accompanied [illegible] by more scientific methods of cultivation and by an efficient use of farm resources (Maiga, 1983).

2.2 Theory of Production

2.2.1 The Production Process

Production involves the transformation of some goods and services, called inputs, into other goods and services, called outputs. Inputs in agricultural production are classified into land, labour, capital and management. These inputs are usually organised by producing units (or farm-firms) whose ultimate objectives or goals may be profit maximization, cost minimization, output maximization, maximization of security, or a combination of all or any of these motives (Olayide and Heady, 1982).

2.2.2 The Production Function

In the production process, it is assumed that there is a causal link between the quantity of inputs and the quantity of output. In other words, the quantity of output is determined by the quantity of inputs (Dillon, 1977). A production function (or response function) displays the technical relationship between inputs and output in the production process (Upton, 1979). In mathematical terms, a production function can be implicitly expressed as follows:

$$Y = f(X_1, X_2, X_3, \ldots\ldots, X_m) \ldots\ldots (1)$$

where Y = physical quantity of output

X's = physical quantity of input.

Equation (1) says that the quantity of output, Y, is some unspecified mathematical function of the quantity of inputs $X_1, X_2, X_3, \ldots\ldots X_m$. In using this mathematical function to undertake an economic analysis of the input-output relationships in agriculture, it is assumed that there is a continuous smooth causal relation between the X's (inputs) and Y (output). Looking at the response equation (1), this assumption implies that the first derivatives $\partial Y/\partial X_i$ or the marginal physical products with respect to each of the X's exist.

2.2.3 Theoretical Quantities from the Production Function

If we assume a single-variable response function, four quantities of interest can be derived. These are the average physical product (AP), the marginal physical product (MP), the maximum level of output that can be obtained, and the elasticity of response (E) with respect to the variable input. The common characteristic of all these four quantities is that they variously relate input and output. Hence, they are classified as factor-product relations (as against factor-factor and product-product relations) (Dillon, 1977).

The average physical product of a variable input X_1 is defined as:

$$AP_{X_1} = Y/X_1 \quad \ldots\ldots\ldots\ldots (2)$$

In other words, the AP_{X_1} is the output per unit of variable input X_1. The AP_{X_1} may decrease with increase in Y_1 but it can never be negative.

The marginal physical product of X_1 is defined as:

$$MP_{X_1} = \partial Y/\partial X_1 \quad \ldots\ldots\ldots\ldots (3)$$

Marginal physical product is the slope or the rate of change of the response curve. It tells us the rate of change in Y if X_1 is changed by an infinitesimal amount. From the viewpoint of production economics analysis, the concept of marginal physical product is much more important than that of the average physical product. Marginal physical product helps in determining the economic optimum level of production, combination of resources, and combination of enterprises (Upton, 1979). If the price of the product is given, the marginal value product of the variable resource X_1 is obtained as the product of the marginal physical product and the unit price of the product. The marginal value product could also be obtained by taking the first order partial derivative of the total value product function.

The maximum level of output that can obtained occurs where the marginal physical product is zero. Beyond this level of X_1, the marginal physical product becomes negative.

Elasticity of response (or elasticity of production) with respect to X_1 is defined as:

$$E_{X_1} = (\partial Y/\partial X_1)(X_1/Y) \quad \text{.........................} (4)$$

$$= MP_{X_1}/AP_{X_1} \quad \text{..............................} (5)$$

The elasticity of response is a pure number and it is conveniently interpreted as the percentage change in output resulting from one percent change in X_1. We say that there is decreasing, constant, or or increasing returns to the variable input according as if the elasticity of production with respect to the input is less than, equal to, or greater than unity. Elasticity of production can be used to obtain returns to scale that prevail in an agricultural setting. The definition for returns to scale is presented in equation (6).

$$\text{Returns to scale} = \sum(\partial Y/\partial X_i)(X_i/Y) \quad \text{...............} (6)$$

In other words, returns to Scale is the sum of the elasticities of production with respect to all the variable inputs used in a production process. Again according as if the sum of the elasticities is less than, equal to or greater than unity, we say that there is decreasing, constant or increasing returns to scale.

For a two-variable response function, the quantities of interest that could be derived include isoquant equations and the marginal rate of technical substitution of one factor for another.

These quantities are known as factor-factor relations. The isoquant equations represent loci of input combinations that yield a fixed level of output. An isoquant equation can be obtained from the two-variable response function by expressing one of the inputs as a function of output level and quantity of the other input. The marginal rate of technical substitution is the rate at which we have to substitute one factor for the other if one factor is changed by a small amount and we wish to maintain the same level of output. It is defined as:

$$MRS_{X_1, X_2} = \partial X_1 / \partial X_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where MRS_{X_1, X_2} is the marginal rate of technical substitution of variable resource X_1 for X_2. The marginal rate of technical substitution is the slope of the isoquant.

2.2.4 Efficiency in Resource Use

Resource-use efficiency is of two types. There is the "technical" efficiency and the "allocative" or "economic" efficiency. Technical efficiency is measured by relating the level of output achieved to the levels of inputs used (Upton, 1979). A firm is said to be technically efficient if it yields the maximum possible output per unit of variable resources. In such a firm resources are combined in such a way that they cannot be rearranged to give a greater physical output with the same collection of resources, or the same physical output with less of one or more resources. Although technical efficiency is a necessary condition for the overall efficiency of a firm, it is not a sufficient condition. To ascertain whether a firm is really efficient in resource use, price relationships have to be employed to denote maximum profit (Heady, 1952). This brings us to the concept of economic efficiency.

According to Upton (1979), economic efficiency is defined only if resources and enterprises are chosen and combined in such a way that they attain or are near economic optimum. If the response function permits a single-variable analysis, economic optimum or the most efficient level of resource use is defined where the marginal physical product (MP) of the resource equals the resource/product price ratio. This condition can be stated as:

$MP_X = P_X$ ....(8)

or $MP_X . P_y \ (MVP_X) = P_X$ ....(9)

where MP_X is the marginal physical product of the variable resource, MVP_X is the marginal value product of the resource, P_X is the price per unit of the resource, and Py is the price per unit of the product.

For a two-variable response function, economic optimum or the least-cost-combination of resources occurs where the marginal physical products of the variable resources equal the respective resource/product price ratio. This condition can be expressed as:

$MP_{X_1} = P_{X_1}/Py$ ....(10)

$MP_{X_2} = P_{X_2}/Py$ ....(11)

or $MRS_{X_1, X_2} = P_{X_1}/P_{X_2}$ ....(12)

The condition for economic efficiency stated for the two-variable response function above can be generalised for a response function having more than two variables. All that is required is that, for all the inputs or variables used in the production of a product, the marginal product should be equated with the resource/product price ratio. Only then can it be considered that all the inputs are being optimally utilized.

2.2.5 <u>The Effect of Time and Uncertainty on Resource-Use Efficiency</u>

The foregoing analysis has treated crop response as if it were instantaneous. In reality, crop response is never instantaneous. Rather, there is usually a time-lag between input commitment and output realization. The analysis of response, therefore, becomes more realistic when time is taken into consideration. Time may have four direct effects on the response process. These influences are as follows:

(1) the contribution of fixed inputs may vary directly with the time length of the response process;

(2) the capacity of the set of fixed inputs to accommodate variable inputs may be a function of time and of the mix of variable inputs;

(3) the time sequence or pattern of either input injections or output harvests, may influence yield;

(4) input carry-over effects may occur from one production period to another if the injection of variable inputs within one production period is not completely utilized within that period.

Perhaps, a more important influence of time, is its effect on response efficiency through risk and/or uncertainty about the future. Due to the time-lag in production, the farmer makes decision, now, about the future and cannot be absolutely certain of the outcomes of his decision. A farmer can be in one of two imperfect knowledge situations about the expected outcomes of his decisions. He may eith be in a "risky" situation, in which the probability distribution of expected outcomes is known to him, or in an "uncertain" situation where the probability distribution of expected outcomes is not known. For the purposes of this study, however, the terms "risk" and "uncertainty" are used interchangeably, since they both refer to an imperfect situation.

The major sources of uncertainty are yield variations and price changes. Uncertainty about yield arises because some input variable are not under the decision-maker's control and their levels are not known at the time decisions have to be made. ~~From a decision-maker's~~ viewpoint, we can group the inputs used in crop production into three categories. The first category includes the inputs whose levels are controlled by the decision-maker. They are known as the decision-variables. Typical controlled variables in crop production include fertilizers, seed quantity, crop variety, herbicides and insecticides. The second category of inputs include those variables that are referred to as predetermined variables. They are the variables whose levels are not controlled by the decision-maker but are known at the time of decision-making. Predetermined variables in crop production include soil fertility and soil moisture. The third category includes variables whose levels are neither controlled by nor known to the decision-maker. They are known as uncertain variables. The major uncertain inputs are such climatic variables as rainfall, temperature, wind and solar radiation. Yield uncertainty arises from these uncertain variables whose levels are unknown (Dillon, 1977).

Price uncertainty arises from possible price changes. The input and output prices are not controlled by the decision-maker. Prices may change from the anticipated levels and this constitutes an important source of uncertainty to the producer.

Uncertainty arising from these and other sources has significant impact on the way resources should be allocated. As Upton (1979) pointed out, most farmers make some efforts to avoid risks and are willing to give up some profits for this purpose. Thus the most attractive level of output for most farmers is likely to be somewhere below the economic optimum, since they will discount potential marginal return for risk.

Although ~~time and uncertainty complicates the analysis of~~ response efficiency, Anderson et al (1977) have warned that the relevance of any theory of response that ignores uncertainty may be put to question. A number of approaches to handling risk, in response analysis, have been advocated. Dillon (1977) has adequately articulated these approaches.

2.3 A Review of Previous Studies on the Economics of Small-Scale Irrigation

Relatively few studies have been undertaken on the conomics of small-scale irrigation. Orewa (1978) investigated the economics of dry-season tomato production under the Cadbury Scheme in Zaria area. His study covered three categories of farmers including those operating under the Cadbury Scheme, those under group organizations, and private individuals, growing tomato under shadoof and pump irrigation systems. He used Farm Budget and Cobb-Douglas production function models to analyse the cross-section data obtained from 74 farmers in three villages. The analysis from the Farm Budget model revealed, in general, that farmers were operating at a loss. With total revenue per acre as the dependent variable, the production function analysis revealed that most of the resources were being allocated below the economic optimum levels.

In another study, Erhabor (1982) determined the efficiency of resource use under shadoof and pump irrigation systems in two villages in Ringim Local Government Area of Kano State, Nigeria. He used the production function model to obtain the coefficients for a linear programming model to analyse the farm level data obtained from 125 farmers in the two villages. He found high returns to farming under these irrigation techniques and concluded that promoting them is worthy of consideration by policy makers in Nigeria.

In his study of the economics of tomato production under the

Galma Irrigation Scheme, Ofojekwu (1982) worked with 39 farmers participating in the scheme. He used both farm budget and Cobb-Douglas production function models to analyse the data obtained from these farmers. His farm budget analysis revealed that labour constituted over 55 percent of the total cost of production while seed, fertilizer and water accounted for 7.03 percent, 18.61 percent and 10.27 percent, respectively. From the production function analysis, he found that labour was being used above the economic optimum level, while fertilizer was being used below the economic optimum level.

Makarfi (1985) also investigated the economics of wheat production under the Kano River Project. He used both the farm budget and Cobb-Douglas production function models to analyse farm data obtained from 39 farmers under the project. His farm budget analysis revealed that farmers realised a profit of 819.68 naira per hectare at the (then) market price. From his production function analysis, he found that fertilizer and seed were being underutilized while labour and irrigation water were being overutilized.

CHAPTER THREE

METHODS OF DATA COLLECTION AND ANALYSIS

3.1 The Study Area

This study covers the area under the Western Zone of the Bauchi State Agricultural Development Programme (BSADP). The Western Zone of the BSADP consists of Dass, Toro, Tafawa Balewa and Bauchi Local Government Areas (LGAs). It covers an estimated land area of 13,220 square kilometres. The demographic, rainfall, vegetation, soil and topographic features of the zone are as described in the sections that follow.

3.1.1 Demographic Features

The Western Zone of the BSADP has an estimated 75,256 households and a population of about 483,878 persons. The population density of the zone is estimated to be 37 persons per square kilometre (BSADP, 1983). The low population density perhaps explains the predominance of shifting cultivation in upland farming in the area.

3.1.2 Rainfall and Vegetation

Annual rainfall in the study area ranges from 1,000 mm to 1,300 mm. The rainfall duration is about 5 months, beginning in May and ending around October. This leaves a period of dry season of about 7 months during which dry season farming under various systems of irrigation is undertaken.

The vegetation in the area is predominantly shrub savanna scantly interspersed with Baobab, Acacia and locust bean trees.

3.1.3 Topography and Soils

The topography of the area consists of dissected plains and pediments, with outcropping hills of basic intrusive rocks and younger granites. The soils consist of weakly developed and non-leached ferruginous soils of alluvial and colluvial origins. Also found in parts of the area are deep and very deep, well-drained coarse-textured soils.

3.1.4 Rivers and Streams

The study area is blessed with a network of rivers and streams, mostly tributaries of the Gongola and the Bunga Rivers. Amongst these are Rivers Lere, Ribon, Rafin Bagel, Tilde, Juga, Delemi, and so on. Along the flood plains of most of these rivers, farmers can be seen cultivating small plots of land under irrigation.

3.2 Data Requirements

The data required for this study are of two types. The first set of data are the "fixed-point" and/or "registered" information which are unlikely to change during the research period. They include information on sizes of households, ages, sexes and education levels of household members who work in the fadama, types, number, ages and value of tools and equipment used on irrigated farms during the research period as well as sources and amounts of loans obtained and used for crop production in the fadamas.

The second set of data required for the study are the "continuous" and "non-registered" types. These include information on input-output relationships such as hours of family and non-family labour input, tasks undertaken, number, ages and sexes of persons involved, as well as wages paid. Other types of data included in this set are type, quantity, sources and costs of seeds and fertilizers used on a specific plot on a specific day; number and length of water application; quantities of crops harvested on a particular day, quantities consumed at home or given out as gifts, quantities sold, where sold and to whom sold; mode and cost of transport and prices received; number of pump breakdowns, place and cost of repairs, expenditure on fuels and lubricants.

3.3 Data Collection Methods

3.3.1 Sampling Procedure

The sample for this study was drawn from four villages in the area covered by the Western Zone of the BSADP. The Zone consists of four Local Government Areas (LGAs) namely, Dass, Tafawa Balewa, Toro, and Bauchi LGAs. The Western Zone was selected for this study because of the predominance of dry season farming in the area, and also because it is the nearest zone to Bauchi town. Since the researcher operated from Bauchi town, it was hoped that the nearness of the zone will cut the research cost, in terms of reduced transport cost. Two villages (Juga and Tudun Wada Ribina) were selected from Toro L.G.A., while one village (Dajin) was selected from Tafawa Balewa L.G.A. The fourth village (Dass) was selected from Dass L.G.A. Two villages were selected from Toro L.G.A. because dry season farming appeared to be more widespread here than in any of the remaining three L.G.As. in the zone. On the other hand, no village was sampled from Bauchi LGA because dry season farming was not popular in the LGA. It was, therefore, impossible to obtain enough number of pump users, in any single village to justify stationing an enumerator there.

The sampling of the villages from the L.G.As was based on two criteria - accessibility and the extent to which pump irrigation is practised. Using an household list obtained from the BSADP, a purposive sample of 12 households, including only those who are known to use motorised pumps for irrigation, was selected from each of the four villages. Later in the season, 3 households from Juga village were dropped for lack of cooperation. This brought the total sample size down to 45 households, which were retained throughout the research period.

3.3.2 Data Collection

Data for this study were collected through a field survey conducted by the researcher and four well-trained enumerators, between December 1987 and June 1988. Information from the respondents were recorded on pre-tested structured questionnaires. The information collected are those outlined in secton 3.2. The first set of data, the "fixed-point" and "registered" types, were collected in a single visit interview. The second set of data, on the other hand, were collected twice weekly through the "cost-route" method. The "cost-route" method was used to obtain these data in view of their "continuous" and "non-registered" nature, and also in view of the fact that the respondents do not keep records of farm activities. The advantage of the cost-route method as pointed out by Spencer (1972), is that events are recorded as they occur and undue reliance is not placed on farmer's memory recall ability.

3.3.3 Nature and Measurement of the Input-Output Data

(i) Land

Land, as defined by Baba (1975), is the surface of the earth on which man carries out his agricultural and other related activities. In this study, land specifically refers to Fadama, an Hausa word applied to low lying land often with high water table (Nwa, 1976). The area of the fadama under cultivation by each respondent was physically measured using measuring tape, range poles and compasses. The dimensions obtained were then used to compute the actual sizes of the fadamas, in hectares.

(ii) Labour

Labour input has been defined as the work done by human beings and not the human beings themselves (Upton, 1979). In measuring labour input therefore, it is the actual number of hours spent working that is relevant and not the number of persons available in an area.

Two classes of labour input have been identified in traditional agriculture of Northern Nigeria (Norman, 1972). The first category, the family labour input, is the labour input by the farmer himself and household members, including adult male, adult female, large child and small child. The second category, which is the non-family labour input, may be kwadago (or labour hired and paid on a rate per hour basis), jinga (or labour hired and paid on the basis of work to be done), or gayya (communal labour) which is provided free of charge except that a drink or meal may be provided. Regarding communal labour, however, Baba (1975) argued that the farmer has the obligation to make himself available to work on others' farms when their turns come.

A problem encountered in measuring labour input in man-hours is the fact that most of the respondents did not keep time and thus had no exact idea of hours spent on an operation or on the fadama generally. To get around this problem, moslem prayer times were used as reference points in asking farmers to give the length of time spent on an operation or on the fadama.

In aggregating labour input of different age categories of farmers, Norman's weighting formula was adopted. In this formula, the weights of 1.0, 0.75, 0.50, and 0.00 adult man-hour equivalents were attached to one hour of labour input by adult male, adult female, large child, and small child, respectively (Norman, 1973).

(iii) Capital input

Capital can be defined as produced means of production. Two categories of capital goods are differentiated in this study. The first category is the "durable" capital goods, which include hoes, cutlasses, pumps, water hoses and washbores. These capital goods last for more than one farming season. To measure the values of these goods used up during the irrigation season, depreciation costs were computed for them, using the straight line method.

The second category of capital is made up of non-durable goods, such as fertilizers, and seeds, which contribute to production only once. These goods were valued on the basis of their market prices.

(iv) Irrigation water

Irrigation water input refers to the total quantity of water applied through pumps during the irrigation season by the respondents. To obtain the total quantity of irrigation water applied by a respondent, the discharge rate of the pump used by the respondent was determined. This was accomplished by using stopwatches to record the length of time it took the pump to fill a 200 litres drum with water. This was repeated three times and the seasonal average discharge rate for each pump computed. The discharge rate for each pump was multiplied by the total number of hours the pump was operated during the season, to obtain the total quantity of irrigation water applied during the season, in litres. The resulting figure, in litres was divided by 100,000 to obtain the total quantity of water applied in hectare -centimetres (Ha-Cm).

(v) Output

Output in this study refers to the value of the total quantity of the vegetable crops harvested in the irrigation season. In measuring the total output, the "five unit" method, as suggested by Norman (1973), was adopted. This method involves weighing five units of the crop drawn at random, and using this to obtain the average weight of the crop. The total weight of the crop is then obtained by multiplying the average unit weight by the total number of units harvested. This was done for all the crops produced by the respondents. Before aggregating together the total output from the various crops, the quantity of each crop was multiplied by its average price.

3.4 Analytical Framework

3.4.1 Analytical Tools Used in Farm Studies

Many analytical techniques have been used in farm management and production economics investigations. Those commonly used include average productivity ratios, farm budget, linear programming and production function analysis. A brief description of each of these techniques is given in the sections that follow.

(a) Average Productivity Ratios

This is the simplest method for measuring resource productivity (Ogunfowora et al., 1975). The technique involves the computation of input-output ratios for individual resources. The ratios commonly computed in a productivity study include output per hectare, output per man-day or man-hour, return to capital, etc. The average productivity ratios for any particular year can be compared with those of previous years or with those of other farms growing the same crops under similar conditions. A higher ratio indicates higher productivity and higher level of efficiency. Although the technique is useful in detecting the weak points in farm business, and in makiing the required adjustments, it is not recommended in overall efficiency studies. The derived indices, while being good measures of performance (technical efficiency), are usually poor indicators of economic efficiency (Ekele, 1982). Chawdhari et al. (1969), also noted that the average productivity ratios do not tell us the contribution, to the output, of individual resources in a situation where more than one resource interact.

(b) Farm Budgeting

The budgetary analysis involves operations leading to estimates of gross revenue and total cost for the same production period. The difference between the two parameters is a measure of profit (or less) or net return for that period (Olayemi and Oni, 1971). Total revenue represents the value of all the output from the farm (i.e. physical quantity of each crop multiplied by the respective unit prices and summed over all crops). The total cost, on the other hand, is made up of the "variable" and "fixed" components. Variable costs, also called specific costs, vary directly with the level of production and include expenditure on seeds, fertilizers, hired labour, pesticides, fuel, lubricants etc. Fixed costs, known as overhead costs do not vary with the level of output and consist of cash expenses (on repairs and maintenance, interest on long term loans, etc), as well as depreciation on durable capital goods.

The computed costs and returns could be used to derive various measures of performance of the farm, including Net Farm Income, Net Cash Income, Enterprise Gross Margin, and returns to each of the inputs used in the production of the output. The farm budget technique therefore, gives a measure of the profitability of farming and productivity of all the resources used on the farm. A major shortcoming of the technique however, is its inability to define how optimum returns can be obtained from limited resources (Orewa, 1978). Other shortcomings of the tehnique, as pointed out by Eicher and Baker (1982) include the fact that:

(1) no standard approach has been used in deciding what to include in the farm budget;

(2) valuation of inputs and outputs poses a problem;

(3) interpreting budgets that have been constructed from average input-output relationships on surveyed farms poses another problem. Averages, as Dillon and Hardaker (1980) pointed out, can obscure wide fluctuations.

Despite these shortcomings the budgeting technique has been widely applied in productivity studies (Orewa, 1978; Ofojekwu, 1982; Makarfi, 1985; Cisse, 1987). This is probably due to its ease of computation and the fact that it directly gives a measure of profits on the farms.

(c) Linear Programming

Linear programming is a systematic methematical procedure for finding the optimum or best possible plan for a given set of conditions (Upton, 1979). It is often helpful in decisions requiring a choice among a large number of alternatives (Beneke and Winterborer, 1973). A typical linear programming problem has the following components:

(a) an objective function which may be profit maximization, cost minimization, etc.;

(b) a number of functional (e.g. resources and institutional) and non-negativity, constraints;

(c) a number of decision variables - activities to be considered in planning, and

(d) a number of parameters - production coefficients stated in terms of the amount of each resource required per unit of activity.

The conventional linear programming problem can be formalised as follows:

$$\text{Maximise } Z = CX$$

$$\text{Subject to } AX \leq B$$

$$\text{and } X \geq 0$$

where Z = objective to be maximised

C = n x 1 vector of prices

X = n x 1 vector of activities of level

A = m x n matrix of input-output coefficients

B = m x 1 vector of factors or other restrictions.

A linear programming problem usually has a large number of solutions. However, as Gass (1964) pointed out, only the feasible solution that satisfies the given objective (e.g. maximization of profit) is the optimum solution. The optimum solution usually contains the value of the programme, the final plan, and the shadow prices. It is in the shadow prices that the interest of a productivity study, using the linear programming technique, lies. The element in the Z - C row of the final plan are the shadow prices. Shadow prices for real activities indicate the magnitude by which the objective would be penalised if an additional unit of the corresponding activity were forced into the plan. On the other hand, the shadow prices for the disposal activities represent the marginal value productivities of the corresponding resources. The marginal value productivities could be compared with the acquisition costs of the resources to determine the feasibility of acquiring such resources.

Also, by conducting linear programming exercises for different farming systems or for the same farming systems in different regions, the marginal value productivities can be compared and used as a basis for resource adjustments and pricing policies.

Ogunfowora et al (1975) have identified two shortcomings with using linear programming in productivity studies. The first of the shortcomings is the fact that only resources which are exhausted in the production have marginal value productivities in the final plan; resources which are in surplus supply have zero marginal value productivities. The second shortcoming identified is that the marginal value productivities of resources relate only to their use in the given enterprise system considered in the programming exercise; their marginal value productivities may differ significantly when used for the production of the individual enterprises that comprise the system. Although these shortcomings constitute a limitation to the use of the technique, it has been argued that the advantages of the technique outweigh the limitations (Etuk, 1986).

(d) Production Function

The production function has been described as the traditional tool for analysing problems of resource productivity and returns to scale in agriculture (Ogunfowora et al., 1975). The implicit production function presented in equation (1) can be explicitly stated as an algebraic or a number of algebraic equation forms which can then be estimated to obtain the economic quantities of interest. The commonly estimated functional forms are linear, quadratic, square root and Cobb-Douglas (power) functions.

If we assume a three-variable response function, the linear function could be stated as:

$$Y = a + B_1X_1 + B_2X_2 + b_3X_3 \qquad (13)$$

where Y is the quantity of output, X_1, X_2 and X_3 are the quantities of variable inputs, and b_1, b_2, b_3 are coefficients to be estimated. The linear function is based on the assumption that the inputs and outputs are all related by straight lines. This implies that the marginal product of each input is constant. Hence, diminishing marginal returns is ruled out. Also the function assumes constant rates of technical substitution among the inputs. There is no allowance for economic optimum.

The quadratic function is of the form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_1^2 + b_5X_2^2 + b_6X_3^2 + b_7X_1X_2 + b_8X_1X_3 + b_9X_2X_3 + b_{10}X_1X_2X_3 \ldots\ldots\ldots\ldots(14)$$

It allows both diminshing and negative marginal productivity, but not both decreasing and increasing marginal products. The elasticity of production is not constant, but declines with input magnitude. The possible disadvantages of this function are that it may give negative total products for very high or very low levels of input and that it becomes complex if many variable inputs are included.

The square root function may be stated as:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_1^{.5} + b_5X_2^{.5} + b_6X_3^{.5} + b_7X_1^{.5}X_2^{.5} + b_8X_1^{.5}X_3^{.5} + b_9X_2^{.5}X_3^{.5} + b_{10}X_1^{.5}X_2^{.5}X_3^{.5} \ldots\ldots(15)$$

It allows a diminishing total product, a diminishing marginal product and a defined maximum. Like the quadratic function, it has the disadvantage of being a bad utiliser of degrees of freedom.

The Cobb-Douglas (power) function can be expressed as follows:

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(16)$$

This is usually estimated in the logarithmic form. The logarithmic transformation of the function is as follows:

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 \qquad (17)$$

This function allows either constant, increasing, or decreasing marginal products. It does not allow an input-output curve embracing all three. It assumes constant elasticity of production. The Cobb-Douglas function is the most widely used functional form in farm-production studies. Its popularity probably derives from its computational ease and the fact that it gives the economic quantities of interest like the elasticity of production, returns to scale and marginal product directly. It is also an efficient user of degrees of freedom.

None of the functional forms discussed above can be used to characterise agricultural production under all environmental conditions. As Heady and Dillon (1961) pointed out, the algebraic form of the function chosen, and the magnitude of its coefficients will vary with soil, climate, type and variety of crops or livestock, resources being varied, state of mechanization, magnitude of other inputs in "fixed quantity", etc. Hence, a problem in each study is in the selection of a functional form which appears or is known to be consistent with the phenomenon under investigation.

Yotopoulos (1967) has identified three decision rules that should guide a researcher in choosing among the numerous alternative functional forms. The first rule refers to the logic, or the basic mechanics of the production process. In this sense, a "true" functional representation underlies a given production process. He however admitted that it is difficult to establish empirically that a functional form adequately describes the logic and mechanics of the production process. The second decision rule is the theoretical fruitfulness of the function. Given the body of established economic theory, the explicit relation chosen should offer possibilities of providing a unified explanation of a wide range of empirical phenomena. The third decision rule partins to the computational manageability of the function.

To obtain the quantities of economic interest, the functional form that is chosen for the study is estimated through multiple regression analysis. The production function, on estimation should reveal the marginal products, the elasticities of production and returns to scale in the farms under study.

3.4.2 Specification of the Models

Section 3.4.1 discusses the analytical tools generally used in farm-firm studies. In the present section, the specific analytical tools used in this study are described. The analytical tools used in this study were the farm budget and the production function models. The farm budget model was chosen because it yielded the costs and returns of crop production in the study area, thus helping to achieve the second objective of the study. The production function model was also used because it provides comprehensive information on productivities of resources, efficiency of resource use, elasticities of production and returns to scale. Through this, the third and fourth objectives of the study were achieved. Average productivity ratios would have provided some information on resource productivity and technical efficiency. They were however not used because they fail to define marginal value productivities, economic efficiency, elasticities of production and returns to scale, implying that they could not help in satisfactorily achieving any of the objectives of the study. Perhaps, the linear programming technique would have provided more useful information than the average productivity ratios. It could provide information on optimum farm plans, marginal value productivities and economic efficiency. It however fails to give information on marginal value productivities of resources not exhausted in the final plan and was therefore found unsuitable for fully achieving the objectives of the study.

The selected farm budget and production function models are presented as follows:

(a) The Farm Budget Model

The farm budget model used in this study can be specified as follows:

NFI = GFI-VC-FC

where NFI = net farm income or profit and it is the difference between gross farm income and the total cost of production. The NFI can be withdrawn from the business without affecting the scale of operation of the business.

GFI = gross farm income which represents the sum of the total value of tomato, garden egg, onion, and pepper harvested on the survey farms during the research season. Included in the GFI are the value of these produce sold, consumed at home, given out as gifts, or stored.

VC = Variable costs incurred by the respondents during the survey period, including costs of fertilizer, seed, labour, pesticides, fuel, lubricants and repairs on pumps and other equipment.

FC = Fixed costs incurred by the respondents including depreciation on pumps, hoes, cutlasses, washbores and water hoses.

The limitations of this model are similar to those outlined in section 3.4.1(b) of this thesis.

(b) The Production Function Model

In this study, linear, quadratic, square root and Cobb-Douglas functions were separately fitted to the farm data collected during the field survey. Thereafter, the Cobb-Douglas function was chosen for the analysis of the input-output relationships on the sampled farms. The selected Cobb-Douglas function has been widely applied in other productivity studies (Yotopoulos, 1967; Saini, 1969; Chawdhari et al., 1969; Ogunfowora et al., 1975; Orewa, 1978; Ofojekwu, 1982; Makarfi, 1985). The Cobb-Douglas function was chosen in preference to the other functional forms, because, on estimation, it produced an equation with more correctly "signed" regression coefficients than any of the other forms. It was selected also because it gave the economic quantities of interest directly.

The estimated Cobb-Douglas function can be expressed as follows:

$$Y = AX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5U \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

This function was estimated in the logarithmic form. The logarithmic transformation of the model can be stated as:

$$\text{Log } Y = \log A + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + \log U \ldots\ldots (19)$$

where Y = total value per hectare of all crops produced by the respondents during the research season (in Naira)

X_1 = human labour input (in man-hours per hectare)

X_2 = plant population stand count per hectare

X_3 = fertilizer (in kilogram per hectare)

X_4 = irrigation water (in Hectare centimetre per hectare)

U = error or random disturbance term

A = Constant term

$b_1 \ldots\ldots b_4$ = Regression coefficients

The constant term, A, and the regression coefficients, b_i, in respect of the explanatory variables were estimated through multiple regression analysis.

<u>Reasons for the Selected Variables</u>

The explanatory variables (X_1, X_2, X_3, X_4) were, each expected to have a causal relationship with the total value product. They were included in the model to determine:

(i) the extent to which each of them explains variation in gross receipts (total value product);

(ii) the returns to each of the variables, and

(iii) the efficiency of their use.

The error or random disturbance term (U) in the model is a residual and captures all variables (such as managerial ability, sunshine, and land quality), which affect the total value product, but are for various reasons omitted from the model.

<u>Economic Quantities obtained from the Production Function Analysis</u>

The economic quantities of interest obtained from the Cobb-Douglas production function analysis are marginal value product of the inputs, elasticity of production with respect to each input category, and returns to scale prevalent in the study area.

The marginal value product with respect to each input category was obtained by taking the first order partial derivative of the total value product function, with respect to the input, when the other inputs were held at their geometric means. The marginal value product of the input was then compared with the acquisition cost of the input to determine the efficiency of use of the input.

The elasticity of production with respect to each input was given as the regression coefficient of the input; while returns to scale in the study area was obtained by adding together, all the elasticities of production (i.e. returns to scale = Σb_i).

CHAPTER FOUR

DESCRIPTION OF FARMING CHARACTERISTICS IN THE STUDY AREA

4.1 Resource Availability and Use

Resources in agricultural production have been broadly grouped into land, labour, capital and management. Due to the importance of water in irrigation systems, however, it is treated as another category of resource in this study. This section discusses the availability of, and the constraints to, the use of these resources in the study area.

4.1.1. Land

The total area of *fadama* land under cultivation by the respondents was 30.029 hectares. Sizes of holdings by individual respondents ranged from 0.071 hectares to 2.968 hectares, with a mean of 0.667 hectares. The system of land tenure seems to be by inheritance and rentage. Specifically, 58 percent of the respondents indicated that they hold their fadama through inheritance, while the remaining 42 percent hold their *fadama* through rentage.

Availability of *fadama* land does not appear to be a constraint to expansion of cultivation in the study area. In fact, 51 percent of the respondents disclosed that they own *fadama* plots presently lying fallow, while the remaining 49 percent indicated that they would not find it difficult to acquire more *fadama* land, through rentage, if they wanted to.

4.1.2 Labour

The total labour input by the respondents was 79,359 adult man-hour equivalents. Out of this 71,741 adult man-hour equivalents (or 90 percent) was contributed by family labour, while the non-family labour accounted for the remaining 7,618 adult man-hour equivalents (or 10 percent). The average labour use was 1,764 adult man-hour equivalents per respondent or 2,643 man-hour equivalents per hectare.

The hours of family and non-family labour input for the various fadama operations are presented in Table 4.1. As can be seen from the Table, watering (23.73 percent) and harvesting (23.80 percent) used the largest proportion of total labour. These were followed by weeding (20.84 percent) and then land preparation (17.25 percent). Nursery work and planting required relatively low labour input. Majority (93 percent) of the respondents employed non-family labour. Non-family labour was employed mostly for land preparation, weeding and harvesting.

4.1.3 Capital

Two types of capital input are distinguished in this study. These are the durable capital input which include man-made resources, that last for more than one production period, and the non-durable capital goods which are used up in a single production period.

The durable capital goods employed in the study area include hoes, cutlasses, motorised pumps, waterhoses, and washbores. All the respondents indicated that they used cutlasses and hoes in the fadama during the season. Thirty-three respondents (or 73 percent) indicated that they owned motorised pumps, while the remaining 12 respondents (or 27 percent) hired pumps to water their crops during the season. Only 6 respondents (or 13 percent) indicated owning washbores which served as a supplementary source of water when the streams dried up.

The non-durable capital goods employed in the study area include inorganic fertilizers and seeds (or seedlings). All the respondents employed inorganic fertilizers during the season. The total quantity

Table 4.1: Relative contribution of family and non-family labour to key operations in the fadama.

Fadama operation	Man-hours: Family operation	Non-family	Total	Percent of total labour input
1. Nursery	373.50	Nil	373	0.47
2. Land preparation	10,645	3,043.5	13,688.50	17.25
3. Planting	4,108.50	31	4,139.50	5.22
4. Watering	18,626	203	18,829	23.73
5. Weeding	15,075.5	1,464.50	16,540	20.84
6. Harvesting	16,048	2,835.50	18,883.50	23.80
7. Others	6,864.50	41	6,905.50	8.70
Total	71,741	7,618.5	79,359	
%	90%	10%	100%	100%

Source: Field Survey, 1988.

of fertilizers used by all the respondents during the season was 23,950 kilograms. This gives an average of 532 kilograms per respondent, or 798 kilograms per hectare. Thirty-nine respondents (or 87 percent) conceded that they obtain fertilizer when required. The general complaint seems to be that the prices charged were too high (sometimes up to 20 *naira* per 50 kilograms per bag).

Most of the respondents purchased seedlings of the different vegetable crops, direct from the market or neighbours, while few raised their seedlings on nursery beds. No respondent indicated planting improved varieties of the crops. They all planted local varieties which, they indicated were easier to come by than the improved ones.

4.1.4 Water

Early in the season, water for irrigation was pumped directly from rivers and streams to fadama plots. During this period, there was relatively abundant water flowing through the rivers and streams. With time, however, the rivers and streams dried up, and the farmers were forced to dig shallow wells in the river beds to obtain water for irrigation. For most respondents, water in the shallow wells dried up after a short while and the well-digging exercise had to be repeated several times in the season. Only the few farmers with functional washbores evaded this drudgery.

The total quantity of irrigation water applied by the respondents during the season was 341.61 Ha-cm. This gave an average of 7.54 Ha-cm per respondent or 11 Ha-cm per hectare.

4.1.5 Management

Management can be defined as the process of organising and coordinating the physical resources of land, labour, capital and water, with the aim of achieving the objective of dry season farming - profit maximization. The quality of management input is a personal characteristic of individual farmer and varies from one farmer to another. It is extremely difficult to quantify the management input. Hence, no attempt was made in this study to determine the level of management in the study area.

4.2 Cultural practices

The irrigation season in the study area begins around October/ November and ends May/June. The dry season cropping operations begin with the raising of seedlings in the nurseries, through land preparation, transplanting, watering, weeding, to harvesting and marketing of the crops grown. This section describes, briefly, each of these operations as practised in the study area.

4.2.1 Nursery

The crops grown under irrigated agriculture in the study area, are mostly vegetables which are first raised in the nursery before transplanting to the field. The nursery operation is usually undertaken early in the irrigation season. It involves clearing small plots of land and constructing vegetable beds, as well as sowing seeds and watering the beds, until the seedlings are ready for transplanting.

4.2.2 Land Preparation

Land preparation is the first field operation undertaken in the fadama. It usually involves clearing of debris from the field, plowing and levelling the plots, and dividing plots into small basins. These are then followed by the construction of water channels, for the passage of irrigation water. Land preparation operations in the study area are manually accomplished using cutlasses and hoes.

4.2.3 Transplanting

Most farmers usually obtain seedlings directly from the market or neighbours, while others raise theirs in the nurseries. The seedlings obtained through either of the two sources are then planted out in the fields where they will remain until they are harvested. The transplanting operation is manually accomplished.

4.2.4 Watering

Watering is accomplished by pumping water from rivers, streams, wells, and/or washbores, using motorised pumps. The pumped water is conducted through the basins by repeated opening and closing of a series of water channels.

4.2.5 Weeding

Most of the respondents weed their plots 1-3 times in the season. Weeding is manually done using small hoes.

4.2.6 Harvesting

Harvesting (or picking) of the crops is done manually. It is an operation in which women are very active. The involvement of many women in the operation is probably to enable the respondents obtain enough labour to harvest reasonable quantities of the produce for marketing, during each harvest. It may also be to avoid perishing of the produce. The harvested fruits are usually packed in baskets, which are the common units of sale.

4.3 Cropping Patterns

The crops grown under irrigation in the study area are mostly vegetables and include tomato, sweet pepper, garden egg, onion and spinarch. These crops are interplanted in various combinations. Crops of pure stands are rare, while it is easy to encounter plots carrying all the crops listed above, at a time.

4.4 Marketing of Produce

All the respondents indicated that they market their produce within the same week of harvest. This is most likely done in order to minimise loss of vegetable fruits which are highly perishable.

Table 4.2 shows the distribution of the respondents according to where they sold their produce. As presented in the Table, most (91 percent) of the respondents sold their produce on the farm. Apparently, most of the respondents try to avoid the extra cost of moving the produce away from the farm to distant markets. Only about 44 percent of the respondents sold their produce in major urban centres like Jos and Bauchi. About 8 percent sold their produce in their own settlement. None of the respondents indicated selling their produce in neighbouring markets or small towns.

The categories of traders to whom the respondents sold their produce are presented in Table 4.3. As can be seen from the Table, majority (93 percent) sold their produce to big traders who come from outside the local area. No respondents indicated selling their produce to any government agency. This is not surprising since no government in Bauchi State undertakes the buying of vegetables. The respondents also did not sell their produce directly to any commercial firm. Perhaps, the only commercial company that might have been interested in buying vegetable fruits in the area is the VEGFRU tomato company limited. The fact that no respondent sold to any commercial firm may imply that the buying activities of the company does not extend to the study area.

4.5 Prices

The average prices and price ranges of the major crops produced under irrigated agriculture, during the research season, are presented in Table 4.4. As presented in the Table, tomato had the widest price range (20-263 kobo per kilogram). This was followed closely by garden egg (19-260 kobo per kilogram). Sweet pepper followed with a price range of 34-200 kobo per kilogram. The least price range was exhibited by onion (40-135 kobo per kilogram). For all crops, except onion, the lower limit of the range occurred around the middle of the irrigation season (around February/March) while the upper limit occurred at the end of the season (June). The prices of the crops are lowest in the middle of the season probably because of the abundant supply of these crops, brought about by the fact that most of the crops would have reached their physiological maturity, around this period.

Table 4.2: Distribution of respondents according to place of sale of produce.

Location of market	Number of respondents	Percent of total respondents
1. In field	41	91.1
2. In farmer's settlement	4	8.9
3. Nearby market	0	0
4. Town or small city	0	0
5. Major urban centre	20	44.4
Total	65*	

*Higher than total number of respondents (45) because some respondents indicated more than one selling center.

Source: Field Survey, 1988.

Table 4.3: Distribution of respondents according to whom they sold their produce to.

To whom sold	Number of respondents	Percent of total respondents
1. Consumer in small units	10	22.22
2. Local farmer or small trader in bulk	21	46.67
3. Big trader from local area	4	8.89
4. Large trader from outside local area	42	93.33
5. Commercial firm	0	0
6. Government	0	0
Total	77*	

*Greater than sample size (45) because some respondents sold to more than one category of buyer.

Source: Field Survey, 1988.

Table 4.4: Mean and range of prices of crops produced under irrigated agriculture (kobo/kg).

Crop	Mean Price	Seasonal Price Range
Tomator	64	20-263
Garden egg	61	19-260
Sweet pepper	81	34-200
Onion	65	40-135

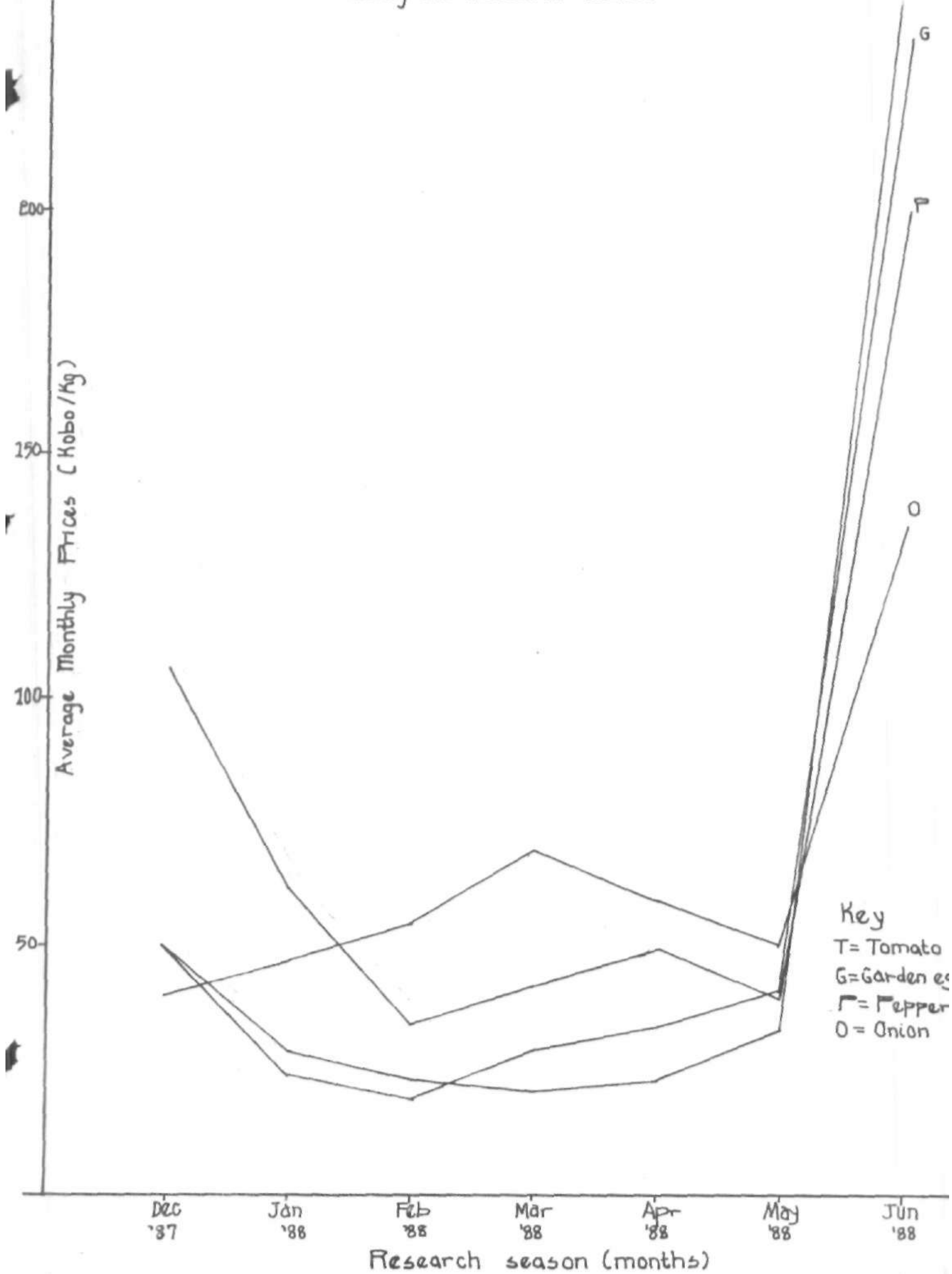
Source: Field Survey, 1988.

The monthly price movements for the four crops, during the irrigation season, are presented in Figure 4.1. As can be seen from the figure, all the crops exhibited sharp monthly price fluctuations. This is probably due to the fact that the crops are highly perishable. This makes it difficult for the farmers to regulate the supply of the crops. Consequently, prices are forced down in months that the farmers' harvest is plenty and forced up again when the harvest is lean.

4.6 Constraints to Increased Crop Production Under Irrigation Agriculture

Availability of land and labour inputs does not seem to be an important factor militating against expansion of crop production in the study area. The method of land acquisition, which is mainly through renting, is relatively easy. In fact, 51 percent of the respondents disclosed that they own fadama plots presently lying fallow, while the remaining 49 percent indicated that they would find it easy to acquire more fadama land, through rentage, if they wanted to. Also, most of the respondents indicated that they have enough labour to hire for all their fadama operations. They maintained that the problem was not that of having labour to hire, but having

Figure 4.1: Monthly Variation in Commodity Prices during the research season.



the money to pay for hired labour.

The most important constraint to increased hectarage, identified by the majority (75 percent) of the respondents, is shortage of irrigation water. The respondents indicated that although water is relatively abundant at the beginning of the irrigation season, the streams later dry up and it becomes difficult obtaining water to irrigate even the existing plots. Any attempt to expand production in the study area, therefore, must address the problem of water availability throughout the season. It is only when this problem is solved that farmers may be encouraged to increase their sizes of holding and production.

Another constraint identified by the respondents is inadequate supply of farm inputs, especially fertilizer. They maintained that although fertilizer is usually available when needed, the prices are usually available when needed, the prices are usually too high, sometimes reaching 20.00 naira per 50 kilogram per bag. This limits the quantity of fertilizer the farmers can afford and also limits the sizes of holdings they can maintain.

Instability in produce prices is another factor identified by the respondents. According to them, the prices of output fluctuate highly and are sometimes very low. This situation is further encouraged by the inability of the farmers to regulate produce supply due to the highly perishable nature of the products. Since government does not undertake the purchase of these products or offer guaranteed minimum prices for them, farmers are left at the mercy of the market forces and are compelled to accept whatever prices are offered by traders.

The respondents also identified the incidence of diseases as a factor limiting production in the study area. They indicated that their crops are disturbed by certain vegetable crops diseases which they are unable to control. Asked whether they reported the disease cases to any agricultural institution in the state, most of the farmers conceded that they did not, because from past experience, their complaints to such institutions usually do not receive any attention.

Another constraint to increased crop production is shortage of money. All the respondents indicated that they lack enough money to purchase farm inputs and hire labour. None of the respondents indicated obtaining any external financial assistance in the form of credit. The implication of this is that the impact of government and financial institutions lending activities in the state is not being felt in the study area.

CHAPTIVE FIVE

RESULTS OF THE FARM BUDGET AND PRODUCTION FUNCTION ANALYSIS

5.1 Budgeting Analysis

The farm budget model was employed to estimate the costs, returns and net farm income (NFI) of the respondents. This section presents and discusses the results of the budgetary analysis.

5.1.1 Costs of Production

The total cost of production incurred by all the respondents was 114,528.16 naira. This gave an average total cost of 2,545.07 naira per respondent or 3,813.92 naira per hectare. The total cost is made up of "variable" and "fixed" components. Variable costs include expenditure on seeds, fertilizers, fuel, hired labour, pump repairs, as well as imputed cost of family labour. While the fixed costs, in the study area, are limited to depreciation on pumps, washbores, water hoces, cutlasses and hoes. The values of these components of the fixed and variable costs are presented in Table 5.1. The variable costs constituted 94.44 percent of total cost of production. This was slightly lower than the 99.49 percent and 99 percent obtained by Ofojokwu (1982) and Makarfi (1985) respectively, in their separate studies. The proportion of variable cost to total cost is higher in these studies, probably because of the absence of "depreciation on pumps" from the fixed costs.

Among the variable costs, the imputed cost of family labour input constitute 61.85 percent of total cost. When the non-family labour input is added, total labour input accounts for about 67.77 percent of total cost of production. This identifies labour as the most costly single input in crop production under irrigated agriculture in the study area. This result is similar to the findings of Ofojokwu

Table 5.1: Components of fixed and variable costs among the respondents.

Items of cost		Cost (₦)	Percent of Total
Variable Costs			
1.	Seeds/seedling	5,488.72	4.79%
2.	Fertilizer	6,226.00	5.44%
3.	Pump repairs	3,684.60	3.22%
4.	Fuel	7,376.650	5.92%
5.	Family labour	70,833.881	61.85%
7.	Marketing and others	7,768.40	6.78%
Total variable cost		108,114.58	94.44%
Fixed Costs			
8.	Depreciation on pumps, hoes, cutlasses, washbores and water hoses.	6,371.01	5.56%
Total fixed cost		6,371.01	5.56%
Total Cost		114,528.16	100%

Source: Field Survey, 1988.

(1982) who reported that labour input constituted 55 percent of total cost of production under small-scale irrigation. Marketing and fuel came second, accounting for 6.78 percent and 6.44 percent, of the total cost of production, respectively.

The fixed costs constituted only 5.56 percent of the total cost of production. The low level of fixed costs reflects the low level of investment on fixed inputs in the study area. The absence of "interest charges" from the list of fixed costs tend to indicate that none of the respondents has benefitted from credit facilities with respect to irrigated agriculture.

5.1.2 Gross Farm Income

The gross farm income from all respondents was 191,356.30 naira. It was obtained by multiplying the physical quantity of each crop by the unit price and summing together for the four crops (onion, tomato, pepper and garden egg) and for the 45 respondents. The unit prices used were the farm gate prices. The average gross income was 4,252.36 naira per respondent or 6,372.38 naira per hectare.

5.1.3 Net Farm Income (NFI)

The NFI represents the difference between the gross farm income and the total cost of production. The NFI for all the respondents was 76,828.14 naira, giving an average of 1,707.29 naira per respondent or 2,558.46 naira per hectare. The average rate of return (defined as net farm income per hectare divided by total cost per hectare and multiplied by 100) was found to be 67.08 percent, implying that farmers in the study area realised a profit of about 67 kobo for every naira invested.

Table 5.2 shows the distribution of respondents according to their net farm income per hectare. As presented in the Table, 11 respondents or 24.44 percent of the respondents produced at a loss, while the remaining 34 respondents or 75.56 percent realised profits on their fadama. Six respondents or 13.33 percent of the respondents made profits of between 1 naira and 2,000 naira, while 10 respondents or 22.22 percent realised profits of between 2,001 naira and 4,000 naira. Nine respondents or 20 percent of the respondents made profits falling in the range 4,001 naira to 6,000 naira. Only 1 (or 2.22 percent of the) respondents' profit fell in the range 6,001 naira to 8,000 naira. The profits made by 6 respondents or 13.33 percent of the respondents was between 8,001 naira and 10,000 naira, while 2 respondents or 4.44

percent of the respondents realised profits of over 10,000 naira per hectare.

Table 5.2: Distribution of the respondents according to their Net Farm Income per hectare.

Net Farm Income Range (₦/ha.)	No. of Respondents	Percentage
≤ 0	11	24.44
1 - 2,000	6	13.33
2,001- 4,000	10	22.22
4,001- 6,000	9	20.00
6,001- 8,000	1	2.22
8,001- 10,000	6	13.33
> 10,000	2	4.44
Total	45	100

Source: Field Survey, 1988.

5.1.4 Factors Affecting Costs and Returns

To determine the possible causes of variation in production costs among farmers in the study area, thirteen each of the "highest-cost" and "lowest-cost" producers were selected from the respondents and the averages of their fadama sizes, family, non-family and total labour input, fertilizer use, total cost and net farm income (NFI), were compared. These variables are presented in Table 5.3. A t-test was conducted to ascertain the extent of variation between each pair of variables. The results showed that fadama size was not significantly different between the two groups, even at 10 percent level of significance. This implies that sizes of fadama is not an important factor causing variation in production costs among the respondents.

Table 5.3: Distribution of inputs, costs and returns among high-cost and low-cost producing farmers.

Category of Cost	Number of Respondents	Average Fadama Size(ha)	Average Labour Input (Man-hours per Hactare)			Average Fertilizer Use (kg/ha)	Average Total Cost (₦/ha)	Average NFI ₦/ha.
			Family	Non-family	Total			
High-cost	13	0.509	4,429.49	405.83	4,835.36	1,328.30	7,755.61	2,247.96
Low-cost	13	0.555	1,231.07	67.85	1,298.91	652.37	2,069.22	3,950.98

Source: Field Survey, 1988.

Family, non-family and total labour use were however significantly different among the two groups of producers (at 1 percent level). This indicates that labour input is an important factor accounting for variation in costs. Similarly, fertilizer use was found to be significantly different among the groups (at 5 percent level), implying that fertilizer, too, is one of the factors affecting cost of production.

The net farm income was found not to be significantly different (at 10 percent level) between high-cost and low-cost producers. This is an indication that the differences in production costs is not an important factor explaining variation in net farm income among the respondents.

A t-test was conducted to compare the average net farm income between farmers who owned motorised pumps used for irrigation and farmers who hired pumps to irrigate their farms. It became evident that, at 10 percent level, the average net farm income of farmers who owned pumps was significantly higher than the average net farm income of farmers hiring pumps. This might have resulted from the fact that farmers owning pumps would have had better control over their irrigation schedule and would have (therefore) realised higher yields from their plots than farmers hiring pumps. This assertion is further substantiated by the general complaint by the respondents hiring pumps that they do not obtain the pumps when required.

The average net farm income of farmers owning washbores was also compared with that of farmers without washbores. The test however revealed no significant difference in net farm income between the two groups of respondents.

The place of marketing of produce was found to have a significant effect on the net farm income of farmers. It was found that farmers who took their produce to distant markets had lower average net farm income than farmers who sold their produce on the farm. This indicates that the cost of transporting the produce to distant markets is not adequately compensated for by possible higher prices of produce in these markets. Thus, farmers who sold their produce on their farms were better off than farmers who transported away their produce.

Other possible sources of variation in costs and returns among the respondents are variation in prices and managerial abilities of the respondents. The prices of the vegetable products fluctuate highly in the study area and the net farm income of the respondent will depend on the level of prices during the period he sells his produce. Those that sell their produce when price levels are high are likely to obtain higher returns than those that sell their produce when the prices are low.

Farmers differ in their managerial abilities. Although no attempt was made in this study to determine the management input of individual respondents, it might be safe to conclude that those farmers receiving higher net income would have put in better management input than those receiving lower net income. It is expected that farmers who manage their farms better would realise higher yields from their plots and (other things being equal) higher net returns.

5.2 Production Function Estimates and Analysis

5.2.1 Results from the Estimated Equations

The results of the estimated Cobb-Douglas production function are presented in Table 5.4. Those of the other estimated equations (linear, quadratic, and square root) are presented as appendices A, B, and C. As can be seen from Table 5.4, the coefficient of determination, R^2, for the Cobb-Douglas function is 0.72. This implies that 72 percent of variation in the dependent variable (total value product) is explained by variations in the explanatory variables included in the model. The remaining proportion can therefore, be attributed to the error or random disturbance term. The F-ratio, also presented in the Table, is a measure of joint significance of all the explanatory variables in the model. The value of this ratio is 25.69, which is significant at 1 percent level. This implies that, taken together, the included explanatory variables significantly explain variation in the total value product.

Table 5.4 also shows the regression coefficients with respect to each of the explanatory variables, and their t-values. The regression coefficient with respect to a particular variable shows the extent to which variation in that variable explains variation in the dependent variable. The coefficients with respect to all the variables are positive, indicating that an increase in any one of the variables, holding others constant, will lead to an increase in the total value product. The t-values, obtained by dividing the regression coefficients by their respective standard errors, are used to test the significance of the coefficients.

In view of the fact that the selected equation form is the Cobb-Douglas function, the regression coefficient also represents the elasticity of production with respect to the corresponding explanatory variable. Thus, for labour input, the regression coefficient or elasticity of production is 0.056, implying that an increase in labour input by 1 percent, holding other inputs constant, will increase total value product by 0.056 percent. This value, however, is not significant, statistically. The non-significant labour input coefficient suggests that, contrary to expectations, increasing the use of labour input among the population of farmers from which the sample for this study was chosen, will not affect the total value product. A probable explanation for this may be that this input is already being overutilized in the study area.

The regression coefficient and elasticity of production with respect to plant population is 0.172. This value is significant at 5 percent level, and it implies that a 1 percent increase in plant population, will increase total value product by 0.172 percent.

Fertilizer input has a regression coefficient or elasticity of production of 0.388. This value is significant at 1 percent level. It indicates that an increase in fertilizer input by 1 percent, will increase total value product by 0.388 percent.

Table 5.4: Regression coefficients and t-values from the Cobb-Douglas production function analysis.

Variables	Regression Coefficients	t-values
Constant term (A)	0.953	3.405***
Labour (X_1)	0.056	$0.629^{n.s}$
Population count (X_2)	0.172	2.174**
Fertilizer (X_3)	0.388	2.762***
Irrigation water (X_4)	0.688	2.514**

R^2 = 0.72
F-ratio = 25.69***
** = Significant at 5 percent level
*** = Significant at 1 percent level
n.s = not significant

Source: Field Survey, 1988.

Irrigation water has a regression coefficient or elasticity of production of 0.688. This value is significant at 5 percent level, and it shows that increasing irrigation water input by 1 percent, holding other inputs constant, will increase the total value product by 0.688 percent.

The four explanatory variables included in the model have one thing in common: their regression coefficients or elasticities of production are positive and less than unity. This implies that decreasing returns, to each of the variable inputs, prevail in the study area. This suggests that farmers in the study area operate in stage II (the rational zone) of production.

5.2.2 Returns to Scale

Returns to scale measures the proportionate change in output, if all the inputs are changed simultaneously by 1 percent. It represents the sum of the elasticities of production with respect to all the inputs, which is 1.304 in this study. This means that if all the explanatory variables are simultaneously increased by 1 percent, the total value product will increase by 1.304 percent. In other words, doubling the quantities of all the explanatory variables, will more than double the total value product. This implies that increasing returns to scale prevails in the study area. A test for constant returns to scale was conducted to ascertain whether this value is significantly different from unity. The result revealed a significant difference, confirming that increasing returns to scale prevails in the study area.

5.2.3 Marginal Value Productivities and Resource-use Efficiency

The marginal value productivities, as well as the acquisition cost per unit of the variables are presented in Table 5.5. As shown in the table, labour input has a marginal value product of 0.02 naira. This implies that, if other inputs are held constant (at their geometric means), increasing labour input by 1 man-hour would increase the total value product by 0.02 naira. On the other hand, the unit cost of labour in the study area is 0.99 naira per man-hour. Evidently, the acquisition cost is higher than the marginal value product. This indicates that labour is being used above the economic optimum level in the study area. The over-utilization of this input is probably due to the low opportunity cost of the input during the dry season in the study area. About 90 percent of labour input is provided by family members who would have probably been idle, in the absence of irrigated farming during the season. There is, therefore, the tendency for farmers to spend more time on fadama operations, rather than remain idle.

Table 5.5: Marginal value products and acquisition costs of inputs.

Variable Input	Marginal Value Product (naira)	Acquisition Cost (naira/unit)
Labour (X_1)	0.02	0.99/man-hour
Plant population (X_2)	0.002	0.003/stand
Fertilizer (X_3)	0.32	0.29/kilogram
Water (X_4)	29.26	8.00/Ha-Cm

Source: Field Survey, 1988.

The marginal value product of plant population is 0.002 naira. This implies that increasing plant population by one stand would increase total value product by 0.002 naira, if all the other variable inputs are held at their geometric means. The average acquisition cost of one stand of seedling in the study area, however, is 0.003 naira, which is slightly higher than the marginal value product. This indicates that plant population is being maintained slightly above the economic optimum level. Profit can be increased if plant population is slightly reduced in the study area.

Fertlizer has a marginal value product of 0.32 naira. If other inputs are held constant, increasing fertilizer input by 1 kilogram would increase total value product by 0.32 naira. The cost of fertilizer input in the study area is 0.29 naira per kilogram which is lower than the marginal value product. This implies that fertilizer is being used below the economic optimum level. Farmers can increase their profit by using more fertilizer in the fadama. Farmers in the study area under employ fertilizer input probably because of inadequate supply of fertilizer and shortage of funds that most of them complained about. More fertilizer use can be encouraged by ensuring adequate supply of fertilizer and injecting capital into the area.

Irrigation water has a marginal value product of 29.26 naira. This indicates that if other inputs are held at their geometric means, increasing irrigation water input by 1 Hectare-Centimeter would increase total value product by 29.26 naira. Although no direct water charges were incurred in the study area, the cost of pumping 1 hectare-centimeter of irrigation water was computed from fuel costs as well as pumps and pumps spare parts depreciation costs. This cost was found to be 8.00 naira per hectare-centimeter of irrigation water. This cost is lower than the marginal value product, indicating that irrigation water is being used below the economic optimum level. Profits can be increased by an increased use of irrigation water input in the study area. The under employment of irrigation water input in the area is most likely due to shortage of irrigation water identified as a constraint to increased production, by the respondents.

CHAPTER SIX

SUMMARY, POLICY IMPLICATIONS, CONCLUSIONS, LIMITATIONS AND SUGGESTIONS FOR FURTHER STUDIES

6.1 Summary

The food crises in the country, as well as the dwindling and uncertain revenue from the country's leading revenue earner - petroleum, have motivated the Nigerian Government to establish a number of strategies to revive and promote the country's agricultural sector. Prominent among the strategies is the development of water resources for irrigated agriculture, which has led to the establishment of various irrigation schemes in the country. The irrigation schemes established by government agencies are large-scale schemes which have been associated with a long list of short-comings in Nigeria. The short-comings identified with the large-scale irrigation schemes are as follows:

(a) the projects usually record high non-farmer participation;

(b) the benefits of the projects go mostly to the wealthy and locally powerful people, while the small farmers get marginalised from them;

(c) they are capital-intensive, expensive and constitute a heavy drain on scarce foreign exchange;

(d) they typically use heavy equipment for levelling, a procedure that seriously disturbs the soil;

(e) they make heavy demands on management, already a very scarce resource;

(f) they have adverse effect on farming and fishing below the dams, and

(g) they often involve large-scale displacement of human settlements with potentials for social upheaval.

Because of these shortcomings, it is thought that the prospects of achieving the desired objectives of increased agricultural production, through the large-scale irrigation schemes are slim. While government thrust on irrigation development has focused on the establishment of large-scale schemes, many farmers in the north of Nigeria privately irrigate their fadama land with water from streams, ponds and wells, using pump and shadoof water lift devices. The capital requirements of these systems are low, and the technologies are simple and allow the farmer the best control over the time and rate of water application. High returns to crop production have also been reported under the systems. There is little wonder, therefore, that they have found acceptance and popularity among traditional small-scale farmers who dominate the country's farming scene. Despite their potentials, irrigation development planners have continuously neglected these small-scale lift irrigation systems. It is reasoned that this neglect is probably due to the lack of adequate research information on the economics of crop production under the systems. This study was, therefore, designed to describe farming practices under pump systems in the study area; to determine the costs, returns and profitability of crop production under the systems; to estimate the productivities of resources employed under the systems; to determine the efficiency of resource use and the nature of returns to scale that prevail under the systems; and to derive from the results of the analysis, implications for research and extension work, and for government policy on irrigation development.

To achieve the objectives of the study, 45 farmers were sampled from four villages in the area covered by the Western Zone of the Bauchi State Agricultural Development Project, Nigeria. Input-output data were collected from these farmers, twice weekly, using structured questionnaires, between December 1987 and June 1988. The data so collected were analysed using simple descriptive statistics, a farm budget model, and a production function model.

The descriptive statistics were used mainly to describe farming characteristics under irrigated agriculture in the study area. The results of the descriptive analysis revealed that the total land area cultivated by the respondents was 30.029 hectares. The sizes of holdings ranged from 0.071 hectares to 2.968 hectares, with a mean of 0.667 hectares. Land tenure system in the study area is largely by inheritance and rentage. The total labour input by the respondents was found to be 79,359 man-hours, with 71,741 man-hours (or 90 percent) being contributed by family labour, and the remaining 7,618 man-hours (or 10 percent) being accounted for by non-family labour. Harvesting and watering operations used up 23.80 percent and 23.73 percent of the total labour input, respectively; while weeding took 20.88 percent of the total input. Land preparation, planting and nursery work used up 17.25 percent, 5.22 percent and 0.47 percent, respectively.

The durable capital goods employed in the study area include hoes, cutlasses, motorised pumps, waterhoses and washbores. All respondents owned cutlasses and hoes, while 73 percent owned pumps and waterhoses. Fertilizer and seeds were the major non-durable capital goods used by the respondents. All indicated using both fertilizers and seeds. The total fertilizer used by the respondents was 23,950 kilograms, giving an average of 532 kilograms per respondent or 798 kilograms per hectare. All the respondents use only local varieties of crops planted.

Irrigation water was pumped from streams, wells and washbores. The total quantity of irrigation water used was 341.61 Ha-Cm, giving an average of 7.59 Ha-Cm per respondent or 11.38 Ha-Cm per hactare.

The cultural practices performed in the study area include nursery work, land preparation, transplanting, watering, weeding, and harvesting. These practices usually begin with nursery work around October/November and end around June. All the practices are manually accomplished with the aid of cutlasses and hoes.

The crops grown in the study area are mainly vegetables and include tomato, sweet pepper, garden egg, onion and spinarch. These crops are interplanted in various combinations.

In marketing their produce, all the respondents sold their produce within the same week of harvesting, most likely to avoid perishing of the produce. Ninety-one percent of the respondents sold their produce on the farm while 44 percent sold in urban centres. Ninety-three percent of the respondents sold their produce to big traders from outside the local area, while none sold their produce to any commercial firm or government agency.

The average prices of tomato, garden egg, sweet pepper and onion, were 64 kobo per kilogram, 61 kobo per kilogram, 81 kobo per kilogram and 65 kobo per kilogram respectively. The prices of these crops were found to exhibit sharp monthly fluctuations during the irrigation season. The seasonal price ranges for the crops were 20-263 kobo per kilogram, 19-260 kobo per kilogram, 34-200 kobo per kilogram, and 40-135 kobo per kilogram for tomato, garden egg, sweet pepper and onion, respectively.

The constraints to increased crop production in the study area are shortage of irrigation water, shortage of fertilizer unstable produce prices, incidence of diseases, and shortage of money. Availability of fadama land and labour does not seem to be a constraint to the expansion of cultivation.

The results of the budgetary analysis revealed the total cost of production incurred by all the respondents to be 114,528.16 naira, giving an average total cost of 2,545.07 naira per respondent or 3,813.92 naira per hectare.

Variable costs accounted for about 94 percent of the total cost, while fixed costs accounted for the remaining 6 percent. Among the variable costs, labour input, alone, accounted for 67.77 percent of the total cost, while marketing accounted for 6.78 percent. Seeds, fertilizer, pump repairs and fuel jointly accounted for only 19.87 percent of the total cost.

The gross farm income for all the respondents was found to be 191,356.30 naira, giving an average of 4,252.36 naira per respondent or 6,372.28 naira per hectare. The net farm income for all the respondents was 76,828.14 naira, giving an average of 1,707.28 naira per respondent or 2,558.46 naira per hectare. Seventy-six percent of the respondents were found to produce at a profit while the remaining 24 percent produced at a loss.

The factors that accounted for variation in costs and returns among the respondents were quantity of labour input, quantity of fertilizer used, place of marketing of produce, ownership of pumps, produce prices and differences in managerial ability.

The analysis of the Cobb-Douglas production function revealed the R^2 to be 0.72 and the F-ratio to be 25.69. This ratio is significant at 1 percent level. The regression coefficients with respect to labour, plant population, fertilizer and irrigation water were 0.056, 0.172, 0.388 and 0.688 respectively. All the four variables have positive regression coefficients indicating that their increase will increase total value product. Due to the fact that the chosen production function is the Cobb-Douglas type, the regression coefficient with respect to each variable input is also the elasticity of production of the variable. The regression coefficients are all positive, but less than unity indicating that there is decreasing returns to the variable inputs in the study area.

The sum of the elasticities of production (1.304) with respect to all the inputs is significantly greater than unity. This implies that there is increasing returns to scale in crop production under irrigated agriculture in the study area.

Labour, plant population, fertilizer and irrigation water had marginal value products of 0.02 naira, 0.002 naira, 0.32 naira and 29.26 naira respectively. Their respective unit acquisition costs were 0.99 naira per man-hour, 0.033 naira per stand, 0.29 naira per kilogram and 8.00 naira per Ha-cm. This means that labour and plant population were being used above their economic optimum levels, while irrigation water and fertilizer were being used below their economic optimum levels. Hence, all the inputs were being utilised inefficiently, indicating that there is scope for increasing net income, through resource adjustment, in the study area.

6.2 Policy Implications

The findings of this study revealed that a major constraint to expansion of cultivation or even increasing yields and net farm incomes on the presently cultivated fadama plots, is inadequate supply of irrigation water. Presently, farmers depend mainly on natural sources of irrigation water supply such as rivers, streams and ponds, which usually dry up in the irrigation season, leaving the farmers with the only alternative of digging wells which in turn dry up within short periods of time. It is believed that any policy, such as building of small dams and sinking of washbores, which could lead to increased water supply would have the effect of increasing yields and net farm incomes on the cultivated fadama lands, as well as increasing holdings and input of other resource factors.

The findings of the study, that fertilizer is being employed below the economic optimum level, implies that increased profits could be realised in the study area through increased use of this input.

Efforts should, therefore, be made to ensure adequate provision of this input at reasonable prices to the farmers.

The study also revealed that the population density of the crops produced in the area is being maintained above economic optimum. This suggests that there is a problem of seeding rate and plant spacing among the farmers. Extension efforts in the area should be directed towards ensuring that farmers adhere to recommended agronomic practices, especially as they relate to seeding rates and plant spacings for the various vegetable crops produced in the area.

One of the constraints to production identified by the respondents is shortage of funds. The study also revealed that the respondents do not benefit from credit facilities with respect to dry season farming. To enable the farmers afford modern practices such as increased use of fertilizer suggested above, their financial position should be improved through the provision of credit for the purpose of dry-season farming. To reduce administrative costs of giving out credit to these small-holder farmers located in scattered and remote areas, government should encourage the dry-season farmers to form cooperative societies, through intensive enlightenment campaigns in the area.

Another major problem encountered in the study area is that of sharp fluctuations of produce prices. The fluctations are probably due to the high perishability of products which make it difficult for farmers to regulate supply. Farmers are therefore sometimes forced to accept very low prices for their produce. Farmers could be encouraged to produce more if there is an arrangement that ensures prompt purchase of surplus produce and guarantees minimum prices for the products. This could be achieved if the efforts are made to establish cold stores at strategic locations for the storage of vegetables. Vegetable products can then be purchased at the time of surplus supply, stored, and resold when the supply is low. Also, efforts could be made to establish small-scale fruits processing industries in the study area. These industries would then serve as a ready market for the evacuation of vegetable products.

6.3 Conclusions

This study was designed to analyse the economics of resource use in irrigated agriculture with particular reference to pump systems in the area covered by the western zone of the Bauchi State Agricultural Development Programme. Various aspects of the economics of resource use, including costs and returns of production, productivity of resources, efficiency in resource use, elasticity of production with respect to each of the resources, as well as the returns to scale prevalent in the study area were examined. The results of the study are the subject matter of chapters four and five. From these results, the following conclusions could be made:

(1) Majority of the farmers producing vegetable crops under pump irrigation systems, in the study area realise profits. An average profit of 2,558.46 naira per hectare was realised by the respondents and the average rate of return (67 percent) is high. However, opportunities still exist for increased profits through resource adjustments.

(2) All the resources used in crop production, under the systems have positive marginal value products;

(3) There is decreasing but positive returns to each of the inputs employed under the systems, implying that the farmers are producing in the rational zone of production;

(4) There is increasing returns to scale in the study area.

Based on the results of this study and the conclusions stated above, it could be asserted that pump irrigation systems have high potentials for increasing agricultural production in the country. Their promotion should therefore be given serious consideration by policy makers.

6.4 Limitations of the Study and Suggestions for Fu.ther Studies

6.4.1 Limitations of the Study

(a) One Season Data

This study was conducted over a period of only one irrigation season, extending from December 1987 to June 1988. But production characteristics in crop production may vary from one year to another, even for a particular location, depending on such variables as weather and biological factors (such as diseases and pests). There is the possible danger that the irrigation year 1987/88 may not be r presentative of other years. It is therefore suggested that caution be exercised in interpreting the results of this study.

(b) Sample Size

In this study, intensive data collection was undertaken throughout the research season. Because of this, and time and financial constraints, data for this study were collected from only 45 respondents located in four villages. It is possible that the 45 respondents may not be representative enough of other dry-season farmers in the study area. Perhaps a larger sample size would have been more representative.

(c) Small Geographical Area

This research covered only the western zone of the Bauchi State Agricultural Development Project consisting of four Local Government Areas. This area is relatively small when compared to the size of

Nigeria. Since production characteristics in crop production vary from one geographical location to another, caution must be exercised in trying to use the results of this study to generalise for the entire country.

(d) Farm Production Function

In the study area, most farmers cultivate their crops in mixtures. It was, therefore, impossible to associate particular input quantities with each type of crop, in order to fit separate physical functions for each crop. In view of this, an aggregate (value) farm production function, covering all the four major crops grown under pump irrigation system in the study area, was fitted to the data collected. Perhaps greater insight would have been allowed into the input-output relationships if separate functions were fitted for each crop.

Nonetheless, Heady and Dillon (1961) have argued that farm production function based on aggregative value of input and/or output may be quite useful to a government policy maker. Also rationalising the use of value functions Khare (1961) argued that the value production function is a transformation from physical units into monetary units and that the algebraic form of a function is the same regardless of the unit of measurement. Accordingly value functions have been estimated in several studies (Khare, 1961; Achari, 1965; Desai, 1973; Singh and Kahlon, 1973; Orewa, 1978; Bagi, 1981; Singh, 1981).

5.4.2 Suggestions for Further Studies

This is just a case study covering only four Local Government Areas in one state out of the 21 states in the Federation. To generate adequate and reliable research information useful for small-scale irrigation policy in Nigeria, it would be necessary to undertake this type of study in several other locations in the country. Such future studies should make efforts to develop analytical models that would enable the determination of input-output relationships for individual crops grown under crop mixtures. Future research should not be limited to vegetable crops alone. Rather, it should cover other crops such as wheat, rice, and maize produced under irrigation.

BIBLIOGRAPHY

Achari, T.K.T. (1965). "A Note on Optimum Resources Allocation as Estimated from Cobb-Douglas Production Function". Indian Journal of Agricultural Economics. Vol. XX No.4, October-December.

Anderson, J.R.; Dillon, J.L., and Hardaker, B. (1977). "Agricultural Decision Analysis". The Iowa State University Press, Ames, Iowa, U.S.A.

Abifarin, A.O. (1974). Annual Report (IITA, Ibadan), pp. 167.

Baba, J.M. (1975). "Induced Agricultural Change in a Densely Populated District: A Case Study of the Existing Agricultural Systems in Kaura District and the Projected impact of the Kano River Irrigation Project, Kano State, Nigeria" Unpublished Ph.D. Thesis, A.B.U., Zaria.

Bagi, F.S. (1981). "Economics of Irrigation in Crop Production in Haryana". Indian Journal of Agricultural Economics. Vol. XXXVI, No. 3. July-September, pp. 15-26.

Balogun, E.D. (1986). "Agricultural Development Strategies in Nigeria: Past, Present, and Future". Nigerian Agricultural Outlook (with Special Reference to Budgets). NAAE. A. Okorie and M.O. Ijere (ed).

Bauchi State Agricultural Development Programme (1983). "Zonal and Development Area Statistics".

Beneke, R.R. and Winterborer, R. (1973). "Linear Programming Applications in Agriculture". Iowa State University Press, Ames.

Chawdhari, T.P.S.; Tripathy, R.N.; Rao, T.V.S.; Sharma, J.N. (1969). "Resource use and productivity on farms: A Comparative Study of intensive and non-intensive Agriculture Area". National Institute of Community Development, Hyderabad.

Cisse, Y. (1987). "Resource use and Productivities: A Comparative Study of Intensive and Non-Intensive Farming Systems in 'Mali-Sud' Rural Development Project". Unpublished M.Sc. Thesis. Dept. of Agric. Econs. and Rural Sociology, A.B.U., Zaria.

Clark, C. (1964). "The Economics of Irrigation". Indian Journal of Agricultural Economics. Vol. XIX Nos. 3 and 4, July-December, pp. 25-32.

Desai, B.M. (1973). "Economics of Resource Use on Sample Farms of Central Gujarat". Indian Journal of Agricultural Economics, Vol. XXVIII, No. 1, pp. 71-82, January-March.

Dillon, J.L. (1977). "The Analysis of Response in Crop and Livestock Production". Pergamon Press.

Dillon, J.L. and Hardaker, J.B. (1980). "Farm Management Research for Small Farmer Development". F.A.O. Rome.

Eicher, C.K. and Baker, D.C. (1982). "Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey". Michigan State University, International Development Paper No.1.

Ekele, E.A. (1980). "Farm Size and Economic Efficiency: A Case Study of Small and Large Crop Farms in the Funtua Agricultural Development Project Area of Kaduna State". M.Sc. Research Proposal. Department of Agricultural Economics and Rural Sociology, A.B.U., Zaria.

Erhabor, P.O. (1982). "Efficiency of Resource use under small-scale Irrigation Technology in Nigeria". Indiana Purdue University, Technical Report No. 148.

Etuk, E.G. (1986). "A Comparative Study of Optimum Farm Plans for small farmers with Traditional and New Technologies in Zaria Area of Northern Nigeria". Samaru Miscellaneous Paper 109. Institute for Agricultural Research, A.B.U., Zaria.

Etuk, E.G. and Abalu, G.O.I. (1982). "River Basin Development in Northern Nigeria: A Case Study of Bakolori Project". Fourth Afro-Asian Regional Conference of ICID, Lagos, Nigeria, Vol. II (Publ. 26): 335-346.

F.A.O. (1966). "Agricultural Development in Nigeria, 1965-80" F.A.O. Rome.

Federal Ministry of National Planning (1981). Fourth National Development Plan, 1981-85.

Federal Republic of Nigeria (1970). Second National Development Plan, 1970-74.

Federal Republic of Nigeria (1976). Third National Development Plan, 1976-80.

Gass, S.I. (1964). "Linear Programming Methods and Applications". International Business Machines Inc. McGraw-Hill Book Company, Second Edition.

Heady, E.O. (1952). "Economics of Agricultural Production and Resource use". Prentice-Hall Inc. Englewood Cliffs, New York.

Heady, E.O. and Dillon, J.L. (1961). "Agricultural Production Functions". Iowa State University Press, Ames, Iowa.

Idachaba et al (1980). "The Green Revolution: A Food Production Plan for Nigeria". A Study by the Food and Strategies Mission, Federal Ministry of Agriculture. Vol. I, Main Report.

Jones, G. (1971). "The Role of Science and Technology in Developing Countries". Oxford University Press.

Khare, B. (1961). "The Mathematical Formulation of Production Functions". The Indian Journal of Agricultural Economics, Vol. XVI No.3, July-September, pp. 33-37.

Kolawole, A. (1982). "The Extent of Local Farmer's Participation in Large-Scale Irrigation Projects in Nigeria: A Preliminary Study of South Chad Irrigation Project. Fourth Afro-Asian Regional Conference. Vol. II, pp. 325-334.

Maiga, A.S. (1983). "Optimum Farm Plans in Irrigated Agriculture: A Case Study of the Niger River Development Project 'Office Du Niger' in the Republic of Mali". Unpublished M.Sc. Thesis Dept. of Agric. Econs. & Rural Sociology, A.B.U., Zaria.

Makarfi, A.M. (1985). "Economics of Wheat Production under Surface Irrigation: A Case Study of Kano River Project - Phase I". Unpublished M.Sc. Thesis, Dept. of Agric. Econs. and Rural Sociology, A.B.U., Zaria.

Makarfi, A.M. (1987). "Rural Development through Irrigation: A Case for Small-Scale Approach". A paper presented at the Fourth National Conference of Rural Sociological Association of Nigeria, 17th-20th May.

MRT Consulting Engineers Ltd (1973). "Investigations and Feasibility Study for a Project South of Lake Chad.

N.E.D.E.C.O. (Netherlands Engineering Consultants) (1959). "River Studies and Recommendations on Improvement of Niger and Benue". North-Holland Publishing Company, Amsterdam.

Norman, D.W. (1972). "An Economic Survey of Three Villages in Zaria Province". 2 Input-Output Study, Vol. I Text. Samaru Miscellaneous Paper 37.

Norman, D.W. (1973). "Methodology and Problems of Farm Management Investigations: Experiences from Northern Nigeria". Samaru Research Bulletin 195.

Nwa, E.U. (1976). "Water Resources and Agricultural Development in Nigeria". Paper presented at the 12th Annual Conference of Agricultural Society of Nigeria. University of Ife, Ile-Ife.

Nwa, E.U. (1980). "An Evaluation of Small Pump and Shadoof Systems of Irrigation in Northern Nigeria", Zaria, Dept. of Agricultural Engineering.

Nwa, E.U. and Martins (1982). "Irrigation Development in Nigeria". Proceedings of the Fourth Afro-Asian Conference of ICID, Lagos, Nigeria, Vol. I (Publ. 01:1), 1-8.

Nwuba, U. and Onwuji, J.I. (1982). "Shadoof Irrigation for Increase in Horticultural Production in Nigeria". A paper prepared for Presentation at 5th Annual Conference of the Horticultural Society of Nigeria, Zaria, 21st-24th November.

Ofojekwu, P.O. (1982). "Economic Analysis of Tomato Production under a Small-Scale Surface Irrigation Scheme: A Case Study of Galma Irrigation Scheme, Zaria. Unpublished M.Sc. Thesis, Dept. of Agric. Econs and Rural Sociology, A.B.U., Zaria.

Ogunfowora, O.; Essang, M.S., Olayide, S.O. (1975). "Resource Productivity in Traditional Farming: A Case Study for Four Agricultural Divisions in ~~Kwara~~ State of Nigeria". Nigeria Rural Study. Rural Development Paper No. 16.

Olayemi, J.K., and Oni, S.A. (1971). "Costs and Returns in Peasant Cocoa Production: A Case Study of Western Nigeria". Bulletin of Rural Economics and Sociology 6(2).

Olayide, S.O. (1972). "Agricultural Productivity and Increased Food Production under Economic Development in Nigeria". Proceedings of the 1972 Annual Conference of the Nigerian Economic Society, pp. 45-76.

Olayide, S.O. and Hendy, E.O. (1982). "Introduction to Agricultural Production Economics", University of Ibadan Press.

Orewa, S.I. (1975). "The Economics of Dry Season Tomato Production under the Cadbury Tomato Scheme in Zaria Area". Unpublished M.Sc. Thesis. Dept. of Agric. Econs. and Rural Sociology, A.B.U., Zaria.

Palmer-Jones, R.W. (1980). "Why Irrigate in the North of Nigeria?". Paper presented at Seminar on Change in Rural Hausa Land, Kano, 29-30th February.

Saini, G.R. (1969). "Resource use efficiency in Agriculture. Indian Journal of Agricultural Economics. Vol. XXIV No.2, pp. 1-18.

Sing, J.P. (1981). "Caste Institution and Production Efficiency of Farmers in Eastern Uttar Pradesh". Indian Journal of Agricultural Economics, Vol. XXXVI No.3, July-September, pp. 35-41.

Singh, K. and Kahlon A.S. (1973). "Resource Productivity Comparisons at Varying Levels of Technology in the Punjab". Indian Journal of Agricultural Economics, Vol. XXVIII No.2, April-June, pp.12-25.

Schultz International Ltd. for the Canadian International Development Agency (1976). "Hadejia River Basin Development Study: Development Plan Final Report". Vancouver, Canada.

Spencer, D.Sc. (1972). Micro-Level Farm Management and Production Economics Research among Traditional African Farmers: Lessons from Sierra Leone". Africa Rural Employment Study. Rural Development Paper No. 3.

Upton, M. (1979). "Farm Management in Africa. The Principles of Production and Planning". The English Language Book Society and Oxford University Press.

Wallace, T. (1979). "Rural Development Through Irrigation: Studies in a town on the Kano River Project. C.S.E.R. Research Report No. 3, A.B.U., Zaria, Nigeria.

Wickramasuriya, A.T.G. (1975). "Some Thought on the Development of Water Resources of Nigeria". National Irrigation and Agricultural Engineering Seminar.

Wood, W.W. (Jr) (1980). "Benefits of Irrigation to Consumers". Proceedings of the American Society of Agricultural Engineers, 2nd National Irrigation Symposium, October.

Young, R.A. (1980). "The need for Irrigation: An Economist's View". Proceedings of the American Society of Agricultural Engineers, 2nd National Irrigation Symposium, October.

Yotopolous, P.A. (1967). "Allocative Efficiency in Economic Development: A Cross-Section Analysis of Epirus Farming". Research Monography Series 18. Center of Planning and Economic Research.

Appendix A: Regression Coefficients and t-values from the linear Production Function Analysis.

Variables	Regression Coefficients	t-Value
Constant term (A)	-4356.75	-3.56***
Labour (X_1)	0.66	1.64$^{n.s.}$
Plant Population (X_2)	- 0.003	-0.60$^{n.s.}$
Fertilizer (X_3)	3.38	1.90*
Water (X_4)	777.63	3.83***

R^2 = 69
F-ratio= 22.05***
* = Significant at 10 percent level
*** = Significant at 1 percent level
n.s. = Not Significant

Source: Field Survey, 1988.

Appendix B: Regression Coefficients and t-values from the Quadratic Production Function Analysis.

Variables	Regression Coefficients	t-Values
Constant term (A)	4025.82	$1.64^{n.s.}$
Labour (X_1)	-0.27	$-0.23^{n.s.}$
Population count (X_2)	0.03	$1.52^{n.s.}$
Fertilizer (X_3)	1.83	$0.40^{n.s.}$
Water (X_4)	-1100.96	$-1.56^{n.s.}$
X_1^2	1.23	$0.57^{n.s.}$
X_2^2	-6.22	$-1.527^{n.s.}$
X_3^2	6.07	$0.20^{n.s.}$
X_4^2	94.86	2.55^{**}

R^2 = 0.84
F-ratio = 24.33^{***}
** = Significant at 5 percent level
n.s. = Not Significant

Source: Field Survey, 1988.

Appendix C: Regression Coefficients and t-values from the Square Root Production Function Analysis.

Variables	Regression Coefficients	t-Values
Constant term (A)	-3532.71	-1.13 n.s.
Labour (X_1)	2.86	1.77*
Population count (X_2)	-0.022	-1.25 n.s.
Fertilizer (X_3)	12.95	2.11**
Water (X_4)	2.54	3.56***
X_1^2	-202.94	-1.38 n.s.
X_2^2	14.69	1.13 n.s.
X_3^2	-442.65	-1.47 n.s.
X_4^2	4166.38	3.72***

R^2 = 0.76
F-ratio = 16.30***
* = Significant at 10 percent level
** = Significant at 5 percent level
*** = Significant at 1 percent level
n.s. = Not Significant

Source: Field Survey, 1988.