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Production, income and employment effects of agricultural technology in the central cocoa belt of western Nigeria: a multiperiod programming approach

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Production, income and employment effects of agricultural technology in the central cocoa belt of western Nigeria: A multiperiod programming approach

by

Kolawole Mobolaji Alli

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I. INTRODUCTION

A. The Problem Situation

The problem of developing the rural sector[1] of Nigeria has received increasing attention in recent years(36, pp. 2, 155). There are several reasons for this attention: first, the rural population constitutes 70 percent of the total population. Second, most of the rural population are engaged in agriculture or agricultural related activities. Third, agriculture is one of the most important segments of the Nigerian economy, accounting for 23.4 percent[2] of the gross national product (79, p. 19). For these reasons, efforts should be made to improve the contribution of agriculture to the national economy and an improvement of the lives of those that engage in it.

The importance of agriculture to the national economy

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[1]It is not only in Nigeria that the problem of rural development is receiving much attention. It is a general concern in less developed countries of the world. The less developed countries being those countries with average per capita incomes of less than $180. According to 1972 data, this included 84 of the 112 countries with populations over one million (42, p. 7). Total population of these 84 countries was estimated at 2.59 billion (42, p. 6).

[2]Agriculture including forestry and fishing accounted for this 23.4 percent and it is measured at product prices in 1974/75. The percentage contribution has varied over the years. It used to be 66 percent in 1958/59, 55 percent in 1966/67 and 50 percent 1970/71. Part of the decline can be attributed to the increases in the growth rate of mining and petroleum.

is further emphasized by increasing need for food, fiber and employment by the rapidly increasing population which is estimated at 2.7 percent per annum (82, p. 1). There is also an increasing demand on agriculture to supply foreign exchange and capital formation. However, the agricultural sector appears to be plagued by problems of low productivity, unemployment and underemployment, lack of capital, low levels of technology and tenure arrangements.

The objectives of modernizing this sector and increasing agricultural productivity has been dominant in the past three national development[1] plans (20, pp. 2-3). Within these past development plans, various activities have been included with the purpose of alleviating some of these inherent problems in the agricultural sector. The programs pursued have taken various forms; credit programs were initiated to provide loans to the farmer. This is due to the realization by the government that credit plays an important role in agricultural productivity.

[1]These various development programs carried with them, the goal of improving and developing the rural areas of Nigeria. But most have been fashioned in line with the capital model of W. A. Lewis, which provided the economic development theory for many developing countries in the 1950's and 1960's. By following this model the rural people did not benefit. This is because this approach involved a capital accumulation model where rural labor and resources would move to the more productive modern sector of the economy so that productivity could be increased. By keeping wages low, a surplus was to be generated and reinvested in new capital which would contribute to economic growth and more jobs. In this manner, the modern sector would expand rapidly and absorb the rural poor who resided in the traditional sector of the rural area.

Farm settlement schemes[1] have been initiated to attract young educated farmers into the agricultural sector. Subsidy programs for farm input, including seeds and fertilizers, were introduced to help farmers purchase and use inputs at lower prices. Unfortunately, however, most of these programs have not yielded the expected results. The reasons why some of the development projects have not yielded their desired effect is not well understood. This has been a major concern of both administrators and intellectuals alike. This concern may best be summarized by Uma Lele (42, p. 19) who asked:

> What explains the limited impact of past development programs on the low incomes of rural population in Africa? Why - despite a great variety of approaches tried by donor and national agencies and despite a great amount of experience generated by these efforts has the problem of rural poverty remained acute?

Development planning and project implementation have become accepted as a means of achieving agricultural development objectives in Nigeria for almost two decades.

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[1] In the early 1960's, when the idea of farm settlement scheme was first conceived, it was held as a major panacea, to the problems facing the agricultural sector. One of the objectives of the scheme was to use farm settlements as a means of demonstrating to the farming population that farming could be both a profitable and an attractive way of life, and that young men and women can, in fact, make a comfortable living on the farms rather than compound the problems of urban centers by migrating to them. By and large, the objectives of the scheme have not been met; so it has proved to be an illusion.

This has been regarded as a means of allocating scarce resources. The objectives expressed in the National Development plans include; an adequate food supply both in terms of quality and quantity to keep pace with increased population and urbanization; the expansion of the production of export crops, with the view to increasing and diversifying the country's foreign exchange earnings; the production of agricultural materials for domestic manufacturing activities, especially in the field of agro-based industries; creation of rural employment opportunities to absorb more of the increasing labor force and minimizing the tendency for inadequate and inefficient use of human resources; the evolving of appropriate institutional and administrative apparatus to facilitate a smooth integrated development of the agricultural potential into the national economy. In order to bring about the realization of these objectives, some of the problems that plague the agricultural sector and the solutions that have been tried over the years need to be mentioned.

Although the agricultural sector of Nigeria contributes 23.4 percent[1] at 1974/75 product prices to the Gross National

[1]The estimates have varied over the years, due to the significant contribution of the petroleum sector. Estimates have varied from 50-70% (79, p. 126).

Product of the country, it serves as the greatest employer of labor force in Nigeria. Those engaged in agriculture are also very poor.[1] Land areas they cultivate are generally small ranging between 2.50 acres in the Eastern States to 10.50 acres in the Northern States.[2] Apart from the small acreages cultivated, the productivity of such farms are generally very low and use of improved technology almost nonexistent. On the aggregate this sector is further constrained by:

1. Shortage of qualified man power in the extension service. The ratio of extension worker to farmer is estimated at 1:10,000. This is very discouraging, since an effective extension system is needed to bring the package of improved system of production to the farmers, are not readily available.

2. Agricultural inputs such as seeds, fertilizers, insecticides and other improved systems of production are not readily available. The problem here is a distributional

[1]The definition of rural poor is in line with the definition adopted by the International Bank for Reconstruction and Development and complemented in its use by the United States Agency for International Development. The rural poor are those in absolute terms who earn less than $150 in 1969 prices per annum (30, pp. 19-20).

[2]This refers to the average per acre cultivation in the country. This however varies within and among regions. There are also large plantations owned by individual farmers and government institutions.

problem, although in some areas lack of knowledge of new technologies on the part of farmers still prevail.

3. Effective supportive services to facilitate a quick adoption of improved technologies and methods of production are not easily found or when they exist, they are not efficient. The credit system is being plagued by both administrative problems and low repayment rates (78, p. 35).

4. In some parts of the country, problems of land ownership due to the land tenure[1] system makes adoption of improved practices unprofitable and unrealistic (2, p. 259).

5. Rural-urban migration[2] poses a problem of labor shortage. The rate of rural-urban migration has grown steadily over the years. It was 1.1 percent in 1961 and has increased to about 7.5 percent in 1971. The rapid rise being observed to be positively correlated with rural-urban income differential. It also varies between ages. It is higher amongst the youngest members of the population than amongst the older members of the population (47a, p. 28).

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[1]Land tenure here is defined as rights governing and regulating such things as ownership, tenancy and inheritance to land.

[2]Migration of rural youths to urban centers has been one of the reasons why the Farm Settlement Scheme in Nigeria failed. This has resulted in high unemployment rates in urban centers. This problem might perhaps continue to escalate, because of recent wage increases in some government and private sectors.

6. Diseases and pests create problems and deter increased agricultural productivity.

Because of the problems facing the agricultural sector as a whole, and the farmers in particular, there is a gap between "what is," and "what ought to be." This, therefore, results in a problem.

According to Hildreth and Castle (32b, p. 23), a problem is said to exist if there is:

1. a need felt by an individual or society,
2. a gap between achievement and the goal of an individual or society,
3. a deviation from optimum as defined by theory,
4. an intellectual difficulty by researcher.

These various approaches are generally interrelated; the characteristics they portray are quite evident in Nigerian agriculture. There is clearly a need felt by the general society for the improvement of the agricultural sector. This might be due to the fact that in recent years, the food and fiber requirement of the country seem to be outrunning the present capacity of agricultural production. This is being expressed in terms of rises in the prices of food crops. The agro-industries are also known to be working below capacity due to the inadequate supply of raw materials. The root causes of this problem of inadequate supply could be due to insufficient resource base, the small sizes of

farms, the lack of price incentive or the low level of technology.

Various studies on agricultural production in Nigeria (36, p. 155) have been done and most of the recommendations made call for a provision of favorable price relationships and incentives to motivate agricultural producers to produce more. Other broad suggestions have been made as to investments in agriculture (36, p. 1). However, before effective planning and project implementation can be done, efficient and accurate data sources are required.

Accordingly, information is required on the physical availabilities of resources, farm income levels and production levels. An adequate solution for solving the problem of our agricultural sector requires a clear understanding of how the aggregate production system interrelates. How do resource supplies, output demand situations and constraints on production activities affect the farmers incomes and productivity levels?

Inadequate data sources have plagued our agricultural system, but recently the Ministry of Agriculture and Natural Resources of the former Western State (Ogun, Oyo and Ondo States) conducted a farm-management survey between 1971-1972, the results have gone a long way to improve on the existing data bank. Other researchers are conducting scientific research on various crops grown under the

existing environmental conditions. With adequate data, one can evaluate the potential impact of agricultural programs on the volume of production, farm income, and employment.

Recent studies have concentrated on studying the unemployment problems in the developing sectors of most less developed countries (3b). Inadequate returns to labor have been attributed to the high rate of rural-urban migration in the developing countries. The major question then becomes, can these problems be solved? Relevant sub-questions are:

1. How can production and investment in farming be organized to help effectively solve the problems inherent in agriculture within the existing technological environment?

2. What research efforts, in terms of new technologies, are needed to help alleviate these problems?

3. What types of farming programs should the government engage in, in light of the above?

4. Are resource level changes necessary for the achievement of the socially desirable results?

5. What are the consequences of the new technologies in terms of production, income and employment generating potentials?

This study is designed to make some suggestions in these and other problem areas by providing the missing links in the chain of knowledge and information needed for

rational formulation of rural income and employment policies at both the micro and macro levels.

B. The Objectives of the Study

Given that the goal of the farm-firm is the maximization of net income or the present value of a stream of net income over time, the objectives of this study are:

1. To determine the pattern of export and food crop production over a defined planning horizon, under a) traditional and b) improved technologies;

2. To determine the effect of technology in terms of income, production and employment generation;

3. To evaluate the effect on production, income and employment of varying the land resource base;

4. To quantify the potential impact of aggregate food and export crop price support programs.

From the above objectives, modest policy suggestions may be made regarding the effect of technology under different levels of land resource base and the impact of the various support levels on production, income and employment of the farm-firm.

C. Methods Used in Pursuing Objectives

Although various analytical approaches are available for this type of study. The one chosen is a Multiperiod Linear Programming Approach. There are three basic models, namely, A1, A2 and B1. Within each basic model there are submodels. The submodels are for:

1. A1: A11, A12, A13, A14 and A15
2. A2: A21, A22, A23, A24 and A25
3. B1: B11, B12, B13, B14, B15, B16, B17, B18, B19, B10.

Model A1:

This consists of a programming analysis of the optimal production plans in food and export crops under the traditional technology. The submodels are actually a computer run of the basic model. Submodels A11, A12, A13, A14 and A15 assumes 5, 10, 15, 20 and 25 acre annual revolving acreage levels during the entire planning horizon.

Model A2:

This consists of a programming analysis of optimal production patterns in food and export crop production under the improved technology. The five submodels are A21, A22, A23, A24 and A25. In these submodels the land base is

varied from 5, 10, 15, 20 and 25 acre revolving acreage levels during the entire planning horizon.

Model B1:

This consists of a programming analysis of optimal production patterns in export and food crop production under varying levels of aggregate food and export crop price support levels. The submodels B11, B12, B13, B14 and B15 correspond to 10, 20, 30, 40 and 50 percent subsidy levels on export crop prices, and B16, B17, B18, B19 and B10 correspond to 10, 20, 30, 40 and 50 percent subsidy levels on food crops price support. Here the land resource base was fixed at 5 acres. The land resource base was not varied because of limited computer funds.

D. Area of the Study

The area chosen for the study is called the Central Cocoa Belt. There are two basic reasons for choosing this study area.

First, it is an area which exemplifies all the problems enumerated earlier that plague the agricultural system of Nigeria.

Second, its soil type, vegetation and institutional characteristics allow for a diverse cultivation of export and food crops.

The detailed description of this area including its socio-economic characteristics, is in Chapter III.

E. The Plan of Study

Chapter II contains a brief, but detailed description of the Nigerian economy emphasizing the role of agriculture.

Chapter III contains a description of the study area.

Chapter IV contains a description of the problem associated with using the production investment approach and other related theoretical issues.

Chapter V gives the structure and activities included in the empirical model; it also contains constraints facing the farm-firm assumed in the study.

Chapter VI summarizes the results of the models under three basic headings to bring into focus the effect of technology, the increase in land resource base and, finally, the effect of the different levels of aggregate price support programs.

Chapter VII contains a framework for identifying, formulating and implementing an agricultural technological drive. It also contains suggestions of types of policy based on results of the models.

Chapter VIII contains the summary of the results, the shortcomings of the study and suggestions for further research.

II. BACKGROUND AND NATURE OF NIGERIAN ECONOMY

A. Location, Size and History of Nigeria

The Federal Republic of Nigeria is a country of 923,773 sq. kilometers lying along the tropical curve of the West African Coast. It lies between the parallels of 4° and 14° North and is thus entirely within the tropics. It is bordered on the West by Dahomey, North by the Niger Republic and on the East by the Republic of Cameroons. On the entire Southern border is the Atlantic Ocean.

The country became a single political unit on the 1st of January, 1914, when the former colony and protectorate of Southern Nigeria was amalgamated with the protectorate of Northern Nigeria. After the amalgamation, the country was organized into two groups of provinces, the Northern Province and the Southern Provinces which included Lagos Colony. The Southern Provinces were later divided into the Eastern and Western Provinces in 1939 (19, pp. 12-13).

Nigeria became an independent nation on October 1, 1960, as a federation consisting of three regions: the Northern, Eastern and Western Regions. By 1963, the country was composed of four regions with the Western Region broken down into two regions, the Western Region and the Midwestern Region. In 1967, the country was divided into twelve states.

Recently the country has experienced a new structural division into 19 states.[1]

B. Population Characteristics

The population of Nigeria is divided into numerous tribal and linguistic groups, speaking different languages and professing different religions.

Nigeria is a nation of 56 million people according to the 1963 census figures. The population is made up of 248 language groups. The sizes of these groups vary from a few hundred to several million. There are, however, three major groups: the Hausas in the North, Yorubas in the South-West and the Ibos in the South-East. In the 1963 census the major groupings formed 11.65, 11.32 and 9.50 percent, respectively, of the Nigerian population (Table 2.1).

English is the official language, but Hausa, Yoruba and Ibo are widely spoken.

There are three major religious groupings: Moslems, Christians and Animists (Table 2.2). From Table 2.2, one can see that the major religious groupings account for 47.2, 34.5 and 18.3 percent, respectively, of the population of Nigeria. A census enumeration was carried out in 1973 but

[1]For a detailed structure of each state see Figure 2.1. The regional boundaries, North, West and East have been delineated due to new state structure.

Table 2.1. 1963 population of Nigeria by regions (59, p. 49)

Region	Area in sq/km	Population	Person/sq km
Northern	729,815	29,808,658	41
Eastern	76,364	12,394,464	162
Western	78,876	10,265,848	130
Midwestern	38,648	2,535,839	66
Lagos	70	665,246	9,504
Nigeria	923,773	55,670,055	60

Table 2.2. Size and distribution of religious groups in Nigeria (59, p. 49)

Region	Religious Groups		
	Moslems	Christians	Animists[a]
North	21,386,450	2,881,437	5,540,771
East	29,964	9,573,622	2,790,878
West	4,458,531	4,995,692	811,625
Mid-West	106,857	1,393,009	1,035,973
Lagos	294,694	363,384	7,168
Total	26,249,528	19,207,144	10,186,415
% of Total	47.2	34.5	18.3

[a]This grouping reflects those belonging to traditional religious and other types of religious beliefs different from the two other classifications. There are hundreds of them in Nigeria.

Figure 2.1. Map of Nigeria showing new state structure

the figures are not normally used.[1]

C. Topography, Climate, Vegetation and Soils

Along the Nigerian coastline lies a belt of mangrove swamp forest from 6.2-37.2 kilometers in width. This is intersected by numerous rivers and branches of the Niger Delta.

Beyond the mangrove swamps, is another zone which is 31-62 kilometers of undulating tropical rain forest. The country then rises to a plateau at a general elevation of about 610 meters but reaches 1830 meters to the east. The vegetation also changes from woodland to Savannah (34, p. 72).

In the extreme north, the country approaches the southern part of the Sahara Desert. The Niger River, which is the third largest river in Africa, enters Nigeria from the northeast and runs in a southeasterly direction, meeting its principal tributary, the Benue at Lakoja, about 800 kilometers from the sea. It flows south to the Delta, through which it empties into the Gulf of Guinea via numerous channels.

The natural vegetation is divisible into two kinds

[1]The 1973 census data count that puts the population figures at 80 million has been rejected and cancelled because of alleged irregularities.

that are directly related to the chief climatic regions of the country:

1. high forest (mainly swamp and rain forest);
2. Savannah.

Although the country lies wholly within the tropical zone, there are wide climatic variations in different regions of the country. Near the coast the seasons are not sharply defined, temperature rarely exceeds 90°F, but humidity is very high. Basically there are two seasons, a wet season from April to October and a dry season from November to March. Average rainfall varies from about 1.8 meters in the west to about 4.3 meters in some parts of the east.

Soil types are dependent upon the nature of the rocks that are available in that region. Vegetation and the climatic factor also help to determine soil type. The soils of Southern Nigeria, where the vegetation is thicker, tends to have more humus than those of the northern parts. Thus, soils in the south are potentially more fertile. The soils in Nigeria can be broadly grouped into four zones (34, p. 79):

1. Northern zone of sandy soils;
2. Interior zone of laterite soils;
3. Southern Belt of forest soils;
4. Zone of alluvial soils.

In terms of crop productivity, the Northern zone of

sandy soil produces the largest yield of cotton. The laterite soils are better for road paving and wall construction than for farming. There is, however, some subtypes in this zone which offer prospects for the expansion into the area of cotton production.

The Southern Belt forest soils are good for cocoa, palm produce and rubber. They are, therefore, of considerable economic importance. The zone of alluvial soils are of two types. Some are found along the courses of rivers, while others are found along the delta areas. Along the courses of rivers, they are generally sandy and often sterile. In the delta, they are clayey or muddy dark grey in color, usually water-logged and good for rice production. Where the soils are found on higher and drier ground other crops could be grown on them.

D. The Structure of the Nigerian Economy

Nigeria is a country with a per capita income of $180.00, and, like most other low income countries, derives its main source of income and employment from the agricultural sector. The future growth of income and employment will continue to depend largely on the development of agriculture. The

overall development[1] of the country does not, however, depend solely on this sector. The other economic sectors in the country include Mining and Quarrying, Manufacturing and Crafts, Building and Construction, Transport and Communications, Education and Health and General Services. In terms of sectoral contribution to the Gross National Product (in percentage terms as shown in Table 2.3), the percentage contribution of the agricultural sector has been falling steadily over the years, while that of mining and quarrying has been increasing. Increasing prices and production of crude oil could be attributed to this sector's increasing share. Other sectors' net returns, as a percentage of the Gross Domestic Product, seem to have steadied over the years. Since this study is basically concerned with the agricultural sector, a basic analysis of the structure of the agricultural subsector of the economy is needed.

[1]Development is hereby used as composed of three components: a) economic growth which implies an overall increase in per capita real income, b) social progress which implies the development of the rural inhabitants as informed and participating members in the social and economic life of the country. This, however. involves the provision of an environment, and opportunity for individuals to develop the talents with which they are endowed, c) political stability which involves an orderly transition toward social progress and economic growth (67, p. 85).

Table 2.3. Gross domestic product at constant 1974-75 prices: percentage distribution (20, p. 9)

Sector	Percentage				
	1970-71[a]	1971-72	1972-73	1973-74	1974-75
Agriculture	36.0	32.0	27.9	24.7	23.4
Mining and Quarrying	33.1	39.3	43.4	45.1	45.5
Manufacturing and Crafts	5.0	4.1	4.8	4.8	4.7
Electricity and Water	0.3	0.3	0.4	0.4	0.4
Building and Construction	3.5	4.1	4.7	5.4	5.7
Distribution	9.1	8.1	7.4	6.9	6.7
Transport and Communications	1.8	1.9	2.1	2.1	2.3
General Government	6.3	5.5	4.6	5.8	6.3
Education	2.7	2.6	2.5	2.3	2.6
Health	0.8	0.6	0.8	0.8	0.9
Other Services	1.4	1.4	1.4	1.5	1.5
Total	100.0	100.0	100.0	100.0	100.0

[a]Year 1970-71 starts April 1, 1970 to March 31, 1971. This constitutes a fiscal year.

E. The Agricultural Sector

Agriculture in Nigeria plays very important roles. Amongst these roles are:

1. an important source of income and foreign exchange for the country;
2. provision of raw materials for the agro-based industries and food for the country's population;
3. employment for the population.

Thus the development of this sector will play a very important role in the overall development of the nation, through increased production per worker and capital formation. It will continue to provide laborers for other sectors and generate markets for nonagricultural products and services.

The contribution of this subsector to the Gross Domestic Product has steadily fallen from about 55 percent (1966-67) to as low as 23.4 percent (1974-75). One important reason explaining this decrease is that oil prices and production have been increasing steadily over the years and this contributes significantly to the proportion of Gross Domestic Product from the Mining sector of which petroleum is included.

In the early 1950's and during the 1960's, agricultural exports were responsible for an average growth rate of 5

percent per annum. Export crops were the main focus because they earned the needed foreign exchange. New production techniques were introduced in the area of agriculture. Technological changes were introduced and export crops oriented research stations[1] were set up. Although, the export crops serve as a source of foreign exchange, they also serve as inputs for some of the agro-based industries. The overall incomes generated were expected to supply, the capital needed for the industrialization process. The emphasis was on industrialization. The policy makers thought that the development of the nation was to manifest itself through this process. This orientation arose, probably from the understanding of historical experience in countries with higher per capita incomes, where industrialization played a central role in the course of economic growth. Import substitution, that is the domestic production of goods formerly imported, seemed to be the optimum choice as this could permit the exploitation of already available markets. It was further thought that this mechanism would generate a critical level of income and once this income level was reached growth would be expected to continue as a self-sustaining

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[1]Examples of such research stations are: Cocoa Research Institute of Nigeria, Nigerian Institute for Oil Palm Research and Nigerian Rubber Research Institute.

process, ultimately leading to higher incomes and better opportunities for all members of the community.

Nigerian agriculture is marked by a considerable diversity of output. There is fairly sharp regional specialization in the production of cash crops, based on ecological characteristics. Groundnuts and cotton are grown in the North, tree crops--cocoa, palm oil and rubber in the South. Mixtures of food crops, tree crops are grown by farming families in the southern part of the country.

The country produces 30 percent of the world output of groundnuts. This is exported in the form of kernels and prior to the growth of the petroleum sector contributed about 20 percent of the export earnings. Total production of groundnuts has relatively declined over time because of the substitution of cotton for groundnuts. This is due to relative shifts in producer prices (79, p. 127).

Prior to the petroleum era, cocoa contributed 18 percent of Nigeria's export earnings with an annual crop output of about 210,000 tons. Fluctuating world prices affected the revenue generated from the cocoa producing regions.

Oil palm products is produced predominantly in the eastern states and production of these crops were slightly disrupted during the civil war. There is increasing domestic

demand for this produce, therefore, to increase production increased planting is being engaged in and also the rejuvenation of destroyed plantations during the war is being pursued.

Nigeria produces 3 percent of world supply of rubber. The Midwestern state (Bendel) produces about 80 percent of the national output and it is estimated that one half the number of trees will be out of production within a very short time (79, p. 128). The production of this crop was also affected by the civil war.

Cotton is second to groundnuts as a cash crop in the northern states. The bulk is consumed internally, but cotton seed is exported because of the oil it contains. The cash crops mentioned above, were supposed to generate foreign exchange but this anticipation was badly hurt over time, by declining producer prices (Table 2.4).

Reductions in the quantities of rubber, palm oil and palm kernel between the years 1966-70 were mostly due to the civil war. Production was curtailed in the war affected areas. Otherwise, the few increases in output of some of the crops could be attributed to short run fluctuations in yield due to weather conditions.

While there was much effort being diverted to the export crops production sector, the food production sector was virtually ignored. Most policy makers believed that the food economy could take care of itself without any

Table 2.4. Production of major export crops in thousand tons and production prices ($/ton) (79, p. 238)

Crop	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Rubber	NA[a,b]	57	61	65	74	70	72	49	54	58	67
	406[c]	372	378	316	330	330	282	280	320	362	296
Cocoa	149[b]	186	191	186	216	294	165	263	234	180	218
	312[c]	216	192	202	212	232	122	172	182	292	302
Groundnut	533[b]	446	619	686	787	679	978	1026	684	764	634
	72[c]	74	66	60	60	64	68	68	58	52	56
Palm Kernel	NA[b]	423	360	393	396	448	421	242	217	257	290
	58[c]	58	50	50	54	54	54	54	54	54	58
Palm Oil	NA[b]	523	493	494	499	514	492	315	338	411	474
	88[c]	88	68	70	70	70	70	70	70	70	70
Seed Cotton	NA[b]	149	83	144	129	129	127	146	76	166	272
	94[c]	94	NA	NA	NA	72	74	70	64	84	84

[a] NA = Not available.

[b] Output.

[c] Prices.

Table 2.5. Trend in agricultural production (1967-71)[a] (57, p. 6)

	1961-65	1967	1968	1969	1970	1971
Total Production Index	100	101	101	114	110	117
Per Capita Production Index		92	89	98	93	96

external stimulus. Of course, this confidence could have been due to the fact that traditionally, Nigeria had taken immense pride in being able to produce enough food to satisfy her domestic requirements. Except for short run fluctuations and seasonal scarcities, the country had not experienced any famine for several decades. In the past few years, however, some serious food problems have emerged. While a lot of people are aware of this food problem, the reasons for the causes of the problem remains a subject of controversy.

Some hypothesis have been advanced. These are those who believe that production has become less responsive to changes in demand largely because of a stagnant and traditional level of production technology and generally low returns to producers. Although it is seemingly possible that other factors might contribute to the problem there

are evidences to show that per capita annual production of food crops have been falling over the years (Table 2.5).

Some economists have hypothesized that the problem of increasing food shortage is not that of lack of adequate production but basically due to poor and inefficient marketing and distribution. In a subsistence agriculture, like that of Nigeria, there are usually wide divergencies between the amounts produced for sale and the amount that ultimately gets to the consumers. Since farmers are subsistent farmers, they retain part of what is produced for consumption. The quantities varies from family to family and variation exists with respect to the type of crop (57, p. 102). For root crops it varies from 20-60 percent of the output from an acre. Between the farm and the ultimate consumer wastages occur. Estimates vary according to crop (Table 2.6). This table shows that waste as a percentage of food supply varies from 4 to 92 percent. These estimates, however, represents a very small fraction of the total waste since losses on the farm, though very high, are very difficult to quantify. Food supply could thus be increased significantly through the elimination of some of these wastes. These wastes result, not only from poor marketing and transportation facilities but some are due to inefficient harvesting techniques, poor processing and storage facilities.

Table 2.6. Food production and wastage in Nigeria (1968-69) (56, pp. 15-40)

	Production (1000 long tons)	Total Supply[a] (1000 long tons)	Waste (1000 long tons)	Waste as % of supply
Maize	1,039.00	1,039.00	90.78	8.7
Millet	2,152.00	2,152.00	208.35	9.7
Sorghum	342.81	342.81	325.76	9.5
Rice	374.00	348.64	17.28	9.0
Cassava	8,691.00	8,691.00	1,254.66	10.0
Yam	12,197.00	12,197.00	2.71	3.9
Melon Seeds	70.00	70.00	150.75	16.5
Beans	640.00	640.00	127.05	10.0
Vegetables	NA[b]	12,270.31	14.63	.1
Fruits	NA	146.22	134.43	91.9
Fish	731.71	1,012.02	73.11	7.2
Bush Meat	293.43	292.43	1.00	.4
Milk	402.96	432.52	21.63	5.0

[a]Total supply is production plus net imports. Those were calculated from consumption data.

[b]Not available.

A third hypothesis, for explaining the recent steep increases in food prices have been attributed to government fiscal and monetary policies. The money supply increased by about 35 percent in 1969, 30 percent in 1970 and about

52 percent in 1971.[1] Food prices in these periods also increased 13.8 percent in 1970, and, an additional 15 percent occurred in 1971 (79, pp. 3-4). Although all the above factors are important, the truth might be, however, that all probably contributed to varying degrees. The net result is that demand has outstripped supply, thereby touching off inflationary price increases. And, in view of increasing population and prices of food stuff, the importance of the food production sector cannot be overemphasized. Adequate feeding is required for a healthy population and this is a prime factor in increasing the productivity of the labor force.

As an employment sector, agriculture provides jobs directly or indirectly for 70 percent of the working population. Incomes of this majority are generally lower compared with the incomes of urban dwellers. This provides, therefore an incentive for rural-urban migration. Net migration from rural-urban areas is estimated at 2.5 percent per annum increasing the urban population growth rate at 6.0 percent per annum (79, p. 28). The resulting effect is a high urban population density and an increasing level of unemployment.

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[1]The large increase in 1971 was mostly due to remonetization in the eastern states, which was where the civil war was fought. After the war the money supply had to be increased to exchange a proportion of the Biafran currency for Nigerian currency.

In reducing this flow of labor, rural-urban income gaps have to be bridged. If this rural transformation is to take place, it will not necessarily involve only the absolute expansion of agricultural activities, but the whole range of changes necessary to raise the level of agricultural productivity and incomes. Some policy makers have suggested different types of price support programs. This, however, rests on the assumption that peasant farmers are price responsive and that they will react favorably to measures designed to relax production and expansion constraints.

F. Future Plans and Prospects for the Agricultural Sector

A new national development plan referred to as the "Third National Development Plan" covering the period from 1975-80 has been initiated by the federal government. The expected expenditure for the five years is about $30 billion.[1] This plan stresses agriculture, industry transportation, communication, utilities and many other improvements. This is not surprising, since one of the primary goals of the government is economic growth.

[1]This plan was released under the previous military regime. The present one that came into power on July 29, 1975, promises a review of this plan. This might ultimately lead to a shift in emphasis or a cut in expenditure.

Achievement of the goal, as specified in the plan, is through the use of fiscal, monetary and incomes policy.

In the agricultural sector there is a lot of emphasis on food-stuff[1] production: this is due to the realization that food demands will continue to increase. It is anticipated that:

1. disposable income will grow at an annual rate of 6 percent;
2. population will grow at the average rate of 3 percent per annum (57, p. 9).

These two factors contribute to increased food demand both in terms of quality and quantity. In light of the anticipated increases in demand for food, it is figured that increased production would have to be embarked upon. This increased agricultural productivity would have to be met through the production of scientifically proven, economically feasible and culturally compatible innovation; and also on the willingness and ability of the farmers to accept and use on a continuing basis, the technology.

Another basic reason why the government is placing much emphasis on agriculture is the constant speculation

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[1]The importance to the government, of achieving an abundant food supply, could be seen by the recently established program of Operation Feed the Nation. The main goal of this program is the achievement of an increased agricultural food production in the country through providing farmers with adequate inputs and knowledge for their use.

that Nigeria's oil wells will run out within the next 10-15 years. Groundnuts and cocoa were the major sources of revenue during the civil war reinforcing the belief that the agricultural sector could still occupy its role as a major source of foreign exchange. Evidences have shown that peasant farmers are price responsive (57, p. 22). Short-run agricultural policies such as improved price incentives and an increased supply of farm inputs is being planned during the implementation of the new program.

Although skeptics believe that the development of synthetic and other substitutes for Nigerian export crops makes the market outlook for the export crops a bleak one. An analysis, however, by the F.A.O., and the World Bank seems to support the view that for the individual agricultural products the major constraints seems to be on the supply side rather than on the demand side. There are also evidences to show that domestic demand for the agricultural crops will continue to grow. The shortages of supply is not so much a consequence of constrained production potential, but, is rather a lack of infrastructure and organization. Those responsible for production and distribution are not able to respond promptly and effectively to changes in the market situation and more specifically, to increases in demand. Improvement programs

that would create conditions in which an adequate supply response is assured is being contemplated. Improved roads, especially federal roads, which will end the isolation of traditional agriculture from the modern sector are also part of the development programs.

Promotion and use of modern inputs, provision of improved plant materials through a revitalized extension service[1] system is equally under consideration. Also, adequate marketing channels and storage facilities are promised.

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[1]As part of the "Operation Feed the Nation" the government is now employing university undergraduates during the summer vacation, after some training in agriculture to help distribute improved varieties and other extension techniques to the farmers.

III. FEATURES OF THE STUDY AREA

A. General Characteristics

The area chosen for the study is a small section of what used to constitute the Western state of Nigeria. For purposes of planning, the former Western state[1] of Nigeria was divided into six[2] resource situations. The basis for division being similarities in ecological and socio-economic features. The farms in each of these regions are assumed to be similar in various respects namely:

1. land use patterns;
2. labor supply;
3. land tenure patterns;
4. enterprise combination;
5. physical conditions such as: soil type, rainfall, humidity, temperature and sunshine.

The region chosen for this study is referred to as the Central Cocoa Belt, where both food and export crops are grown.

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[1]Due to new state formation the western state has now been divided into three states namely: Ogun, Oyo and Ondo States. The resources zone cuts across the three states (Figure 3.1).

[2]For a detailed description of the resource zone see (75, pp. 1-20). However, they are namely: North Savannah, Central Cocoa Belt, Southern Rain Forest, Guinea Savannah, Mangrove and Rubber.

B. The Central Cocoa Belt

This area, is otherwise referred to as Resource Situation B. It forms a strip across most of the three states, which comprises the new state structure. The eastern areas of Abeokuta and the whole of Ekiti Divisions forms part of this resource zone (see Figure 3.1). This area supplies the major output of cocoa produced in the region. Rainfall is generally very high, ranging from 60-75 inches per year. Other export crops produced in this area are kolanut, oil palm and food crops such as yam, corn, melon, cocoyam and rice and varying mixtures of these crops. Kenaf, often referred to as an import substituting crop is also produced. These crops are produced jointly on the farms with average sizes between 2-50 acres. The area is very good for agricultural production and has a high potential for increasing the agricultural output of food and fiber for the country.

However, the technology being used by the farmers are not highly productive, resulting in low outputs and low farm incomes.

C. Data Needs and Methodology of Collection

The data needs for this study are similar to those needed in a budgeting study. Input-output data are required in order to be able to effectively use the methodology of

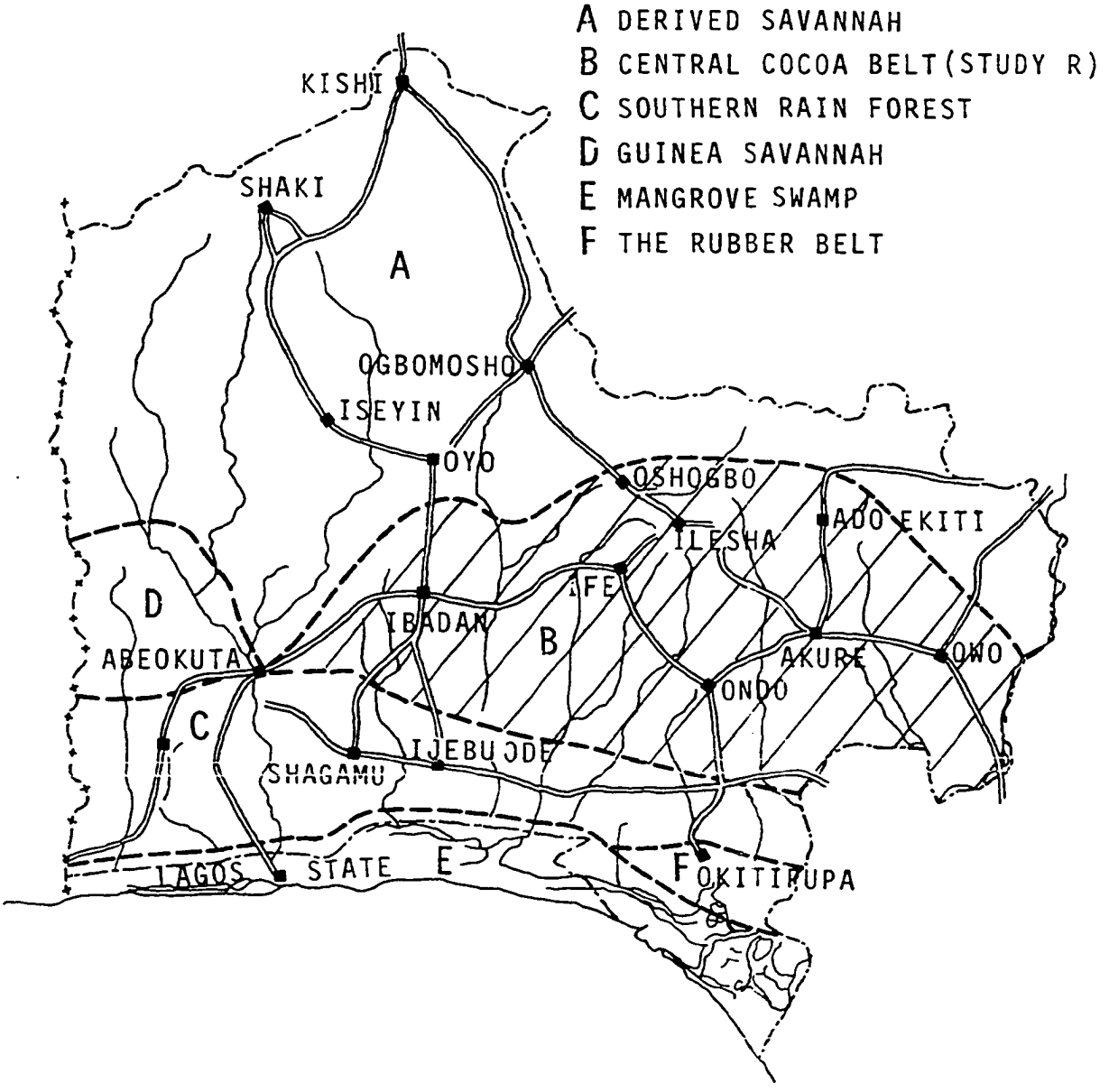

Figure 3.1. Agricultural regions of Western State of Nigeria

linear programming. Factors, often referred to as constraints affect the production of the farm-firm. These have to be identified and quantified. The data needs for this study could briefly be summarized as follows:

1. There must be an identification of the technically feasible crop or livestock activities in the area of concern. Their production coefficients in terms of crop yields, labor, land requirements and capital needs are required. These production coefficients are stated in terms of inputs required per unit of activity and the time periods for which these activities refers must be identified.
2. The farmer as a decision maker is always faced with decisions on how to get the best out of the limited resources that he has. There are always constraints on some of the factors of production. These might be in terms of the amounts of land available, the labor or the capital availabilities. Opportunities, however, may exist to relax some of these constraints. Land renting, labor hiring and capital borrowing through financial institutions are some of the ways to increase the amount of resources available. Thus the amounts of resources available or that can be made available should be known.

3. Prices of the outputs generated, inputs used in the production process, and costs of various farm operations are required. The data used in this study are drawn from two sources:
   a. primary data source,
   b. secondary data source.

D. Primary Data Source

A sample survey of farm families in the study area was conducted. Two agricultural circles were selected for the study. These two agricultural circles[1] fall within the Resource Situation C. Procedure for data collection included an initial visit to the headquarters of the two agricultural circles, at Abeokuta and Ado-Ekiti Area, respectively. On this visit a random sample of the villages to visit were selected from the list in the files of the Circles Ministry of Agriculture. Questionnaires were then made for pre-testing. A second visit was made to administer the questionnaires. Modifications and adjustments were then made and a final visit was made. During this visit, 121 farmers were sampled. The information contained in the questionnaires relate to:

[1] In the former Western State, the region was divided into various agricultural circles. The purpose of the division is purely administrative.

1. Socio-economic characteristics of the farmers. This includes available resource base and family size and structure.
2. Land Tenure System.
3. Pattern of allocation of produced goods to sales and consumption.

1. The farm labor force

Labor is a very important factor of agricultural production, especially in developing countries, where agriculture is practically unmechanized. Labor availability is a constraint to increasing agricultural productivity. The availability of labor is affected by three factors:

1. the seasonality of labor usage;
2. time allocation between farm-work, nonfarm activities and leisure;
3. division of labor between the sexes.

There is seasonality of labor usage because of ecological factors and types of crop mixtures the farmers cultivate. Seasonal labor usage varies substantially between regions. Table 3.1 shows the distribution of owned and hired labor usage by months in the study area. Hired labor supplies 51% of the total amount of labor requirements while the remaining is supplied by family labor.

Peak labor demands are for the months of January-

Table 3.1. Labor use distribution by type in man-days and wage rate per man-day

Month	Family Labor	Hired Labor	Total	Wage Rate
January	45.33	79.95	125.28	.76
February	40.67	65.50	106.17	.74
March	45.00	54.06	99.06	.74
April	44.00	45.73	89.73	.76
May	41.67	42.20	83.87	.88
June	37.67	45.73	83.40	.72
July	44.00	27.54	71.54	.82
August	47.33	53.97	101.30	.66
September	45.33	49.46	94.79	.82
October	43.67	33.22	76.89	.82
November	41.67	20.57	62.24	.86
December	42.33	21.28	63.61	.76
Total	518.67	539.21	1057.88	.78
Percentage	49	51	100	

February during which land is prepared for arable crops. Tuber crops and tree crops are also harvested during this period of the year. These two months accounts for a labor requirement of 22% of the annual total labor usage.

In August and September almost all the important arable crops are harvested and late crops (corn) are also planted. Harvesting and processing of tree crops also is

started.

Division of labor between men and women is an important factor that affects labor availability in peasant agriculture. Labor input also vary by age. The smaller children in the household are made to do menial jobs such as weeding and the carrying of part of the harvested crops to the village. The structure and composition of the rural household is as shown in Table 3.2.

Table 3.2. Average composition of farm-family by sex and age

Type	Number	Percent	Man-equivalent
Male Adults > 16 years	2	22.2	1
Female Adults > 16 years	3	33.3	.75
Children < 16 years	4	44.4	.50
Percent		99.9[a]	

[a]The figure obtained is due to rounding errors.

Finally, demographic patterns and rural-urban migration strongly influence the availability of labor in the rural sector. The farm families have experienced a decrease over the years in the amount of available owned-family labor due to out-migration of rural youths to urban centers. Various demographers and other social scientists have through their own biases come up with different

hypothesis as to why this phenomenon occurs. There are many forces which underlie the phenomenon of migration. These forces are referred to as centrifugal forces which can be social, psychological, political and economic in nature.

The sociological and psychological factors include love of adventure, escape from the dull life of the village, desire to keep sophistication acquired abroad, and avoidance of political and kingship obligations. Political pressure also results from schemes sponsored by the government such as farm settlement schemes and various development projects.

Economic necessity is, however, viewed as a far more universal and important determinant of labor migration. Many studies on rural development seems to support this idea. Mabawonku and Essang (47a, p. 3) in their study of migration amongst rural-urban sectors concluded thus:

> . . . statistical results appear to confirm our hypothesis regarding the association of rural-urban migration with the rural-urban income gap.

Kilby (38, p. 489), Knight (40, p. 199) and Diejomaoh (18, p. 97) in their studies on migration suggests that the wage rates in urban sectors are much higher than in the rural sectors and this induces rural youths to migrate to the city.

They further argued that the urban workers tend to earn a wage rate which is much greater than their marginal

productivity. In their view levels of wage rate in the urban sector reflects such nonmarket factors as minimum wage laws and strength of trade unionism. Thus this rural-urban income gap has a positive relationship with the rate of migration. The overall consequent effect of this migration is the resulting intersectoral transfer of capital and the increase in population and unemployment in the urban areas.

2. Land tenure system

Agricultural development was said to have begun in the world, centuries ago, only when man as an individual or in groups, was assured by society that he would harvest the fruits of his sowing and otherwise be rewarded of his productive efforts (67, p. 81). Thus, according to Dr. Timmons:

> . . . the initial stage of agricultural development began with rudimentary means to protect man's right to use and control land.

Thus rights governing and regulating such things as ownership, tenancy and inheritance, which are now called land tenure evolved. These land tenure structures vary amongst communities and across countries. This pattern of land rights eventually have an impact on the pattern of land use. Many of the managerial decisions relating to the use of factor inputs have a direct bearing on the nature of land tenure institution. Within the agricultural sector, land

tenure institutions affect productivity per worker. It influences the movement of factors of production from one sector of the economy to another. It also affects the adoption of improved factors of production.

Traditionally, amongst the Yorubas of Nigeria, land is the property of the extended family system or of the community.[1] Land is therefore, corporately owned. The general situation among the Yoruba is that the group exercises the right of ownership. The group manages the family land and allocates this to members according to needs. The individual does not possess absolute title to land. His right is co-equal to that of the other members of the community to which he was born or adopted. Individual use rights are established by initial clearance and uses of land, by mixing his labor with the soil and appropriating the land from the state of nature.

Individual use rights are heritable, becoming a family property to be shared out among the heirs according to the rules of inheritance, when the initial user dies.

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[1]The definition of community here is in line with Oluwasanmi's (58, p. 25). The term community may refer to a family, a clan or village consisting of a number of kindred or lineage groups or family. Also, a family is hereby used to refer to a unit consisting of the man, his wife or wives and children including the wives of his sons and their children plus other close relatives.

In the study region, three types of tenure arrangement were observed. The three types are, family land, leased land and gift or outright purchase. The most prevalent is family tenure which constitutes 55.3 percent, followed by leasing and purchase respectively. They form 43.8 and .9% respectively (Table 3.3).

Table 3.3. Land tenure patterns

Type of tenure	Number	Percentage
Family land	67	55.3
Leased land	53	43.8
Gift/Purchased	1	.9
Total	121	100

E. Secondary Data Sources

This consists of publications, research reports and information from files of the following institutions:

1. Ministry of Agriculture and Natural Resources of Western State of Nigeria in Ibadan, Abeokuta and Ado-Ekiti.
2. Western State Agricultural Finance and Credit Cooperation at Ibadan, Abeokuta and Ado-Ekiti.

3. International Institute for Tropical Agricultural in Ibadan.

Other sources of information include the publication of other international organizations like:

1. Food and Agriculture Organization, Rome.
2. World Bank, Washington, D.C.
3. Economic Commission for Africa Addis-Ababa.
4. United Nations Publications.
5. U.S.D.A. Reports.

The types of information obtained from these sources relate to the technical coefficients of each type of cropping activity in the study area. Details for each crop are in Appendix B.

IV. THEORETICAL AND CONCEPTUAL FORMULATION OF THE MODEL

The study involves the incorporation of export crops and food crops into the same analysis. Unlike food crops, export crops have longer gestation periods. When investments are made, returns from output do not come within a short period of time, thus production and investment do not occur at the same time. A production-investment model is therefore adequate for such analysis. In this chapter, an examination is made of the theory of production and investment, the conceptual problems involved in incorporating production with investment from a microtheory point of view, factors that affect production and investments, the criteria used in investment analysis, the conceptual formulation of the model and the various analytical techniques that is applicable to the study.

A. The Theory of Production and Investment: A Microtheory Approach

Investment involves the analysis of acquisition of capital goods for productive purposes. A farm-firm is a productive unit and thus decisions are made on what to produce, how to produce and how much to produce. The structure of decision making is very complex because it is

interwoven within a system of economic, institutional and social constraints. The behavior of producers are influenced by a set of circumstances; their objectives and the set of constraints under which the efforts to reach the objectives have to take place. Factors such as management capabilities and the goal of the farm-firm are two of these factors that determine the investment made. The ability to translate useful economic information is management dependent. Management and the educational level of the investor are related, thus according to Welch (73, p. 35), education contributes to production through an "allocative effect" and also a "worker effect". Education's effect on technical efficiency is referred to as the worker effect, while allocative efficiency is rooted in the decision making process. This also refers to the firm's ability to acquire, decode and use market and technical information efficiently. The assumption being that education augments skills that facilitates the gathering, processing and interpretation of information, thereby enhancing allocative ability, reducing uncertainty and contributing to efficient decision making. Managerial ability is known to affect farm-firm's incomes and the ability to make interest and principal payments as well as accessibility to credit and acquiring resources.

Goals of management is often via the objective function of the firm. In the case of a farm-family unit an adequate

nutritional level or some specified family objective function might be the desired goal. These objectives in certain agricultural situations, especially that of developing economies, can override the traditionally assumed goal of profit maximization. There are a lot of arguments, as to what the choice of the objective function should be. Even if the profit maximization approach is followed, there are those who have different interpretations of this goal and argue that its interpretations may help lead to different choices of investments. Helliwell (31, p. 30) argues that different versions of the interpretation of this maximand leads to different investment strategies. The assumption of maximizing profit leads to particular investment strategies and thus implies a particular pattern and rate of farm-firm[1] growth. Baumol (4, p. 1078) argues for the choice of gross-revenues.

Other factors, often referred to in literature as constraints, also influence the pattern of investment. There are different types of constraints; classified as technological, economic and institutional. The technological constraints determine what is technologically feasible. In agricultural production, as in many other types of pro-

[1]Otherwise stated, a farm-firm is used here to refer to any type of farming unit; farm family units, cooperatives or any type of farming unit.

duction, there exists a number of methods of production. These different methods or techniques are characterized by utilizing different combinations of inputs. The method of production may therefore increase or decrease or they may remain unchanged when new techniques are utilized by the producer. Thus the types of techniques adopted and available to the farm-firm determines a defined level of production and input-output relationship.

The farm-firm operates within some specified institutional framework. Certain institutions are known to govern and direct certain environments. The most prevalent institution in developing economies is the land tenure arrangement. The farm-firm may own the resources of land or rent. Thus ownership patterns of resources might determine what is economically viable, technological feasible and institutionally permissible. For example in some land tenure institutions, a land rental operator may not be able to grow some particular types of crops nor make profitable capital improvements. The rate of capital formation is dependent upon the saving and consumption activities of the farm-firm. This is further limited by the institutional environment. Other institutions including the credit institutions, provide working capital for farming units. These institutions have their own policies as regards giving loans, the interest payments, and how the borrowed funds are to be re-

paid. Whether these institutions are available or not, they surely play a role in determining the pattern of production and investment.

Some of the other factors, are often not under the control of the farm-firm and thus are supposed to be taken as given. They must therefore operate within this environmental factors. Two of the most common ones being risk and uncertainty. Like in most industries, the agricultural sector is plagued by a lot of uncertainties and risk. Price fluctuations and yields alter the pattern of farm-firm operation. This causes a discrepancy between actual profits and anticipated profits. These variabilities in yields and prices are often caused by changes in uncontrollable factors like weather fluctuations and unanticipated fluctuations in prices of factors and outputs.

Physical resource availabilities is another important factor in determining the amount of investment made by the firm. The farm-firm requires labor, capital and land for the production of crops. The relative requirement of different crops in terms of these resources differs to a great extent. Changing from one crop to another, or from the use of one technique to the other, results in the substitution of one factor of production for the other. Consequently, the relative availability of the different resources will influence the enterprises included in the

organization of the firm as well as the techniques of production which are used. The relative availabilities of resources refers not only to the resources owned by the farm-firm, but also to those resources he can obtain from other sources. Consequently, the institutional, technological and economic limitations as to hiring labor, renting land and obtaining credit all influence the production and investment pattern of the farm-firm.

Within the framework of the stated objectives of the study, the objective function assumed in this study is the conventional and traditional profit maximization. This heroic assumption is being made to permit a simple characterization of the optimal production-investment path. The farm-firm is assumed to have a production function expressed in the following mathematical form

$$Q = f(x_1, x_2) \tag{4.1}$$

where

Q = output level

x_1 and x_2 = sets of inputs.

The properties of continuity of first and second partial derivatives are also assumed.

The farm-firm sells the output and is known or assumed to make a profit, the profit equation being represented thus

$$\pi = pq-c \tag{4.2}$$

where

$c = r_1x_1 + r_2x_2$

r_1 = price of input x_1

r_2 = price of input x_2

pq = total revenue from the sales of q

c = cost of obtaining inputs x_1 and x_2

The above equation can thus be rewritten thus

$$\pi = pq - r_1x_1 - r_2x_2 \tag{4.3}$$

taking the first partial we have the following equations which define the optimal behavior of the farm-firm

$$\frac{\partial \pi}{\partial x_1} = pf_1-r_1 \qquad f_1 = \frac{\partial q}{\partial x_1} \tag{4.4}$$

$$\frac{\partial \pi}{\partial x_2} = pf_2-r_2 \qquad f_2 = \frac{\partial q}{\partial x_2} \tag{4.5}$$

The first-order conditions for profit maximization require that each input be utilized up to a point at which the value of the marginal product (VMP) equals its price. The second-order condition defined is assumed to be

obeyed.[1]

In the real world, the farm-firm does not operate within the framework of the single period, neither does it utilize only two inputs. Thus, one has to reformulate the farm-firm behavior to incorporate the time factor, in order to have a multiperiod production pattern; since it is a known

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[1]The second order conditions require that the principal minots of the relevant Hessian determinant alternate in sign:

$$\frac{\partial^2 \pi}{\partial x_1^2} = pf_{11} < 0, \quad \frac{\partial^2 \pi}{\partial x_2^2} = pf_{22} < 0 \text{ and}$$

$$\begin{vmatrix} \frac{\partial^2 \pi}{\partial x_1^2} & \frac{\partial^2 \pi}{\partial x_1 \partial x_2} \\ \frac{\partial^2 \pi}{dx_2 dx_1} & \frac{\partial^2 \pi}{\partial x_2^2} \end{vmatrix} = p^2 \begin{vmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{vmatrix} > 0$$

These conditions imply that profit must be decreasing with respect to further applications of either X_1 or X_2 and also to both X_1 and X_2.

fact in agricultural production that production is not instantaneous. Time elapses between application of inputs and securing the output. If one assumes that the farm-firm has a planning horizon of T years, one can thus represent the implicit production function in the following mathematical form

$$F(Q_{11},Q_{12}\cdots Q_{it},Q_{jt}Q_{st}) = 0 \qquad (4.6)$$

where

$i = 1,2,3\ldots S$

$t = 1,2,3\ldots T$

and

Q_{jt} = quantity of output j in period t

and the production function for each output is of the form

$$Q_{jt} = f(L_{jt},N_{jt},K_{jt}) \qquad (4.7)$$

where

L_{jt} = amount of land input required by output j in period t

N_{jt} = amount of labor input required by output j in period t

K_{jt} = amount of capital required by output j in period t.

Due to the introduction of time, opportunities are available for the introduction of capital markets, thus particu-

lar levels of interest rates need be specified. Thus given this opportunity, the farm-firm desires to maximize the present value of his net benefits over its planning horizon, subject to technological constraints imposed by the production function.

The multiperiod optimization process becomes

$$\underset{\pi^*}{\text{Max}}^{1} \sum_{j=1}^{S} \sum_{t=1}^{T} \frac{P_{jt}Q_{jt}}{(1+r)^t} + \lambda(F(Q_{11},Q_{12}\cdots Q_{it}Q_{jt})) - \sum_{j=1}^{S} \sum_{t=1}^{T} \frac{x_{jt}r_{jt}}{(1+r)^t} \tag{4.8}$$

$$\frac{\partial \pi^*}{\partial Q_{jt}} = \frac{P_{jt}}{(1+r)^t} + \lambda \frac{\partial F}{\partial Q_{jt}} = 0 \tag{4.9}$$

$t = 1,2,3\ldots T \quad j = 1,2,3\ldots S$

$$\frac{\partial \pi^*}{\partial \lambda} = f(Q_{11},Q_{12},\ldots Q_{it}\ldots Q_{st}) = 0 \tag{4.10}$$

$$-\frac{\partial Q_{it}}{\partial Q_{jt}} = \frac{\partial F/\partial Q_{jt}}{\partial F/\partial Q_{it}} = \frac{P_{jt}/(1+r)^t}{P_{it}/(1+r)^t} \tag{4.11a}$$

$$\frac{\partial \pi^*}{\partial X_{jt}} = -\frac{r_{jt}}{(1+r)^t} + \lambda \frac{\partial F}{\partial Q_{jt}} \frac{\partial Q_{jt}}{\partial X_{jt}} = 0 \tag{4.11b}$$

$$-\frac{\partial X_{jt}}{\partial X_{it}} = \frac{\partial F/\partial x_{it}}{dF/dx_{jt}} = \frac{r_{it}/(1+r)^t}{r_{jt}/(1+r)^t} \tag{4.11c}$$

where

$$\frac{\partial Q_{jt}}{\partial N_{jt}}, \quad \frac{\partial Q_{jt}}{\partial L_{jt}}, \quad \frac{\partial Q_{jt}}{\partial K_{jt}}$$

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[1] π and π^* are used synonymously, they mean the same thing.

if X_{jt} equals N_{jt}, L_{jt} and K_{jt} are defined as the marginal products from inputs of labor, land and capital. Then

$$\frac{\partial Q_{jt}}{\partial N_{jt}} \frac{P_{jt}}{(1+r)^t} = \frac{w_{jt}}{(1+r)^t} \tag{4.12}$$

$$\frac{\partial Q_{jt}}{\partial L_{jt}} \frac{P_{jt}}{(1+r)^t} = \frac{r_{jt}}{(1+r)^t} \tag{4.13}$$

$$\frac{\partial Q}{\partial K_{jt}} \frac{P_{jt}}{(1+r)^t} = \frac{k_{jt}}{(1+r)^t} \tag{4.14}$$

1. Equation 4.11 requires that the rate of product transformation equal to the ratio of their discounted prices and 4.11c requires that the rate of technical substitution between the two inputs equal the ratio of their discounted prices.

2. Equation 4.12, 4.13, and 4.14 implies that the discounted value of the marginal product of inputs of labor, land and capital applied during the period t with respect to each output must equal to the discounted value of the input price.

The above decision constitutes the multiperiod production decisions of the farm-firm. This formulation obscures the incorporation of investment into the production process. This is however a difficult problem to introduce.

Investment decisions are based on different criteria. One criteria is the comparison of the marginal efficiency of capital with the market rate of interest. Alternatively one

can compare the price of the asset to the present value of the income stream received from the asset. Relying on the assumption of fixed actual and expected input and output prices, the problem of multiperiod investment can be incorporated into the theory of firm production. The problem involves the derivation of an investment-opportunities function which would later be introduced into the theory of farm-firm production to obtain a production-investment model of the firm.

In doing this, it is assumed that the farm-firms investments in period t is represented by I_t which equal the value of input purchases in that period. Thus

$$I_t = \sum_{j=1}^{S} r_{jt}x_{jt} \tag{4.15}$$

in the model one can represent

(L_{jt}, N_{jt}, K_{jt}) to be X_{jt} for simplicity.

The total investment function by

$$I_t = \sum_{j=1}^{S} \sum_{t=1}^{T} \frac{r_{jt}x_{jt}}{(1+r)^t} + \lambda(F(Q_{11}Q_{12}-Q_{it}-Q_{jt})) \tag{4.16}$$

$$\frac{\partial I_t}{\partial X_{jt}} = \frac{r_{jt}}{(1+r)^t} + \lambda \frac{\partial F}{\partial Q_{jt}} = 0 \tag{4.17}$$

where

r_{jt} = price of input in period t, for

$L_{jt} = r_{jt}$, $N_{jt} = W_{jt}$ $K_{jt} = k_{jt}$

$$\frac{\partial I_t}{\partial \lambda} = F(Q_{11}, Q_{12}, \ldots Q_{ij} \ldots Q_{st}) \tag{4.18}$$

and

$$\frac{\partial x_{it}}{\partial x_{jt}} = \frac{r_{jt}}{r_{it}}; \quad \left(\frac{\partial L_{it}}{\partial L_{jt}} = \frac{r_{jt}}{r_{it}}; \frac{\partial N_{it}}{\partial N_{jt}} = \frac{W_{jt}}{W_{it}}; \frac{\partial K_{it}}{\partial K_{jt}} = \frac{k_{jt}}{k_{it}}\right) \tag{4.19}$$

$$\frac{\partial Q_{it}}{\partial Q_{jt}} = \frac{P_{jt}}{P_{it}} \tag{4.20}$$

The investment opportunities function is always constructed with the assumption that:

1. the multiperiod production function is satisfied;
2. he equates his intra-period rates of technical substitution to the fixed input ratios and the intraperiod rate of product transformation to fixed output ratios. Thus the investment opportunities are described by Equations 4.15, 4.16, 4.17, 4.18, 4.19 and 4.20.

An implicit investment function can be written as

$$J(I_1, I_2, I_3 \ldots I_T, R_1, R_2, \ldots R_T) \tag{4.21}$$

This function gives the revenues and investment expenditures, where each revenue depends upon the investments. Having known the relationship between investment and revenues, one can now incorporate the whole model into a production-

investment model of the firm. This incorporates the investment and the revenues from production into the same activity and decision making procedure. The objective being for the farm-firm to choose a set of investment and revenue streams that maximizes the present value of his net revenue stream.

From the above, the objective can be written as an equation of this form

$$\pi = \sum_{t=1}^{T} \frac{R_t}{(1+r)^t} - \sum_{t=1}^{T} \frac{I_t}{(1+r)^t} + \lambda J(I_1 \ldots I_t, R_1 - R_t) \quad (4.22)$$

where

$$(R_t = P_{jt}Q_{jt}) \quad (4.23)$$

$$\frac{\partial \pi}{\partial R_t} = \frac{1}{(1+r)^t} + \lambda \frac{\partial J}{\partial R_t} = 0 \quad (4.24)$$

$$\frac{\partial \pi}{\partial I_t} = -\frac{1}{(1+r)^t} + \lambda \frac{\partial J}{\partial I_t} = 0 \quad (4.25)$$

$$\frac{\partial \pi}{\partial \lambda} = J(I_1, I_2, \ldots I_T, R_1 \ldots R_T) \quad (4.26)$$

The first order condition requires that Equations 4.24 and 4.25 be of opposite signs. The interpretation is that the farm firm must equate the marginal internal rates of

return[1] to the corresponding market rate of return.

Prior to the development of the conceptual model to be used in this study, it would be of use for purposes of clarity and simplicity to show the discussion of farm-firm behavior assumed in this study. The farm-firm is assumed to have an initial stock of funds, either through acquiring credit or from personal savings. The farm-firm is assumed to be rational and thus invest the money in feasible crop production activities, that is conducive to his environment. The investment and production later yields a stream of returns. This return is either used for further investments, payments on principal and interest, part for consumption purposes and the remainder saved for further investment. The farm-firm is assumed to have a particular land resource. These are the various levels of revolving land base in the model. Government policy such as food and export crop subsidy affects the in-

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[1]There is no generally accepted name for this concept. Freidrich Lutz and Vera Lutz (46) used "marginal internal rate of return; Irving Fisher (21) used "marginal rate of return over cost." Other names for this or closely allied concepts include marginal productivity of investment; marginal efficiency of investment and "marginal efficiency of capital".

come and production pattern of the farm by acting as a stimulus. This is also considered as part of the reaction to changing environmental conditions.

B. Conceptual Model

A model usually contains an objective function which is used to compare different alternative strategies. The farm-firm in this model is assumed to be maximizing the present value of the stream of annual net benefits in the planning horizon. Within the framework of the problem and the objectives to be achieved, a multiperiod linear programming model is chosen for the analysis.

Conceptually therefore, the producing unit is assumed to have a production function

$$Q_{it} = f(N_{it}, L_{it}, K_{it}) \tag{4.27}$$

where

Q_{it} = output of a given crop i in period t.

L_{it}, N_{it}, K_{it} are as defined in Equation 4.7.

$$NB_{it} = P_{Q_{it}} Q_{it} - (P_{L_{it}} L_{it} + P_{N_{it}} N_{it} + P_{K_{it}} K_{it}) \tag{4.28}$$

where

NB_{it} = Net Benefit derived from crop i in period t

further in the model two net benefits are defined

NB^{F}_{it}, NB^{E}_{it}

F, E standing for food and export crops respectively. This implies that

NB^{F}_{it} = Net Benefit derived from food crop i in period t

NB^{E}_{it} = Net Benefit derived from export crop i in period t

$P_{Q_{it}}$, $P_{L_{it}}$, $P_{N_{it}}$ and $P_{K_{it}}$ are unit price of output, land, labor and capital.

The assumption of linear programming although not without its shortcomings are relied upon in the formulation of the conceptual model.

Different activities in the model can be carried out simultaneously and independently of each other. Linear combinations of activities is also feasible. For example if there are S activities; $Q_1, Q_2, \ldots Q_s$ with input-output coefficients a_{ij} is defined as the time rate of flow of item i into j, the total time rate of flow of item the total time rate of flow of item i into all processes may be represented by

$$\sum_{j=1}^{S} a_{ij}Q_j \quad j = 1,2,3,4\ldots S \tag{4.29}$$

This is one of the strongest assumptions in linear

programming and it implies that nonlinear functions could be approximated by a means of a series of linear segments. Outputs and factors are assumed to have continuous properties, that is, outputs can be produced in fractional amounts. This is what is otherwise known as the feasibility assumption of linear programming.

Resources and activities being considered in the model are assumed to be finite. In empirical terms, this assumption does not create any difficulty since in practical terms there is a limit to the number of alternative activities that an operator is interested in.

Resource supplies, input-output coefficients and prices, are known with certainty. This is one of the shortcomings of the model. This being so, because agricultural production is plagued by a lot of uncertainty, risks in prices and output yields. This is very inconsistent within the framework of an agricultural production environment.

Since the assumption chosen is maximization of the present value of the stream of net benefits; the objective function is of the form

$$C = \sum_{i=1}^{P} \sum_{j=1}^{S} \sum_{t=1}^{T} \frac{NB^{F}_{ijt}}{(1+r)^{t}} + \sum_{i=1}^{P} \sum_{j=1}^{S} \sum_{t=1}^{T} \frac{NB^{E}_{ijt}}{(1+r)^{t}} \qquad (4.30)$$

the availability of resources.

t = refers to time

j = refers to activities or output

i = the process through which produced

1. Land

An annual land allocation is assumed in the model. In the model, a particular amount of land is made to revolve over every year, thus it is referred to as revolving acreage availability. The total amount of land supply in period t is the amount of revolving land base in the model.

$$L_t = L_c + L_r \tag{4.31}$$

L_t = total available land in period t

L_c = amount already in tree crops

L_r = supply of land in period t, this is the level of revolving land base assumed

$$L_t = L_c + L_r$$

and

$$\sum_{i=1}^{P} \sum_{j=1}^{S} L_{ijt} \leq L_t \tag{4.32}$$

this indicates that the sum of the amount of land resource used in period t in the production of the jth crop using process i should not exceed the amount available.

2. Labor

There are generally two sources of labor in the model. Owned family labor and hired labor. Since quantifying the employment affect of the use of technologies is one of the basic objectives of this model, it stands to reason that they should be included as constraints and activities, thus

$$N_k = N_{ft} + N_{ht} \tag{4.33}$$

N_{ft} and N_{ht} are the amounts of family and hired labor in the model

$$\sum_{i=1}^{P} \sum_{j=1}^{S} N_{ijt} \leqq N_t \tag{4.34}$$

Equation 4.34 indicates that the amounts of labor input into activity j using process i in time t should not exceed the total available supply in that period.

3. Household consumption

The household is assumed to have a consumption function. The household needs, are satisfied through two means, satisfying needs through consuming some of the food produced on the farm and through purchases from other markets. This equation implies that the household has a minimum requirement for survival

$$C_{Ht} = \sum_{i=1}^{P} \sum_{j=1}^{S} \lambda_{ij} NB^{F}_{ijt} \qquad (4.35)$$

where the jth crop referred to in this equation being the food crops only where

λ_{ij} = marginal propensity to consume from the net benefit from crop j using process i.

C_{Ht} = home consumption of on-farm crops in t

$0 < \lambda < 1$.

The value of λ varying from 0 to 1. It can also take different values for different crops.

There is also allowances for consumption of off-farm goods, since it stands to reason to assume that the households cannot necessarily produce or provide for the total consumption required by the household. Thus an assumption is made that off-farm consumption in year t is:

$$C_t \leqq \alpha Y_{t-1} \qquad (4.36)$$

where

C_t = consumption expenditure in year t.

Y_{t-1} = income generated and transferred from period t-1 to t

α = marginal propensity to consume out of income.

Estimates of what the value of α should take varies from study to study. However to avoid confusion and in-

consistency, α is assumed to be constant over the planning horizon.

$$Y_{t-1} = S_{t-1} \tag{4.37}$$

$$I_t = S_{t-1}+B_t \tag{4.38}$$

where

$$S_t = \pi_t(Y_t) \tag{4.39}$$

where

S_t = amount of savings in period t

I_t = investment in period t

B_t = amount of net borrowing in period t

π_t = marginal propensity to save in period t

$1 < \pi_t < 0$

Y_t = amount of total income generated in period t.

4. Capital

The amount of capital available in period t is of the form:

$$K_t = K_{ot} + S_{t-1} + B_t - D_t \tag{4.40}$$

where

K_t = total amount of capital available in period t

K_{ot} = annual allocation of capital in the model

B_t, S_{t-1} = are as defined in Equations 4.37, 4.38 and 4.39

D_t = amount of debt servicing and interest payment made during the year t

and also

$$\sum_{i=1}^{P} \sum_{j=1}^{S} K_{ijt} \leqq K_t \qquad (4.41)$$

The conceptual model does take into consideration, multiple product combinations and multiple resource restrictions. The crops considered are both perennials, biannuals and annual crops. The annual crops, mostly food crops are grown and harvested annually, Kenaf which is often referred to as an import substitution crop is also considered in the model. Included in the conceptual model, is the concept of the effect of two types of aggregate subsidy levels. The government has available, fiscal and monetary tools to influence farmers behavior. For example, tax concessions have been known to enhance the profitability of certain investments.

There are no types of aggregate support levels assumed, a food price support level and an export crop support program. The effect coming in via the changes in the Net Benefits generated by these two groups of crops. Thus, it is postulated that

$$NH^*_{ijt} = \tau(NH_{ijt}) \qquad (4.42)$$

NB^{*}_{ijt} = new net returns from project j through process i in period t for food crops, if they are being considered and for export crops otherwise.

NB_{ijt} = old level of net benefit. If $\tau>1$ we have a subsidy on price, $\tau<1$ we have a taxation.

C. Issues on the Discount Rate

Investment by definition yields its stream benefits with the passage of time, implying therefore that decision on how much to invest in a particular project activity inevitably involves intertemporal decisions. Costs and benefits do occur over time, thus the need for a choice of a discount rate. There are many arguments concerning the choice of the discounted rate and there are many interpretations of the actual meaning of the word discount rate.[1]

[1]The terminology used to define relative weights attached to money flows at different points in time is frequently confusing. The term discount rate refers solely to the rate used to calculate the discounted present value of money flow. The term interest rate is understood to be the price of capital but is frequently used as an equivalent term for the discount rate. Often the interest rate is employed as the discount rate. The rate of return is also a term employed in literature that may be confused with the terms interest rate and discount rate. This is properly defined as the discount rate at which a given initial investment is equal to the discounted value of its future income stream. The primary purpose in the text is to select the rate of discount, this rate may be equal to the rate of interest or rate of return but conceptually, it is distinct from the two.

In investment analysis, the choice of the discount rate is one of the most important decision problems, since the value selected has a marked effect upon the composition of the investment, and production strategies. A high rate of time discount might favor an investment program which are less capital intensive and whose returns are obtained in relatively short periods of time; whereas a low rate of discount might permit the choice of capital intensive programs showing gains far into the future. Among the alternative forms that the discount rate might take; the following have been discussed extensively in literature:

1. private rate of return on invested capital;
2. rate of social time preference.

The approaches to the determination of this discount rate are varied and some argue in support of the choice of one criteria over the other. Marglin (47b) argues that the rate of social time preference is the appropriate measure for discounting investment activities. This rate, he argues is determined outside the market by the interaction of individual and policy makers time preferences through the political mechanism.

Another view, as to what the level of discount should be is that the marginal productivity of capital should be used. This is equivalent to using the private rate of return on invested capital. This, however, assumes perfect

capital markets which might not really be in existence.

D. Choice of Investment Criteria[1]

The benefit flowing from an investment project, as also the costs incurred has a time profile which poses a problem of evaluation. Given an expected time profile of costs and benefits, one can ask a first question: should I recommend that the investment in question be undertaken? A number of investment criteria are available for arriving at the answer to the question raised above. There are still controversies as to the efficiency of each criteria? Those to be discussed briefly are:

1. cut-off period;
2. pay-off period;
3. the average rate of return;
4. net average rate of returns.

Emphasis are placed on the following criteria:

1. the present discounted value criterion;
2. the internal rate of return rule.

The cut-off period criterion has been described as

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[1]The model involves the incorporation of investment analysis with production analysis. Investment criteria are used to select among the tree crops to incorporate in the model. The criteria in selection is the present discounted value approach. If other approaches had been used the types of tree crops chosen might have differed. Thus the need to include this section.

perhaps the crudest possible method of investment choice (70b, p. 72). A period is chosen over which the money invested must be fully recoupled. It has been suggested by Mishan that the use of this criterion may be justified in cases of innovation in products, or methods, that cannot be protected by patent, and in which innovations are likely to be copied by competing firms within two or three years. A cut-off period of t years may be chosen in the belief that after three years further profits are uncertain and increasingly unlikely. The shortcomings of this criterion are easy to perceive. If the returns were not expected to accrue mainly in the first few years but mainly after the first few years, worthwhile projects would be rejected.

Pay-off period argues in favor of ranking the investment options according to the number of years necessary to recoup the initial outlay rather than choosing an arbitrary cut-off period. Justification for use of this criterion is similar to that for cut-off period. So in the absence of uncertainty it is difficult to justify the use of these two criteria.

The average rate of return is the simplest way of taking account of all the data in the investment stream. One simply adds together all the subsequent positive net benefits divides this sum by the number of years, and expresses the resulting figure as the percentage of the initial

investment outlay. The weakness suffered by this method is similar to that encountered in the internal rate of return approach.

Net average rate of return is similar to the average rate of return approach, only that the outlays are subtracted prior to dividing by the number of years. Under conditions of certainty as argued by Mishan (50, p. 188) the net average rate of return is clearly superior to the other investment criteria but is unsatisfactory for two reasons.

1. Relies on the number of years chosen.
2. The method takes no cognizance of the pattern or profile of the net benefits over time. Thus, given the total amount of benefits say Y, arising over a number of consecutive years, whether the net benefits are hunched together over the first years, spread evenly over the years, or hunched toward the end of the period, makes not the slightest difference to the net average rate of return.

The two other methods are more sophisticated and are based on the common procedure of reducing a stream of net benefits (some negative, positive) to a single value at a point in time.

The net present discounted value approach is the present

value of the benefits less the present value of the costs. This procedure suffers from the fact that the choice made is greatly influenced by rate of discount used. This is because the determination of which of the investment: yielding the greatest stream of benefits, depends on the rate of discount assumed. Since choice of what investment to choose depends upon the value taken by the net present value, the rate plays a significant role in the choice made. Other problems also involve the argument of what constitutes the cost and benefits. This also takes us into the realms of external costs and benefits which often plague project investment analysis especially if they involve public choice.

Generally the stream of benefits and costs associated with any project is usually expressed in monetary terms. Divergences between private and social product also create problems in identifying costs and benefits in project analysis. These external effects occur because:

1. Some projects are characterized by infeasibilities of exclusion and thus market prices associated with a project do not accurately reflect the true benefits accrueable to the project.
2. There might exist the characteristic of public good such as indivisibility and noncompeting consumption, society's valuation of social marginal

product may not be adequately made.

The internal rate of return rule is also one of the criterion used in investment choice. The internal rate of return on any project is that rate of discount which makes the present value of a stream of net benefits equal to zero. In other words, knowing the streams of benefits and costs, one can find one or more rates of discount which make the present value of net benefits zero.

The internal rate of return has had great appeal as a criterion for choice in public and private investment theory and in economic theory generally. The reason is that it appears to permit a ranking of investment without pre-specifying an interest rate. Because of this, it has been advocated for use in instances where it is uncertain which rate should be used in project evaluation.

Perhaps the most significant general objection to the internal rate of return is that it does not rank mutually exclusive projects properly, in the sense that the rankings may not correctly reflect the investment alternatives open to the firm, in terms of present value calculation based on the market rate of discount.

It has sometimes been claimed probably with validity that the calculation of internal rates of return for projects and project increments is useful in the presence

of uncertainty concerning future costs and returns. Since present value focuses only on net benefits it will not distinguish between a project that has small costs and relatively large benefits and one that has large costs and relatively small benefits if the present value of the net benefits is the same. It has also been argued that under no-risk conditions, this lack of distinction between the two cases is appropriate but where risk must be taken into account, the former may be preferred. Consequently, in risky situations both present value and internal rate of return calculations may yield useful information.

E. Other Analytical Tools Adequate for Achieving Objectives of Study

The objectives set to be achieved in this study as earlier stated in Chapter I can be briefly summarized thus: Obtaining the optimal production plan under varying levels of land resource, technology and aggregate food and export crop support programs with the view of quantifying the effect of technology, land resource changes and the subsidy on production, employment and income of farm-firm.

To achieve this objective other analytical models or tools are available. The following tools are commonly used in economic research:

1. Input-output Approach

2. Programming Approach
    a. Linear Programming
    b. Dynamic Programming
        1) Recursive Linear Programming
        2) Multiperiod Linear Programming
        3) Limitations of the two approaches
3. Budgeting Techniques
    a. Partial Budget
    b. Complete Budget
    c. Capital Budget
4. Regression Technique
5. Simulation Technique
6. Integrated Approaches
    a. Programming and Simulation

1. Input-output models

The first writers to treat economics systematically - Adam Smith and his immediate successors, dealt with the economy as a whole. In today's terminology they were concerned with macroeconomics. Alfred Marshall and his followers in the neo-classical school focused on the household and the theory of the firm. The neo-classical economists and their successors analyzed the forces which result in economic equilibrium, but their approach was that of partial equilibrium, or the method of examining one thing at a time.

The concern about economic interdependence came as early as 1758 when Francis Quesnay published his "Tableau Economique" a device which stressed the interdependence of economic activities. It showed graphically the successive rounds of wealth producing activity, which resulted from a given increment in output. In this sense he was the forerunner of modern multiplier analysis. The culmination of the work started by Quesnay, came in the 1930's when Professor Wassily Leontief developed a general theory of production based on the notion of economic interdependence. Leontief's approach resulted in what is simply referred to as an input-output analysis.

The input-output method is widely used as an analytical tool in highly developed economics, both those which engage in economic planning and those which rely primarily on the market mechanism for the allocation of resources and the distribution of income. More recently, a number of developing nations have turned to this new and powerful technique as a guide to important policy decisions.

The transactions tables in an input-output analysis simultaneously describes the demand and supply relationship of an economy is equilibrium. It is thus useful in comparative analysis of the economics of different countries; for interindustry analysis and as a basis for forecasting. It's relevance in investment analysis is that it can help

specify the desired levels of aggregate investment in each sector and the consequent interrelationship between sectors. The major drawback of input-output analysis according to Carter and Heady (11, p. 978), is that they are only good for interindustry complementarity analysis and not for analysis of competition.

They assume constant input-output coefficients which might not be consistent with the technological changes always plagueing our economic system. Unlike programming models which provide answers of a normative nature, input-output analysis is a positive tool in the sense that it explains the interrelationship between different sectors of the economy or an industry at particular points in time. It can also be used to predict output changes in different sectors of the economy given some exogenous changes.

2. Programming approach

There are many variants of programming models, including:

a. Linear programming Linear programming is a planning tool that is helpful in decisions requiring a choice among a large number of alternatives. It is a normal procedure for providing solutions to courses of action which ought to be taken by individuals, business unit or an economic sector. These decisions are taken within the economic environment that the farm-firm behaves.

The end or objective are assumed to take a particular form, so also are the conditions and restraints.

Four basic assumptions are made in linear programming. They are:

1. Additivity and linearity,
2. Divisibility,
3. Finiteness,
4. Single-value expectation.

Additivity and linearity:

The activities must be additive in the sense that when two or more are used, their total product must be the sum of their individual products. Also, the total amount of resources used by several processes must be equal to the sum of the resource to be used by each individual activity.

Thus, it is possible to carry out more than one activity independently of each other. If two or more processes are carried simultaneously, the rate of flow of each resource into or out of each process is the same as the rate of flow into or out of that activity that would exist if only that one activity were carried out. For example, if there are M different process X_1, X_2, ... X_m with input-output coefficient a_{ij} defined as time rate of flow from item i to j per unit level of jth activity the total time rate of flow of item i into all activities can be represented by:

$$\sum_{j=1}^{M} a_{ij} \times j \qquad i = 1,2,3,\ldots m \tag{4.43}$$

It implies a strong assumption of constant returns to scale. This linearity assumption may be circumvented in some situations by breaking up the smooth curve that defines a function displaying decreasing returns to scale, into a series of straight line segments that approximate very closely the curvilinear function characteristic of decreasing returns function. These straight line segments may then be treated as distinct production functions.

Divisibility:

It is assumed that factors can be used and commodities can be produced in quantities which are in fractional units. This implies that resources and products are considered to be continuous and to be infinitely divisible. This does not create any serious problem since one can easily see examples of many resources being used in fractional amounts readily in agriculture. In situations where fractional answers are meaningless or unacceptable integer programming can be used.

Finiteness:

It is assumed that there is a limit to the number of all alternative activities and to the resource restrictions

which need to be considered. In the words of Heady and Chandler (27, p. 18):

> . . . this is a practical assumption. If a farmer, businessman or planner has an unlimited number of alternatives, he would never have them programmed because he could never finish describing additional activities or could he ever finish the computational task of determining the most profitable program.

Single valued expectation:

Resource levels, input-output coefficients and prices are assumed known with certainty. Problems caused by this assumption can be handled by using Parametric Programming.

In algebraic terms, a problem in linear programming could be best represented by these systems of equations:

$$\text{Max}^{1} \quad Z = \sum_{j=1}^{n} c_j x_j \tag{4.44}$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad i = 1,2,\ldots m \tag{4.45}$$

$$x_j \geq 0 \tag{4.46}$$

where

---

[1]The objective function to be optimized could be a maximization of profit or a minimization of costs.

z = total revenue

xj = the level at which jth activity is to be carried out

bi = the level of availability of ith resource

C_j = the net revenue per unit of each activity

a_{ij} = the per unit requirement of the jth activity for the ith resource

n = number of activities

M = number of resources

The specification contains the following:

1. an objective function (Equation 4.44),
2. alternative methods of attaining objective,
3. resource or other restrictions.

With a real model, computational package programs are available for solving any linear programming specified problem.

Although there are numerous advantages to using linear programming[1] in solving problems, the method is plagued by its disadvantages. Amongst them is the assumption of fixed input-output coefficients. The solutions are normative and there are some difficulties in meeting its data demands. Nonetheless, there are various variants of linear programming that help eliminate some of the problems. The

[1]Enumeration of these advantages could be found in any text on linear programming techniques.

inclusion of the time factor is present in Dynamic Programming model. Likewise, elements of uncertainty are included in Stochastic Programming Models. While Parametric Programming helps to determine the direction of change in the objective function that results from changes in certain variables in the model. All these are not going to be discussed in this thesis because some of them do not specifically relate to the problem at hand.

b. Dynamic programming The inclusion of time in programming analysis is often referred to as dynamic programming. It considers activities and restrictions over a finite period of time. It is a mathematical technique which is useful in many types of sequential decision problems.

Dynamic programming is useful in most decision problems where a series of consecutive decisions have to be made, the optimal solution over all decisions could be arrived at by considering the effects of each decision separately. In many problem situations, it is possible that a bit of reduction in a period's returns may improve the overall returns of the program over specified periods. Dynamic programming provides a tool for investigating such possibilities.

The development of dynamic programming is owed to Richard Bellman and his associates at Rand Corporation. The essence of this approach is the fact that it provides a procedure which permits the solution of a given n-stage problem by solving a sequence of problems, first for one-stage, the two-stage and finally n-stage problem. The basis for the existence of the recurrence relations that are involved in the solution of a dynamic programming problem was termed the principle of optimality by Bellman. This principle states thus:

An optimal policy has the property that, whatever the initial state and initial decision are, the remaining decisions must constitute an optimal policy with respect to the state resulting from the first decision.

The solution for k-stages is obtained from the solution for k-1 by adding the kth stage and making use of the solution for k-1 stages.

The problems that can be solved by dynamic programming must have certain basic features.

1. It must be possible to break the problem down into a given stage decision problems, where at each stage the decision involves the selection of one or more control variables.

2. The problem must be defined for any number of stages and must have the same structure regardless of how many stages there are.

When a problem involves k-stages each state of the system must be described by a certain set of parameters. These are parameters which the optimal values of the control variables and the value of the objective function for the k-stage problem will depend. The same set of parameters must describe the state of the system regardless of how many stages there are. The basic theory behind multistage problem solving involves decomposing a complex problem into a series of smaller problems to obtain a solution to the whole problem. This concept has been used to develop dynamic linear programming. Mathematically a dynamic linear programming model could be specified thus:

Let the planning horizon be designated as t where t = 1,2,3,...T. Let the number of resource restrictions be designated as i where i = 1,2,...M. Let the number of activities be designated as j where j = 1,2,3,...N. The number of activities in each of the periods be n_t. n therefore is the total number of activities in the planning horizon and this is finite.

$$\sum_{t=1}^{T} n_t = n \qquad (4.45)$$

a = input-output coefficient

x = level of activity

b = level of fixed resource

a_{ijt} is defined as the input of resource i required per unit of output of activity j in period t.

x_{jt} = level of activity j in tth period

b_{it} = defined as the level of resource i in the tth period

r = interest rate used to compound the net revenue from unit activity to take account of the timing of returns from individual activities

C_{jt} = returns per unit of activity

Using these symbols the dynamic programming model can be stated thus: Maximize or Minimize

$$f(x) = \sum_{i=1}^{M} \sum_{j=1}^{N} \sum_{t=1}^{T} C_{ijt} \tag{4.46}$$

sujbect to

$$\sum_{i=1}^{M} \sum_{j=1}^{N} a_{ijt} x_{jt} \leq b_i \tag{4.47}$$

$$x_{jt} \geq 0$$

As earlier stated, there are two types of dynamic linear programming approaches, the recursive and the

multistage programming models.

As earlier stated, there are two types of dynamic linear programming approaches, the recursive and the multistage programming models.

1) Recursive dynamic linear programming model

Various methods have been used to incorporate time into decision models. Recursive programming can be defined as "a sequence of mathematical programming in which the parameters of a given problem are functionally related to the optimal variables of preceding problems of the sequences" (72, p. 197). The first step is to optimize the first period program. The net income generated by the first program is used as an indication of potential increase in net worth. It indicates by how much operator supplied capital and borrowing capacity might reasonably be expected to increase yearly. This information is used to modify the B-column capital entry in a second optimization.

Thenceforth, the succeeding planning periods capital restraint is developed on the basis of the net income provided by the optimization of the previous period. Plans can be projected into the future using this iterative method but because of the compounding of errors, in predicting income and capital growth inherent in this method, it is suggested that plans be not projected for more

than four or five periods.

2) The multiperiod dynamic linear programming model In this model the plan for each planning period emerges from a single optimization over the entire planning horizon. Capital available during any production period is estimated within the model and recycled directly into the next period program. Provisions are made within the model to transfer capital from one period to the other.

According to Chien and Bradford (13, p. 456), this procedure provides a global optimal solution and has other dynamic features but assumes certain knowledge about production and price coefficients and that all inputs are perfectly divisible. However, to a limited extent these assumptions could be relaxed. Johnson et al. (37, p. 908), in their study, relaxed the certainty assumption by using a Monte-Carlo method to allow for variation in yields of crop activities.

3) Limitations of the two approaches Both of these models have limitations. Compounding of errors plagues the recursive programming model. It also ignores the interrelationship of interperiod activities. The results one obtains through the use of this stepwise approach may not be the same if one optimizes the program over the entire planning horizon.

The multiperiod model does not suffer from these limitations thus one can expect a better result through its use. However, it has the disadvantage of resulting in complex models and higher cost of computation.

According to Chien and Bradford (13, p. 48) neither multiperiod nor recursive programming models can adequately handle and predict financial variables. It is also difficult to incorporate behavioral and qualitative decision variables into programming models.

3. Budgeting techniques

Farm planning and budgeting is the technique used in deciding on the most profitable combination of crops and other farm investments to make. Planning involves the setting out of acreages, numbers of different crops or livestock together with the expected physical production, sales and purchases or investments. Formal planning and budgeting can be done in different types of ways. In making plans, the farm operator tries a number of activities and considers the amount of labor, capital required, the risks involved and the expected rates of return. Generally speaking, plans or budgets can be divided into three groups, namely partial budgets, complete budgets and capital budgets.

a. Partial budgets Partial budgets are used when the farm planner is trying to test whether the addition of a productive activity would be profitable or not. It is used to test the profitability of a particular type of investment.

The method of partial budgeting consists of setting out one side of a simple account:

a. the extra revenue from the change being budgeted;

b. the costs saved from the enterprise replaced;

c. the amount of current income sacrificed;

d. the extra costs which will have to be incurred.

This method is very useful in decision making processes. It is a good technique for appraising the profitability of investing capital both in short term or long-term projects.

b. Complete budget Complete budgets are used for the purpose of deciding on the most suitable combination of production and investments for a new farm. The making of such budgets could be very complicated if great detail is required.

c. Capital budgets According to O'Connor (53, p. 188), capital budgeting involves mainly the final testing of the feasibility of a farm plan. Capital budgets are thus prepared to show how much capital is required to finance farm plans under different capital rationing de-

vices. This type of budget enables the farm operator to see if the complete plan or partial plan can be implemented. Plans are adjusted to meet with lending and borrowing situations. Although a main limitation of this budgeting technique is the initial assumption of no capital limitations.

In preparing capital budgets an attempt is made to show the cash flows over the planned period, so as to determine if sufficient cash flow will be available to finance the program. In appraising the anticipated return on new investment, additional investment procedures will be adopted.

4. Regression technique

Statistical regression approach is also a viable tool in production-investment analysis. Although it is traditionally very popular in studies related to demand-supply analysis, its use is applicable to other areas of research. The process involves a statistical estimation of the aggregate production function. This function can be estimated using both cross-sectional data or if available a set of time-series data. This aggregate production function represents the physical relationship between output and a set of major farm inputs (land, labor and capital). Various mathematical forms of this production

function are available (28, p. 5). The problem of which function to choose depends upon the type of problem being faced, the type of technology being used, the available information and the economic environment the researcher is operating in.

There are various problems associated with this technique. One problem has to do with the question of choice of the type of function. Often the Cobb-Douglas production function have been suggested as a basic premise for estimation in many research studies. The use of this basic function is however plagued by the fact that it forces the elasticity of substitution to be equal to unity at all points. However, there are other functions available to remove this basic flaw.

The choice therefore involves a basic trade-off. This being between conceptual complexity, difficulty of obtaining computational funds and simplicity.

5. Simulation models

Another approach to handling firm behavior over time is the simulation models approach. This attempts to simulate behavior of a farm-firm over time. The simulation technique used however does not guarantee an optimum solution as compared with results generated by the multi-period model and recursive programming approaches. This

has been shown to be true especially in studies by Hutton (33, p. 3). However, they have the advantage of being used when the decision process to be described is extremely complex, and analytical procedures either have not been or cannot be developed. These according to Irwin (35, p. 94) include situations with: a) multiple goals, b) indivisibilities, c) sequential decisions within the planning horizon using different criteria, d) nonlinear functions, and e) concepts of organizational, managerial and behavioral theories.

These simulator decision models are usually written in some computer user's language. They call for less abstraction than the other analytical models. Once the computer program describing the desired decision process has been produced, the whole process might be thought in terms of the efficacy of this being used in policy evaluation.
It is a sequence of experiments which might yield the optimum solution but which may be structured in such a way that it might generate several alternative solutions from which the best could be chosen. The experimental aspect gets introduced by varying some independent or policy variables and evaluating the effect on the outcome from the model. Another type of use of this model is to describe a particular decision process to allow tracing through effects

of different inputs.

A very great advantage of this model is its wide flexibility which provides a range of alternatives in production-investment analysis of farm-firms.

6. Integrated approach

An approach recently used by Chien and Bradford (13, p. 456) involves the combination of multiperiod linear programming and computer simulation techniques. Both are integrated into a single recursive-sequential model to investigate the pattern of production and investment over time and the resource utilization.

Four recursive phases of farm business planning and implementation comprises the framework of their model. At the beginning of each planning horizon the farm-firm formulates price and yield expectations in accordance with his goals, the available firm resources, the existing enterprise organization and financial situation. Expectations form a basis for the delineation of an optimal long-run plan which constitutes the second phase of the problem.

The third phase involves taking into consideration, institutional and political factors, which are dynamic thus providing the farm firm enterpreneur with an array of experience. To take this factor into consideration, the

computer simulation submodel which includes behavioral constraints and decision-operation process is specified.

At the end of each period, the current plan becomes the realized plan. The farm firm accumulates information regarding the outcome from previous operations and prepares summary reports. With this updated information he then formulates new price and yield expectations and then new or modified plan for the next planning horizon. A time path of optimal and realized production investment path is thus specified by repeating the sequence of phases over a number of periods.

This integrated approach exhibits descriptive, predictive, stochastic and dynamic features of the farm-firm planning process. It is characterized by the sequential and recursive nature of the model, which contains behavioral constraints, qualitative investment decision rules and a forecasting technique for stochastic yields and prices.

V. EMPIRICAL FORMULATION OF MODEL

Based on the choice of the dynamic simultaneous linear programming and the conceptual model earlier specified, the empirical model involves:

1. choice of the planning horizon;
2. types of activities considered;
3. choice of alternate levels of support;
4. types of technological level to be considered;
5. specification of levels of restraints.

A. Choice of a Planning Horizon

The planning horizon chosen is a twenty year period. Food crops and export crops are considered jointly in this research. The export crops have longer gestation period and many years of productive life. These crops unlike food crops have productive life of between 4-40 years under traditional systems of production and under improved system of production, Table 5.1a shows the productive life of each crop under the two assumed technological levels. The choice of a long period of production allows the capturing of benefits occurring from the production and sale of these crops.

Limitations exist as to the choice of a planning horizon. The validity of the assumption of constant

Table 5.1a. Productive life of export crop in the model under two technological levels (in years)

Crop type or mixture[a]	1	2	3	4	5	6	7	8	9	10	11
COCT[b]	P[c]	D[d]	D	D	X[e]	X	X	X	X	X	X
COCI[f]	P	D	D	X	X	X	X	X	X	X	X
COFT	P	D	D	X	X	X	X	X	X	X	X
COFI	P	D	D	X	X	X	X	X	X	X	X
RUBT							X	X	X	X	X
RUBI							X	X	X	X	X
KOLT							X	X	X	X	X
KOLI							X	X	X	X	X
PAPT											
PAPI					X	X	X	X	X	X	X

[a]For an interpretation of the symbols for crops see Appendix D.

[b]T stands for traditional technology.

[c]P here stands for planting year.

[d]D indicates years of development.

[e]X years of production and sales of crops.

[f]The I stands for improved technology.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X				
X	X	X	X	X	X	X	X	X	X	X	X	X	X	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 5.1a (Continued)

Crop type or mixture[a]	27	28	29	30	31	32	33	34	35	36	37	38
COCT[b]	X	X	X	X								
COCI[f]												
COFT												
COFI												
RUBT	X	X	X	X								
RUBI	X	X	X	X								
KOLT	X	X	X	X	X	X	X	X	X	X	X	X
KOLI	X	X	X	X								
PAPT												
PAPI	X	X	X	X								

39	40	41	42	43	44	45
	X				X	

technical coefficients prices is very critical. Another possible limitation or consideration in the choice of a planning horizon has to do with the computation cost and the solution time required. Increases in planning horizon increases computer costs and solution time. Also there are problems arising due to aggregation of errors in variables. Due to a longer time horizon, errors are aggregated over the period, thus making prediction from results unrealistic.

In light of the above considerations, the choice of the planning horizon is limited to twenty years. This allows for a substantial recovery of the benefits derived from investing in export crops.

B. Types of Activities in the Model

The activities for each year in the planning horizon consists of crop activities (export crops and food crops), 12 monthly hiring activities, a cash flow activity from period t to the t + 1. The model also considers two types of consumption constraints, on-farm consumption[1] and an endogeneously implied consumption constraint through the income transfer activity, also there are two capital lending and borrowing activities. In specifying the model,

[1]The consumption of farm goods and off-farm goods are included as constraints in the model.

assumptions were made as to the value of marginal propensity to consume, interest rate, the levels of resource base.

1. Crop production activities

The crops included in the model are those grown in the ecological resource zone of interest in the study. They are often referred to as export crops and food crops.[1] Export crops, as the name indicates, are produced by farmers for cash and marketed by organized government marketing institutions for foreign exchange. Research and intensive encouragement of their production has been much encouraged in Nigeria for a long time. Food crops are also considered in the model, they are not exported, but rather are produced for farm-family consumption and the excess is marketed. In an agricultural system like that of Nigeria, it is a major responsibility of most farm families to satisfy their food wants, after which, they then produce export crops in order to generate cash income for nonfood items.

Thus, in the model there are 6 export crops. They are Cocoa, Coffee, Kolanut, Rubber and Palm produce and Kenaf. Two levels of technologies are assumed for the production of each of these crops, although they are considered in isolation.

[1]Also included in the model is Kenaf production. This is sometimes referred to in literature as an import-substituting crop. Here it is included as part of export crops.

Ten food crops were included in the model. They are considered either as sole crops or in crop mixtures. The crops are Yam, Corn, Cassava, Rice, Guinea-corn, Cocoyam, Melon/corn, Cassava/melon, Cassava/corn combinations.

2. Selling activities

Since production is defined as a single activity, this does not generate income, the output generated must be transferred into a selling activity to generate the benefits. Consequently, there is a selling activity for each crop production activity.

3. Labor hiring activity

There are 12 labor hiring activities in the model. The assumed available family labor might not be enough for the production of the crops, thus, allowances are made for hiring of labor. The physical supply of labor does not determine the amount utilized by the farm-firm. The funds available is what determines the quantities demanded. Hiring activities are assumed to take place at the regional wage rate.

4. Income transfer and family consumption activity

The income transfer activity transfers income from period t to t + 1 and only a proportion of the total income generated in period t is transferred to t + 1, this is

because a particular level of marginal propensity to consume was assumed in the model. This implies an exogeneously specified income transfer activity, but an endogeneously implied family consumption activity. Estimates of the marginal propensity to consume of farm-families varies from .25 to .90 (57, p. 102). In this study the lower level of .25 was assumed. This value is held constant throughout the planning horizon. There are studies however to support the idea that this value is not generally constant over time, a particular constant level was assumed for conceptual simplicity. In the model although a constant level of .25 was assumed, income levels varies from year to year therefore allowing for fluctuations of the absolute value of consumption income.

Other consumption sources in the model involves consumption of on farm goods. There are various estimates of the propensity to consume of various farm outputs. For farm crops it is .4, .75 for poultry goods (57, p. 102). In this study the level assumed is .4 for food crops. This is however included as a constraint in the model.

This type of consumption activity is to allow the farm-firm a minimum level of sustenance per annum.

Table 5.1b. Summary of activities, restraints and transfer rows in model, annual basis (traditional and improved technology)

Number of rows and columns (per period)	Number traditional	Number improved
Export crop production	6	6
Export crop sales	6	6
Food crop production	10	10
Food crop sales	10	10
Labor hiring activity	12	12
Income transfer activity	1	1
Credit borrowing	1	1
Credit repayment	1	1
Land constraint	1	1
Monthly family labor constraint	12	12
Family on-farm consumption	1	1
Available capital constraint	1	1
Food-crop transfer from sale-production	12	12
Income transfer row	1	1
Total number of rows and columns/annum	75	75

C. Resource Levels and Restrictions in the Model Land

1. Land

As the objective of the study is not strictly directed only to one section of the farming community in the study area, different levels of land resource bases were thus tested. In the model, different annual availabilities of land were tested. This is what is referred to as the revolving land base. Different levels of this revolving acreage were assumed. They are 5, 10, 15, 20 and 25 revolving acreage levels. The upper and lower limits thus set to accommodate different farm size situations.

2. Labor

The assumed labor supply is compatible with that which results from the average family sizes in the study region (Table 3.1). Additional labor can be hired at the prevailing wage rate. Studies have shown that the physical supply of labor is not a limiting factor in this region, because of the high rate of unemployment and the availability of migrant farm workers (57, p. 86). Family labor supply varies within months, thus twelve monthly labor hiring activities were included in the model to augment the supply of family labor. The quantity thus used

of this total labor supply, constitutes the employment potential of the farm-firm.

3. Capital supply

An initial level of capital stock is assumed in the model. This is equivalent to the assumed level of per capita income of N100 for the study area. Although it could also have been assumed that this initial capital stock resulted from borrowing but this was not done. Therefore, in the model there are three sources of funds:

1. Initial supply of operating capital which was assumed to be from the past savings of the family;
2. Reinvestment of the assumed income generated from subsequent periods in the model;
3. Capital borrowing.

Capital which is not used can be invested or loaned out to yield the required interest rates. In this study area, investment opportunities outside the farm are very limited. To get around this problem, savings deposit accounts are assumed and they earn a rate of interest of 4%. The inclusion of this activity has the effect of compounding the farm income after family consumption, at the minimum rate of 4% per annum.

Generally sources of capital for farmers includes; friends, family and other institutions. In this study area, there is an institution known as the Western State Credit Corporation which gives loans to farmers. A capital borrowing and repayment activity included in the model allows farmers to borrow and pay funds back during the assumed planning horizon. The farmer can borrow at the rate of 7-1/2 percent per annum. This is equivalent to the short term loans program of the institution. Interest payment on borrowed capital constitutes a cash out-flow to the farm. The empirical model allows for multiple products, multiple labor restrictions, multiple labor hiring activity, multiple capital activity and restraints, varying resource base and specific consumption levels. Within the situation described, the problem is, to select that combination of enterprise combinations and resource use through time which maximizes the net discounted present value of income stream.

D. The Concept of Technological Levels

Technology refers to the techniques of production which are being used to produce output. In agricultural production, there are many methods of production for producing a homogeneous output. Each method of production

Table 5.2. Improved technologies assumed in the study (75, pp. 1-101)

Crop[a]	Machine technique	Fertilizer	Other chemical technique
Cocoa	-	N:P:K(25:10:0)	gammalin, copper sulphate and lindeox
Coffee	-	N:P:K(25:10:0)	gammalin
Oil palm	-	Murate of potash N:P:K(15:15:15) $(NH_4)_2SO_4$ (Ammonium sulphate)	Captan
Rubber	-	(25:10:0)(N:P:K)	Formac
Kolanut	-	N:P:K(25:10:0)	-
Yam	ploughing	N:P:K(20:0:0)	-
Rice	ploughing harrowing	$(NH_4)_2SO_4$ (Ammonium sulphate)	-
Corn	ploughing	$(NH_4)_2SO_4$ (Ammonium sulphate)	-
Cassava	-	N:P:K(10:10:20)	-
Guinea/ corn	-	Single superphosphate $(NH_4)_2SO_4$ (Ammonium sulphate)	-
Cocoyam	-	N:P:K(20:0:0)	-
Corn/ melon	-	N:P:K(20:0:0)	-

[a]The improved technologies also include the new improved varieties of each type of crop and planted under improved management (better spacing, weed control and disease control methods).

Table 5.2 (Continued)

Crop[a]	Machine technique	Fertilizer	Other chemical technique
Cassava/ melon	-	N:P:K(20:0:0)	-
Corn/ cassava	-	N:P:K(15:15:15)	-
Yam/corn	-	N:P:K(25:10:0)	-
Kenaf	ploughing disking decortication	N:P:K(15:15:15)	-

is characterized by different combinations of inputs. There are two levels assumed in this study:

1. Traditional Technology
2. Improved Technology

Improved technology as used here refers to production of crops using improved seed varieties, better management and cropping systems, fertilizers, weed control devices and better disease management. On the contrary, the production under traditional technology implies the nonuse or application of any of the inputs under improved technology. Thus, these two levels of technology reflects two different levels of costs, returns and input-output

relationships.

Table 5.2 shows the different types of technologies under improved systems that are assumed in the model. These technologies used on improved varieties of each type of crop have been known to yield threefold more than under traditional technology.

E. The Level of the Rate of Discount

The level of discount rate chosen is 4%. There are some who argue that the interest rate is as high as 8 percent. The rate used here is the ongoing interest rates of savings deposits.

F. Types of Policy Program

As part of the study, two policy programs were included in the model. They are: (a) food crop support program, and (b) export crop support program.

The levels of support varying from 10%, 20%, 30% 40% and 50% of the next benefits per acre production of all export crops, and food crops when an export crop subsidy or a food crop subsidy is being considered. It would have also been possible to focus on individual crops in the model but the interest was more on aggregate subsidy program rather than on specific crop subsidy program. The

reason being because either policy is desirable to the government of the state. This policy could be accomplished via a fiscal or monetary means. Fiscal through relaxation of the amount of taxes paid on export crops and monetary in the form of income transfers. Another reason why an aggregate support program was chosen, is because of constraints imposed by computation funds.

VI. DISCUSSION OF RESULTS

This chapter contains the discussion of the findings of the study with respect to the study objectives. The discussion focuses on the implications of the assumptions of the revolving acreage levels, the importance of the technological assumptions in terms of their production, income and employment effects and the implications of these results for the development of the area. To achieve these objectives, the chapter is divided into the following subheadings: A. The Concept of Revolving Acreage Levels and Their Implications for Actual Farm Size Under the Assumptions of the Model, B. Results Under the Traditional Technology, C. Results Under the Improved Technology, and D. The Implication of the Technological.

A. The Concept of Revolving Acreage Levels and Their Implications for Actual Farm Size Under the Assumptions of the Model

Models A1, A2 and B1 were developed and applied in the study.

Model A1 has five sub-models with varying levels of revolving acreages. In model A1, traditional technology is assumed. Model A2 has five submodels with varying levels of revolving acreages and the assumption of improved technology. Model B1 contains ten submodels with the

assumption of different aggregate subsidy levels and traditional technology. This model assumes only a particular level of revolving acreage.

A revolving acreage is the amount of land within the farming unit in each annual period of the planning horizon, for allocation between enterprises in the period. The actual farm size may vary during the planning horizon. For example, in period 1 under the 5-acre revolving acreage level and traditional technology, the 5 acres were allocated between export crops and food crops. The export crops are perennial crops and thus yield revenue in later periods in the planning horizon. The amount of land used for the production of these export crops is not available for allocation purposes in period 2. However, those acres allocated to food crops, which are annual crops are available for allocation in the following year. With adjustment in the amount of idle land or through acquiring land from the communal pool, the amount of land available for allocation in period 2 is still 5 acres but actual farm size in period 2 is 7.46 acres which includes 2.46 acres in tree crops and 5 acres in food crops (annually).

Tables 6.1 and 6.2 show the acreage used for export crops, food crops idle land and actual farm sizes for each period (annual) during the planning horizon.

Table 6.1. Revolving acreage levels and farm sizes under traditional technology[a]

Years	5 acres			
	Amount fixed for tree crop[b]	Amount for food crop[c]	Amount idle[d]	Actual farm size[e]
1	2.46	2.23	.31	4.69
2	2.46	5.00	-	7.46
3	2.46	5.00	-	7.46
4	2.46	5.00	-	7.46
5	2.46	5.00	-	7.46
6	2.46	5.00	-	7.46
7	2.46	5.00	-	7.46
8	2.46	5.00	-	7.46
9	3.32	5.00	-	8.32
10	3.32	5.00	-	8.32
11	3.32	5.00	-	8.32
12	3.32	5.00	0	8.32
13	3.32	5.00	-	8.32
14	3.32	5.00	-	8.32
15	3.32	5.00	-	8.32
16	3.32	5.00	-	8.32
17	3.32	5.00	-	8.32
18	3.32	5.00	-	8.32
19	3.32	5.00	-	8.32
20	3.32	5.00	-	8.32
Total	59.52	97.23	.31	156.75
Average	2.98	4.86	.02	7.84

[a]For each period allocation of the revolving acreage levels see Table 6.3-6.7.

[b]This is the amount of land devoted to tree crop production.

[c]Amount of land in each period used for food crop production.

[d]This is the amount of land unused. The addition of c plus d makes up the revolving acreage level.

[e]The actual farm size is the total amount of land in crops. This includes all the land in both tree crops and food crops annually.

10 acres				15 acres			
Amount fixed for tree crop[b]	Amount for food crop[c]	Amount idle[d]	Actual farm size[e]	Amount fixed for tree crop[b]	Amount for food crop[c]	Amount idle[d]	Actual farm size[e]
5.24	5.76	4.24	10.00	-	15.00	-	15.00
5.24	10.00	-	15.24	-	15.00	-	15.00
5.24	6.67	3.33	11.91	-	10.67	4.33	10.67
5.24	10.00	-	15.24	-	15.00	-	15.00
5.24	9.46	.54	14.70	.82	13.73	1.27	14.55
5.24	9.47	.53	14.71	1.65	12.00	3.00	13.65
5.24	9.44	.56	14.68	2.47	13.51	1.49	15.98
5.24	8.98	1.02	14.22	4.41	15.00	-	19.41
5.43	10.00	-	15.43	4.41	15.00	-	19.41
6.81	8.62	1.38	15.43	4.41	15.00	-	19.41
6.81	10.00	-	16.81	11.25	8.16	6.84	19.41
6.81	10.00	-	16.81	16.93	8.46	6.54	25.39
6.81	10.00	-	16.81	23.68	6.66	8.34	30.34
6.81	10.00	-	16.81	31.23	8.45	6.55	39.68
6.81	10.00	-	16.81	37.89	8.35	6.65	46.24
6.81	10.00	-	16.81	43.41	8.47	6.53	51.88
6.81	10.00	-	16.81	49.78	8.35	6.37	58.41
6.81	10.00	-	16.81	55.11	8.47	5.33	63.78
6.81	10.00	-	16.81	62.28	8.63	7.17	70.11
6.81	10.00	-	16.81	62.28	9.67	5.33	77.28
132.26	188.34	11.66	309.60	412.01	215.05	75.80	641.09
6.61	9.42	.28	15.48	20.60	10.75	3.79	32.05

Table 6.1 (Continued)

Years	20 acres			
	Amount fixed for tree crops[b]	Amount for food crops[c]	Amount idle[d]	Actual farm size[e]
1	10.44	9.48	.08	19.92
2	10.44	20.00	-	30.44
3	10.44	6.66	13.34	17.00
4	10.44	20.00	-	30.44
5	11.26	8.65	11.35	19.91
6	12.09	8.56	11.44	20.65
7	12.90	8.80	11.20	20.70
8	12.90	7.87	12.13	20.77
9	13.92	20.00	-	33.92
10	22.36	11.45	8.55	33.81
11	25.61	8.21	11.79	33.82
12	33.50	8.43	11.57	41.93
13	41.95	8.20	11.80	50.15
14	49.86	8.42	11.68	57.28
15	58.08	8.29	11.71	56.37
16	65.92	8.44	11.56	74.36
17	73.46	8.56	11.44	82.02
18	80.31	8.83	11.17	90.14
19	83.49	6.80	13.20	90.29
20	83.49	20.00	-	103.49
Total	723.88	215.64	160.68	928.86
Average	36.19	10.78	8.03	46.44

25 acres			
Amount fixed for tree crops[b]	Amount for food crops[c]	Amount idle[d]	Actual farm size[e]
13.12	11.88	-	25.00
13.12	25.00	-	38.12
13.12	16.66	8.34	18.78
13.12	25.00	-	38.12
13.95	8.75	16.25	22.70
14.78	6.66	18.34	21.44
15.58	8.89	16.11	24.47
15.58	9.66	15.34	25.24
15.58	25.00	-	40.58
23.31	17.15	7.85	40.46
26.84	18.36	6.64	45.20
34.73	8.43	16.57	43.16
42.62	8.20	16.80	50.82
50.53	8.42	16.58	58.95
58.85	8.29	16.71	67.14
65.67	8.45	16.55	74.12
73.25	8.75	16.25	82.00
80.92	9.91	15.09	90.83
87.63	6.67	18.33	94.30
87.62	25.00	-	112.63
759.93	270.13	229.87	1014.84
37.99	13.51	11.49	50.70

Table 6.2. Revolving acreage levels and farm sizes under improved technology

Years	5 acres			
	Amount fixed for tree crops	Amount for food crops	Amount idle	Actual farm size
1	-	5.00	-	5.0
2	-	5.00	-	5.0
3	-	5.00	-	5.0
4	-	5.00	-	5.0
5	-	5.00	-	5.0
6	-	5.00	-	5.0
7	-	5.00	-	5.0
8	-	5.00	-	5.0
9	-	5.00	-	5.0
10	-	5.00	-	5.0
11	-	5.00	-	5.0
12	-	5.00	-	5.0
13	-	5.00	-	5.0
14	-	5.00	-	5.0
15	-	5.00	-	5.0
16	-	5.00	-	5.0
17	-	5.00	-	5.0
18	-	5.00	-	5.0
19	-	5.00	-	5.0
20	-	5.00	-	5.0
Total	-	100.00	-	200.0
Average	-	5.00	-	5.0

10 acres				15 acres			
Amount fixed for tree crops	Amount for food crops	Amount idle	Actual farm size	Amount fixed for tree crops	Amount for food crops	Amount idle	Actual farm size
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	10	-	10	-	15	-	15
-	200	-	200	-	300	-	300
-	10	-	10	-	15	-	15

Table 6.2 (Continued)

Years	20 acres			
	Amount fixed for tree crops	Amount for food crops	Amount idle	Actual farm size
1	-	20	-	20
2	-	20	-	20
3	-	20	-	20
4	-	20	-	20
5	-	20	-	20
6	-	20	-	20
7	-	20	-	20
8	-	20	-	20
9	-	20	-	20
10	-	20	-	20
11	-	20	-	20
12	-	20	-	20
13	-	20	-	20
14	-	20	-	20
15	-	20	-	20
16	-	20	-	20
17	-	20	-	20
18	-	20	-	20
19	-	20	-	20
20	-	20	-	20
Total	-	400	-	400
Average	-	20	-	20

25 acres			
Amount fixed for tree crops	Amount for food crops	Amount idle	Actual farm size
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	25	-	25
-	500	-	500
-	25	-	25

Table 6.3. Annual allocation of the 5 acre annual revolving land base (traditional and improved technology) in acres (for conversion of acres to hectares see Appendix A)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	1		2		3		4		5		6		7		8		9	
COC																	.86	
COF																		
PAP	2.46																	
RUB																		
KOL																		
YAM		3.00	3.92	3.02	2.37		3.92		3.06	2.56	3.42	3.06	3.25	2.06	3.28	1.08	2.00	2.94
RIC																		
CAS	.18			1.08	2.63	4.05	1.08	4.92	1.46	2.44	.84	1.94	1.13	2.06	1.08	2.92	2.14	1.06
GCN																		
ECN																		
COY																		
MME																		
CME																		
CAM	2.05	2.00	1.08	.90		1.95		.08	.48		.74		.62	.88	.64	1.00		1.00
KEN																		
IDLE	.31																	
TOTAL	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 6.3 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	10		11		12		13		14		15		16		17		18	
COC																		
COF																		
PAP																		
RUB																		
KOL																		
YAM	3.92	1.90	2.13	1.08	3.07	1.02	3.39	1.29	3.18	3.05	3.34	1.61	3.24	2.04	3.37	1.60	3.41	2.06
RIC																		
CAS		1.21	2.17	1.92	1.45	3.00	.90	2.11	1.25	.09	.97	.90	1.15	.50	.93	.20	.85	.89
GCN																		
ECN																		
COY																		
MME																		
CME																		
CAM	1.08	1.89		2.00	.49	.92	.71	1.60	.57	1.86	.68	1.00	.61	1.56	.70	3.20	.74	1.97
KEN																		
IDLE																		
TOTAL	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 6.3 (Continued)

Type of Crop	Tra	Imp	Tra	Imp
	19		20	
COC				
COF				
PAP				
RUB				
KOL				
YAM	3.31	1.20	3.60	1.14
RIC				
CAS	1.03	1.64	.53	1.26
GCN				
ECN				
COY				
MME				
CME				
CAM	.66	2.46	.87	2.60
KEN				
TOTAL	5.00	5.00	5.00	5.00

Table 6.4. Annual allocation of the 10 acre annual revolving land base (traditional and improved technology) in acres

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	1		2		3		4		5		6		7	
COC														
COF														
PAP	5.24													
RUB														
KOL									.82		.83		.83	
YAM							3.92	.90		2.16		2.63		2.63
RIC														
CAS	.39	5.12	6.67	5.12	6.67	6.98		9.10	6.66	5.23	6.66	4.25	6.66	4.25
GCN														
ECN														
COY														
MME														
CME														
CAM	4.37	4.88	3.33	4.88		3.02	6.08		1.98	2.61	1.93	3.12	1.95	3.12
KEN														
IDLE					3.33					.45	.53		.56	
TOTAL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Table 6.4 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	8		9		10		11		12		13		14	
COC			.19		1.38									
COF														
PAP									.58		.72		.58	
RUB														
KOL	.88						1.43		.83		.85		.83	
YAM		3.05		2.92		2.94		2.96		3.13		3.67		2.61
RIC														
CAS	6.66	6.66	6.93	6.10	6.66	6.16	6.66	6.12	6.66	6.08	6.66	6.02	6.66	6.60
GCN														
ECN														
COY														
MME														
CME														
CAM	1.44	.29	3.07	.98	1.96		1.92		1.93	.79	1.76	.21	1.92	.79
KEN														
IDLE	1.02					.92		.92				.10		
TOTAL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Table 6.4 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	15		16		17		18		19		20	
COC												
COF												
PAP	.66		.56		.40		.56		.30			
RUB												
KOL	.84		.82		.81		.83		.79			
YAM		2.67		2.72		2.74		2.82		3.24		3.16
RIC												
CAS	6.67	6.70	6.66	6.63	6.66	6.82	6.66	6.10	6.67	6.23	6.89	6.50
GCN												
ECN												
COY												
MME												
CME												
CAM	1.83	.63	1.94	.65	2.13	.54	1.95	2.08	2.24	.53	3.11	.34
KEN												
IDLE												
TOTAL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Table 6.5. Annual allocation of the 15 acre annual revolving land base (traditional and improved technology) in acres

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	1		2		3		4		5		6		7	
COC														
COF														
PAP														
RUB														
KOL									.82		.83		.82	
YAM	4.10		4.20		4.30	3.92	4.00		4.26		3.99		4.01	
RIC														
CAS	.59	8.19	6.67	8.39	6.67	8.65		8.67	6.67	8.67	6.66	8.96	6.66	8.76
GCN														
ECN														
COY														
MME														
CME	6.54	2.71	2.33	2.41		2.05	11.00	1.96	1.98	2.07	1.92	2.15	2.02	2.23
CAM														
KEN														
IDLE	3.77	4.10	1.80	4.20	4.03	0.38	0.00	4.37	1.27	4.26	1.60	3.89	1.49	4.01
TOTAL	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

Table 6.5 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	8		9		10		11		12		13		14	
COC					6.84									
COF														
PAP									5.69		5.88		5.70	
RUB														
KOL	.94						3.54		.85		.87		.85	
YAM	4.27			4.16		4.36		4.37		4.48		4.56		4.63
RIC														
CAS	6.66	8.66	6.96	8.87	6.66	8.92	6.66	8.91	6.66	8.72	6.66	8.69	6.66	8.96
GCN														
ECN														
COY														
MME														
CME	.92	2.07	8.04	1.07	1.50	1.72	1.66	1.72	1.80	1.80		1.75	1.79	1.41
CAM														
KEN														
IDLE	2.21	4.27	0.00	1.00	6.84	0.00	3.14	0.00	0.00	0.00	1.59	0.00	0.00	0.00
TOTAL	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

Table 6.5 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	15		16		17		18		19		20	
COC												
COF												
PAP	5.80		5.68		5.54		5.52		6.26			
RUB												
KOL	.86		.84		.83		.82		.92			
YAM		4.16		4.26		4.36		4.18		4.23		4.69
RIC												
CAS	6.66	8.96	6.66	8.76	6.66	8.90	6.66	8.61	6.66	8.28	6.96	8.26
GCN												
ECN												
COY												
MME												
CME	1.67	1.88	1.81	1.08	1.97	1.74	2.00	2.21	1.16	2.49	8.04	2.05
CAM												
KEN												
IDLE	0.01	0.00	0.01	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

Table 6.6. Annual allocation of the 20 acre annual revolving land base (traditional and improved technology) in acres

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	1		2		3		4		5		6		7	
COC	10.44													
COF														
PAP														
RUB														
KOL									.82		.83		.81	
YAM							3.92							
RIC														
CAS	.78	10.50	6.66	10.67	6.66	11.25		11.61	6.66	11.36	6.66	11.76	6.66	11.65
GCN														
ECN														
COY														
MME														
CME	8.70	9.50	13.33	9.33		8.75	16.08	8.39	1.99	8.64	1.90	8.24	2.14	8.35
CAM														
KEN														
IDLE	0.08	0.00	0.01	0.00	13.34	0.00	0.00	0.00	10.53	0.00	10.61	0.00	10.39	0.00
TOTAL	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Table 6.6 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	8		9		10		11		12		13		14	
COC					8.54									
COF														
PAP									7.04		7.58		7.06	
RUB														
KOL	1.02						3.35		.85		.87		.85	
YAM														
RIC														
CAS	6.66	11.72	6.66	11.67	6.66	11.65	6.66	11.78	6.66	12.01	6.66	11.96	6.66	11.26
GCN														
ECN														
COY														
MME														
CME	.21	8.28	13.34	8.33	4.79	8.35	1.55	8.22	1.77	7.99	1.54	8.04	1.76	8.74
CAM														
KEN														
IDLE	12.11	0.00	0.00	0.00	0.01	0.00	8.15	0.00	3.68	0.00	3.35	0.00	3.67	0.00
TOTAL	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Table 6.6 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	15		16		17		18		19		20	
COC												
COF												
PAP	7.36		6.99		6.71		6.05		12.16			
RUB												
KOL	.86		.85		.83		.80		1.03			
YAM												
RIC												
CAS	6.66	13.36	6.66	12.06	6.66	11.16	6.66	11.36	6.66	11.72	6.67	11.16
GCN												
ECN												
COY												
MME												
CME	1.63	6.64	1.78	7.94	1.90	8.84	2.17	8.64	.14	8.28	13.33	8.84
CAM												
KEN												
IDLE	3.49	0.00	3.72	0.00	3.90	0.00	4.32	0.00	0.01	0.00	0.00	0.00
TOTAL	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Table 6.7. Annual allocation of the 25 acre annual revolving land base (traditional and improved) in acres

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	1		2		3		4		5		6		7	
COC														
COF														
PAP	13.12													
RUB														
KOL									.83		.83		.80	
YAM							3.92							
RIC														
CAS	.98	16.25	6.66	16.35	6.66	16.37		16.45	6.66	16.35	6.66	16.45	6.66	16.76
GCN														
ECN														
COY														
MME														
CME	10.90	8.75	18.33	8.65		8.63	21.08	8.55	1.99	8.65		8.55	2.23	8.34
CAM														
KEN														
IDLE	0.00	0.00	0.01	0.00	18.34	0.00	0.00	15.52	0.00	0.00	17.51	0.00	15.31	0.00
TOTAL	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Table 6.7 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	8		9		10		11		12		13		14	
COC					7.43									
COF														
PAP									7.04		7.58		7.06	
RUB														
KOL							3.53		.85		.87		.85	
YAM														
RIC														
CAS	6.66	17.25	6.66	17.35	6.66	17.36	6.66	18.36	6.66	18.36	6.66	18.06	6.66	19.01
GCN														
ECN														
COY														
MME														
CME		7.75	18.34	7.65	10.59	7.64	1.66	6.64	1.77	6.64	1.54	6.54	1.76	5.99
CAM														
KEN														
IDLE	18.34	0.00	0.00	0.00	0.32	0.00	13.15	0.00	8.98	0.00	8.35	0.40	8.67	0.00
TOTAL	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Table 6.7 (Continued)

Type of Crop	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	15		16		17		18		19		20	
COC												
COF												
PAP	7.36		6.99		6.74		5.88		6.71			
RUB												
KOL	.86		.84		.84		.79					
YAM												
RIC												
CAS	6.66	19.25	6.66	18.76	6.66	18.21	6.67	18.37	6.67	18.35	6.67	18.07
GCN												
ECN												
COY												
MME												
CME	1.63	5.75	1.79	5.24	1.89	6.79	2.24	6.63		6.65	18.33	6.93
CAM												
KEN												
IDLE	8.88	0.00	8.72	1.00	8.87	0.00	9.42	0.00	11.62	0.00	0.00	0.00
TOTAL	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

Under the 5 acre revolving acreage levels, farm sizes increased from 4.60 acres in period 1 to 8.32 acres in period 20.

Under the 10 acre assumption actual farm size changes from 10 acres to 16.81 acres.

Under the 15 acre assumption with traditional technology the farm size changes from 14.98 to 77.28 acres.

Under the 20 acre assumption and using traditional technology the acreage levels or actual farm size varies from 19.92 acres in period 1 to 103.49 acres in period 20.

Under the 25 acre revolving land base, acreage sizes in period 1 was 25 and at the end of the planning horizon was 112.63 acres.

The reason for farm size expansion is due to accumulated investment in tree crops over the planning horizon.

3.32, 6.81, 62.28, 83.89 and 87.63 acres were allocated to tree crops under the 5, 10, 15, 20 and 25 acre revolving land base, respectively. The mixtures and types of tree crops, however differ with each revolving acreage level.

Under improved technology, farm sizes remained constant over time. The reason for this is that there is no accumulation of export crops throughout the planning horizon.

The available owned land for annual allocation is used for food crop production, thus there is no need for

increases in farm sizes.

B. Results under Traditional Technology

The traditional technologies are those found on the farms in the study area. These technologies are characterized by poor management practices and low productivity relative to improved technologies that have been developed in experimental stations in Nigeria.

Table 6.8 shows the average sizes of farms under traditional technology. As the revolving acreage levels are adjusted there is an accumulation of tree crops. Average Net Benefit also increases from ₦312.82 to ₦425.81 between 5 and 10 acre revolving land bases. ₦312.82 was generated from a farm size of 7.84 acres while ₦425.81 was generated from 15.48 acres. Although farm sizes approximately doubles, incomes increased only slightly more than one-third. The apparent reason for this is due to differences in enterprise combinations and also due to home consumed goods. As food crops, yams and cassava, production increases the total amounts of these goods used for food consumption on the farm increases. Thus, when enterprise combinations are different between these sizes of farms, coupled with the consumption component, farm incomes will not necessarily double. More yam and cassava are produced

Table 6.8. Average farm size, average net benefits, average labor use and productivity measures under traditional and improved technology

Average farm size (acres)	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
	5		10		15		20		25	
Average farm size (acres)	7.84	5	15.48	10	32.05	15	46.44	20	50.70	25
Average annual net benefit[a] (₦)	312.82	457.88	425.81	533.25	440.79	598.10	462.16	897.74	473.08	1252.43
Average annual labor use (man-days)[b]										
Family labor	376.07	494.54	418.07	509.35	426.45	528.67	446.91	528.67	457.01	528.67
Hired labor	21.37	226.36	232.95	285.85	253.77	461.41	262.52	609.79	293.88	709.79
Total labor	397.44	720.90	651.02	785.20	670.22	990.08	709.43	1138.46	730.89	1238.46
Net benefit in ₦ per man-day	.79	.64	.65	.67	.66	.61	.65	.79	.65	1.10
Net benefit in ₦ per acre	39.90	91.57	27.51	53.33	13.75	39.87	9.95	44.89	9.33	50.10

[a]For annual net benefits see Table 6.20.

[b]For annual labor use see Tables 6.9-6.19.

Table 6.9. Annual labor utilization of hired and family labor in man-days under traditional technology and a 5 acre annual revolving land base

Month	1		2		3		4		5		6		7	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	12.18	17.70		15.78		17.70		16.63		17.08		16.88	
Feb	40.67	18.05	21.98		26.16		21.98		24.30		23.32		23.77	
Mar	45.00	19.15	38.19		35.18		38.19		36.96		37.48		37.24	
Apr	44.00	11.41	33.91		28.18		33.91		30.73		32.07		31.45	
May	41.67	33.32	40.26		41.67	11.47	40.26		41.67	5.74	41.67	2.72	41.67	4.12
Jun	37.67	27.28	32.56		16.93		32.56		27.56		25.86		25.86	
Jul	44.00	21.21	30.28		16.93		30.29		26.01		24.56		24.56	
Aug	40.05	14.42	20.02		23.45		20.02		21.12		21.49		21.49	
Sep	45.33	2.92	45.33	12.49	45.33	3.48	45.33	2.49	45.33	7.48	45.33	9.59	45.33	8.62
Oct	53.67	1.97	43.10		37.65		43.09		41.35		40.76		40.76	
Nov	41.67	2.02	41.67	1.42	41.68	10.50	41.67	1.42	41.35		40.76		40.86	
Dec	-	-	18.76		11.36		18.76		16.39		15.59		15.73	
TOTAL	469.06	163.93	383.76	13.91	340.30	24.45	383.76	4.91	359.09	13.22	370.73	12.31	365.36	12.84

Table 6.9 (Continued)

Month	8		9		10		11		12		13		14	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	16.91		15.78		17.70		15.78		16.64		17.04		16.79	
Feb	23.69		26.16		21.98		26.16		24.28		23.41		23.96	
Mar	37.29		35.98		38.19		35.98		36.96		37.44		37.14	
Apr	31.58		28.18		33.91		28.18		30.75		31.95		31.19	
May	41.67	3.86	41.67	11.47	40.26		41.67	11.47	30.75	5.68	41.67	3.00	41.67	4.70
Jun	26.16		17.79		32.56		17.63		41.67		27.21		25.15	
Jul	24.82		18.39		30.29		18.12		23.96		25.71		23.96	
Aug	21.43		27.94		20.02		27.12		22.93		21.19		21.64	
Sep	45.33	8.80	45.33	10.49	45.33	12.49	45.33	9.21	21.91	7.53	45.33	9.40	45.33	8.26
Oct	40.86		43.67	1.00	43.09		43.38		45.33		41.23		40.51	
Nov	40.86		41.67	.26	41.67	1.42	41.15		40.10		41.23		40.51	
Dec	15.73		15.81		18.76		14.99		14.69		16.23		15.25	
TOTAL	366.33	12.66	358.37	23.12	383.76	13.91	355.49	18.68	349.97	13.21	369.64	11.40	363.1	12.96

Table 6.9 (Continued)

Month	15		16		17		18		19		20	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	16.99		16.86		17.02		17.07		16.94		17.31	
Feb	23.53		23.82		23.46		23.34		23.62		22.83	
Mar	37.37		37.22		37.44		37.47		37.32		37.74	
Apr	31.78		31.39		31.88		32.05		31.66		32.75	
May	41.67	3.37	41.67	4.25	41.67	3.15	41.67	2.78	41.67	3.66	41.67	1.20
Jun	26.76		25.70		27.04		27.47		26.41		29.40	
Jul	25.34		24.42		25.56		25.94		25.03		27.58	
Aug	21.29		21.53		21.23		21.13		21.37		20.71	
Sep	45.33	9.15	45.33	8.53	45.33	9.30	45.33	9.57	45.33	8.95	45.33	10.66
Oct	41.07		41.16		41.16		41.33		40.96		41.99	
Nov	41.07		41.16		41.16		41.32		40.96		41.67	.32
Dec	16.02		16.14		16.14		16.36		15.85		17.29	
TOTAL	411.29	12.52	366.4	12.78	369.06	12.45	370.47	12.35	367.12	12.61	418.26	12.18

Table 6.10. Annual labor utilization of hired and family labor in man-day under improved technology and a 5 acre annual revolving land base

Month	1		2		3		4		5		6		7	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	15.50		21.98		27.12		40.16		41.16		41.62		41.62	
Feb	23.50		30.25		33.14		35.28		33.25		38.19		39.23	
Mar	32.93		40.16		33.26		33.46		33.46		35.26		36.10	
Apr	44.00	14.27	44.00		44.00		44.00	15.45	44.00	27.12	44.00	29.41	44.00	30.11
May	41.67	19.60	41.67	20.11	41.67		41.67	19.98	41.67	20.16	41.67	23.16	41.67	29.26
Jun	37.67		44.37	30.11	44.37	36.35	44.35	29.21	44.35	28.41	44.35	29.92	44.35	28.45
Jul	38.66		38.66		38.89		44.00		44.00	4.25	44.00	4.23	44.00	5.23
Aug	39.01		47.33	14.36	47.33	15.26	47.33	19.21	47.33	20.31	47.33	23.16	47.33	29.16
Sep	45.33	9.74	45.33	20.13	45.33	21.26	45.33	23.36	45.33	26.30	45.33	26.72	45.33	27.12
Oct	43.67	19.38	43.67	21.68	43.67	21.72	43.67	22.37	43.67	28.92	43.67	29.16	43.07	30.16
Nov	41.67	18.23	41.67	28.16	41.67	28.96	41.67	31.92	41.67	19.26	41.67	20.17	41.67	30.27
Dec	22.90		35.72		30.23		36.20		38.90		38.90		39.00	
TOTAL	469.84	81.22	474.81	134.55	440.22	123.55	497.12	161.50	498.79	174.73	505.99	185.93	507.97	209.76

Table 6.10 (Continued)

Month	8		9		10		11		12		13		14	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	41.62		30.16		41.10		40.36		41.00		42.00		42.00	
Feb	39.23		41.26		41.26		40.16		40.26		40.16		40.26	
Mar	42.16		41.31		41.32		41.00		41.30		42.10		42.36	
Apr	44.00	34.00	44.00	35.26	44.00	31.26	44.00	30.16	44.00	29.26	44.00	30.16	44.00	31.26
May	41.67	30.67	41.67	32.67	41.67	32.16	41.67	30.26	41.67	30.76	41.67	32.17	41.67	33.19
Jun	44.35	30.35	44.35	29.36	44.35	30.35	44.35	30.45	44.35	30.46	44.35	34.26	44.35	33.36
Jul	44.00	6.40	44.00	7.80	44.00	8.90	44.00	10.00	44.00	19.10	44.00	29.16	44.00	30.26
Aug	47.33	28.16	47.33	29.36	47.33	28.26	47.33	29.30	47.33	30.26	47.33	31.76	47.33	32.10
Sep	45.33	28.16	45.33	29.26	45.33	31.26	45.33	31.60	45.33	31.26	45.33	32.36	45.33	33.26
Oct	43.67	29.67	43.67	30.16	43.67	29.96	43.67	31.60	43.67	31.70	43.67	32.76	43.67	33.76
Nov	41.67	40.10	41.67	40.10	41.67	39.36	41.67	40.26	41.67	40.16	41.67	40.26	41.67	39.98
Dec	40.00		39.16		40.16		41.10		41.10		40.16		40.26	
TOTAL	515.03	227.57	503.91	213.97	515.86	231.51	514.64	233.63	515.68	242.96	516.44	262.89	519.90	267.17

Table 6.10(Continued)

Month	15		16		17		18		19		20	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	41.26		41.30		40.16		39.26		40.17		39.98	
Feb	40.16		40.27		40.12		40.12		38.16		39.16	
Mar	42.36		41.98		40.91		40.94		40.91		40.91	
Apr	44.00	36.10	44.00	36.60	44.00	40.26	44.00	39.30	44.00	40.16	44.00	39.20
May	41.67	34.26	41.67	35.36	41.67	39.20	41.67	38.16	41.67	39.40	41.67	40.16
Jun	44.35	34.36	44.35	35.36	44.35	35.26	44.35	36.16	44.35	37.16	44.35	40.16
Jul	44.00	31.92	44.00	33.94	44.00	35.26	44.00	34.30	44.00	34.70	44.00	35.20
Aug	47.33	33.26	47.33	35.10	47.33	34.10	47.33	35.11	47.33	36.26	47.33	37.10
Sep	45.33	31.93	45.33	30.93	45.33	31.78	45.33	38.10	45.33	39.28	45.33	39.20
Oct	43.67	39.26	43.67	40.16	43.67	40.16	43.67	39.20	43.67	39.61	43.67	39.26
Nov	41.67	39.36	41.67	38.36	41.67	38.16	41.67	39.26	41.67	39.36	41.67	39.97
Dec	40.98		39.20		38.16		40.12		39.98		39.26	
TOTAL	516.78	280.25	514.77	285.81	511.37	294.18	512.46	299.68	511.24	305.93	427.99	310.31

Table 6.11. Annual labor utilization of hired and family labor in man-days under technology and 10 acre annual revolving land base (traditional)

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	43.33	25.97	32.33	6.50	19.33		37.20	11.37	27.06		26.85	
Feb	40.67	38.68	40.67	70.41	40.67	4.99	40.67	59.81	40.67	20.57	40.67	20.05
Mar	45.00	41.04	45.00	66.08	45.00	.66	45.00	71.69	45.00	16.24	45.00	15.72
Apr	44.00	24.34	38.87	14.37	25.00		44.00	28.91	33.59		33.39	
May	41.67	7.05	41.67	128.86	41.67	47.51	41.67	96.19	41.67	66.88	41.67	66.23
Jun	37.67	58.17	37.67	75.05	12.86		37.67	114.69	36.62		35.99	
Jul	44.00	45.22	44.00	51.21	12.86		44.00	85.09	32.46		31.93	
Aug	40.06	30.74	47.33	34.20	37.52		47.33	271.30	47.33	5.61	47.33	5.31
Sep	45.33	6.22	43.63	4.95	37.52		45.33	27.79	40.56		40.47	
Oct	43.67	4.14	34.96		31.19		43.67	10.72	35.90		35.86	
Nov	41.67	4.25	1.51	182.68	41.67	25.50	41.67	12.72	41.67		41.67	
Dec							18.75		2.88		2.90	
TOTAL	467.07	285.82	407.64	634.31	345.29	78.66	486.96	790.28	425.35	109.30	423.73	107.31

Table 6.11 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	26.92		24.96		32.07	6.21	26.95		26.81		28.00	
Feb	40.67	20.87	40.67	12.17	40.67	70.42	40.67	16.76	40.67	17.98	40.67	23.35
Mar	45.00	16.54	45.00	7.84	45.00	65.79	45.00	12.43	45.00	13.65	45.00	21.86
Apr	33.45		31.49		38.86	14.36	33.48		33.35		34.30	
May	41.67	67.26	41.67	56.44	41.67	129.94	41.67	62.14	41.67	63.67	14.67	92.93
Jun	36.19		30.16		37.67	72.05	37.67		35.86		36.75	4.68
Jul	32.10		27.13		44.00	48.84	34.53		31.86		32.33	
Aug	47.33	5.80	47.33	.70	47.33	34.31	17.06	13.88	47.33	20.15	47.33	8.16
Sep	40.50		39.73		45.33	6.17	45.33	50.54	40.46		40.47	
Oct	35.87		35.48		37.52		43.67	45.26	37.61		35.86	
Nov	41.67		41.67		36.89		40.30	25.39	41.67	26.75	41.67	
Dec	2.90		3.10		1.01		7.18		4.95		2.91	
TOTAL	424.27	110.47	381.26	77.15	448.02	447.79	413.51	226.40	272.24	142.20	426.96	150.98

Table 6.11 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	28.68		32.11	6.21
Feb	40.67	18.77	40.67	70.11
Mar	45.00	17.57	45.00	65.79
Apr	35.09		38.86	14.36
May	41.67	89.49	41.67	129.94
Jun	37.67		37.67	72.05
Jul	35.27		44.00	48.84
Aug	47.33	5.56	47.33	34.31
Sep	40.97		43.50	6.17
Oct	36.12		35.77	
Nov	41.67		35.77	
Dec	2.78			
TOTAL	432.92	131.39	442.35	447.78

Table 6.11 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	27.65	5.88	27.98		27.80		28.03		28.43		28.05	
Feb	40.67	5.88	40.67	23.29	40.67	22.46	40.67	23.45	40.67	24.57	40.67	24.80
Mar	45.00		45.00	21.80	45.00	21.03	45.00	21.96	45.00	23.01	45.00	23.23
Apr	33.90		34.28		34.06		34.34		34.80		34.36	
May	41.67	21.83	41.67	92.88	41.67	92.26	41.67	93.00	41.67	93.84	41.67	94.04
Jun	35.02	20.44	36.69	4.59	35.74	3.36	36.94	4.83	37.67	6.50	36.98	6.83
Jul	30.84		32.28		31.46		32.49		34.20		32.53	
Aug	47.33	91.79	47.33	8.13	47.33	7.66	47.33	8.22	47.33	8.85	47.33	8.98
Sep	40.22	2.41	40.46		40.32		40.49		40.77		40.51	
Oct	35.73		35.85		35.78		35.87		36.02		35.88	
Nov	41.67	7.30	41.67		41.67		41.67		41.67		41.67	
Dec	2.97		2.91		2.94		2.90		2.83		2.89	
TOTAL	422.67	155.53	426.79	150.69	424.44	146.77	427.40	151.46	431.06	156.77	427.54	157.88

Table 6.12. Annual labor utilization of hired and family labor in man-days under improved technology and a 10 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	44.00	34.36	44.00	26.11	44.16	32.32	28.54		30.71		31.32	
Feb	40.67	26.11	40.67	26.14	40.67	31.30	40.67	24.58	40.67	11.62	40.67	20.64
Mar	45.00	26.11	45.00	26.14	45.00	26.30	45.00	20.23	45.00	13.22	45.00	23.00
Apr	44.00	1.56	44.40	4.80	44.00		44.00	2.56	44.00	20.64	44.00	21.81
May	41.67		39.02		28.51		33.15		26.34		26.46	
Jun	37.67	33.67	37.67	34.00	33.67	24.65	37.67	22.06	37.67	21.84	37.67	27.36
Jul	44.00	27.61	44.00	27.61	44.00	5.19	44.00	16.00	44.00	7.57	44.00	24.00
Aug	47.33	20.30	47.33	19.33	47.33	5.63	47.33	11.62	47.33	19.36	47.33	29.60
Sep	45.33	48.29	45.36	3.29	45.33	6.00	45.33	10.92	45.33	28.26	45.33	23.44
Oct	43.67	18.00	43.67	20.16	43.67	13.09	43.67	11.73	43.67	31.00	43.67	35.00
Nov	41.67	35.33	41.07		41.67	39.69	41.67		41.67		41.67	11.26
Dec	37.63		37.63		37.63		7.03		19.21		37.63	
TOTAL	512.64	271.34	509.99	187.58	495.69	184.17	458.16	119.62	465.60	153.51	484.80	216.11

Table 6.12(Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	31.67		38.36		40.16		47.60	12.60	44.00	11.26	44.00	12.06
Feb	40.27	20.37	40.67	29.40	40.67	30.16	40.67	30.16	40.67	32.41	40.67	36.26
Mar	45.00	23.92	45.00	23.92	45.00	26.16	45.00	27.23	45.00	28.11	45.00	28.26
Apr	44.00	25.81	44.00	21.81	44.00	22.91	44.00	30.12	44.00	32.16	44.00	33.29
May	26.46		26.42		32.16		41.67		41.67	2.16	41.67	2.16
Jun	37.67	29.32	37.67	29.32	37.67	40.16	37.67	39.26	37.67	40.16	37.67	38.26
Jul	44.00	28.55	44.00	18.25	44.00	20.16	44.00	23.42	44.00	26.10	44.00	28.19
Aug	47.33	21.39	42.33	21.72	47.33	28.16	47.33	29.36	47.33	30.33	47.33	31.33
Sep	45.33	32.49	45.33	32.32	45.33	39.32	45.33	39.92	45.33	39.29	45.33	38.99
Oct	43.67	42.32	43.67	42.32	43.67	46.26	43.67	38.67	43.67	39.65	43.67	40.16
Nov	41.67	16.25	41.67	17.32	41.67	19.18	41.67	19.20	41.67	20.19	41.67	21.26
Dec	23.35		23.35		35.62		37.63	4.16	37.63		37.63	1.36
TOTAL	470.12	240.42	477.47	236.38	497.28	262.47	528.67	293.66	528.67	301.62	528.67	308.42

Table 6.12 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	44.00	13.08	44.00	14.01	44.00	15.26	44.00	18.20	44.00	19.36	44.00	20.36
Feb	40.67	38.28	40.67	39.28	40.67	40.16	40.67	45.00	40.67	45.00	40.67	44.30
Mar	45.00	23.46	45.00	24.56	45.00	29.26	45.00	30.26	45.00	30.26	45.00	36.76
Apr	44.00	35.29	44.00	36.76	44.00	35.16	44.00	36.70	44.00	36.70	44.00	37.20
May	41.67	3.16	41.67	4.16	41.67	5.36	41.67	5.68	41.67	6.70	41.67	7.20
Jun	37.87	42.71	37.67	38.96	37.67	39.45	37.67	40.45	37.67	41.26	37.67	41.29
Jul	44.50	30.19	44.00	29.20	44.00	43.26	44.00	43.46	44.00	43.67	44.00	44.67
Aug	47.33	32.33	47.33	34.63	47.33	33.63	47.33	34.70	47.33	38.70	47.33	38.70
Sep	45.33	41.00	45.33	42.00	45.37	41.00	45.33	42.00	45.33	41.00	45.33	47.00
Oct	43.67	44.26	43.67	45.00	43.67	42.10	43.67	41.26	43.67	41.26	43.67	42.10
Nov	41.67	23.70	41.67	24.60	41.67	24.60	41.67	26.80	44.67	26.80	41.67	28.60
Dec	37.63	2.36	37.67	1.06	37.67	2.03	37.67	3.70	37.07	4.60	37.67	6.80
TOTAL	528.67	327.46	528.67	333.16	528.67	357.27	528.67	368.21	528.67	375.31	528.67	394.38

Table 6.12 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	44.00	26.30	44.00	28.30
Feb	40.67	40.26	40.67	40.30
Mar	45.00	37.00	45.00	37.00
Apr	44.00	37.20	44.00	37.36
May	41.67	8.90	41.67	9.20
Jun	37.67	42.69	37.67	42.16
Jul	44.00	43.67	44.00	43.26
Aug	47.33	39.20	47.33	38.19
Sep	45.33	49.00	45.33	45.00
Oct	43.67	42.62	43.67	43.26
Nov	41.67	38.30	41.67	38.30
Dec	37.67	7.90	37.67	8.92
TOTAL	528.67	413.04	528.67	378.75

Table 6.13. Annual labor utilization of hired and family labor in man-days under traditional technology and a 15 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	38.94	15.33	6.50	19.33		45.33	11.37	27.06		26.81	
Feb	40.67	57.69	40.67	70.41	40.67	4.99	40.67	59.81	40.67	20.57	40.67	20.05
Mar	45.00	61.24	45.00	66.08	45.00	.66	45.00	71.69	45.00	16.24	45.00	15.72
Apr	44.00	36.49	44.00	14.37	25.86		44.00	28.91	33.00		33.34	
May	41.67	106.52	41.67	128.86	41.67	47.51	41.67	96.19	41.67	66.88	41.67	66.23
Jun	37.67	87.20	37.67	75.05	12.86		37.67	114.69	36.64		35.85	
Jul	44.00	67.80	44.00	51.21	12.86		44.00	85.09	32.47		31.82	
Aug	40.05	46.09	47.33	34.20	37.52		17.47	271.30	47.33	5.61	47.33	5.31
Sep	45.33	9.32	45.33	4.95	37.52		45.33	27.79	40.56		40.46	
Oct	43.67	6.30	40.61	182.68	31.19		43.67	10.72	35.91		35.85	
Nov	41.67	6.47	18.50		35.48	34.37	41.67	12.72	41.67		41.67	
Dec							18.76		2.88		2.91	
TOTAL	469.06	524.06	444.11	634.31	339.96	87.53	465.24	790.28	425.46	109.30	423.38	107.31

Table 6.13 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	27.22		22.90		45.33	6.21	25.18		25.79		37.72	
Feb	40.67	20.87	40.67	12.87	40.67	70.12	70.67	16.76	40.67	17.98	40.67	23.35
Mar	45.00	16.54	45.00	7.84	45.00	65.79	45.00	12.43	45.00	13.65	45.00	21.86
Apr	33.75	67.26	29.43		44.00	14.36	31.71		32.32		41.97	
May	41.67		41.67	56.44	41.67	129.94	41.67	62.14	41.67	63.67	41.67	92.93
Jun	37.11		23.84		37.67	72.05	37.67		32.71		37.67	4.68
Jul	32.86	5.80	21.91		44.00	48.84	39.30		29.23		34.87	
Aug	47.33		47.33	.70	47.33	34.31	20.47	313.88	47.33	20.15	47.33	8.16
Sep	40.62		38.92		45.33	6.17	45.33	50.54	40.05		40.27	
Oct	35.93		35.06		41.67		43.67	45.26	43.67		35.75	
Nov	41.67		41.67		41.67		41.67	25.39	41.67	6.75	41.67	
Dec	2.87		3.30				35.54		12.58		2.96	
TOTAL	426.70	110.47	391.70	77.15	474.34	447.79	447.88	526.40	432.69	122.20	447.55	150.98

Table 6.13 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	37.27		37.70		37.46		37.75	23.45	38.08		38.15	
Feb	40.67	21.83	40.67	23.29	40.67	22.46	40.67	21.96	40.67	24.57	40.67	24.80
Mar	45.00	20.44	45.00	21.81	45.00	21.63	45.00		45.00	23.01	45.00	23.23
Apr	41.45		41.95		41.67		42.00	93.00	42.39		42.48	
May	41.67	91.79	41.67	92.88	41.67	92.26	41.67	4.83	41.67	93.84	41.67	94.04
Jun	37.67	2.41	37.67	4.59	37.67	3.36	37.67		37.67	6.50	37.67	6.83
July	32.93		34.80		33.74		35.01	8.22	36.44		36.73	
Aug	47.33	7.30	47.33	8.13	47.33	7.66	47.33		47.33	8.85	47.33	8.98
Sep	39.94		40.35		40.07		40.29		40.52		40.59	
Oct	35.58		35.74		35.65		35.76		35.59		35.92	
Nov	41.67		41.67		41.67		41.67		41.67		41.67	
Dec	3.04		2.96		3.00		2.95		2.89		2.87	
TOTAL	444.22	143.77	247.51	150.70	445.60	146.77	447.77	151.46	449.92	156.77	450.75	157.88

Table 6.13 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	36.36		45.33	6.21
Feb	40.67	18.77	40.67	70.12
Mar	45.00	17.57	45.00	65.79
Apr	40.39		44.00	14.36
May	41.67	89.49	41.67	29.94
Jun	35.48		37.68	72.05
Jul	28.99		44.00	48.84
Aug	47.33	5.56	47.33	34.31
Sep	39.30		45.33	6.17
Oct	35.25		41.67	
Nov	41.67		41.67	
Dec	3.21			
TOTAL	435.32	131.39	474.34	347.79

Table 6.14. Annual labor utilization of hired and family labor in man-days under improved technology and a 15 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	64.84	45.33	64.03	45.33	63.90	45.33	64.07	45.33	64.55	45.33	64.34
Feb	40.67	28.03	40.67	26.40	40.67	25.98	40.67	26.59	40.67	28.54	40.67	27.86
Mar	45.00	40.94	45.00	39.94	45.00	39.76	45.00	40.00	45.00	41.11	45.00	40.49
Apr	44.00	23.36	44.00	24.20	44.00	24.89	44.00	23.86	44.00	21.98	44.00	21.86
May	41.67	51.18	41.67	52.20	41.67	52.30	41.67	52.19	41.67	53.58	41.67	52.08
Jun	37.67	49.09	31.67	41.33	37.67	40.40	37.67	41.46	37.67	41.84	37.67	42.72
Jul	44.00	27.50	44.00	21.59	44.00	20.91	44.00	21.66	44.00	21.82	44.00	22.48
Aug	47.33	38.23	47.33	37.21	47.33	37.16	47.33	47.17	47.33	37.34	47.33	36.99
Sep	45.33	41.35	45.33	44.44	45.32	45.32	45.33	44.01	45.33	41.72	45.33	41.22
Oct	43.67	63.95	43.67	64.01	43.67	64.50	43.67	63.63	43.67	61.38	43.67	61.39
Nov	41.67	7.25	41.67	8.84	41.67	9.56	41.67	8.50	41.67	6.77	41.67	6.27
Dec	42.33	42.75	42.33	42.56	42.33	42.77	42.33	42.37	42.37	40.90	42.33	41.22
TOTAL	528.67	478.51	528.67	466.75	528.67	424.47	528.67	423.14	528.67	461.53	528.67	458.92

Table 6.14 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	64.07	45.33	62.80	45.33	64.04	45.33	64.03	45.33	63.68	45.33	64.00
Feb	40.67	26.55	40.67	24.51	40.67	26.56	40.67	26.51	40.67	25.33	40.67	25.72
Mar	45.00	40.00	45.00	37.61	45.00	40.29	45.00	40.28	45.00	39.44	45.00	40.08
Apr	44.00	23.96	44.00	21.32	44.00	24.82	44.00	24.91	44.00	25.47	44.00	26.62
May	41.67	52.19	41.67	48.95	41.67	53.89	41.67	53.88	41.67	52.51	41.67	53.70
Jun	37.67	41.49	37.367	35.49	37.67	38.78	37.67	38.81	37.67	38.70	37.67	39.78
Jul	44.00	21.69	44.00	16.81	44.00	19.69	44.00	19.72	44.00	19.66	44.00	20.60
Aug	47.33	37.19	47.33	34.39	44.00	37.40	44.00	37.42	44.00	37.05	44.00	37.89
Sep	45.33	44.11	45.33	41.97	45.33	46.00	45.33	46.11	45.33	46.69	45.33	47.97
Oct	43.67	63.74	43.67	59.83	43.67	64.40	43.67	64.51	43.67	65.19	43.67	66.70
Nov	41.67	8.57	41.67	7.30	41.67	10.29	41.67	10.36	41.67	10.75	41.67	11.70
Dec	42.33	42.43	42.33	40.83	42.33	42.39	42.33	42.45	42.33	43.07	42.33	43.68
TOTAL	528.67	465.99	528.67	431.81	528.67	468.55	528.67	468.99	528.67	467.53	528.67	478.44

Table 6.14 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	63.19	45.33	64.30	45.33	60.37	45.33	64.07	45.33	64.25	45.33	64.54
Feb	40.67	24.22	40.67	27.61	40.67	19.29	40.67	26.58	40.67	27.10	40.67	27.70
Mar	45.00	38.80	45.00	40.71	45.00	32.70	45.60	40.31	45.60	40.26	45.60	40.52
Apr	44.00	26.30	44.00	23.26	44.00	19.14	44.00	24.85	44.00	23.34	44.00	24.13
May	41.67	53.08	41.67	53.75	41.67	41.88	41.67	53.86	41.67	52.01	41.67	51.47
Jun	37.67	34.21	37.67	40.20	37.67	27.15	37.67	39.03	37.67	42.99	37.67	46.70
Jul	44.00	16.27	44.00	20.66	44.00	10.12	44.00	18.88	44.00	22.80	44.00	25.73
Aug	44.00	36.51	44.00	37.33	44.00	29.92	44.00	37.44	44.00	37.31	44.00	38.03
Sep	45.33	48.83	45.33	43.72	45.33	40.56	45.33	45.97	45.33	42.98	45.37	43.02
Oct	43.67	65.58	43.67	62.71	43.67	56.20	43.67	64.47	43.67	63.21	43.67	64.67
Nov	41.67	12.79	41.67	8.44	41.67	6.61	41.67	10.24	41.67	7.57	41.67	7.29
Dec	42.33	43.08	42.33	41.55	42.33	40.06	42.33	42.43	42.33	42.20	42.37	43.16
TOTAL	528.67	462.86	528.67	464.24	528.67	384.00	528.67	469.13	528.67	495.86	528.67	476.46

Table 6.14 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	45.33	64.16	45.33	64.16
Feb	40.67	25.38	40.67	25.38
Mar	45.60	40.15	45.60	40.15
Apr	44.00	28.01	44.00	28.01
May	41.67	53.26	41.67	53.26
Jun	37.67	42.72	37.67	42.72
Jul	44.00	22.98	44.00	22.98
Aug	44.00	38.60	44.00	38.60
Sep	45.33	48.95	45.37	48.95
Oct	43.67	68.79	43.67	68.79
Nov	41.67	12.19	41.67	19.19
Dec	42.33	44.93	42.33	42.33
TOTAL	528.67	490.12	528.67	487.52

Table 6.15. Annual labor utilization of hired and family labor in man-days under traditional technology and a 20 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	51.77	45.33	65.0	19.33		45.33	11.37	27.08		26.75	
Feb	40.67	76.71	40.67	70.41	40.67	4.98	40.67	59.81	40.67	20.67	40.67	20.05
Mar	45.00	8.142	45.00	66.08	45.00	.66	45.00	71.69	45.00	16.24	45.00	15.72
Apr	44.00	48.51	44.00	14.37	25.86		44.00	28.91	33.61		33.28	
May	41.67	141.62	41.67	128.86	41.67	47.51	41.67	96.19	41.67	66.88	41.67	66.23
Jun	37.67	115.94	37.67	75.05	12.86		37.67	114.69	36.67		35.65	
Jul	44.00	90.14	44.00	51.12	12.86		44.00	85.09	32.50		31.66	
Aug	47.33	61.27	47.33	34.20	37.52		47.33	271.29	47.33	5.61	47.33	5.31
Sep	45.33	12.40	45.33	49.5	37.52		45.33	27.70	40.56		40.43	
Oct	43.67	8.37	43.67		31.19		43.67	10.72	35.91		35.84	
Nov	41.67	8.60	41.67	182.68	41.67	50.82	41.67	12.72	41.67		41.67	
Dec												
TOTAL	476.34	696.75	476.34	634.31	346.15	269.31	495.10	790.27	425.55	109.30	422.86	107.31

Table 6.15 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	27.68		20.14		45.33	6.21	38.61		25.80		40.28	
Feb	40.67	20.87	40.07	12.17	40.67	70.42	40.67	16.76	40.67	17.98	40.67	23.35
Mar	45.00	16.54	45.00	7.84	45.00	65.79	45.00	12.43	45.00	13.65	45.00	21.86
Apr	34.21		26.67		44.00	14.36	44.00		32.34		44.0	
May	41.67	67.26	41.67	56.44	41.67	126.94	41.67	62.14	41.67	63.66	41.67	92.93
Jun	37.67		15.36		37.67	72.05	37.67		32.76		37.67	4.68
Jul	34.01		14.92		44.00	48.84	44.00		29.27		35.58	
Aug	47.33	5.79	44.77	.69	47.33	34.31	47.33	37.73	47.33	20.15	47.33	8.16
Sep	40.80		37.84		45.33	6.17	45.33	50.54	40.06		40.22	
Oct	36.03		34.50		43.67		43.67	45.26	43.67		35.23	
Nov	41.67		41.67		41.67		41.67	125.39	41.67	26.75	41.67	
Dec	2.82		3.59				42.33		12.37		2.97	
TOTAL	429.56	110.46	366.20	77.14	476.34	444.79	511.95	350.25	432.61	142.19	452.79	150.98

Table 6.15 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	40.50		40.29		40.41		40.26		40.15		39.89	
Feb	40.67	21.83	40.67	23.28	40.67	22.46	40.67	23.45	40.67	24.51	40.67	24.80
Mar	45.00	20.44	45.00	21.81	45.00	21.03	45.00	21.96	45.00	23.01	45.00	23.23
Apr	44.00		44.00		44.00		44.00		44.00		44.00	
May	41.67	9.78	41.67	92.88	41.67	92.26	41.67	93.00	41.67	93.84	41.67	94.04
Jun	37.67	2.41	37.67	4.58	37.67	3.36	37.67	4.82	37.67	6.50	37.67	6.83
Jul	33.76		35.51		34.51		35.73		36.66		38.82	
Aug	47.33	7.30	47.33	8.13	47.33	7.66	47.33	8.22	47.33	8.85	47.33	8.98
Sep	39.88		40.21		40.01		40.25		40.42		40.85	
Oct	35.55		35.72		35.62		35.74		35.83		36.06	
Nov	41.67		41.67		41.67		41.67		41.67		41.07	
Dec	3.06		2.97		3.02		2.96		2.92		2.81	
TOTAL	450.76	61.76	452.71	150.48	451.58	146.77	452.95	151.45	453.99	156.77	455.84	157.88

Table 6.15 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	44.20		45.33	6.21
Feb	40.67	18.77	40.67	70.12
Mar	45.00	17.57	45.00	65.79
Apr	44.00		44.00	14.36
May	41.67	89.49	41.67	129.94
Jun	31.55		37.67	72.05
Jul	23.35		44.00	48.84
Aug	47.33	5.56	47.33	34.31
Sep	37.74		45.33	6.17
Oct	34.45		43.67	
Nov	41.67		41.67	
Dec	3.61			
TOTAL	435.24	131.39	476.34	447.79

Table 6.16. Annual labor utilization of hired and family labor in man-days under improved technology and a 20 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	68.45	45.33	68.26	45.33	67.62	45.37	67.40	45.33	67.50	45.33	67.06
Feb	40.67	47.92	40.67	47.72	40.67	47.06	40.67	46.64	40.67	46.93	40.67	46.47
Mar	45.00	47.92	45.00	47.42	45.00	47.06	45.00	46.64	45.00	46.93	45.00	46.47
Apr	44.00	89.47	44.00	89.25	44.00	88.53	44.00	88.08	44.00	88.39	44.00	87.89
May	41.67	50.97	41.67	51.26	41.67	52.28	41.67	52.91	41.67	52.47	41.67	53.17
Jun	37.67	59.24	37.67	57.08	37.67	49.72	37.67	45.14	37.67	48.32	37.67	43.24
Jul	44.00	32.64	44.00	30.96	44.00	25.22	44.00	21.65	44.00	42.13	44.00	20.16
Aug	47.33	33.49	47.33	33.12	47.33	31.84	47.33	31.05	47.33	31.60	47.33	30.71
Sep	45.33	97.01	45.33	97.29	45.33	98.24	45.33	98.83	45.33	98.42	45.33	99.07
Oct	43.67	24.47	43.67	23.91	43.67	22.03	43.67	20.86	43.57	21.67	43.67	20.37
Nov	41.67	71.27	41.67	71.66	41.67	73.03	41.67	73.87	41.67	73.39	41.67	74.22
Dec	42.33	22.13	42.33	21.73	42.33	20.38	42.33	19.54	42.37	20.13	42.37	19.19
TOTAL	528.67	644.98	526.67	639.66	528.67	534.48	528.67	612.61	528.67	619.88	528.67	608.02

Table 6.16 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.37	67.18	45.33	67.10	45.33	67.16	45.33	67.18	45.33	67.04	45.33	66.78
Feb	40.67	46.60	40.67	46.52	40.67	46.57	40.67	46.60	40.67	46.45	40.67	46.18
Mar	45.00	46.60	45.00	46.52	45.00	46.57	45.00	46.60	45.00	46.45	45.00	46.18
Apr	44.00	88.03	44.00	87.94	44.00	88.00	44.00	88.03	44.00	87.86	44.00	87.57
May	41.67	52.98	41.67	53.10	41.67	53.01	41.67	52.98	41.67	53.20	41.67	53.61
Jun	37.67	44.64	37.07	43.74	37.67	44.38	37.67	44.64	37.67	42.98	37.67	40.06
Jul	44.00	21.26	44.00	20.56	44.00	21.06	44.00	21.26	44.00	19.97	44.00	17.69
Aug	47.33	30.96	47.33	30.81	47.33	30.92	47.33	30.96	47.33	30.68	47.33	30.17
Sep	45.33	98.89	45.32	99.01	45.33	98.93	45.33	98.89	45.33	99.11	45.33	99.49
Oct	43.67	20.73	43.67	20.50	43.67	20.66	43.67	20.73	43.07	20.31	43.67	19.56
Nov	41.67	73.97	41.67	74.13	41.67	74.01	41.67	73.97	41.67	74.28	41.67	74.81
Dec	42.37	19.47	42.37	19.29	42.37	19.40	42.37	19.45	42.37	19.15	42.37	18.61
TOTAL	528.67	611.31	528.67	610.22	528.67	610.67	528.67	590.56	528.67	607.48	528.67	600.71

Table 6.16 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	66.84	45.33	67.61	45.33	65.30	45.33	66.73	45.33	67.72	45.33	67.50
Feb	40.67	46.24	40.67	47.05	40.67	44.63	40.67	46.13	40.67	47.16	40.67	46.93
Mar	45.00	46.64	45.00	47.05	45.00	44.63	45.00	46.13	45.00	47.16	45.00	46.93
Apr	44.00	87.64	44.00	88.51	44.00	88.89	44.00	87.52	44.00	88.64	44.00	88.39
May	41.67	53.52	41.67	52.29	41.67	55.97	41.67	53.70	41.67	52.12	41.67	52.47
Jun	32.67	40.70	37.67	49.59	37.07	22.92	37.67	39.43	37.67	50.85	37.67	48.32
Jul	44.00	18.19	44.00	25.12	44.00	4.33	44.00	17.20	44.00	26.10	44.00	24.13
Aug	47.33	30.28	47.33	31.82	47.33	27.20	47.33	30.06	47.33	32.04	47.33	31.60
Sep	45.33	99.40	45.33	98.26	45.33	1.70	45.33	99.57	45.33	98.10	45.33	98.42
Oct	43.67	19.72	43.67	21.99	47.67	15.17	43.67	19.40	43.67	22.52	43.67	21.67
Nov	41.67	74.70	41.67	73.05	41.67	77.99	41.67	74.94	41.67	72.81	41.67	73.29
Dec	42.37	18.73	42.37	20.36	42.37	15.47	42.32	18.50	42.33	20.59	42.33	20.13
TOTAL	528.67	602.60	528.67	622.70	528.67	461.23	528.67	599.31	528.67	625.61	528.67	619.78

Table 6.16 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	45.33	67.10	45.33	67.72
Feb	40.67	46.52	40.67	47.16
Mar	45.00	36.52	45.00	47.16
Apr	44.00	87.94	44.00	88.64
May	41.67	53.10	41.67	52.12
Jun	37.67	43.74	37.07	50.85
Jul	44.00	20.56	44.00	26.10
Aug	47.33	30.81	47.33	32.04
Sep	45.32	99.01	45.33	98.10
Oct	47.67	20.50	43.67	22.32
Nov	41.67	74.13	41.67	72.81
Dec	47.33	19.29	42.33	20.59
TOTAL	528.67	582.22	528.67	635.61

Table 6.17. Annual labor utilization of hired and family labor in man-days under traditional technology and a 25 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	65.04	45.33	6.50	19.33		45.33	11.37	27.09		26.70	
Feb	40.67	96.37	40.67	70.41	40.67	4.98	40.67	59.81	40.67	20.05	40.67	20.05
Mar	45.00	102.30	45.00	66.08	45.00	.66	45.00	71.69	45.00	15.72	45.00	15.72
Apr	44.00	60.95	44.00	14.37	25.86		44.00	28.91	33.62		33.23	
May	41.67	177.94	41.67	128.86	41.67	47.51	41.67	96.19	41.67	66.23	41.67	66.23
Jun	37.67	145.67	37.67	75.05	12.86		37.67	114.69	36.69		35.51	
Jul	44.00	113.25	44.00	51.21	12.86		44.00	85.09	32.51		31.54	
Aug	40.06	76.99	40.00	34.20	37.52		42.33	271.29	47.33	5.31	47.33	5.31
Sep	45.33	15.57	45.33	4.95	37.52		45.33	27.70	40.57		40.42	
Oct	43.67	10.52	43.67		31.19		43.67	10.72	35.91		35.83	
Nov	41.67	10.81	41.67	182.68	41.67	434.37	41.67	12.72	2.88		41.67	
Dec							18.75				2.92	
TOTAL	469.07	875.38	469.07	634.31	333.29	487.52	490.09	470.27	383.94	107.31	422.49	107.31

Table 6.17 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	27.98		19.33		45.33	6.21	45.33		25.80		40.28	
Feb	40.67	20.87	40.67	12.17	40.67	70.12	40.67	16.76	40.67	17.98	40.67	23.35
Mar	45.00	16.54	45.00	7.84	45.00	65.79	45.00	12.43	45.00	13.65	45.00	21.86
Apr	34.51		25.86		44.00	14.36	44.00		32.34		44.00	
May	41.67	67.26	41.67	56.44	41.67	126.94	41.67	62.14	41.67	63.66	41.67	92.93
Jun	37.67		12.86		37.67	72.05	37.67		32.76		37.67	4.68
Jul	34.77		12.86		44.00	48.84	44.00		29.27		35.58	
Aug	47.33	5.79	37.52	.69	47.33	34.31	47.33	313.88	47.33	20.15	47.33	8.16
Sep	40.92		37.52		45.33	6.17	45.33	50.54	40.06		40.22	
Oct	36.09		31.19		43.67		43.67	45.26	43.67		35.73	
Nov	46.67		26.81		41.67		41.67	25.39	41.67	26.75	41.67	
Dec	2.79						40.26		12.37		2.92	
TOTAL	431.07	110.46	331.29	77.14	476.34	444.77	516.60	546.40	432.61	142.19	452.74	150.98

Table 6.17 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	40.50		40.29		40.41		40.26		40.17		39.82	
Feb	40.67	21.83	40.67	23.28	40.67	22.46	40.67	23.45	40.67	24.57	40.67	24.80
Mar	45.00	20.44	45.00	21.81	45.00	21.03	45.00	21.96	45.00	23.01	45.00	23.23
Apr	44.00		44.00		44.00		44.00		44.00		44.00	
May	41.67	9.78	41.67	92.88	41.67	92.26	41.67	93.00	41.67	93.84	41.67	94.04
Jun	37.67	2.41	37.67	4.58	37.67	3.36	37.67	4.82	37.67	6.50	37.67	6.83
Jul	33.77		34.52		34.52		35.75		36.55		39.39	
Aug	47.33	7.30	47.33	8.13	47.33	7.66	47.33	8.22	47.33	8.85	47.33	8.98
Sep	39.88		40.02		40.02		40.25		40.40		40.96	
Oct	35.55		35.62		35.62		35.75		35.82		36.11	
Nov	41.67		41.67		41.67		41.67		41.67		41.67	
Dec	3.06		3.02		3.02		2.96		2.92		2.78	
TOTAL	450.77	61.76	451.48	150.68	409.93	146.77	452.98	151.45	453.87	156.77	457.07	157.88

Table 6.17 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	32.76		45.33	6.21
Feb	40.67	18.77	40.67	70.12
Mar	45.00	17.57	45.00	65.79
Apr	36.61		44.00	14.36
May	41.67	89.49	41.67	129.94
Jun	22.27		37.67	72.05
Jul	17.90		44.00	48.84
Aug	41.56	5.56	27.33	34.31
Sep	37.52		45.33	6.17
Oct	31.20		43.67	
Nov	31.20		41.67	
Dec				
TOTAL	378.17	131.39	476.34	447.79

Table 6.18. Annual labor utilization of hired and family labor in man-days under improved technology and a 25 acre annual revolving land base

Month	1		2		3		4		5		6	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	68.45	45.33	68.26	45.33	67.62	45.33	67.22	45.33	67.50	45.33	67.06
Feb	40.67	47.92	40.67	47.72	40.67	47.06	40.67	46.64	40.67	46.93	40.67	46.47
Mar	45.00	47.92	45.00	47.72	45.00	47.06	45.00	46.64	45.00	46.93	45.00	46.47
Apr	44.00	89.47	44.00	89.25	44.00	88.53	44.00	88.08	44.00	88.39	44.00	87.89
May	41.67	50.97	41.67	51.26	41.67	52.28	41.67	52.91	41.67	52.42	41.67	53.17
Jun	37.67	59.24	37.67	57.08	37.67	49.72	37.67	45.14	37.67	48.32	37.67	43.24
Jul	44.00	32.64	44.00	30.96	44.00	25.22	44.00	21.65	44.00	24.13	44.00	20.16
Aug	47.33	33.49	47.33	33.12	47.33	31.84	47.33	31.05	47.33	31.60	47.33	30.71
Sep	45.33	97.01	45.33	97.29	45.33	98.24	45.33	98.83	45.33	98.42	45.33	99.07
Oct	43.67	24.47	43.67	23.91	43.67	22.03	43.67	20.86	43.67	21.67	43.67	20.37
Nov	41.67	71.27	41.67	71.66	41.67	73.03	41.67	73.87	41.67	73.29	41.67	74.22
Dec	42.33	22.13	42.33	21.73	42.33	20.38	42.33	19.54	42.37	20.13	42.33	19.19
TOTAL	528.67	622.85	528.67	639.96	528.67	622.96	528.67	612.43	528.67	619.78	528.67	608.02

Table 6.18 (Continued)

Month	7		8		9		10		11		12	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	67.06	45.33	67.18	45.33	67.10	45.33	67.16	45.33	67.18	45.33	67.04
Feb	40.67	46.47	40.67	46.60	40.67	46.52	40.67	46.57	40.67	46.60	40.67	46.45
Mar	45.00	46.47	45.00	46.60	45.00	46.52	45.00	46.57	45.00	46.80	45.00	46.45
Apr	44.00	87.89	44.00	88.03	44.00	87.94	44.00	88.00	44.00	88.03	44.00	87.86
May	41.67	53.17	41.67	52.98	41.67	53.10	41.67	53.01	41.67	52.98	41.67	53.20
Jun	37.67	43.24	37.67	44.64	37.67	43.74	37.67	44.38	37.67	44.64	37.67	42.98
Jul	44.00	20.16	44.00	21.26	44.00	20.56	44.00	21.06	44.00	21.26	44.00	19.97
Aug	47.33	30.71	47.33	30.96	47.33	30.81	47.33	30.92	47.33	30.96	47.33	30.68
Sep	45.33	99.07	45.33	98.89	45.33	99.01	45.33	98.93	45.33	98.89	45.33	99.11
Oct	43.67	20.37	43.67	20.73	43.67	20.50	43.67	20.66	43.67	20.73	43.67	20.31
Nov	41.67	74.22	41.67	73.97	41.67	74.13	41.67	74.01	41.67	73.97	41.67	74.28
Dec	42.33	19.19	42.33	19.45	42.33	19.29	42.33	19.40	42.33	19.45	42.33	19.15
TOTAL	528.67	608.02	528.67	611.29	528.67	609.22	528.67	610.67	528.67	611.29	528.67	607.48

Table 6.18 (Continued)

Month	13		14		15		16		17		18	
	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir	Fam	Hir
Jan	45.33	66.78	45.33	66.84	45.33	67.61	45.33	65.30	45.33	66.73	45.33	67.72
Feb	40.67	46.18	40.67	46.24	40.67	47.05	40.67	44.63	40.67	46.13	40.67	47.16
Mar	45.00	46.18	45.00	46.24	45.00	47.05	45.00	44.63	45.00	46.13	45.00	47.16
Apr	44.00	87.57	44.00	87.64	44.00	88.51	44.00	85.87	44.00	87.52	44.00	88.64
May	41.67	53.61	41.67	53.52	41.67	52.29	41.67	55.97	41.67	53.70	41.67	52.12
Jun	37.67	40.06	37.67	40.70	37.67	49.59	37.67	22.92	37.67	39.43	37.67	50.85
Jul	44.00	17.69	44.00	18.19	44.00	25.12	44.00	4.33	44.00	17.20	44.00	26.10
Aug	47.33	30.17	47.33	30.28	47.33	31.82	47.33	23.20	47.33	30.06	47.33	32.04
Sep	45.33	99.49	45.33	99.40	45.33	98.26	45.33	91.70	45.33	99.57	45.33	98.10
Oct	43.67	19.56	43.67	19.72	43.67	21.99	43.67	15.17	43.67	19.40	43.67	22.32
Nov	41.67	74.81	41.67	74.70	41.67	73.05	41.67	77.99	41.67	74.94	41.67	72.81
Dec	42.33	18.61	42.37	18.73	42.33	20.36	42.33	15.47	42.33	18.50	42.33	20.69
TOTAL	528.67	582.10	528.67	602.20	528.67	622.70	528.67	551.20	528.67	599.31	528.67	625.71

Table 6.18 (Continued)

Month	19		20	
	Fam	Hir	Fam	Hir
Jan	45.33	67.50	45.33	67.10
Feb	40.67	46.93	40.67	46.52
Mar	45.00	46.93	45.00	46.52
Apr	44.00	88.39	44.00	87.94
May	41.67	52.47	41.67	53.10
Jun	37.67	48.32	37.67	43.74
Jul	44.00	24.13	44.00	20.56
Aug	47.33	31.60	47.33	30.81
Sep	45.33	98.42	45.37	99.01
Oct	43.67	21.67	43.67	20.50
Nov	41.67	73.29	41.67	74.13
Dec	47.33	20.13	47.33	19.29
TOTAL	528.67	619.78	528.67	609.02

Table 6.19. Annual net benefits under alternate annual revolving land resource base in traditional and improved technology

Periods	5 acres		10 acres		15 acres		20 acres		25 acres	
	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp	Tra	Imp
1	100.10	301.01	185.10	480.10	199.20	500.10	201.35	750.10	380.10	980.22
2	351.46	492.11	489.96	513.10	434.37	525.12	489.96	800.10	489.96	955.16
3	150.11	435.00	195.00	510.00	250.10	612.10	448.00	900.11	489.60	1020.50
4	351.49	500.00	473.74	503.10	473.73	583.73	473.72	903.53	473.72	1025.26
5	338.20	412.00	479.97	512.07	480.04	590.20	480.15	904.26	480.15	1126.31
6	344.92	450.11	477.83	511.00	477.34	578.12	476.59	890.25	476.59	1421.19
7	341.85	431.17	478.88	515.10	482.27	582.31	486.82	895.11	486.82	1326.26
8	342.39	413.11	455.96	513.10	432.72	560.11	399.87	960.25	399.87	1435.11
9	3.62	405.11	5.68	461.17	6.46	613.20	7.50	975.33	7.50	1326.25
10	351.55	471.16	351.55	480.10	459.31	538.11	460.17	945.23	460.11	1141.11
11	355.91	450.11	355.91	490.20	480.39	591.62	481.39	973.45	481.39	1242.11
12	338.45	480.11	479.05	510.10	480.21	591.72	480.50	950.44	480.50	1425.11
13	344.31	461.11	472.57	513.00	473.42	573.26	473.61	973.11	473.61	1145.26
14	340.55	412.00	478.52	514.10	479.54	590.63	479.80	983.22	479.80	1143.28
15	343.53	475.00	474.81	577.12	475.67	573.45	475.83	995.11	473.83	1142.16
16	341.09	385.12	479.86	480.12	480.92	593.10	481.35	956.23	481.35	1213.25
17	344.09	490.17	487.74	489.12	487.42	595.16	486.29	908.33	486.29	1217.26
18	344.69	480.11	479.40	500.12	486.47	599.10	493.09	916.22	493.09	1141.16
19	342.87	391.10	491.20	580.11	456.68	600.91	422.02	1165.11	422.02	1050.11
20	485.17	812.11	723.54	912.11	899.63	970.12	1045.25	1165.55	1045.25	1546.41
TOTAL	6256.35	9157.60	8516.27	10664.94	8895.89	11962.17	9243.26	17954.70	9461.55	25048.68

under 15.48 acre farm thus increasing the home consumed goods, which have an effect of lowering the net benefit generated under this acreage level.

Under the 15, 20 and 25 acre revolving acreage levels farm net benefits are ₦440.79, ₦462.16 and ₦473.08 respectively. The acreages devoted to food crop production under the different revolving acreage levels of 5, 10, 15, 20 and 25 are 4.86, 9.40, 10.25, 10.78 and 11.49 acres respectively (Table 6.1).

These food crops generate revenue on an annual basis and provide annual income for the farming unit. An examination of annual benefits generated under traditional technologies as shown in Figures 6.1-6.6, shows a drop in annual net benefit in period 9. This appears to result from: (1) capital lending and borrowing activities, (2) consumption component, and (3) initiation of new investment.

The farming unit borrows funds for production and investment purposes. In period 9, it can be observed that it is a year during which new investments in tree crops are initiated. It is also a year in which most of the revolving acreage is used for production of food crops. As food crop acreages increase and the amounts allocated to yams and cassava increase, home consumption of food crops

Figure 6.1. Annual net benefits under 5 acre annual revolving acreage under traditional and improved technologies

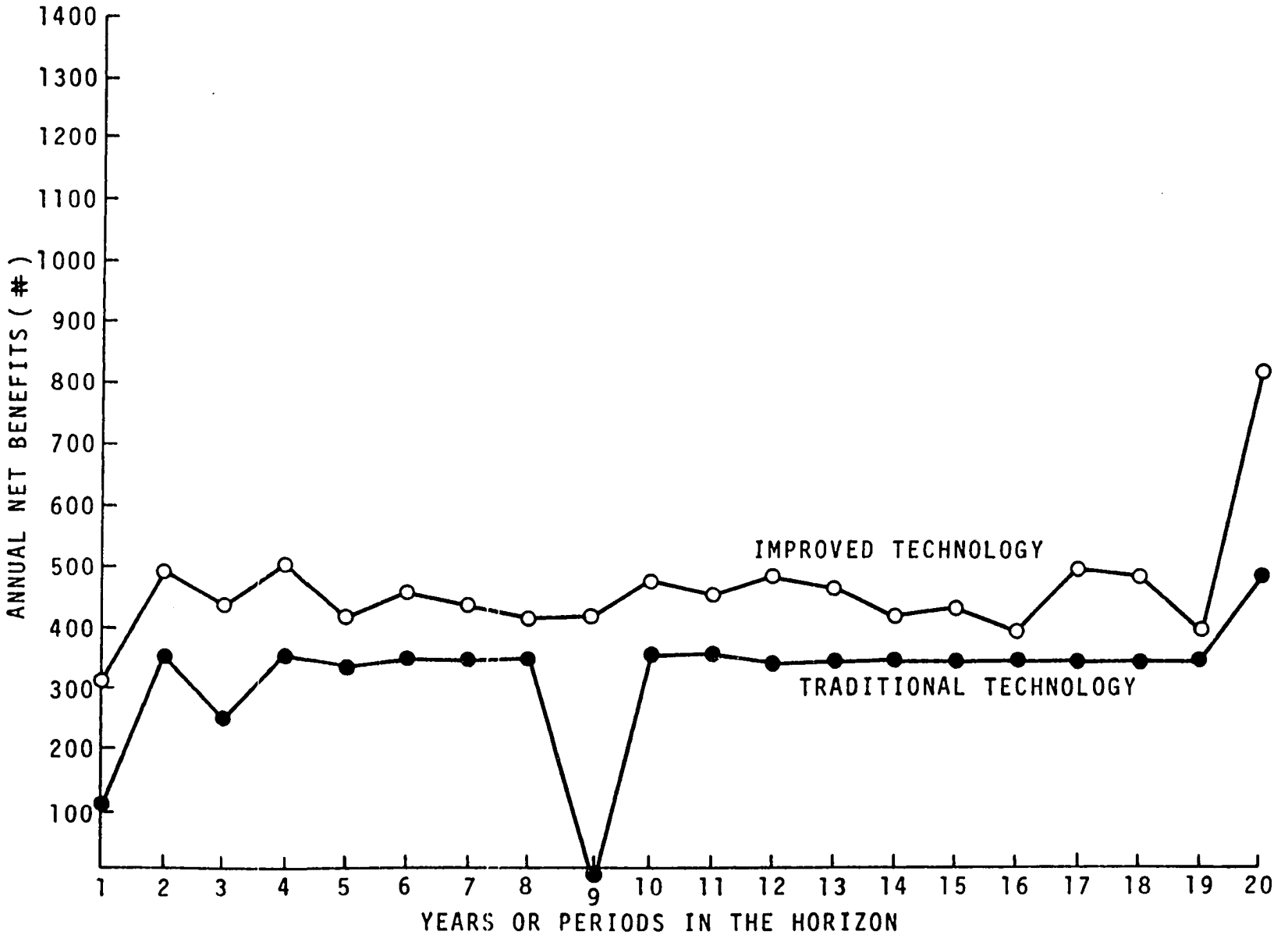

ANNUAL NET BENEFITS (#)
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
IMPROVED TECHNOLOGY
TRADITIONAL TECHNOLOGY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEARS OR PERIODS IN THE HORIZON

Figure 6.2. Annual net benefits under 10 acre annual revolving acreage under traditional and improved technologies

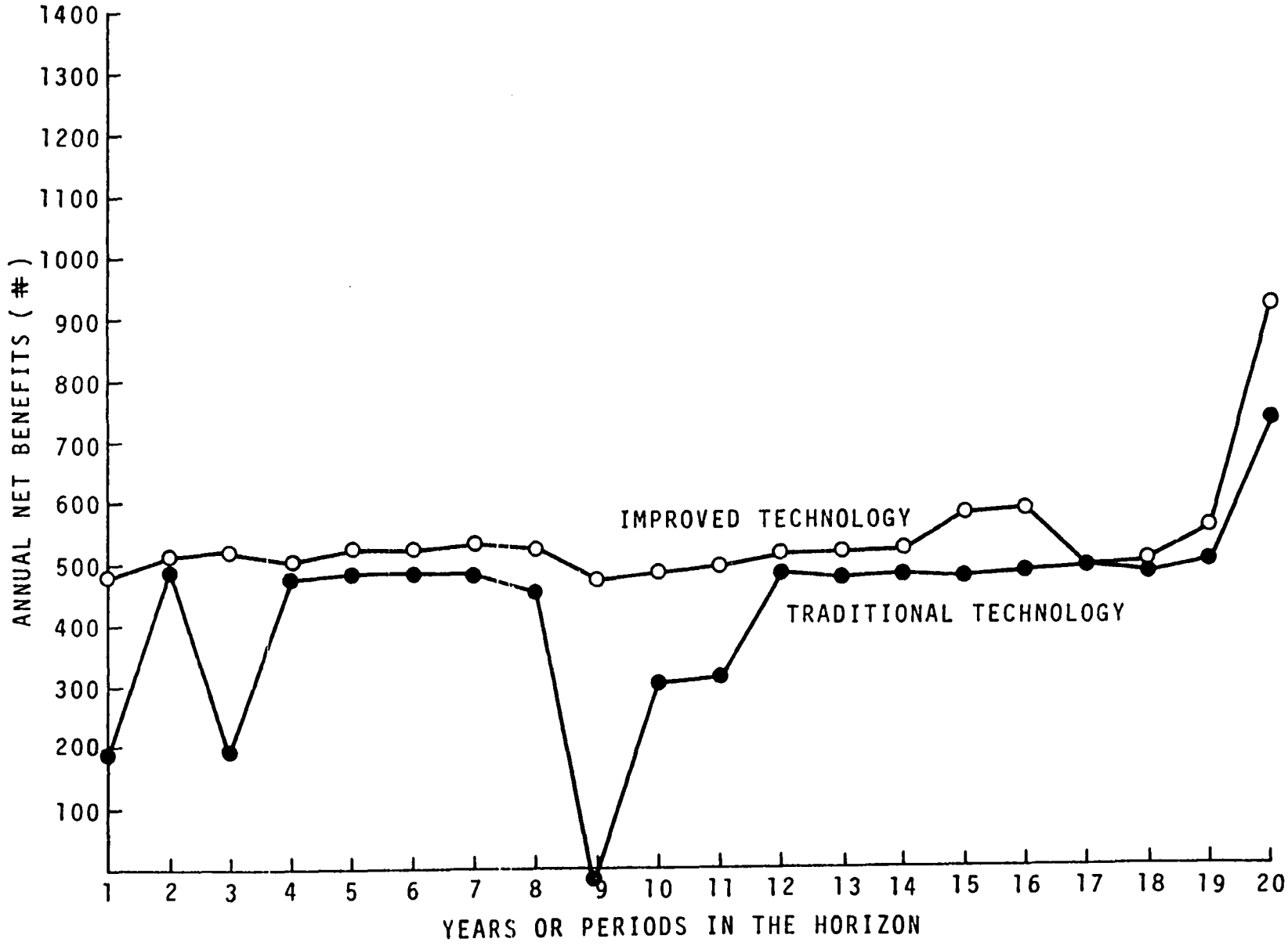

ANNUAL NET BENEFITS (#)
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
IMPROVED TECHNOLOGY
TRADITIONAL TECHNOLOGY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEARS OR PERIODS IN THE HORIZON

Figure 6.3. Annual net benefits under 15 acre annual revolving acreage (traditional and improved technologies)

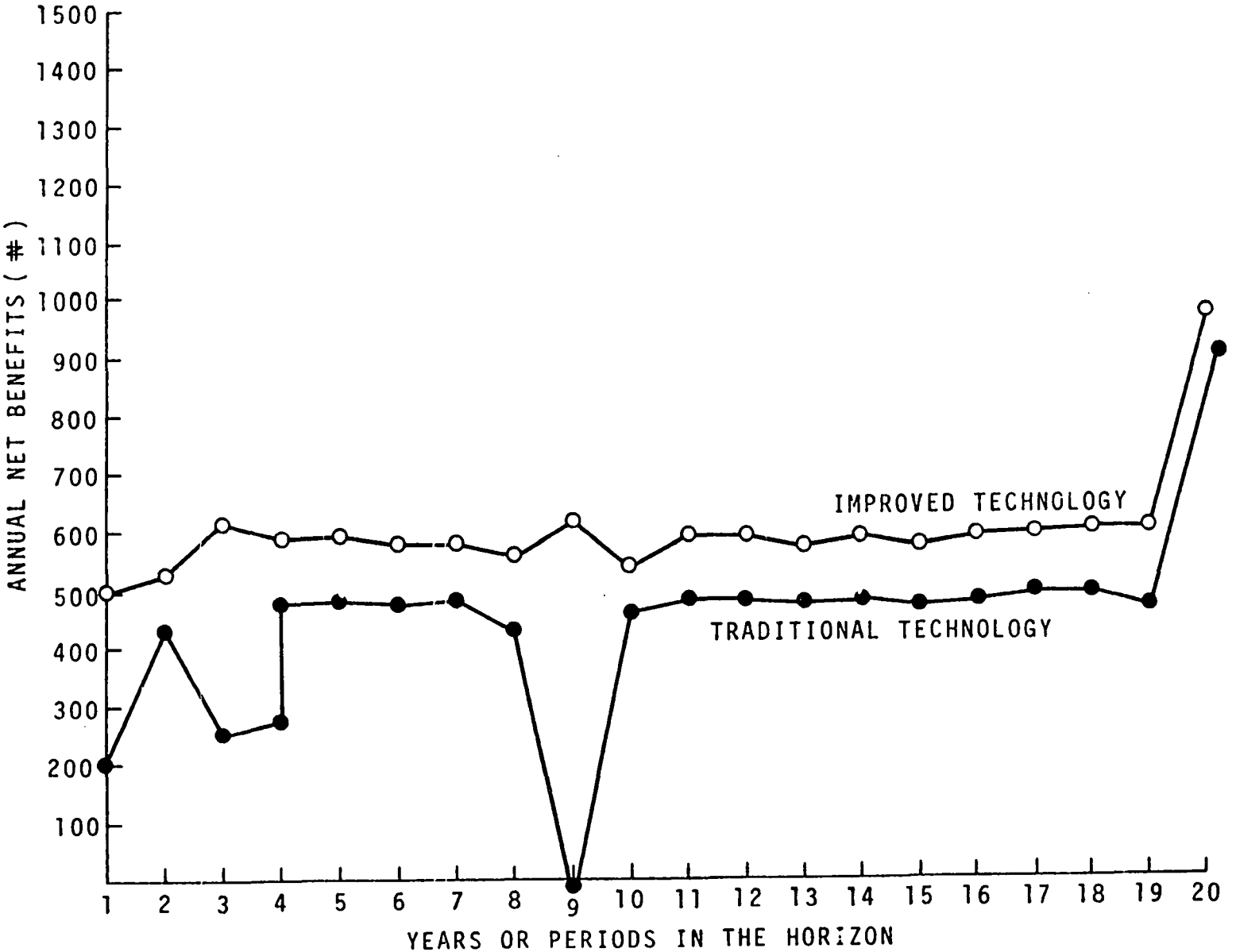

ANNUAL NET BENEFITS (#)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
IMPROVED TECHNOLOGY
TRADITIONAL TECHNOLOGY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEARS OR PERIODS IN THE HORIZON

Figure 6.4. Annual net benefits under 20 acre annual revolving acreage under traditional and improved technologies

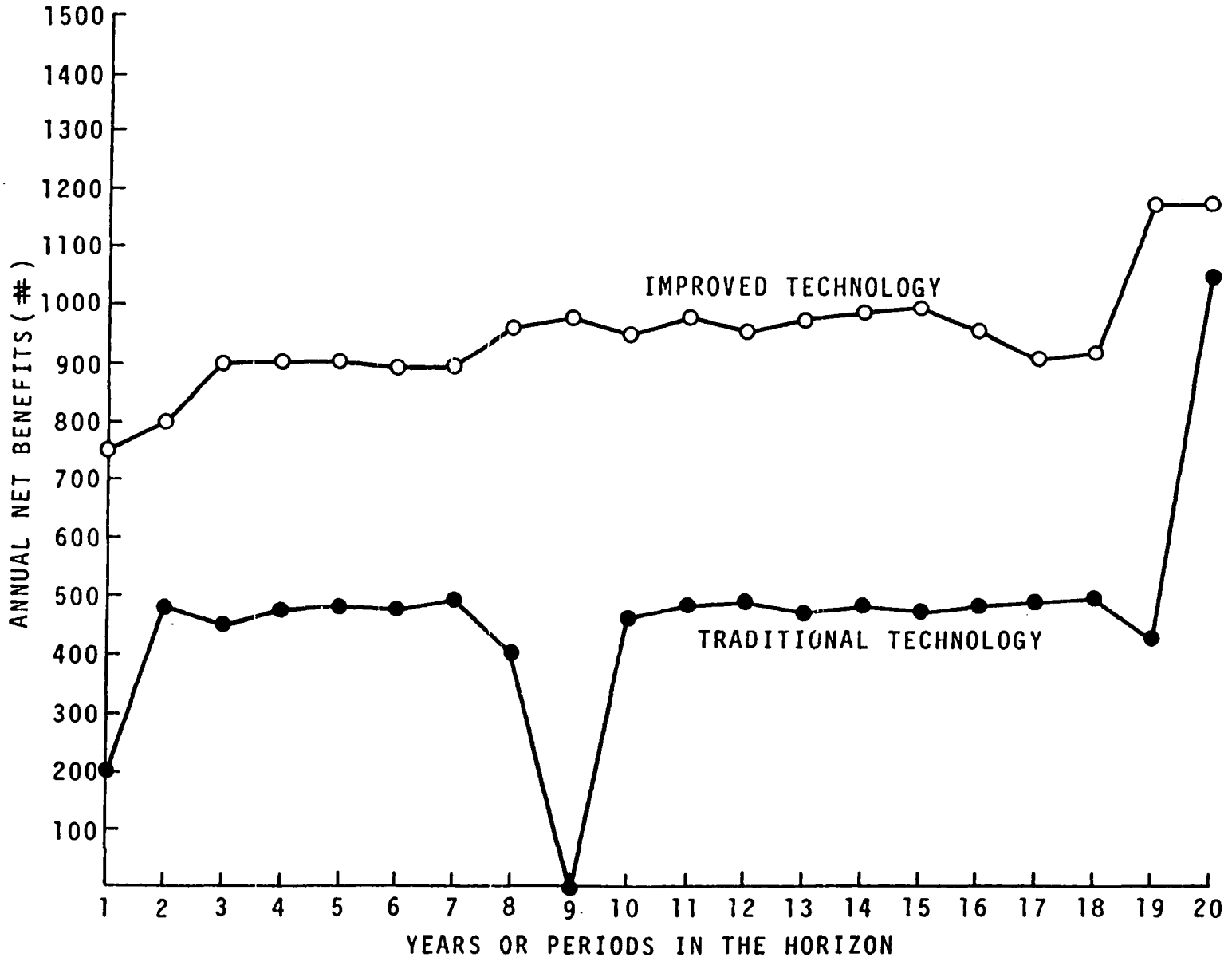
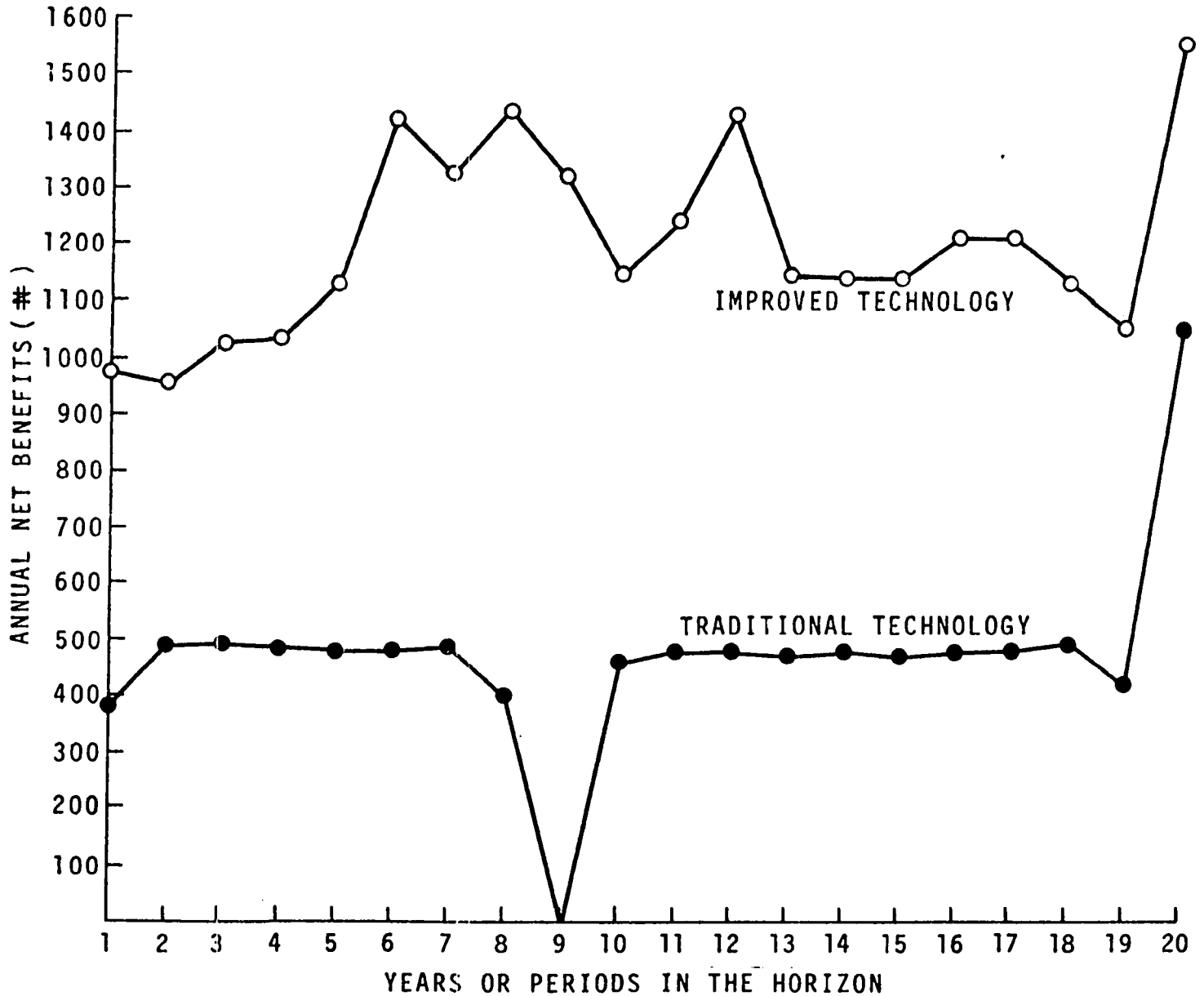

ANNUAL NET BENEFITS (#)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
IMPROVED TECHNOLOGY
TRADITIONAL TECHNOLOGY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEARS OR PERIODS IN THE HORIZON

Figure 6.5. Annual net benefits under 25 acre annual revolving acreage (traditional and improved technologies)


ANNUAL NET BENEFITS (#)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
IMPROVED TECHNOLOGY
TRADITIONAL TECHNOLOGY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEARS OR PERIODS IN THE HORIZON

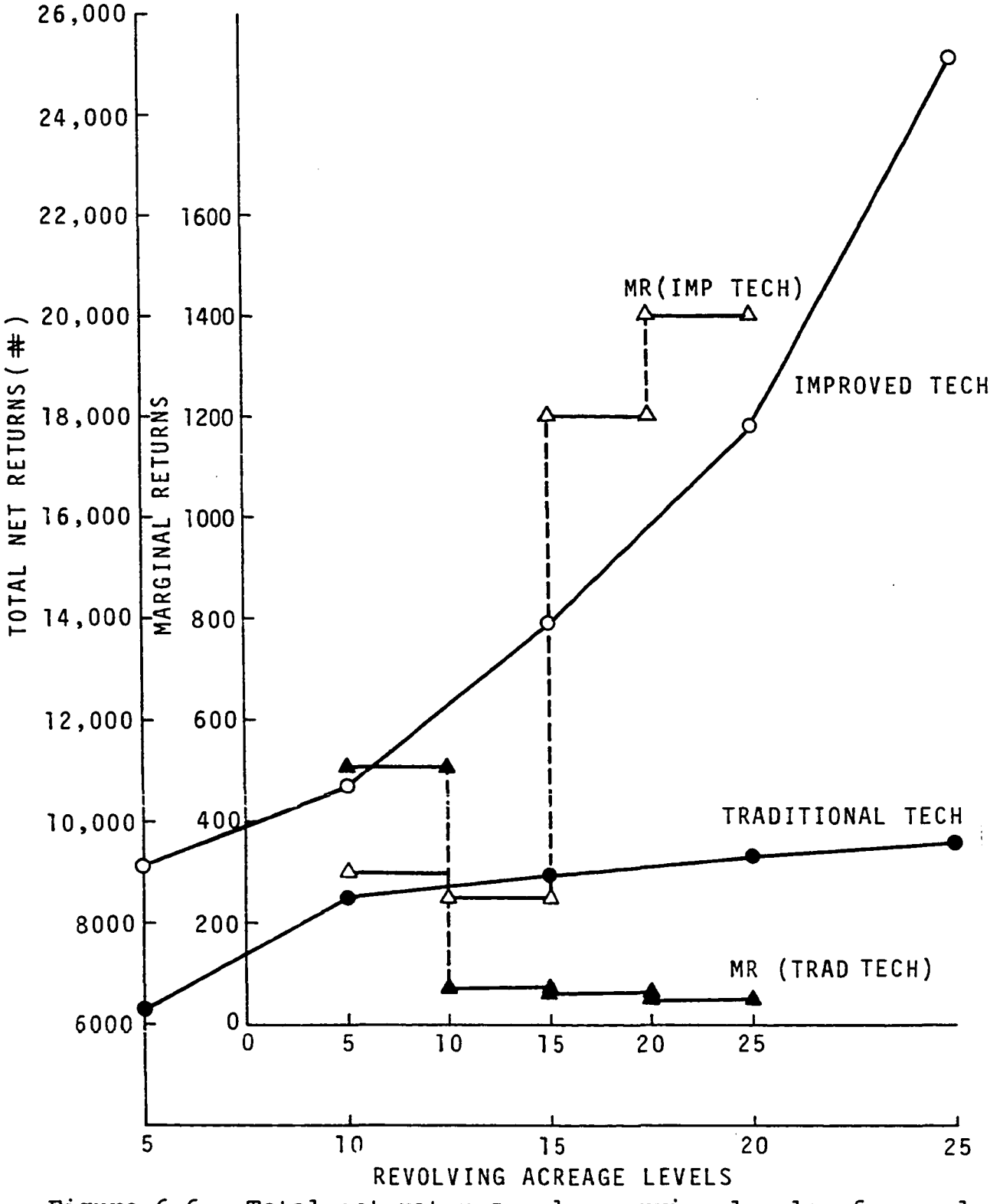


Figure 6.6. Total net returns under varying levels of annual revolving acreages under traditional and improved technologies

increases. The investment, the home consumption component and the payment of borrowed funds all have a downward effect on the annual net benefits generated. A basic question readily comes to mind, why does not this downward effect become expressed in later periods of the planning horizon? The reason for this is that, although investment, consumption and borrowings are taking place, there are added activities in these later periods. Investments made in earlier periods start to yield substantial returns which helps to increase the annual net benefits generated in these later periods.

In Table 6.8 a comparison is made of the labor and land productivities. Productivity is hereby defined as the net benefit derived per unit of land or labor resource. These measures serve a useful purpose in comparative analysis.

Labor productivity is estimated at ₦.787/man-day under the 5 acre revolving land base assumption. It remains constant through the 10, 15, 20 and 25 acre revolving land base. Actual farm sizes under these assumptions are 7.84, 15.48, 32.05, 46.44 and 50.70 acres respectively. Labor productivity is highest on 7.84 acre farm remains approximately the same between 15.48 to 50.70 acres.

In terms of land productivity on a per acre basis, the values are ₦39.90, ₦27.51, ₦13.75, ₦9.95 and ₦9.93.

Productivity per acre of land used is also highest on the 7.84 acre farm and decreases as farm sizes increase.

In terms of resource use, the smallest farms, apparently used labor and land most effectively. The 7.84 acre farm falls within the intermediate farm size within the study area. In the study are farm sizes between 6-12 acres are classified as medium sized farms.

The same Table 6.8 shows: 1) the average annual usage of both family and hired labor, 2) the average total labor requirement, and 3) the average annual net benefits. The average labor use is 397.44 man-days for 7.54 acres of farm size. It is 651.02 man-days for 15.48 acres and 670.22, 709.43 and 730.89 man-days for 32.05, 46.44 and 50.70 acre farms respectively. As farm size increases, the total amount of labor utilized increases. However, on a per acre basis the labor utilization of smaller farms is higher. It is 50.69, 42.06, 20.92, 15.30 and 14.42 man-days per acre for 7.84, 15.48, 32.05, 46.44, and 50.70 acre farms respectively. Smaller farms under the assumptions of the submodels A11, A12, A13, A14 and A15 are more productive in terms of labor and land usage. If, the aggregate labor usage is used as a proxy for labor employment indications are that in terms of net benefits, it is better to have two 7.84 acre farms than one single 15.68 acre farm. The

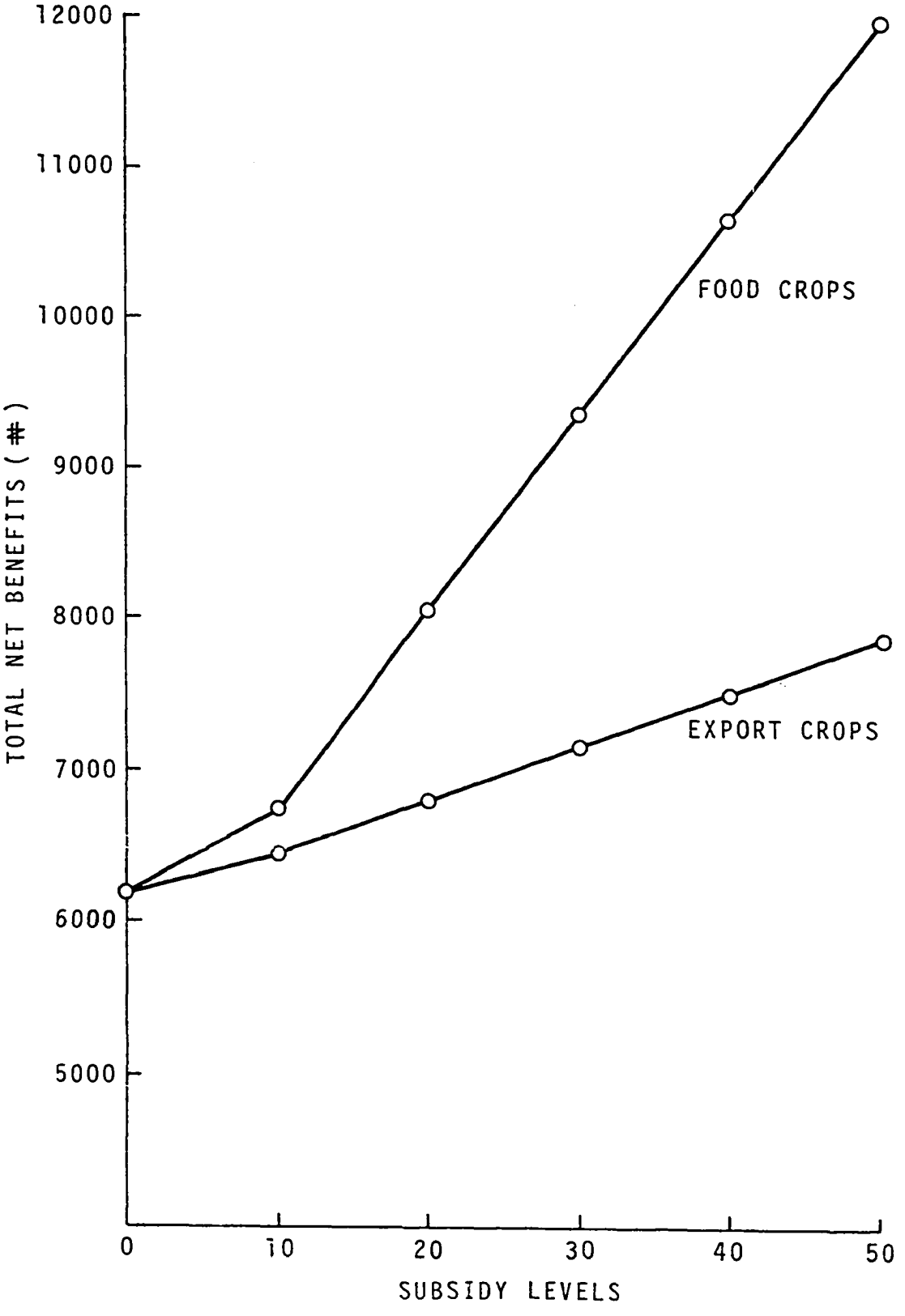
net benefits from these two 7.84 acre farms, the employment as defined by total labor usage and the productivity of labor and land usage are higher than from a single 15.68 acre farm. This result has implications for structural adjustment.

The results of the price policy analysis also indicates that the aggregate subsidy of food crops is superior to aggregate price support on export crops in terms of income generation (Figure 6.7). However, this result might have been due to the price structure of food and export crops in the region. The export crops have been relied upon by the government as a source of revenue. Thus, the prices paid to the farmers does not reflect the world price of these crops. If taxes on these crops are reduced, the result of the model under the aggregate support program might well differ from those shown in Figure 6.7.

The prices of food crop products included in the study have experienced increases since the Udoji wage increase. This inflationary trend, reflected in the price coefficients for food crops might have exaggerated their potentials in generating higher revenues.

The basic implication of the results under the assumptions of the model B1, is that if improvement in incomes of the farmers is the basic goal, a short-run policy of a

Figure 6.7. Total net benefits under different levels of export and food crop support levels under traditional technologies


12000
11000
10000
9000
8000
7000
6000
5000
TOTAL NET BENEFITS (#)
FOOD CROPS
EXPORT CROPS
0
10
20
30
40
50
SUBSIDY LEVELS

price support on food crops might be a feasible alternative. Adjustment in the pricing structure of export crops could also be considered. Price increases or increases in support levels could help increase the incomes of farmers that engage in export crop production. This could be considered a short-run policy alternative. A long-run policy consisting of developing improved planting materials, information management and the introduction of supplementary enterprises would appear warranted.

C. Results under Improved Technology

Contrary to the results under traditional technology where farm sizes change under the different revolving acreage assumption, farm sizes under the improved technology seems to stay constant at the revolving acreage levels. This implies that farm sizes are fixed and therefore no adjustment in the tenure structure such as bringing in new fallow land from the communal land pool takes place.

Cassava and yam form the on-farm consumption component in the model. If yam is not produced, cassava serves as the main source of food consumption. The elimination of yam and the increased production of cassava-melon is probably the reason why net benefits increased substantially on the

20 and 25 acre assumption. Annual net benefits under 5, 10, 15, 20 and 25 acre farms are ₦457.88, ₦533.25, ₦598.10, ₦897.24 and ₦1252.43 respectively.

Labor utilization on an annual basis for the five size groups averages 720.90, 795.20, 990.08, 1138.46 and 1238.46 man-days respectively. Differences in labor usage are a result of differences in farm size and enterprise combination. Therefore, according to these data, a 25 acre farm would provide employment of 1238 man-days as compared with 795.20 man-days from 10 acres. In terms of employment in the agricultural sector, smaller farm sizes seems preferable to a single large farm size.

If the problem of underemployment of family labor is the goal however, as farm size is increased, there is a greater utilization of available family labor. The problem with smaller sizes of farms is that aggregate incomes from agriculture in the study area will increase due to smaller size but this does not eliminate the problem of aggregate family labor under utilization. However, other policy measures such as the introduction of supplementary enterprises may help eliminate the underutilization of family labor. The amount a farmer can produce from a single enterprise is limited by his supply of resources.

When the supply of one of these resources is in full

use the farmer cannot produce any more of that enterprise. However, he may be able to introduce supplementary enterprises without additional land. For example, a farmer may have used all his land to grow a certain crop. He may be able to intercrop between rows of his main crop or to raise poultry without needing any extra land. Introduction of supplementary enterprises such as poultry could help increase the use of owned family labor.

The comparison of the productivity measures defined earlier shows some inconsistency. Labor productivity is highest on the 25 acre farm at ₦1.1 per man-day. The 20 acre farm has a labor productivity of ₦.78 while under the remaining acreage levels labor productivity is relatively stable. The average returns per acre used is also higher under large farm sizes. This apparent inconsistency results due to a shift from yam, cassava and cassava-melon combination to cassava-melon and cassava, thus eliminating one of the on-farm consumed good. Consumption of on-farm goods is highest at the 15 acre revolving acreage level. It is lower at 20 and 25 acres due to the elimination of yam from the enterprise combination. Net benefits from allocation of resources to cassava-melon revealed a rapid increase in the net benefits as farm size moves from 15 to 20 acres and from 20 to 25 acres. This is why the

productivity ratios as defined earlier increases in moving from 15 to 20 and 20 to 25 acres.

Thus under improved technology, there is an increase in the utilization of available family labor which reduces underutilization of family labor accompanied by increases in incomes as the revolving acreage level increases. However, the goal of increased employment, as defined by total labor usage on farms, the increase in aggregate income from agriculture may be achieved by limiting farm sizes to smaller acreage levels rather than having single large farms.

D. Implications of Technology

Results generated by the models should be interpreted with caution, but they seem to indicate certain directions in terms of various agricultural policies. Greater farm productivity through improved allocation of agricultural resources are part of the goals of agricultural development. The co-ordination of related activities and the achievement of desirable goals may be realized through an integrated system of micro and macro planning. Amongst some of the goals of the government are: 1) an increase in incomes of farmers in the area and 2) technological progress in the area of agriculture.

Higher average annual benefits appear generated under improved technology. There is an improvement in utilization of farm family labor as increases in sizes of farms take place under improved technology. If, however, the goal is purely that of aggregate employment of available labor force, smaller farm size per farm family appears superior to fewer large farms.

Traditional technology, to be productive over time necessitates increase in farm size. The most productive in terms of returns per unit of labor and per acre are those that fall within the medium sized farms in the study area.

It appears that the goal of developing the new technologies alone will not solve the problem of the agricultural sector of Nigeria. It has also been observed that most of the available technologies referred to in the study are not being used by the farmers in the study area. Some of the failures of the nonadoption of these technologies have been attributed to the isolation of the scientist from the problem situations facing the farmers. Thus, the scientist may be developing new technologies which are not necessarily adaptable to farm situations. Also, government backup policies to make the adoption of new technologies feasible, are sometimes not provided. In the next chapter, discussion is made of how to identify and implement a policy on technological progress in the study area. This however is

based on the premise that there is need for technological progress coupled with other government policies in order for the agricultural sector to be made more productive.

VII. POLICIES RELATED TO RESULTS

A. Identifying, Formulating and Implementing a Policy on Agricultural Technology

Consideration is given here, for the basis of formulating an adequate policy of technological transfer in the study area. It is assumed therefore that the goal of technological transfer is a goal assumed desirable for enhancing the productivity of the agricultural sector.

In summary, the agricultural sector of Nigeria is characterized by low productivity and those that engage in this sector constitutes about 70 percent and are generally poor. Problems faced include low productivity, high and increasing unemployment, inadequate food supplies, serious malnutritional problems, widespread ill health and low rates of literacy. Underlying these problems are:

1. The current distribution of income which prevents the rural poor from gaining access to modern technologies which could increase their incomes.

2. Excessive population growth.

The technology referred to in this study as earlier mentioned are new seed varieties, fertilizers, better weed control techniques and other management practices. Shultz (64b, pp. 37, 47) suggested that traditional societies use their resources efficiently, therefore existing physical

resources by themselves, cannot provide increases in output, thus the need for better technologies. Vernon Ruttan (64a) has expressed the important role of technology thus:

> During the early stages of economic development the capacity of rural areas to successfully respond to the opportunities for growth that are potentially available to them depends initially on the achievement of rapid technical change leading to productivity growth in agriculture. Significant growth in agricultural productivity can rarely be realized by the reallocation of resources within traditional agricultural systems. The capacity to respond to growth opportunities becomes available primarily through technical change, changes embodied in new more efficient inputs - better crop varieties, cheaper plant nutrients, and more efficient sources of power - capable of releasing the constraints on growth of agricultural output.

Technologies apart from increasing incomes, increases the opportunities for employment.

In order to improve the agricultural sector of Nigeria in general, and of the study area in particular, basic policies should be adopted, with the objective to maintain a level of self-sufficiency and development of the incomes for the agricultural population, to a level comparable to the other sectors of the economy. It is thought that this objective can be reconciled by increasing productivity through the improvement of agricultural structure.

To formulate an adequate policy for the country or sub-areas in the country a clear understanding of the structure of that area should be known. For inadequate information could lead to undesirable consequences. In the

past, many development programs have been pushed without clearly understanding their potential effect, in the long-run the effects often are not capable of being remedied. In order to formulate an adequate technological policy for this study area, Timmons' analytical framework of problem solution is going to be relied upon (68).

The problem involves identifying, developing and adopting adequate solutions to enhance the productivity of the agricultural sector. Figure 7.1 shows the main components of Timmon's analytical framework.

Timmons explains the analytical framework as follows:

> Under the delimiting phase, goals are identified; the existing situation is stated; and the problematic gap between the goals sought and the existing situation is indicated. The diagnostic phase identifies and measures, insofar as possible, the failure elements and the success elements. The failure elements are those factors that cause the existing situation to differ from the desired goal. The success elements are the factors that have prevented the gap from being larger than it is. The remedial phase consists of corrective action. This phase includes two parts. Part one consists of the removal of failure elements that were identified and measured in the diagnostic phase. In part two, the success elements that were identified in the diagnostic phase are expanded and new success elements are developed.

Agricultural research began in Nigeria as far back as 1899. A general crop research station was established at Moor Plantation. Many Agricultural Research Stations have been established since then (36, p. 40). Thus, it is clearly a policy of the government to improve agricultural

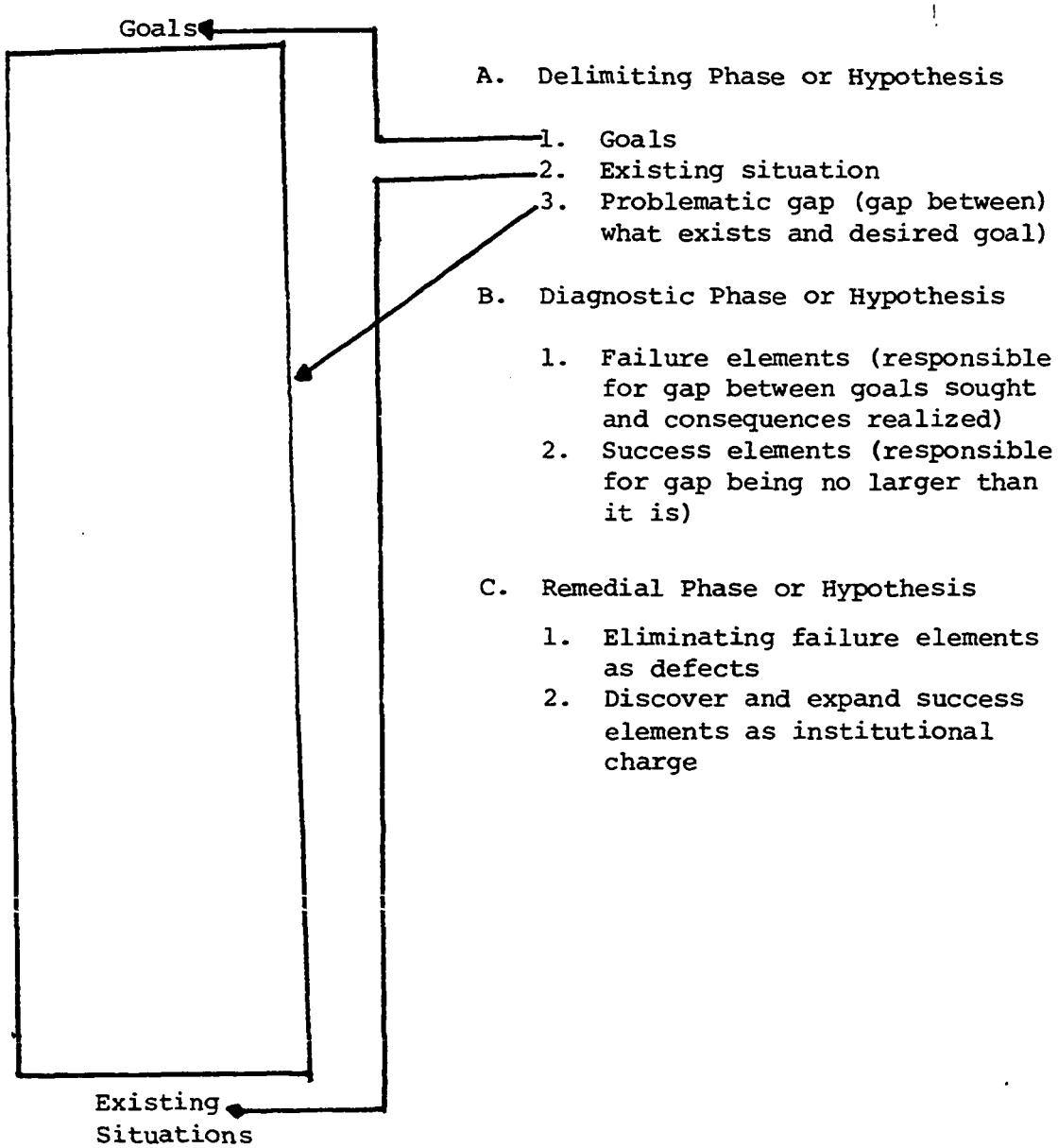


Figure 7.1. Interrelationship between goals, means and consequences (67, p. 88)

productivity via improving the state of agricultural technology.

The goal therefore of using technology is to improve the productivity and incomes of the farmers. The present situation in the study area, is far short of the desired goal. Questions such as, Why is the desired goal not achieved by the farmers in the study area? What hinders the effective transfer and adoption of the technologies that have been developed up to date by the research stations within the country?

Answers to such questions are not only to be found within the farmer's behavior situation but, some of the faults and answers could be found within the policy makers decision process. Either the technologies developed could not readily be adapted to the specific situations or that wrong institutions have not been created to effectively deliver the technologies. Thus the general goal of increasing incomes have met with failure.

Applying the framework to this study area, the goal of development through use of improved technology is assumed. The improved technology is supposed to increase productivity which generates an increase in incomes. Presently, in the study area the level of use of these improved technology is very low. Thus, productivity is very low and incomes are generally low. There, therefore, is a

gap between the goal and existing situations. In using this framework for problem solving, goals might differ from situation to situation. There is therefore the need to identify for each homogeneous problem area, the goals of the people and the existing situation.

On identifying this gap, the diagnostic phase is the next stage. This phase involves measuring the elements that have created such gaps and those that have prevented the gaps from not being larger than the existing gap. In the study area, technologies have been developed by the government institutions, but has not been widely accepted by the farmers. The reasons for its nonuse are due to these various factors;

1. there exists a communication gap between the various institutions and the farmers;
2. credit institutions created by the government do not give enough loans to the farmers;
3. the farmers do not receive enought price incentives for their agricultural produce;
4. land tenure institutions in particular cases have prevented farmers from investing in their use;
5. some of the technologies are not socially compatible.

The success elements therefore are the institutions established by the government. They also serve as the

failure elements. The reason for this is that they do not effectively deliver what they produce and also do not provide supportive services to make them economically viable to the farmers. The land tenure institutions, especially in the area of export crop production, does not permit a land renter to adopt the available new technology. Lack of security of tenure therefore serves as a deterrent to the use of these technologies.

In remedying the situation, therefore, various things have to be done. There is the need for the development of technologies that meet the following criteria:

1. capable of providing improved levels of living and output levels;
2. must be accessible to the poor in technical, economic and socio-political terms;
3. must be conducive to the process of self-sustained development.

In introducing or developing technology for rural use, the technology must be appropriate within the physical, economic and institutional dimensions. Information on many areas is required to effectively develop an appropriate technology, within the three dimensions specified.

Most of the research being done by the institutions are one discipline oriented. There is therefore, the need for interdisciplinary research. The essence of which does not

result from the contributions of separate disciplines acting alone, but rather acting in cooperation with one another. Figure 7.2 shows the interrelationship between various disciplines for carrying out research in the subject area. In this figure, the physical factors include the natural resources, biological, chemical and engineering disciplines. The economic factors include supply and demand prices, efficient allocation of resources and socio-political factors.

Institutions that are available enable the physical and economic disciplines to interact in the process of creating an adequate and appropriate technology. Thus the development of any technology must involve:

1. identification of the needs and priorities of the people;
2. mass participation and involvement of the rural poor;
3. creation of an array of institutions for making the adoption feasible;
4. the understanding of the fact that the development of an appropriate technology should be an inter-disciplinary objective;
5. it must be developed within the social, economic and institutional dimensions of the environment.

The technology should also be:

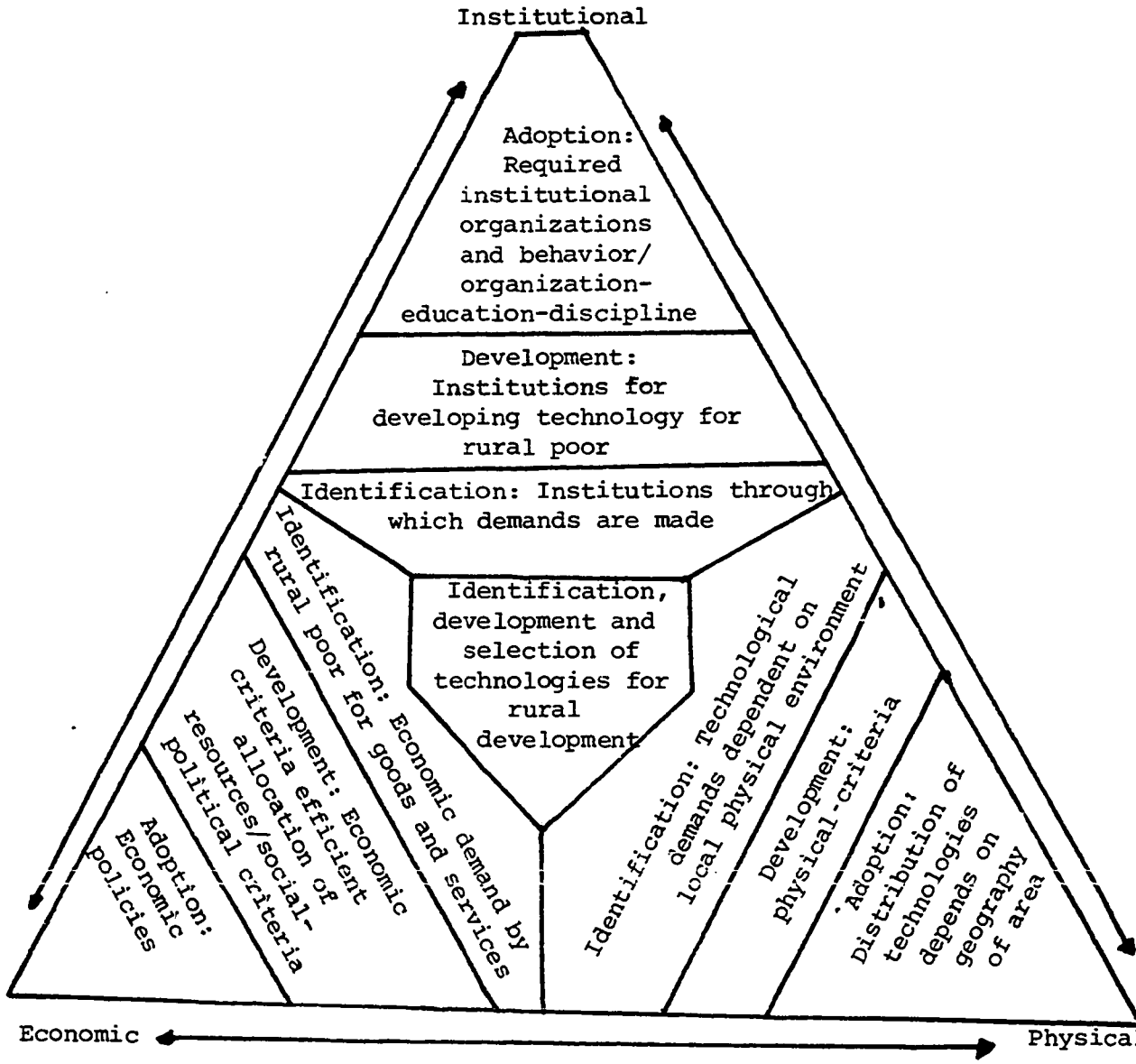


Figure 7.2. Conceptual illustration of physical, economic, and institutional relationships in the identification, development, and adoption of technologies for rural development

1. purposeful and normative;
2. dynamic;
3. predictive.

Having developed an adequate technology, there is the need for removing the already identified failure elements, strengthening the success elements and discovering or expanding new success elements.

The present institutions are plagued by problems of:

1. inefficiency due to complex administrative procedures;
2. lack of adequate knowledge of the needs of the people;
3. isolation from the aspirations and desired goals of the people.

The inherent problems could be eliminated by restructuring these institutions. The complex loan procedures could be eliminated by making loan forms easy to read and interpreted by the farmers and the loan officers. The forms should be processed on time to make loans available to farmers at the right time.

The extension agents could be better provided with facilities to make their job easier to do. Their numbers should also be increased in order to make contacts with farmers more frequent. Other institutions appropriate for success of the new technologies could be identified and created.

VIII. SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

A. Summary

In Chapter I, four basic objectives of the study are enumerated. The first objective sought to determine the pattern of export and food crops over a defined planning horizon, under traditional and improved technology and alternate land resource bases. The objective was achieved by specifying multiperiod programming models A1 and A2 and the effect of land base changes was achieved by running sub-models A11, A12, A13, A14 and A15, under traditional technology and A21, A22, A23, A24 and A25, under improved technology. The levels of constraints and other specifications are the same for A1 and A2 but the technologies differ. This thus implies that the input-output specifications are not the same.

From the results of the first objective the second objective was met. This implies determining the income and employment effects of the two technologies.

Also, the third objective of evaluating the effect of changes in the land resource base was met by attaining the first objective. It is from the results of these models that the conclusions as to their effect were generated.

The fourth objective of determining the effect of

aggregate subsidy levels was satisfied by running submodels B11, B12, B13, B14, B15, B16, B17, B18, B19, B110. In B11-B15, 10, 20, 30, 40, 50 percent subsidy levels were assumed on export crops while from B16-B110, 10, 20, 30, 40, 50 percent subsidy levels were assumed for food crops. However, because of limitations due to lack of computations funds, this was only run for a 5 acre annual land base and also for aggregate levels rather than choosing individual crop support programs.

Although the assumptions of the models may, to some readers look unrealistic, they are not different from those that are usually attributed to any study of this type.

The results of the models shows that adoption of improved technologies might be a profitable venture, if well used. The optimal combination of crops, shows a preference for food crop production in the study area.

In later chapters recommendations were made as to the types of policy that could help improve the efficiency of the sector. Suggestions were made as to how to identify, formulate and implement a policy on technology. The limitations of the study are then enumerated.

B. Limitations of the Study

The major limitations in this study are due to:

1. the data used;
2. the structure of the model;
3. the planning horizon.

The data used in this study were collected from various sources (see Chapter III). However, the bulk of the data came from the 1970/71 Farm Survey Study carried out by the Planning Division of the Ministry of Agriculture and Natural Resources, Ibadan, Western State of Nigeria (75). Apart from the study of this ministry, no other studies in the state establish the set of input-output coefficients from crop enterprises, the timing of input for crop enterprises, and the average level of available farm resources in the study area. However, the other publications mentioned in Chapter III helped to augment, to a limited extent, the data obtained from the Western State's Ministry of Agriculture's publication.

The paucity of sources of data is a major limitation of this present study. Since this study draws heavily from this data source (75), it is evident that this study will be limited by the deficiencies of the major source of data. Some of the limitations are listed thus:

1. The state was divided into the barest minimum of

agricultural regions and so one should expect some heterogeneity among farms classified as homogeneous. To the extent that different features have been classified under the same region, the precision of the study may be expected to suffer.

2. The data were collected by interviewing farmers who depended on their memory for answering questions on farm structures, and mode of operations performed months back. It is easily acceptable that questions relating to farm structures, resource constraints and mode of land settlements can be answered reasonably accurately by memory recount. It is also possible that farmers may remember fairly accurately the sources of his credit, the amount borrowed and amount repaid. However, the farmer may not know the exact measurement of the output from the various parcels of land.

Despite these limitations, it is felt that the employed data are good enough to give reliable solutions to the problems posed in this study.

The model is structured in such a way, that the recursive aspect allows savings to be determined by the marginal propensity to save. It thus becomes difficult to identify the savings component of the value of capital used annually. This will also make calculating the marginal efficiency of investment or the return per unit of capital difficult

to estimate.

The planning horizon chosen, makes prediction from the result difficult to accept. The accuracy with which future prices and market conditions are predicted, plays an important role in determining the usefulness of the plan. The problem of formulating market condition expectations for the cash crops in the study area is aggravated by the international and intertemporal context of the problem. It was possible to obtain current prices and predict future prices for the food crops (77). However, it is impossible to predict with some degree of accuracy the prices of export crops. This serves as one of the major limitations of this study.

C. Suggestions for Further Research

Relaxation in some of the major assumptions of the study could provide an avenue for further research. Before any meaningful policy statements could be made about any research study, the data source should be accurate. Thus a more detailed and up to date information is required on input-output coefficients of the various crops in the model. This data should be collected for the various crops under the different technologies available.

In the model, assumption is not made about the interaction of the farm-firm with respect to the market demand and supply situations for the various crops in the model. This could be part of the assumption for a new study. This, therefore, allows for farmers' adjustments to product and factor markets.

A more realistic parametric analysis could be carried on land availability constraint. This will allow one to study the per unit adjustments on an annual basis.

Studies could be conducted on consumption function of farm-firms to provide a more detailed and useful information on how resources are utilized and how farm families determine their consumption and savings behavior. This will provide a more useful information and a reliable addition to updating the information from this study.

Precluded in the model is the option for land renting for cash crop production. This is not in line with the existing land tenure system in this section of the country. Assuming that institutional arrangement that allows this in the near future exists, and is desirable, it becomes reasonable therefore to allow renting land for export crop production. As a prelude to this therefore, a study to estimate and evaluate their potential effect could be done.

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XI. APPENDIX A: WEIGHTS AND MEASURES

Units of measurements:	Equivalences:
Length:	
1 inch =	25.38 millimeters
1 inch =	.03 meters
1 mile =	1.61 kilometers
Area:	
1 acre =	.40 hectares
1 square mile =	2.59 square kilometers
Weights:	
1 pound =	.45 kilograms
1 pound per acre =	1.67 kilograms per hectare
Labor input conversion:	
1 man-day	8 man-hours
Money:	
1 N	$1.62
October 15th, rate oc conversion	

XII. APPENDIX B: INPUT-OUTPUT DATA

Table B.1. Input-output[a] coefficients per acre of cocoa (traditional and improved), during years of production

Items	Unit	Output (T)	Total Value (T)	Output (I)	Total Value (I)
Total Receipts	lbs	4.25	55.58	9.27	121.23
1. Cocoa dry beans					
Total Costs	N				
1. Chemical Inputs	N	-		3.28	
2. Annual repair and depreciation	N	1.32		1.32	
3. Annual rate of amortization	N	7.90		6.10	
4. Labor costs	N	15.03		26.10	
Net Returns			24.25 31.33		34.80 86.43

[a]These are the input-output coefficients used in the model.

Table B.2. Input-output coefficient for an acre of coffee (traditional and improved) during years of production

Item	Unit	Output (T)	Total Value (T)	Output (T)	Total Value (I)
Total Receipts					
1. Dry coffee beans	lbs	225.00	34.56	6.07	93.24
Total Costs					
1. Interest on annual capital	N		-	2.60	
2. Annual rate of amortization	N		4.36	4.36	
3. Labor cost	N		3.92	6.40	
4. Repair and depreciation	N		6.00	4.20	
5. Chemical inputs	N		-	2.00	
Net Returns			14.28 20.28		19.56 73.68

Table B.3. Input-output coefficient per acre of oil palm (traditional and improved) during years of production

Item	Unit	Output (T)	Total Value (T)	Output (I)	Total Value (I)
Total Receipts					
1. Sale of kernels and palm oil	lbs	3.89	21.56	9.50	52.65
Total Costs					
1. Interest on annual capital	N		.32		1.00
2. Annual rate of amortization	N		1.04		1.36
3. Labor cost	N		6.56		5.20
4. Repair and depreciation	N		.44		1.00
5. Chemical inputs	N		-		2.30
			8.36		10.86
Net Returns			13.20		41.79

Table B.4. Input and output coefficient per acre of rubber (traditional and improved) during years of production

Item	Unit	Output (T)	Total Value (T)	Output (I)	Total Value (I)
Total Receipts					
1. Dry rubber	lbs	3.90	48.18	10.06	124.28
Total Costs					
1. Interest on annual capital	N		.98		1.20
2. Annual amortization	N		9.62		6.36
3. Labor costs	N		10.36		15.30
4. Other cash expenses	N		3.40		4.60
Net Returns			24.36 23.82		27.46 96.82

Table B.5. Input-output coefficients per acre of kolanut (traditional and improved)

Item	Unit	Output (T)	Total Value (T)	Output (I)	Total Value (I)
Total Receipts					
1. Kolanuts	lbs	6.00	21.34	12.01	42.68
Total Cash					
1. Interest on annual capital	N	.52		.60	
2. Annual amortization	N	5.98		5.00	
3. Annual repair and depreciation	N	.76		.51	
4. Labor costs	N	8.51		8.70	
5. Other cash expenses	N	-		2.29	
Net Returns			15.77 5.57		17.10 25.58

Table B.6. Input-output coefficients for annual crops under traditional technology

Item	Yam	Rice	Corn (early)	Cassava	Guinea-corn	Cocoyam
Total receipts	118.00	58.32	30.72	68.70	36.00	80.20
Cost components						
Input costs						
a. seeds	20.26	2.90	.84	1.64	1.16	10.25
b. physical outputs	.30	.32	.26	.20	.12	.18
c. labor	40.10	10.60	5.02	20.10	5.04	30.70
Interest on annual capital	4.14	.90	1.33	1.56	1.02	3.04
Repair and depreciation	2.18	.89	1.22	1.56	1.00	1.26
Rent for land use[b]	4.66	2.62	1.62	1.62	2.62	4.10
Total Cost	71.64	7.63	5.27	6.38	10.94	39.43
Net Returns	46.36	40.09	20.43	42.02	25.06	40.77

[a]The value represents cost of ploughing and disking and also of decortication.

[b]This cost is added to production of food on rented land. For production of food on owned land this value has to be ignored.

Corn/ Melon	Cassava/	Corn/ Cassava	Yam/ Corn	Kenaf (partially mechanized)	Kenaf (manual)
45.39	64.18	74.28	115.12	44.36	39.86
1.78	1.60	1.52	20.96	6.00	6.00
.18	.32	.32	.32	10.48[a]	
10.28	10.20	20.00	40.10	5.02	12.01
1.36	1.50	1.54	2.94	1.44	1.80
1.36	1.52	1.58	2.38	.92	1.62
2.62	3.50	3.50	3.50	2.16	2.31
17.58	18.64	10.46	70.20	26.02	23.73
27.81	45.54	63.82	44.92	18.34	16.13

Table B.7. Input-output coefficients for annual crops under improved technology

Item	Yam	Rice	Corn (early)	Cassava	Guinea-corn	Coco-yam
Total receipts	271.00	72.16	82.36	107.16	68.16	100.27
Cost components						
Input costs						
a. seeds	20.36	3.90	.84	2.16	1.30	10.25
b. physical inputs	5.30	1.26	3.20	3.16	3.10	3.28
c. labor	43.16	10.72	5.02	20.70	4.36	36.00
Interest on annual crop	4.14	.90	1.33	2.10	1.02	3.01
Repair and depreciation	3.16	.89	1.22	1.56	1.00	1.36
Rent for land use[b]	3.20	3.65	1.62	1.62	2.62	4.16
Total Cost	79.32	21.32	13.29	31.30	13.40	58.06
Net Returns	191.68	50.84	69.07	75.86	54.76	42.21

[a]The value represents cost of ploughing and disking and also of decortication.

[b]This cost is added to production of food on rented land. For production of food on owned land this value has to be ignored.

Corn/ Melon	Cassava/ Melon	Corn/ Cassava	Yam/ Corn	Kenaf (partially mechanized)	Kenaf (manual)
72.69	84.18	95.36	193.16	84.16	73.24
1.80	1.70	1.70	20.26	6.h0	6.00
1.30	2.61	1.36	1.30	15.20[a]	2.16
10.20	14.20	10.10	42.10	5.03	12.01
1.26	1.36	1.36	2.94	1.36	1.06
1.26	1.36	1.70	2.50	1.02	1.10
2.62	2.50	4.60	3.50	2.18	2.18
18.44	23.93	20.82	72.60	31.89	24.51
54.25	60.25	74.54	120.56	52.27	48.73

Table B.8. Labor requirement in man-days for export and food crops under traditional techology

Month	Cocoa production	Coffee production	Oil palm production	Rubber production	Kolanut production
Jan.	-[a]	4.50	2.00	2.60	-
Feb.	-	-	.75	2.60	-
Mar.	-	-	1.25	2.60	-
Apr.	-	-	1.60	2.60	-
May	-	2.00	4.90	2.60	-
Jun.	-	-	1.40	2.60	-
Jul.	1.70	5.00	.75	2.60	-
Aug.	5.35	-	.60	2.60	6.00
Sep.	8.20	0	0	2.60	-
Oct.	8.10	5.00	-	3.70	3.00
Nov.	5.00	3.00	-	5.60	10.00
Dec.	5.20	6.00	-	2.60	3.50
Total	34.55	24.50	13.95	10.74	75.95

[a]The amount of labor used in those months are relatively quite small.

Yam	Rice	Cassava	Corn (early)	Guinea corn	Cocoyam	Corn/ Melon	Cassava/ Melon
3.44	11.68	2.90	3.03	1.65	8.27	3.03	7.85
3.44	15.83	6.85	3.85	5.40	8.12	3.70	7.85
7.85	4.53	6.85	8.60	6.23	5.85	8.95	13.12
7.58	7.45	3.88	8.60	7.23	5.85	8.95	7.09
7.58	6.58	13.38	4.65	9.23	-	3.50	4.76
5.00	4.65	13.38	4.65	2.00	-	3.50	4.76
5.00	10.48	1.93	4.07	2.00	-	9.57	7.00
3.65	7.60	5.63	4.07	1.06	8.30	8.23	4.00
14.34	5.38	5.63	4.07	1.81	-	2.43	4.00
10.69	-	4.68	-	1.81	3.70	-	1.09
10.69	-	4.68	-	1.81	8.27	-	1.09
4.79	-	-	-	1.81	-	3.03	-
83.79	73.68	58.39	45.86	42.04	48.36	54.88	63.61

Table B.8 (Continued)

Month	Corn/ cassava	Corn/ yam	Kenaf (partially mechanized)	Kenaf (mechanized)
Jan.	3.90	3.11	3.75	3.75
Feb.	7.85	3.11	3.75	3.75
Mar.	7.85	9.75	-	9.00
Apr.	3.90	15.25	1.00	10.00
May	9.76	9.50	5.00	5.00
Jun.	11.98	5.00	4.00	4.00
Jul.	9.88	10.13	-	-
Aug.	5.28	4.13	17.00	20.50
Sep.	1.53	10.04	2.50	9.00
Oct.	1.13	10.04	-	-
Nov.	1.13	10.04	-	-
Dec.	-	4.33	-	-
Total	65.08	93.43	37.00	59.50

Table B.9. Labor requirement in man-days for export and food crops under traditional technology

Month	Cocoa	Coffee	Oil palm	Rubber	Kolanut	Yam	Rice
Jan.	2.00	6.00	5.40	0.40	3.50	2.50	4.15
Feb.	1.00	5.00	1.80	3.70	-	2.50	4.15
Mar.	-	-	2.70	1.20	-	5.67	2.25
Apr.	2.75	-	3.60	1.50	0	12.67	7.50
May	2.75	5.00	5.10	1.80	-	12.67	5.25
Jun.	4.00	2.00	5.60	5.30	-	5.00	3.25
Jul.	3.00	2.00	5.10	0.70	-	5.00	9.92
Aug.	6.50	-	3.60	2.10	-	7.75	9.17
Sep.	4.50	0.50	5.10	0.50	4.00	15.73	6.67
Oct.	6.00	-	4.60	0.50	7.25	15.73	-
Nov.	6.75	6.50	11.50	3.40	8.00	12.08	-
Dec.	4.00	5.50	5.40	0.40	5.75	6.08	-
Total	43.25	32.50	59.50	21.50	28.50	93.38	52.31

Cassava	Guinea-corn	Corn (early)	Cocoyam	Corn/ Melon	Cassava/ melon	Corn/ cassava
2.90	2.75	3.03	8.72	3.03	3.00	4.00
6.85	10.00	3.85	8.24	3.70	8.60	8.00
6.85	16.75	8.60	6.57	9.20	8.60	8.00
3.88	6.75	8.60	6.57	9.20	13.36	5.13
13.38	9.00	4.65	3.60	3.67	5.70	11.63
1.93	6.25	4.65	3.00	3.67	5.70	14.33
1.93	2.75	4.07	3.00	11.00	8.71	11.83
5.63	1.63	4.07	-	9.93	5.38	7.93
5.63	3.13	4.07	3.50	2.93	1.70	3.99
4.68	3.13	-	3.50	-	1.70	2.33
4.68	3.13	-	4.25	-	1.70	2.33
-	-	-	8.82	3.03	-	-
58.39	64.27	44.86	57.77	49.36	52.15	79.51

Table B.9 (Continued)

Month	Corn/ yam	Kenaf (partially mechanized)	Kenaf (manual)
Jan.	3.23	3.75	3.75
Feb.	3.23	3.75	3.75
Mar.	10.50	-	9.50
Apr.	16.00	-	10.50
May	9.50	6.00	6.00
Jun.	5.00	5.00	5.00
Jul.	14.75	4.00	4.00
Aug.	9.75	29.15	29.10
Sep.	10.51	3.25	12.60
Oct.	10.51		
Nov.	10.51		
Dec.	4.58		
Total	108.17	50.90	84.20

XIII. APPENDIX C: AGRONOMIC CHARACTERISTICS OF THE CROPS

Yams (Dioscorea species):

Yams are stem-tuber crops, indigenous to the humid tropical southern parts of West Africa where they are used as important sources of carbohydrates. It is one of the most important root crops grown in Nigeria.

There are many varieties of yam which are differentiated by varying characters such as the direction of stem and wines (clockwise or counter-clockwise), the shape and color of the leaves, stems and tubers, the cooking quality of the tubers and early or late maturity. Six main groups or species of Dioscorea are commonly grown.

1. Dioscorea rotundata (white yam)
2. Dioscorea cavenensis (yellow yam)
3. Dioscorea alata (water yam)
4. Dioscorea dumetorium (trifoliate yam)
5. Dioscorea esculenta (Chinese yam)
6. Dioscorea bulbifera (potato yam)

Yams require rich loamy soil with plenty of organic matter. The soil in which yam is grown needs to be properly worked. For this purpose, the traditional farmer prepares a big mound or heap.

Yams are sown by seeds consisting of a small tuber. This tuber contains the reserve food material needed by the sprouting embryo during the development stage. An average seed weighs between 6-14 ounces. Planting takes place in

November, February or March. They are harvested from July to December or January depending on the time they mature, which varies with the time of planting. Generally, yams take about 8 months from planting to harvesting. When the leaves turn brown, dry up and fall on the ground, the yam is ready for harvesting.

Yields of yam vary greatly within a wide range from place to place and may be as low as 2 tons or as high as 7 to 8 tons.

Cassava (Manihot utilissima):

Cassava belongs to the genus Manihot of the natural order Euphorbiaceae. It is native to Brazil in South America and was introduced to West Africa by the early Portuguese explorers. Cassava has since spread rapidly along the coast, particularly in the rain forest and the dry Guinea savanna areas of West Africa.

This crop can grow in almost all frost-free, humid or arid tropical areas.

Many varieties are grown in Nigeria, which is differentiated by characters such as height and color of the stem. The crop thrives best in rich, well drained, deep, moderately leached sandy soils. Planting is carried out from stem cuttings, each cutting from a mature stem varying between 9 and 12 inches. Yields vary between soils and

management techniques.

Cocoyam (Colocasia esculentum):

Cocoyam is the third most important root crop cultivated in West Africa following yam and cassava. It is a major root crop in the forest areas of Ghana where, in addition to being an important source of carbohydrate food, it is used as a shade plant for the young developing cocoa tree.

Cocoyam does best in rich alluvial soils in the hot, moist climate of the rain forest regions. They are sown by means of small underground tubers known as cormels. Planting usually takes place during the rainy season between May and June. The sets germinate between 7-15 days and the crop is harvested between 6 and 8 months. Yields vary from 4,000 to 8,000 lbs per acre.

Guinea corn (Sorghum guineese):

Sorghum belongs to the tribe Andropogoneae in the subfamily Panicoidae of the great grass family, Gramineae. Of the numerous cultivated varieites known, Sorghum quineense embraces the many varieties grown in West African countries.

Originating in West Africa, sorghum is essentially a tropical plant although varieties have now been produced which yield well in subtropical and temperate climates. Generally,

the cultivation of sorghum is confined to between 40°N and 40°S latitude, although exceptions may occur outside this climatic area.

Sowing normally takes place from May to June in the northern part of Nigeria and between June and July in the south. They take between 4 to 6 months to mature. Harvesting takes place between November and January in most parts of Nigeria. Yields vary between 400 and 1000 lbs per acre. Improved varieties and good cultivation usually produces up to 2000 lbs per acre.

Corn (Zea mays):

Corn is native to tropical America where it has been cultivated for some 6000 years. This crop is the third most important cereal crop in Nigeria and is grown largely in the rain forest and the Guinea savanna vegetational zones of the country.

Corn is sun-loving, tropical crop admirably suited to tropical conditions and will not stand frosty weather. Takes 3-4 months for maturity yields vary between 1000 and 2000 lbs per acre.

Rice (Oryza sativa):

Rice belongs to the tribe Oryzeae, the subfamily Poacoideae in the great grass family Gramineae. The genus Oryza contains six species of which Oryza sativa is economically the most important. There are two main varieties in cultivation, swamp rice and upland rice.

Swamp rice has to be flooded for a period varying from 60 to 90 days during growth.

Upland rice can grow in soils without irrigation or flooding.

Swamp rice varieties are sown in small flooded nursery plots, 2-3 plants per stand, at depths varying between 1/2 and 1 inch. Germination occurs between 4-5 days. The seedlings are transplanted after 4 to 6 weeks. Sowing takes place at the beginning of the rains, April to May and they ripen in August.

Yields of crops vary depending on variety and management practices.

Oil palm (Elaeis quincensis):

The oil palm is indigenous to tropical West Africa where it grows naturally, sometimes to a height of about 65 feet. It is found along the rain forest belts of West Africa varying between 100 to 300 miles deep, from Senegal through Nigeria to Angola.

The oil palm is a member of the Palnae family. When fully mature, it is a stout, upright tree.

Maximum yields are obtained in different years and depends on the variety.

Cocoa (Theobroma cacao):

Theobroma cacao is not native to Africa, it originates in South America, probably in the tropical rain forest climatic zone of Brazil. It is generally believed that the cocoa bean was introduced to Nigeria from Fernando Po about 1879.

The crop is grown on a commercial scale in Africa at present.

Theobroma cacao belongs to the family Sterculiaceae, the same family as the kola tree. There are two distinct varieties: the Criollo, common to Venezuela, and the Forastero, more widely distributed in South American continents. The cocoa introduced to West Africa belongs to the later group.

Cocoa requires, well drained, porous soils with a large amount of organic matter. The crop is propagated both by seed and vegetative cuttings.

In Nigeria a healthy seedling from selected cocoa types are used. Seeds are sown in baskets in shaded nurseries in September and October to enable field planting to take

place during early rains in May or June.

Yields vary from 100-1000 lbs of dry beans per acre, the average being about 350 lbs. Experiments on farmers plots to which fertilizers were applied and insect pests controlled gave, in Nigeria, yields of the order of 2000 lbs of dry beans per acre.

Rubber (Hevea brasiliensis):

Rubber is a product of immense commercial value, employed in the manufacture of thousands of articles in every day use.

Havea brasiliensis thrives best in areas around the equator. It also does very well in areas where the rain fall is between 80-120 inches per year. Yields vary from variety to variety.

Coffee:

Robusta coffee and arabica coffee the two most prominent grown in Nigeria, are essentially high land crops. They require a warm moist climate, frost-free with abundant rain fall. The coffee tree makes exacting demands upon the soil, yet it is impossible to generalize on soil requirements.

XIV. APPENDIX D: MEANING OF NOTATIONS

COCT[1] = cocoa production under traditional technology

COCI[2] = cocoa production under improved technology

COFT = coffee production under traditional technology

COFI = coffee production under improved technology

RUBT = rubber production under traditional technology

RUBI = rubber production under improved technology

KOLT = kolanut production under traditional technology

KOLI = kolanut production under improved technology

PAPT = palm production under traditional technology

PAPI = palm production under improved technology

YAMT = yam production under traditional technology

YAMI = yam production under traditional technology

YAMI = yam production under improved technology

RICT = rice production under traditional technology

RICI = rice production under improved technology

CAST = cassava production under traditional technology

CASI = cassava production under improved technology

GCNT = guinea-corn production under traditional technology

GCNI = guinea-corn production under improved technology

[1,2]The last letters I or T are used to indicate the level of technology.

COYT = cocoyam production under traditional technology

COYT = cocoyam production under improved technology

MMET = melon/corn mixture production under traditional technology

MMEI = melon/corn mixture production under improved technology

CMET = cassava/melon production under traditional technology

CMEI = cassava/melon production under improved technology

CAMT = cassava/corn production under traditional technology

CAMI = cassava/corn production under improved technology

KENT = kenaf production under traditional technology

KENI = kenaf production under improved technology

ECNT = early corn production under traditional technology

ECNI = early corn production under improved technology

COYT = cocoyam production under traditional technology

COYT = cocoyam production under improved technology

MMET = melon/corn mixture production under traditional technology

MMEI = melon/corn mixture production under improved technology

CMET = cassava/melon production under traditional technology

CMEI = cassava/melon production under improved technology

CAMT = cassava/corn production under traditional technology

CAMI = cassava/corn production under improved technology

KENT = kenaf production under traditional technology

KENI = kenaf production under improved technology

ECNT = early corn production under traditional technology

ECNI = early corn production under improved technology