AN ECONOMIC ANALYSIS OF SMALL SCALE MIXED FARMING SYSTEM: THE CASE OF FARM CROP/LIVESTOCK ENTERPRISES IN GIWA DISTRICT OF KADUNA STATE

BY

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A Dissertation submitted to the Postgraduate School, Ahmadu Bello University, in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Agricultural Economics).

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DEDICATION

This thesis is dedicated to my father, Mr. Okon Udosen who laid a solid foundation for my education and Antigha S. Okon (Mrs), a unique wife.

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

Sunday Okon

Date 6/11/85

The above declaration is confirmed.

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CERTIFICATION

This thesis with the title: AN ECONOMIC ANALYSIS OF SMALL SCALE MIXED FARMING SYSTEM: THE CASE OF FARM CROP/LIVESTOCK ENTERPRISES IN GIWA DISTRICT OF KADUNA STATE, meets the regulations governing the award of Degree of Doctor of Philosophy of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

The main objectives of the study are to derive optimum farm plans for the small scale mixed crop/ livestock farmer and to examine the effect of resource adjustments on total gross margin under the existing technology and resource endowment. The study area is Giwa District of Zaria Local Government area of Kaduna state. The study was carried out during 1986/87 farming season. Data collection was by means of questionnaire to interview the respondents twice a month throughout the year by two well trained enumerators.

Three basic farm models were constructed and labelled A, B, and C and their variants are AI, AII, AIII, BI, BII, BIII, CI and CII. Model A represents production activities at existing resources level while its variants represented adjustments in land and cattle resources. Model B represents production, consumption and selling activities, while its variants indicate adjustments in land and labour resources. Model C differs only from model B by incorporating crop residue and animal manure variables into the model. Models CI and CII indicate adjustments in both land and labour resources.

The analysis of the optimum farm plans for all the models showed substantial increase in total gross margins over the farm income of N3000 estimated during

the survey. An increase in farm size by 40 percent results in 18 percent increase in total gross margin, while an increase in labour by 15 percent reduced the total gross margin by 3.5 percent in models BII and BI respectively, showing the importance of land in the study area. This trend was typical for all the models. Maize/cowpea, guinea corn/millet and cattle production activities were in better competitive positions over other activities. This shows how important these activities are in the study area.

The results show that higher productivity and more revenue could be achieved by the small scale mixed farmer if there is a reorganisation of resources and better planning of farming activities. Cattle was a major revenue earner because any model without cattle activity showed a reduced revenue in the optimum plan. Labour was limiting at the peak farming period as labour has to be rationed between crops and livestock activities. Selective mechanisation with the use of work animals is suggested as a solution to the labour bottleneck.

An examination of the shadow prices of the excluded activities which show the income penalities attached to forcing one unit of the excluded activities into the programme, further reveals the stability of the different production strategies under existing

technology and changing resource levels. The higher the shadow prices of the excluded activities the lower is their competitive position within the optimal programme.

Studies such as this are recommended in other states where agro-pastoral Fulani are settled so that a national policy could be evolved for the mixed farming production strategy in Nigeria.

TABLE OF CONTENTS

		Page
Title Page		i
Dedication		ii
Declaration		iii
Certification		iv
Copyright Statement		v
Acknowledgement		vi
Abstract		viii
Table of Contents		xi
List of Tables		xv
List of Figures		xviii
CHAPTER I: INTRODUCTION		1
1.1	Preliminary Considerations	1
1.2	The Problem Statement	5
1.3	Objectives of the Study	12
1.4	Justification for the Study	13
CHAPTER II: REVIEW OF LITERATURE		16
2.1	Animals in Mixed Farming System	16
2.2	Types of Crop/Livestock Relationships	19
2.3	Complementarity in Mixed Farming System	21
2.4	Initial Constraints of Mixed Farming in Northern Nigeria	23
2.5	Current Policy and Studies on Mixed Farming	26
2.5	Studies Involving Linear Programming Models	29

		Page
CHAPTER III:	DESCRIPTION OF FARMING SYSTEM IN THE STUDY AREA	35
3.1	Utilization of Resources	38
3.1.1	Land	38
3.1.2	Labour Utilization	40
3.1.3	Capital Input	43
3.2	Cropping Pattern	45
3.3	Animal Husbandry	46
3.4	General Herd Management	47
3.5	Technology of Agricultural Production in the Study Area	49
CHAPTER IV:	CONCEPTUAL FORMULATION OF THE LINEAR PROGRAMMING	52
4.1	Preliminary Consideration	52
4.2	Linear Programming Model	57
4.2.1	The Objective Function	60
4.3	Restriction in the Model	62
4.3.1	Land Restriction	62
4.3.2	Labour Restrictions	63
4.3.3	Operating Capital Restrictions	64
4.3.4	Grain Consumption Constraints	64
4.4	Some Limitations of the Model	65
4.5	Other Programming Methods	66
4.5.1	Multi-Period Linear Programming	66
4.5.2	Dynamic Programming	70
4.5.3	Recursive Programming	70
4.5.4	Interger Programming	72
4.5.5	Simulation Approach	73

		Page
CHAPTER V:	DISCRIPTION AND APPLICATION OF THE MODEL	75
5.1	Activities in the Model	77
5.1.1	Crop and Livestock Production Activities	77
5.1.2	Consumption Activities	80
5.1.3	Selling Activities	82
5.1.4	Labour Hiring Activities	83
5.2	Obtaining LP Coefficient for this Study	84
5.3	Farm Resource Situation and Restrictions	91
5.4	Source of Data	95
5.5	Limitations of the Data	96
CHAPTER VI:	INTERPRETATION OF RESULTS	98
6.1	The Characteristics of the Optimal Farm Plan, Model A	99
6.2	Farm Resource Adjustments: Models AI, AII, AIII	105
6.2.1	Optimal Farm Plan for Model AI	105
6.2.2	Model AII	208
6.2.3	Model AIII	111
6.2.4	A Comparison of Models A, AI, AII and AIII	115
6.3	The Analysis of B Model	117
6.3.1	Model B	117
6.3.2	Model BI	120
6.3.3	Model BII	123
6.3.4	Model BIII	125
6.3.5	A Comparison of Models B, BI, BII and BIII	127

		Page
6.4	Crop-Livestock Linkages: An Important Aspect of Mixed Farming Production Systems	130
6.4.1	Model C	133
6.4.2	Model CI	135
6.4.3	Model CII	136
6.4.4	A Comparison of Optimal Plans for Models C, CI and CII	139
CHAPTER VII:	SUMMARY, CONCLUSION, POLICY IMPLICATIONS OF THE STUDY AND SUGGESTIONS FOR FURTHER RESEARCH	141
7.1	Summary	141
7.2	Conclusion	149
7.3	Policy Implications	150
7.4	Limitation and Suggestions for further Studies	153
REFERENCES		157
APPENDICES		167

LIST OF TABLES

Table		Page
1.1	Retail prices of selected items July 1985 - June 1986	2
1.2	Food demand and supply in Nigeria 1985 and 1990 in grain equivalents	3
1.3	Farm holdings reported by activities and by states (1981/82 [in thousand]	10
3.1	Monthly rainfall in (mm) 1983-1987	37
3.2	Channels through which pastoralists acquire farm land	40
3.3	Age distribution of household members	42
3.4	General labour distribution in man-hours	42
3.5	Mean cash expenditures on crops and livestock for household in the study area	44
3.6	Cropping pattern in Zaria, Malumfashi and Sokoto (in percent)	45
3.7	Distribution of yields and mean farm size for household	46
3.8	Structure of cattle ownership in the study area	49
3.9	Structure of small ruminant ownership in Giwa area	50
4.1	Average level of existing resources	62
5.1	Mean farm size in relation to live-stock ownership	79
5.2	Prices of commodities at the open market (1987)	81
5.3	Total crop yield in mixture and individual crop yield (kg/ha)	82
5.4	Mean livestock sales	83
5.5	Labour distribution by crop enterprise in man-hours	85

Table		Page
6.1	Optimum organisation of the representative farm with existing resource levels, Model A	100
6.2	Marginal value products of the existing resource levels, Model A	103
6.3	Optimum organisation of the representative farm with land increased to 3.5 hectares - Model AI	107
6.4	Marginal value product for Model AI	107
6.5	Range analysis Model AI: Price increase, quantity and equivalent yield per unit of activities not in the optimum plan	108
6.6	Optimum organisation of farm plan for Model AII	110
6.7	Marginal value product for Model AII	110
6.8	Price increase required in activities not used, Model AII	111
6.9	Optimum farm plan for Model AIII	114
6.10	Price increase required in activities not used in Model AIII	114
6.11	Comparison of optimal farm organisation of Models A, AI, AII and AIII	116
6.12	Optimum farm plan for Model B	118
6.13	Marginal value products for Model B	119
6.14	Price increase required in activities not used in Model B	120
6.15	Optimum farm organisation for Model BI	121
6.16	Marginal value products for model BI	122
6.17	Price increase required in activities not used in Model BI	123
6.18	Optimum farm plan for Model BII	124
6.19	Model BIII - Optimum plan, land and labour in period 2 increased to 3.5 ha and 680 man-hours respectively	127

Table		Page
6.20	Comparison of optimum farm organisation of Models B, BI, BII and BIII	129
6.21	Important variables and regression coefficients	131
6.22	Quantity, composition and fertilizer value of dry animal faeces	132
6.23	Average composition (DM) basis of faeces on animals grazing mainly cereal crop residue	132
6.24	Optimum farm plan for Model C	134
6.25	Price increase required to include in activities not in the optimum plan for Model C	136
6.26	Optimum solution for Model CI	137
6.27	Optimum farm plan for Model CII	138
6.28	A comparison of optimal plans for Models C, CI and CII	140

LIST OF FIGURES

Figure		Page
1	Schematic representation of interactions within the agricultural sector	18
2	Interactions in the integrated crop/livestock production system	20
3	Interactions between crops/livestock in the mixed farming system	22
4	Map of Giwa District	36

CHAPTER I

INTRODUCTION

1.1 Preliminary Considerations

The agricultural sectors of the Nigerian economy has since the late sixties been unable to cope with the demands made on it by increasing population growth. The population growth rate is estimated at about 3% per annum while the annual growth rate of food production is estimated at 2.5 percent (Federal Ministry of Agriculture, 1974). The result has been sharp increases in the price of food as shown in Table 1.1. Between October 1985 and June 1986 for instance, price of beans was more than doubled. This situation has necessitated the diversion of scarce foreign reserve to the importation of food. Between 1979 and 1983 alone the country's food import bill stood at ₦6 billion (Monthly Economic and Business Digest, August, 1984). Table 1.2 shows gross food demand and supply situation in terms of grain equivalents between 1985 and 1990 as well as deficits and the rate at which the domestic supply of the products would need to grow in order to close the gap. The estimates suggest the need for very high growth rates of crops and livestock production in order that the projected demand for the commodities be met in 1990.

The agricultural sector has continued to show a decline in food production because the productive capacity of the national livestock and crop land is very low and

Table 1.1: Retail prices of selected items in Nigeria, July 1985 - June 1986.

Item	Unit	July - December 1985						January - June 1986					
		July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
Gari	1 kg	0.91	0.88	0.80	0.61	0.66	0.64	0.67	0.67	0.68	0.81	0.94	0.96
Beans	1 kg	2.88	2.38	2.29	1.43	2.30	2.69	2.71	2.61	2.95	2.95	2.05	3.03
Maize	1 kg	0.94	0.91	0.70	0.56	0.67	0.68	0.68	0.77	0.73	0.80	0.91	0.87
Yam tuber	1 kg	1.59	1.70	0.64	0.57	0.57	0.76	1.09	0.85	0.79	0.66	1.46	1.83
Bread	45 kg	1.05	1.05	1.03	0.84	0.56	1.00	0.70	1.06	1.20	1.40	1.60	1.56
Millet	1 kg	1.23	1.11	0.77	0.74	0.68	0.70	0.87	0.58	0.58	0.57	0.63	0.63
Sorghum	1 kg	1.07	1.00	0.89	0.88	0.81	0.62	0.82	0.58	0.56	0.66	0.67	0.67
Beef	1 kg	5.78	5.04	5.94	5.25	6.34	6.79	7.26	6.74	7.21	7.31	8.37	7.84
Palm oil	1 lt.	1.18	1.56	0.88	1.32	0.94	0.95	1.15	0.75	0.69	0.64	1.43	2.55
Tomatoes	1 kg	1.18	1.56	0.88	1.32	0.94	0.95	1.15	0.75	0.69	0.64	1.43	2.55
Okro	1 kg	1.87	0.94	0.86	0.92	1.66	0.63	1.97	1.67	1.58	1.64	1.47	2.29

Source: Federal Office of Statistics, Lagos, 1986: 25-26.

Table 1.2: Food demand and supply in Nigeria, 1985 and 1990 in grain equivalents.

Crops and crop products	1000 tonnes Grain Equivalents		Deficits in 1990
	1985	1990	
Gross Demand	22,125	26,107	
Domestic supply at 2.0% p.a. current growth rate	17,600	19,330	6,777
at 10.0% p.a. to close deficit		26,107	0
Livestock Products			
Gross Demand	1,060	1,251	
Domestic supply at 1.0% p.a. current growth rate	645	677	(574)
at 17.0% p.a. to close deficit	1,251		0

Sources: Constructed by Abalu (1987) from Federal Ministry of Agriculture.

therefore the demand for livestock and crop products outstrips the supply. Importation of livestock and crops products has been the means of supplementing the national supply. However, to allow for orderly growth of the domestic production; beef, poultry, rice, wheat and maize imports have since been banned. But imports of live animals have not been restricted. The domestic off-take of beef animals is supplemented also by imports which run to between 34.90 and 30.140 percent of national requirements from neighbouring countries (Federal Office of Statistics, 1982).

Past efforts of the government to increase agricultural production through large scale introduction of modern inputs has not been very successful. The level of adoption of modern inputs had been partly rather than the whole package (D'Silva and Raza, 1980). Even where there has been serious attempts at adoption, the impact on output has been minimal in comparison with the demand. The potential of the new technology has not been fully expressed on the small farms that produce the bulk of the country's agricultural products. The consequence as already stated is that agricultural production continues to grow at the slow rate of 2.5 percent per annum which is below the annual population growth rate of 3 percent. Shortages of essential agricultural commodities remain as evidenced by spiral increases in food prices and huge import bills. The food importation bill attained the astronomical level of 1.5 billion naira in 1980 (Abalu et. el, 1981).

A number of reasons have been suggested for the failure of past programmes to make a substantial impact on production. These include the lack of appropriate infrastructure for making the inputs available in adequate amounts and at the right time; the ineffectiveness of the extension service in communicating the knowledge of the technology to the farmers; and lack of initial capital to pay for the inputs and finance additional cultivation expenses (Egharevba, 1980).

Production methods are still predominantly traditional. The force of habit, the menace of drought, tse-tse fly infestation in most parts of the country, the absence of effective land tenure and credits for the small farmer are said to be the operating forces that hamper modernisation of the technology in the agricultural sector (Agwuna, 1983). Therefore, crops and animals bloom during the rainy season and livestock particularly depreciate towards the other half of the year which coincides with the dry season, as fodder depreciates with the dry season. The use of irrigation during this period is limited due to heavy capital outlay required for irrigation projects.

1.2 The Problem Statement

The current meat scarcity, the declining contribution of agriculture to the GDP, the need for agriculture to play a greater role in the socio-economic development of the country have further intensified interest in crop/livestock mixed farming system. The agricultural sector is expected to furnish the bulk of the nation's employment, provide for more stable supply of sufficient quantities of food including animal protein for an increasing population; and provide important raw materials for the industries. As a consequence, developing nations are encouraged to intensify efforts in the research and development of mixed crop/livestock farming system (Hermans, 1985).

Increasing empirical evidence shows that the needs of the small integrated crop/livestock farmers often have not been adequately addressed in developing programmes in the third world over the past twenty years (Klan, 1978; Poleman and Freebrain, 1973). Opeke (1977) argued that although valuable results in agricultural research have been achieved, the philosophy and the approach to agricultural research in Nigeria is basic and not applied. Reviewing the ten year-development plan 1946-1956, Nwoko (1977) observed that the planning machinery lacked strong grassroot base, yet agriculture showed high fund absorption capacity. Many development projects have been introduced without sufficient understanding of the environment in which small farmers operate. The chequered pattern of success is traceable in part to the way research has been organised and undertaken in low income countries including Nigeria (Longhurst et al., 1976). Hence public investment in agricultural research has not always been spent on the needs of the small farmers, who should be the major customers of the results of such research. Instead allocation of funds often has been made on:

(1) Expressed needs of more influential farmers who often hold non-agricultural jobs in the society.

(2) Research that will appeal to professional peer groups of the researchers.

(3) Types of technologies that have been developed in high income countries.

Therefore the link between the small farmers and the research organisations has tended to be weak (Stavis, 1979). Traditionally, this interaction should have been facilitated via the extension worker, but for some reasons this has not often worked. Two possible reasons as given by Gilbert et al. (1980) are:

(1) Institutional and administrative barriers which prevent effective interaction between researchers, extension workers and farmers.

(2) Researchers in the third world often have higher academic qualifications than the extension staff thereby reinforcing a tendency toward top-down prescriptions - from research workers to extension workers to farmers.

So far government efforts in agricultural development have been to treat crops and livestock as separate sub-sector. The integrated mixed crop/livestock production system though popular with the numerous small farmers in Nigeria has been the subject of less consideration and discussion. This may have been partly due to relatively little or no research information concerning crop/livestock mixed farming production system. A more important reason may have been the assumption that only a few ranches and large scale farms requiring very high capital

investment could make a significant impact on agricultural production.

Regarding the weakness of the large scale projects Abalu and D'Silva (1980) stated that "Even if the country could afford the heavy investment that would be involved, the tendency would be to create a landless class displacir original owners of land and replacing them with fewer but more powerful and more wealthy individuals". In the absence of alternative employment opportunity, the result would be abject poverty in rural areas, as well as in urban areas which would experience heavy migration from the rural areas.

ILCA had conducted studies on the existing crop/ livestock interaction in the sub-humid zone of Nigeria. Their findings as noted by Powell (1983) is "that to design innovations that will maintain or increase crop yields and fodder resources is a difficult issue. The major livestock resources, like cattle is owned by one group, the Fulani, while the crop largely lies in the hands of another group, the farmer who also controls the land.

Although there is certainly a system of interactions between the two sectors, improving interactions through innovations that will mutually benefit and satisfy both groups remains the challenge".

Nigerian agriculture is largely organised around millions of small farming families as integrated crop/

livestock producing unit (Table 1.3). The bulk of the nations food supply comes from these numerous small farms (Gadzama, 1987; Warriner, 1964; Abalu, 1986). Those farmers must take decisions pertaining to the organization of their farms in terms of the combination of resources to be used in crops, animals and off-farm enterprises. They make these decisions on the basis of tradition developed over a period of generations which are suited to local conditions. Their very survival, even at a subsistence level is indicative of the value of traditional methods.

Decisions of farm organisation based on tradition are inefficient and farmers mostly cannot afford the cost of alternative technology. Hence such decisions have failed to meet the demands made on agriculture for increased food production. Even when modern inputs like chemical fertilizer, tractor hiring units etc. have been made available agricultural output has not increased substantially on these farms since the gap between the supply and demand for crops and livestock products is still wide. FAO report on integrating crops and livestock in West Africa (1983) identified some socio-economic problems impeding the exploitation of the existing potential and benefits of integrated crop/livestock production. Some of the problems include a lack of basic statistical data, knowledge of the socio-economic background, the environment, the resources and the management capacities

Table 1.3: Farm holdings reported by activities and by states (1981/82) [in thousands].

State	Total holdings reported	Number of producing crops only	Holdings keeping livestock only	Operating both
Anambra	139	64(146)	68(42)	17(12)
Bauchi	135	41 (30)	11(8)	83(61)
Bendel	52	23 (44)	13(25)	16(31)
Benue	49	18 (37)	7(14)	24(49)
Borno	4	2 (50)	0(0)	2(50)
C/River	28	16 (57)	10(36)	2(7)
Gongola	16	5 (31)	5(31)	6(38)
Imo	113	27 (24)	36(41)	40(35)
Kaduna	60	7 (12)	(0)	53(88)
Kano	92	12 (13)	23(25)	57(62)
Kwara	202	102 (52)	59(29)	38(19)
Lagos	20	5 (25)	11(55)	4(20)
Niger	203	96 (45)	6(3)	106(52)
Ogun	33	7 (21)	16(48)	10(31)
Ondo	133	41 (31)	57(43)	35(26)
Oyo	245	25 (10)	132(54)	88(36)
Plateau	23	7 (30)	2(9)	14(61)
Rivers	89	33 (37)	26(29)	30(34)
Sokoto	70	15 (21)	1(1)	54(77)
Nigeria	1,706	549(32)	483(28)	674(40)

Source: Federal Office of Statistics, Survey of Modern Holdings of Agriculture, 1981/82.

Figures in brackets are percentage of the total holdings.

within traditional production system which can be used as a basis for planning.

Hopper (1975), has identified four types of opportunities for the development of traditional agriculture. These are:

(a) an extension of area of land under cultivation,

(b) the utilization of more inputs under indigenous condition,

(c) the use of new inputs

(d) the re-organisation of the traditional inputs in an effort to improve efficiency in production.

A lot of researchers believe that a reorganisation of traditional inputs which should be the first step towards improved technology has not received adequate attention, especially the small scale integrated crop/livestock producers (Alkali, 1969; Nuru, 1984; Degado, 1979). Kisopanides (1963) reported substantial increases in farm income following planning and re-organisation of small farms in West Macedonia, Greece. This is an option that should be exploited.

In Nigeria, agricultural research is organised along disciplinary lines such that crops and livestock are treated separately, yet millions of farming families are known to engage in integrated crop/livestock production. This is why there is scarcity of empirical information on the production activities and farm organisation of small scale integrated crop/livestock farmer. This lack

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of adequate information has resulted in poor results of the efforts of the government at improving the lot of these farmers as reflected by efforts to settle the agro-pasturalists who are largely mixed farmers (Van Raay, 1975).

The need for micro studies of the farm organisation and decision making process of small scale integrated crop/livestock production system towards improvement in production methods is particularly relevant to Northern Nigeria. This is so because it is both an important livestock and crop producing area of the country.

1.3 Objectives of the Study

The broad objectives of this study are to provide information that can assist the mixed crop/livestock farmer on the decision about the levels of resources used and enterprise combination which maximises output and income. Thus fostering the policy of increasing their well-being and increased food production in Nigeria. The study seeks to analyse the production methods, explore cultural practices and assess the efficiency of resource use of the mixed crop/livestock production system.

In an attempt to provide the much needed information on resource use and enterprise combinations under small

scale mixed crop/livestock production the following objectives have been identified:

(1) To provide descriptive information about the resource requirements, and the operating characteristics of small scale mixed crop/livestock farmer in the study area.

(2) To design optimum farm plans in relation to resource use and enterprise combinations of the small scale mixed farm.

(3) To examine the effect of resource adjustment on total gross margin.

(4) To assess the implication of the above analysis with particular reference to research, extension and government policy.

1.4 Justification for the Study

Any meaningful development of mixed farms will require considerable farm level information on existing practices. Adequate information does not exist due to limited research on economic analysis of mixed farms. Van Raay (1975), estimated that over half of the Fulani in Northern Nigeria were settled. It can be assumed that virtually all of them are agro-pasturalists (mixed farmers). There is hardly any information on the economic activities of these and other mixed farmers, yet the Federal Government continues to lay emphasis on encouraging settlement as an end in itself. The welfare of already settled

pastoralists must be the most powerful determinant of whether more will agree to settle.

Preliminary reports of the Livestock Systems Research (LSR) Programme of NAPRI in Giwa District of Kaduna State have shown that there are twenty six villages in the district. Also crop and livestock production in an integrated fashion is practised by nearly all the households in the area. So far there is no empirical information available with regards to economic analysis of their production activities e.g. resource use, enterprise combinations, production costs, farm income, credit requirements etc. Such information is vital to supplement the knowledge that might be generated from the LSR programme.

The main goal of LSR programme is to come up with practical packages that could improve the production activities of the farmers in Giwa district. It is known that for any innovation or intervention to be successful, information on the economics of such innovation among other considerations is vital to facilitate adoption. Apart from food security, farmers are also interested in profit maximisation.

It is logical to expect the adoption of idea or concept only after the usefulness or superiority of that new idea over the existing one is overwhelming. It is hoped that this study will provide the much needed

baseline economic information that could assist the Livestock Systems Research Programme in evaluating the economic viability of whatever innovations that might be introduced.

CHAPTER II

REVIEW OF LITERATURE

In Nigeria the studies and policies of agricultural development potential which is relevant to the integrated crop/livestock interaction are actually confirmed to two programmes. These are the mixed farming systems and the range management/pasture development programmes. The latter has been given adequate attention by the National Animal Production Research Institute (NAPRI) and other agencies, while there are very few empirical studies on the former scheme.

2.1 Animals in Mixed Farming Systems

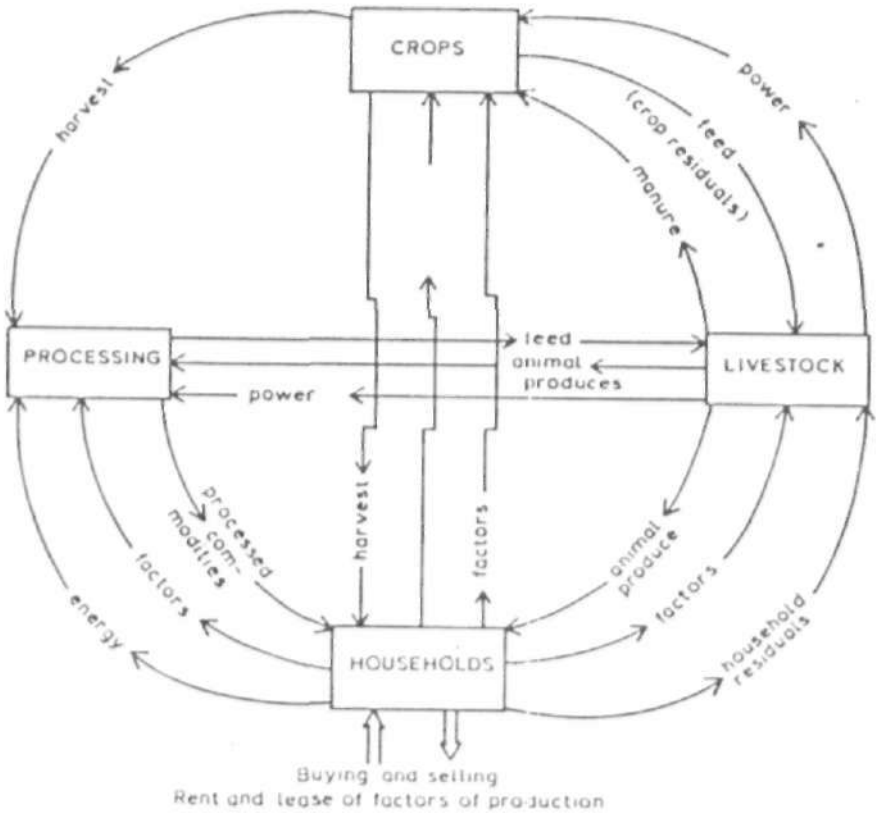
Raising livestock in the tropics is an industry divided into two distinct sectors. Large, commercial enterprises, especially those producing milk, swine and poultry are found in most tropical regions. These large animal enterprises are generally similar in organisation and methods of operation to their counterparts in the developed countries, with large capital investments and a high degree of specialisation. Many of such commercial animal farms do not even grow their own feed. Not surprisingly, this type of commercial animal farms are the focus of most research and development efforts.

The second sector of animal enterprise which involves combining animals with cropping systems, is by far more prevalent in most developing countries including

Nigeria. A schematic representation of interactions within the agricultural sector is presented in Fig. 1. The representation introduces the concept of mixed farming. Mixed farming was originally thought of as the utilization of workbulls in farm operations and the use of crop residue as feed by the animals. Since bulls were widely used for work in the farms, mixed farming was then regarded as integration between crops and cattle. Few small farms in the developing world are without animals. A common characteristic of these small farms with mixed animal crop enterprises is the close interaction between animals and crops. The complexity and variety of these interactions have discouraged research and development efforts of these very important mixtures (Hardwood, 1979). Nevertheless the potential efficiency and productivity of the animal - crop combinations due to the interactions they permit are responsible for their almost universal popularity among farmers.

The efficiency of crop-animal interactions is most pronounced where production resources are scarce. In the most productive crop-animal interactions, the animals are used as sources of power to farm the crop land, sources of meat for domestic consumption and for sale, as consumers of crop by-products and as a means of recycling nutrients back into crop land. This near-total interaction is the most common animal-crop

Figure I. Schematic representation of interactions within the agricultural sector



Source: Modelling of Extensive Livestock Production Systems: Proceedings of ILCA Workshop, Dagan Israel, 5-9 Sept., 1985.

relationship on small farms in Asia and Africa (Hardwood, 1979), and its productivity accounts for the increasing popularity of this type of systems in those regions.

2.2 Types of Crop/Livestock Relationships

There are two types of crop/livestock relationships which are usually erroneously interchanged. These are:

(a) crop/livestock integration

(b) crop/livestock mixed farming

Crop/livestock integration as used by Delgado (1979) and ILCA refers to a situation in which crop farmers as a group and livestock rearers as another group exchange products for their mutual benefits. This involves the exchange of crops like grains, vegetables and crop residue and livestock products such as meat, milk, butter, etc. This is a purely symbiotic relationship between herders and the cultivators with mutual benefits to both parties (Awogbade, 1987). Entrusted cattle is an important feature of this system (Delgado, 1979). Fig. 2 illustrates an integrated crop/livestock production system.

The mixed farming concept of the crop/livestock farming system is the result of interactions among several kinds of crops and livestock which form interdependent components. At the centre of the

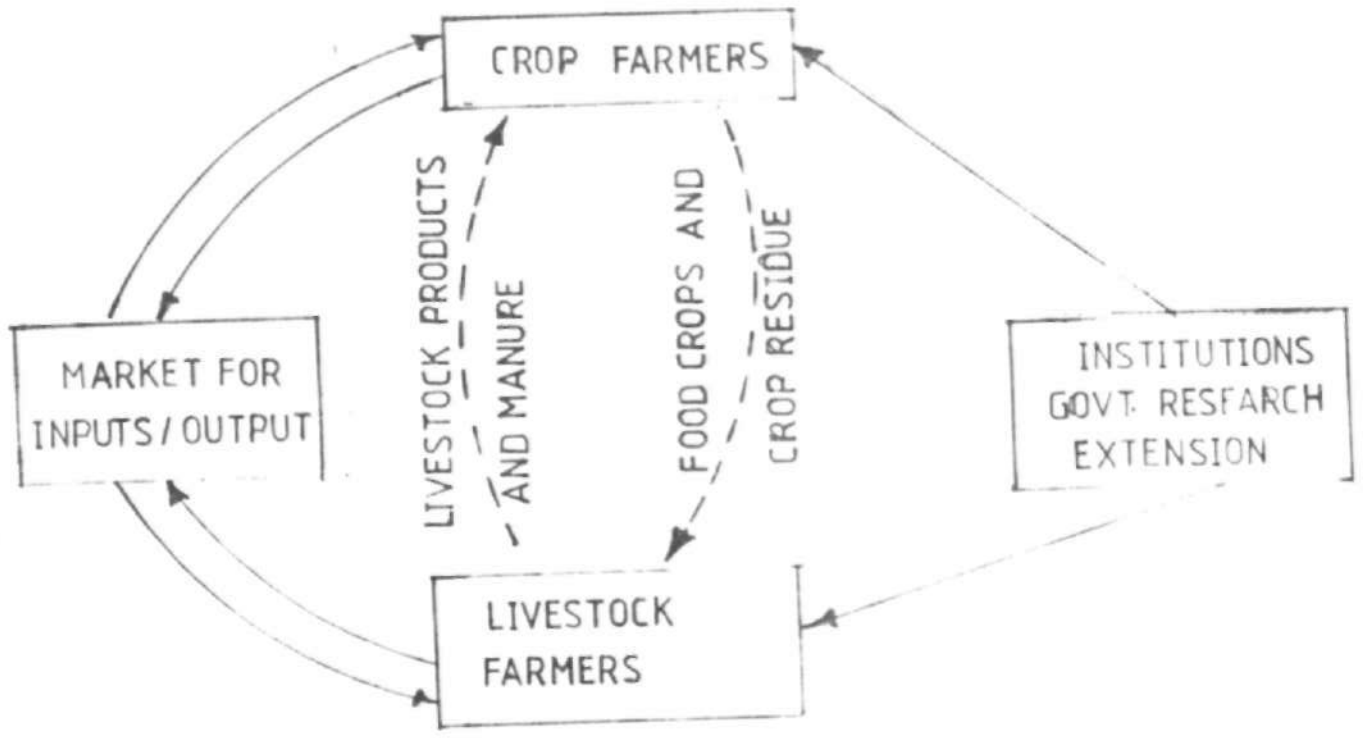


Figure 2 Interelations in the integrated crop/livestock production system

interactions are the farmers themselves, whose household or families and their means of livelihood are intimately linked and must not be separated as shown in Fig. 3. For the mixed crop/livestock farming system, farming families allocate certain quantities and qualities of basic types of resources - land, labour, capital and management to which they have access, to the three processes namely: crops, livestock and off-farm enterprises. Allocation is usually in a manner which, given the knowledge they possess will maximise the attainment of the goals they are striving for. The farming families like most economic unit engage in production, consumption and exchange. The crop/livestock farming system in this study will be analysed on the basis of the mixed farming concept.

2.3 Complementarity in Mixed Farming System

An important aspect of the mixed farming approach to agricultural production lies in the complementarity between crops and livestock. This complementary role is seen in the use of animal wastes as organic fertilizer for the benefit of the crops and the use of crop residue for feeding livestock (See Fig. 2). The dotted lines depict the complementary role between crops and livestock. This is shown in Fig. 3.

In spite of the fact that mixed farming would be considered a substantial improvement on more traditional

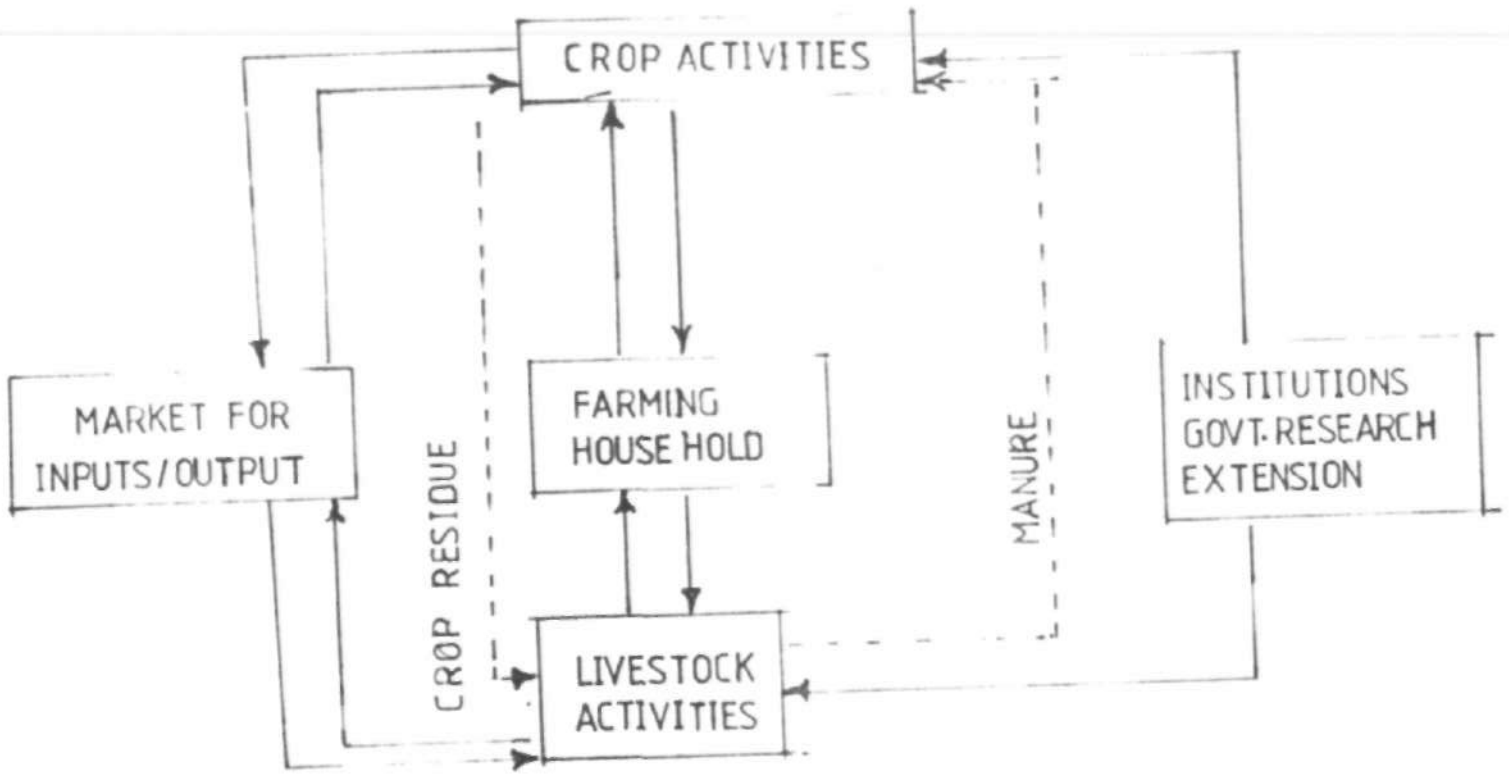


Figure 3 Interactions between crop/livestock in the mixed Farming system

farming systems, the actual rate of expansion has been very slow, due to important constraints. These constraints are discussed below.

2.4 Initial Constraints of Mixed Farming in Northern Nigeria

Norman (1968) reviewed some of the problems inhibiting the adoption of mixed farming in the past. Population density and land tenure arrangements were identified as the most prominent constraints. In many areas, it was extremely difficult for farmers to obtain contiguous holdings large enough for successful mixed farming operations involving work animals. Another major problem was the acquisition of necessary capital. Some form of credit is clearly indispensible in a situation where the capital needed to obtain ploughs and bullocks exceeds the average net farm income of ₦1100 per annum (Hayness, 1969). The low level of farmers income and lack of managerial skills contributed to their inability to shoulder the risk inherent in the adoption of mixed farming. Although government loans had been made available, these were only advanced for implements and not for work animals. Moreover, eligibility for a loan was dependent on the farmer having rights over at least 20 hectares of land so that only the more wealthy farmers could take advantage of the loan scheme. Furthermore, there was a total lack of managerial knowledge and the economic

implications of the operations. While perhaps attractive in theory, the mixed farming loan scheme could not arouse popular appeal.

During the period 1931 - 1956, some 33 percent of the new entrants to the scheme were furthermore unsuccessful. Over 23,000 farmers acquired cattle and ploughs but only 15,450 survived as mixed farmers (Hayness, 1966). Some failures were undoubtedly due to cattle disease and starvation, but there was little doubt that in most instances they were associated with insufficient farm management, technical know-how and lack of suitable equipment (Schenelder et. al, 1967).

However, the adverse experiences have never been of such magnitude as to silence the advocates of mixed farming. Although the need is recognised for a complete reappraisal of the organization of the mixed farming operation and the government's role in inducing its adoption by farmers and pastoralists. The mixed farming system continues to be advanced as holding great promise for many savanna areas of Northern Nigeria. Mixed farming technology as perceived by small farmers in Northern Nigeria is also comparatively simple. It can be grasped readily by extension workers and made intelligible to the farmers. Sometimes it is also suggested that development of savanna agriculture as a whole will largely depend upon a reform of the

livestock industry (F.A.O., 1963). The main direction of reform apparently lies in close integration of livestock with crops in areas where cattle of any kind can be kept. To quote Alkali (1969) "it is clear that no real expansion of rural production can be made in Nigeria unless some form of mechanisation is practised and unless there is greater integration of livestock and arable farming systems. Mixed farming satisfies the two requirements and has been shown to have both a tremendous need and potential in the Northern States of Nigeria".

In the past, efforts in the area of mixed farming focused on farmers or individuals with permanent titles to relatively large tracks of land. But perhaps this was a major weakness of the scheme since it meant in practice that most but the wealthiest farmers were virtually excluded. It is indeed surprising that while Nigeria is so well endowed with human resources in the area of animal husbandry, a mixed farming programme got off the ground that paid so little attention to those who by their skills, values and ideals are excellent cattlemen. The undue emphasis on large farmers cannot be justified when it is realised that many sedentary Fulani pastoralists and the small scale arable farmers have already taken to a potential integration of cropping and livestock husbandry (Van Raay, 1975). It may be true that the settled Fulani and their arable farmers counterparts may not literally be referred to

as true mixed farmers since mixed farming was considered to mean the use of cattle for work, the provision of milk, meat and manure, and the animal utilization of arable fodder resources, but it is clear that this group has the opportunities and skills to mobilise cattle for work purposes and become genuine mixed farmers. One common feature between the two groups is that both keep some animals and grow some food crops in varying proportions.

2.5 Current Policy and Studies on Mixed Farming

The importance of mixed crop/livestock production as a means of increasing agricultural production has continued to receive considerable attention in recent years by both researchers and policy makers. The 1975/80 National Development Plan encouraged the nomadic herders to take to mixed farming because it was recognised that livestock rearing constitutes part of and adjunct to arable farming. Von Kaufmann (1983) indicated that the promotion of integrated crop/livestock is not difficult to conceptualize given the vast amount of data on land areas, ecology and livestock resources. He further noted that the difficulty lies in developing innovations and systems of management that are acceptable to the people involved. The increasing demand on land to produce more food means that cultivated area will expand and the conventional range land will diminish. This has led Powell (1983) to conclude that a closer integration

between cropping and livestock will be necessary with animals becoming increasingly dependent on fodder from cropland. Awogbade and Hassan (1987), gave as one of their recommendations that grazing reserves should be demarcated into paddocks for maximum utilization by grazers. All pastoralists who voluntarily settle should in addition to pasture development plots be allocated with about 3 hectares of land for crop cultivation and the crop residue be used as feeds during the critical periods. They seemed to have recognised mixed crop/livestock production strategy as a possible solution to the settlement of the Fulani.

Van Kaufmann and Ingawa (1987), noted that mixed farming economy defines situations in which pastoral and agrarian activities are combined at household and community levels and that there is an increasing trend towards mixed farming. They further asserted that there should be no doubt in the planners' minds about the certainty that the ruminant livestock industry in countries like Nigeria will have to be integrated with crop farming. FAO (1983) has indicated that there is a growing evidence that it is in the interest of the majority of farmers to integrate forage production and livestock into their farming systems.

Working on the Southern Fulani farming system in Upper Volta on a model for integration of crop and livestock production, Delgado (1979), recommended

symbiotic relationship between the Fulani herders and Mossi crop farmers. He supported his assertion with four major sets of interventions of the policy objectives of Fulani specialization in livestock and of increased integration of Mossi crop and Fulani livestock operations. The four major sets of interventions are:

(a) Increasing the returns to herdsmen for entrusted cattle;

(b) Bolstering the cattle entrusting system;

(c) Encouraging the use of maure on Mossi vegetable gardens;

(d) Improving herders access to purchase food grains.

However, Delgado did not suggest how these could be implemented.

Commenting on the desirability of mixed farming strategy Nuru (1984) observed that the focus of attention of agriculturalists is on applied research that would make the integrated crop/livestock system economically viable enterprise for the farmer with a small land base and often surplus family labour in the rural areas.

Eddy (1979) conducted a linear programming study of mixed farming among the Tuaregs of Niger and showed that farmers have developed a system of integrating cattle and goat rearing with grain production to minimise the risk posed by drought and fluctuating grain prices.

Ware (1979) reported that drought between 1966 and 1973 forced the nomadic Fulani herders in the Diurbol area of Senegal to change to mixed farming by having their older sons grow food crops (millet and sorghum) while the women fatten animals and rear poultry. He noted that mixed farmers in Senegal had developed an east/west pattern of grazing fields in such a way that millet, sorghum, cowpeas, tomatoes, etc. are grown on the western half of a field in a given season, while this area is grazed in the next season, the eastern half is cropped. Kline (1969) studied problems of mechanization in tropical Africa and found cattle herders were more reluctant to become farmers than arable farmers were to adopt animal traction. They reported feeding and trypanosomiasis to be the problems in maintaining oxen and that the ox-plough could be used only for planting and cultivation.

2.6 Studies Involving Linear Programming Models

The production process encountered in the study area consists of growing crops in mixtures (intercropping) and raising different kinds of livestock in the same farm. The complex nature of such production process involving multiple output from a set of resources imposes a serious problem of obtaining coefficients for the LP model. Raising different kinds of livestock together is similar to intercropping.

The attempt to analyse the issue of intercropping within a linear programming setting was undertaken by Balacet and Chandler (1981), and is summarised in the next paragraph.

Balacet and Chandler (1981) in their research which was designed to help understand and explain farmers' behaviour regarding the technology adoption in the World Bank's first three Agricultural Development Projects (ADPs) in northern Nigeria at Funtua, Gusau and Gombe employed production functions and farm budgets to serve as a basis for constructing linear programming models. The LP model was set up to maximise income subject to subsistence constraints in grains.

The production functions were devised to reflect the crucial interdependencies between crops in the mixed cropping system prevailing in the ADP areas, e.g. the yield of crops in the mixture was made dependent not only on inputs applied to the plot but also on the crucial characteristics of the other crops (planting density, crop management etc.).

The use of production function in an intercropping setting created problems which Balacet and Chandler observed that the estimation of the technical production functions in a sole crop environment is relatively straightforward and well understood. There are only a few independent variables: seed variety, planting date,

plant population, fertilizer treatment, harvesting date, together with any special husbandry practices. By contrast in mixed cropping, in addition to the above, one may have multitude of other alternatives. Each crop may be planted in random fashion, in rows etc. Rows may be planted on ridges, in furrows, or individual plants may be planted in heaps. Furthermore, several crops may be combined at random relative intensities. The merits of such alternatives have not been investigated even experimentally in most cases. The above statement no doubt is also true for a production process that not only involves intercropping but also different types of animals.

In the face of the above problems, the authors set to estimate technical production functions employing two basic strategies. The first was to regard each crop mix as having its own separate production function, and hence to estimate yields as functions of inputs and husbandry practices used for that mix. The second was to focus on each crop as a dependent variable, for the purpose of estimating the yield of this crop, to regard other crops in the mix as independent variables helping to explain the yield of the particular crop being studied.

The results from the estimated equations showed a relatively low coefficient of multiple determination, R^2, ranging from 15 to 30 percent of the variation in the dependent variable unexplained. The authors noted

that despite all efforts made to collect detailed agronomic factors, the most important casual effects have been missed and/or that the yield data they were trying to explain contained a very large random element.

The production possibilities convex approximation model was used by Erhabor (1982) to specify the ISO-product or product-product space within a linear programming problem in the study of small scale irrigation technology in Nigeria. In this study the regression of a single input on sets of outputs were used to obtain coefficients for the variable inputs i.e. land, labour and water.

$$X = f(Y_1, Y_2, Y_3, Y_4)$$

Where X = units of input

Y_1 to Y_4 = units of output

The regression equations served as a basis to construct small scale irrigation linear programming activities.

A modified method of programming known as separable programming was used by Feldman (1969) in the study of tobacco production. This method allows for increasing return to scale to be incorperated in a linear programme, although capital differs from labour, in that if it is not used it accumulates. Thus a particular enterprise may either draw upon or contribute to the supply of capital in each month (Stewart, 1961).

However, Clayton (1963) noted that the assumption of rigidly fixed resources is a little unrealistic in many cases. Repeated linear programming with changes in resource mix or the unit revenues of the activities is known as parametric linear programming. It is most useful for measuring the effect of chunky inputs such as regular labour supply or fixed capital. The economics of introducing tractors in both Kenya and Uganda have been investigated in this way by him.

An alternative objective might be to minimize risk for a given minimum acceptable level of income which is then a constraint. Studies by (McFarquher, 1961; McInearney, 1969; Boussard and Pettit, 1967) have been used to allow for risk within the linear programming framework. However, all these approaches require estimates of the risks or variation in inputs and returns for each activity and such information may not be readily available.

Several other studies have been carried out on small scale farms in Northern Nigeria using the linear programming analysis. Such studies include Norman (1974) on crop mixtures under indigenous conditions, Ogungbile (1980) used a multi-period linear programming to evaluate an improved sole-crop production technology on small farms under different farm power in Northern Nigeria. An optimization model for evaluating the stability of sole cropping systems under changing resource and

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technology was studied by Ogunfowura and Norman (1973).

The technique of linear programming has many applications besides its use in farm planning just described. It may be used to find an optimum or "best" solution to any problem provided that the objective can be clearly defined and measured. The programme is equally useful where the objective is to minimize something such as the cost of carrying out industrial process or serving biological needs. A typical example is the use of linear programming analysis to determine a minimum cost ration for livestock which will provide certain dietary requirements (Heady and Candler, 1967).

The method of analysis adopted for this study is the linear programming based on the construction of a representative farm which is fully described in chapter five.

CHAPTER III

DESCRIPTION OF FARMING SYSTEM IN THE STUDY AREA

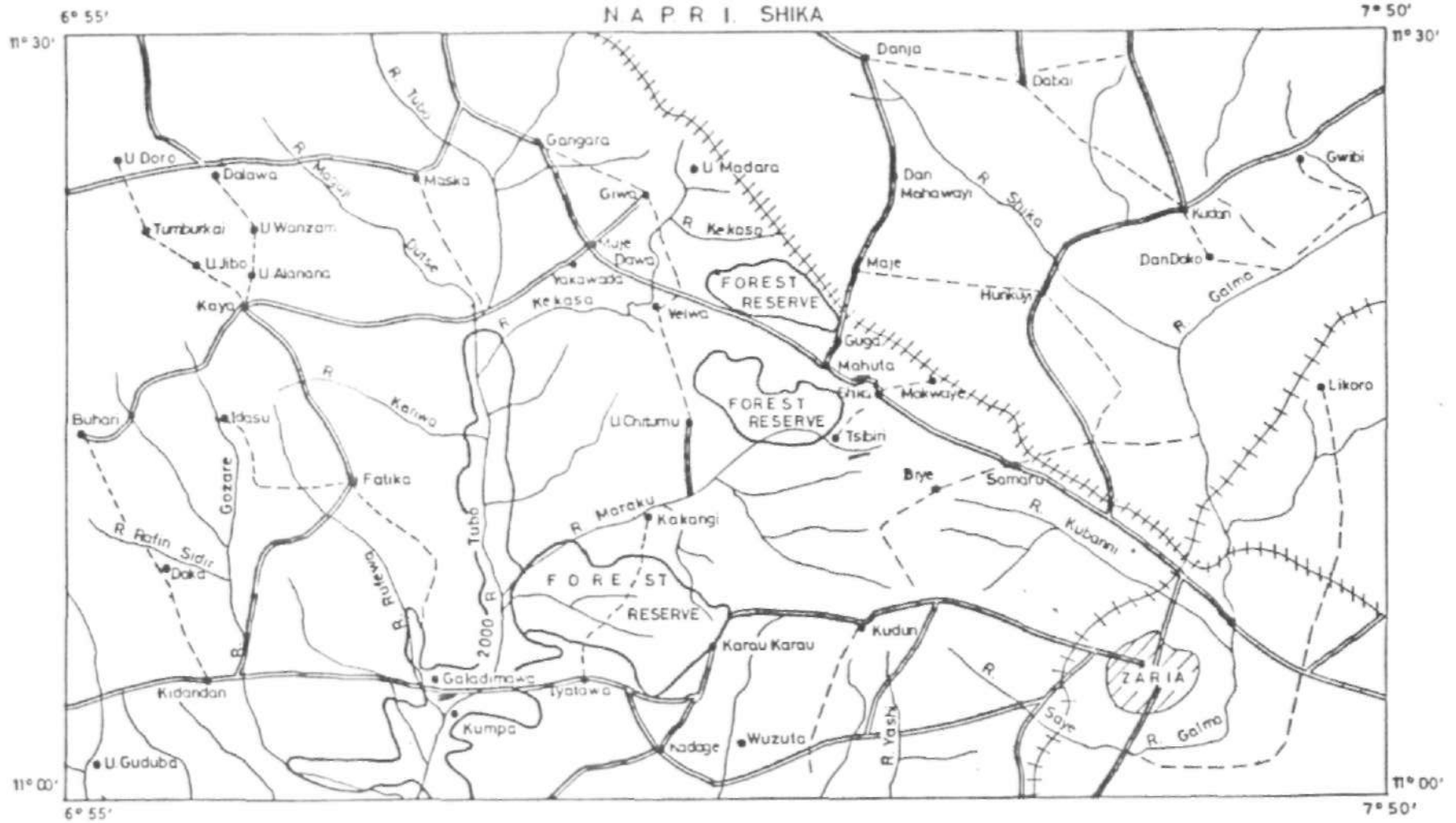
Proper representation of an agricultural situation in a programming framework requires a good understanding of the farming structure of the area under study.

The study area is Giwa district which is situated in Zaria Local Government Area of Kaduna State. The area is chosen because it has many small scale mixed farmers; in addition to its nearness to NAPRI Headquarters at Shika. It covers an area of 3350 sq km and lies between 11°-11° 38'N and 7° - 7°45'E (Fig. 4). It is located North West of Zaria in the transition zone (ecotone) between the Northern Guinea and Sudan Savanna where ruminant livestock population is generally high. There are 20 villages with 197 wards which have about 1320 arable, 1000 Fulani agropastoral and 4300 non-Fulani agropastoral households (Livestock Systems Research, 1989).

Agriculture forms the principal means of livelihood for about 70% of the working population. Farming is traditional in nature with main emphasis on cultivation of crops and keeping of livestock. The use of animal power, heavy equipment, fertilizer and crop protection chemicals are minimal. Animal husbandry relies mainly on grazing the poor natural range land.

There are two seasons - the dry season and the wet season. The wet season usually begins in April

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or May lasts for about 5 to 5½ months. In 1987 the year of this study, the wet season started in May and lasted till mid October. The annual rainfall was 968.3 mm and 972.2 mm for 1986 and 1987 respectively. Details of average rainfall distribution in the study area are given in Table 3.1. The length of the growing seasons both years was shorter than that of 1985. However, 1986/87 season could be considered a fair season for both crops and livestock production.

Table 3.1: Monthly rainfall in (mm) 1983 - 1987.

Month	Long term average 1928-1986	Y e a r				
		1983	1984	1985	1986	1987
January	0.1	0.0	0.0	0.0	0.0	0.0
February	1.0	0.0	0.0	0.0	0.0	0.0
March	6.4	0.0	5.2	32.0	0.0	0.0
April	38.0	0.0	30.1	0.0	5.8	0.0
May	119.3	73.3	98.9	140.7	59.1	135.7
June	152.8	74.3	55.4	142.2	82.0	146.8
July	222.2	107.5	173.8	313.1	293.6	276.7
August	268.8	259.7	158.1	256.3	322.1	268.3
September	210.9	93.4	189.0	163.3	205.7	102.1
October	35.3	0.0	177.5	3.3	0.0	42.6
November	1.0	0.0	0.0	0.0	0.0	0.0
December	0.1	0.0	0.0	0.0	0.0	0.0

Source: Department of Soil Science, Meteorological Division, IAR, ABU, Samaru, Zaria.

3.1 Utilization of Resources

3.1.1 Land

Land is communally owned by the Hausas and individuals only posses rights to the piece of land they own. This means that the individuals in the community have no right to part with the land they own without the consent of the others. Among the Hausas about 65% of land transfers is through inheritance.

On the contrary the Fulani pastoralists have no title to land. The pastoralists in the study area acquire farm sites and areas for settling through the following four channels:

1. The Dagaki (village head)

Farm sites obtained through the Dagaki belong to the village and only the Dagaki can apportion such land to those who need it. No compensation is paid on such land and the duration of stay depends mainly on the relationship between the pastoralist and the vilagers. Pastoralists in Dagaki allocated farm sites usually have large parcels of land and could erect permanent structures if they wish. The children of such pastoralists could renegotiate continued stay after the death of the household head but such land cannot be bequeathed.

2. Farm sites obtained through the Talakawa

The Talakawa refers to village citizens who don't hold traditional titles. The talakawas that leased out land to pastoralists and others interested were mainly farmers, traders and civil servants. The settler is allowed to stay by the civil servant on condition he takes care of entrusted cattle belonging to the civil servant. Others who give out land receive some grains or tubers at the end of each harvesting period from the settler. This is referred to as Gala. This system also allows access to crop residue of the landowner by the livestock of the settler.

The third method of land acquisition by the pastoralists and other settlers is by the system of Jingina or mortage terms. This involves payment of an amount of money to the land owner who refunds the amount when the settler wishes to leave or when the landowner wants to make use of his land.

The fourth method of land allocation to settlers is through Mai Ungwua or the Ward Head. The ward head unlike the Dagaki allocates land within his ward and not in the village as a whole. Such land when allocated cannot be inherited by the children of the settler. Sometimes but less common land can also be obtained through an old fellow settler, who allocates a portion of his land to other new settlers usually in-laws, relatives or close friends. The period of stay of the new settler is usually short.

It was further observed that about 2% of the agropastoralists in the sample actually purchased land. Table 3.2 shows channels through which pastoralists acquired farm land.

Table 3.2: Channel through which pastoralists acquired farm land.

Village	Dagaki	Mai Ungwua	Talakawa	Pasto-ralist	Mai-Ungwua + Talakawa	Jingina
Iyatawa	11 (19.3)	-	-	-	-	-
Mahuta	-	3 (5.3%)	5 (7.5%)	1 (1.8%)	-	1 (1.8%)
Madara	-	-	16 (28.0%)	-	-	-
Gangara	-	1 (1.8%)	8 (14.0%)	1 (1.8%)	2 (3.5%)	1 (1.8%)
Yelwa/ Kakanji	3 (5.3%)	1 (1.8%)	8 (14.0%)	-	-	2 (3.5%)
Totals	14 (24.6%)	5 (4.5%)	37 (65.8%)	2 (3.5%)	2 (3.5%)	4 (7.0%)

Source: Livestock Systems Research Projects, NAPRI Initial Results, Feb, 1985.

3.1.2 Labour Utilization

The average family size in the study area is 8.35. The family provides the bulk of the farm labour requirements on the average farm. About 80 percent of total labour on the farm is contributed from family sources. The available family labour is utilized between crop activities which cover a period of between May and November and livestock activities which take

place all the year round (January - December). There is thus labour bottleneck at the peak of the cropping activities. Family labour is augmented by hired labour during the peak labour demand period. Herding of livestock is done by junior members of the family either male or female children who are generally less than 19 years old in the study area. In most cases, a single member of the family takes the cattle for grazing on each occasion. The women are responsible for milking cows, milk sales and processing of milk and grain products for food. Female adult labour input was insignificant on the family farm. Livestock activities utilize 58.5 percent of family labour, while crop activities take 36.6 percent family labour, only 4.9 percent of the total labour was hired for crop activities. Table 3.3 shows the age distribution of household members in the study area. The percentage of female children drops drastically after the age of 15 years to about 5%. This is due to early marriage practised in the study area. Male children move out to stay on their own and become household heads. Total family labour in man hours was 2643.8 for crops, 3667.8 for livestock activities per household.

The insignificance of female labour is due to the partial or complete seclusion of moslem married women. Hired labour is used by the few people who want to make extra money from cropping activities. Such hired

Table 3.3: Age distribution of household members.

Age bracket (yrs)	Household heads %	Children	
		Male %	Female %
Less than 6	0	28.8	57.10
6 - 15	0	17.4	37.5
16 - 35	38.6	53.8	5.4
36 - 45	14.0	1	0
46 and above	47.4	0	0
Mean age	45.8	11.9	5.9
Range	25-82	1-36	1-22

Source: Computed from LSR Survey, 1986.

labour are mostly engaged in more difficult task like land preparation and ridging. Hired labour here also include some individuals in the sample that utilize the services of work-bull for farm operations. The Hausas are the main owners of work-bull and are mostly hired out to large and medium scale arable farmers. Table 3.4 shows labour distribution in the study area.

Table 3.4: General labour distribution in man-hours.

	Family Labour		Hired Labour	Total
	Crops	Livestock	Crops Only	
January - April	-	1247.8	-	1247.8
May - August	1864.8	564	180.8	3729.6
Sept. - December	779	1356	169.5	2303
Total	2643.8	3667.8	361.6	7280.4
% Total	36.6	58.5	4.9	100

Source: Field Survey, 1986/87.

3.1.3 Capital Input

Capital in farming refers to man made goods or assets that are produced for the purpose of being used in the process of agricultural production. It includes such items as machines, tools, building, roads, land improvements, tree crops, livestock, seeds, fertilizers, etc. These assets are usually classified according to the length of their productive life, into fixed or long term and operating or working or short term capital. The former consists of items such as machines, tools, land improvements and buildings with a productive life that extends beyond one production cycle. Whereas the latter is made up of assets such as fertilizer, seeds, drugs, vaccines, feed and chemicals that are used up in a single production cycle (Upton, 1974; Herbst, 1974; Barnard and Nix, 1979; Etuk, 1984).

The level of fixed asset or capital in the study area among the small scale mixed crop/livestock farmers is relatively low. Farm buildings other than grain store (rumbus) are absent. Farm equipment consists mostly of hand tools, hoes and knives.

Operating capital items for crop activities such as fertilizer, pesticides are inputs that usually involve cash expenditure. For the livestock activities operating items including drugs when the need arises, mineral lick (Kanwu), harawa (legumes haulms residue)

are purchased for dry season feeding. Personal savings from sales of crop and livestock and sometimes credit from informal sources such as local money lenders are the two main sources of cash for the purchases of farm inputs. The level of savings is generally low due to low output leaving little surplus for sales. Institutional credit does not exist among the mixed crop/livestock farmers in Giwa district. High interest rate restricts the use of funds from local money lenders (Norman, 1973). Vigo (1965) as reported by Etuk (1982), observed that farmers in Northern Nigeria sometimes obtain credit from traders who charge interest rates ranging from 50 to 90 percent. Demand for credit was not reported among the agro-pastoralists, but was restricted to the Hausa farmers.

Table 3.5 shows cash expenditures on purchase farm inputs for crops and livestock enterprises. These are the amounts estimated to have been spent on operational capital items. Total mean cash expenses in the study area amounted to ₦109.09 for crops and ₦164 for livestock.

Table 3.5: Mean cash expenditures on crops and livestock per household in the study area.

Type of Crops	Crop Expenses (₦)	Livestock Expenses (₦	
Guinea corn-cowpea mixture	39.79	Cattle	137.07
Maize-cowpea mixture	44.65	Small ruminant	27.14
Millet-Guinea corn mixture	24.65		

Source: Field Survey, 1986/87.

3.2 Cropping Pattern

The climate of the savanna zone is suitable for the production of a variety of crops. Cereal crops and grain legumes are the predominant crops in the area. Considerable quantities of vegetables like okro, pepper and tomato are also grown. The crops are grown on mixed stands although some are grown on pure stand. A total of 17 crops grown in about 6 to 7 combinations were identified in the study area, although there could be more crop combinations in other localities in the villages. Table 3.6 shows the proportion of different type of crop mixtures found around three major towns of Northern Nigeria, Giwa district is in Zaria Local Government Area.

Table 3.6: Cropping patterns in Zaria, Malumfashi and Sokoto (in percent).

Crop mixture	Zaria	Malumfashi	Sokoto
Two mixtures	50.5	41.4	23.5
Three crop mixtures	28.5	20.8	51.0
Four crop mixtures	14.5	25.2	23.8
Five or more crop mixtures	6.5	12.6	1.7

Sources: Derived from Baker and Norman (1975) as quoted by Richard Langhurst (in Rural Development Planning, 1981).

The average number of fields owned per household was 2.0 and ranged between 1-9, and the average farm size was 2.0 hectares per household. Table 3.7 shows the detailed distribution of farm sites and farm size

per household in relation to ownership of cattle.

Table 3.7: Distribution of fields and mean farm size per household.

No. of household	No. of fields owned	Mean farm size per site (ha)	S.D.	Percent household
40(A)	1	1.93	2.24	67
15(B)	2 or 3	2.35	2.31	25
3 (C)	4	1.56	2.51	8

A = Household owning 1 - 40 heads of cattle
B = Household owning 41 - 80 heads of cattle
C = Household owning < 81 heads of cattle.

Source: Computed from Field Survey, 1986/87.

3.3 Animal Husbandry

Cattle, sheep and goats are the major livestock found in the area. The main source of animal feed is free range grazing. The farmers, particularly agro-pastoral Fulani indicate that they practise some limited degree of trans-human movement especially during the dry season. Otchere (1984) reported 4 types of such movements in the study area.

1. Movement up north to Katsina area. The reason given for this movement is to enable animals graze on early crop residue since harvesting of crops is carried out earlier than in the study area.

2. Movement within the case study area. A variety of reasons are given for this movement, some of which are

to search for water, browse trees and crop residue during the dry season, to escape cattle theft which is usually rampant at this time of the year which coincides with some festivals, polution of water and conflicts with arable farmers over crop damage by animals. There is the belief that animals do well on certain areas at certain times of the year.

3. The third movement is usually undertaken during the middle of the dry season to the middle belt areas of the country where rainy season is longer than in the study area and vegetation is green.

4. Sixteen respondents described a fourth type of movement which was said to prevail during the 1979-83 civilian administration. This involved movement of the entire family temporarily to the grazing site if the family head felt that there were no capable member of the family to defend the children against kidnappers. During this period women were either accompanied by their husbands when going to fetch water or they went in large groups. It is not clear why this movement occurred only during civilian administration. However, this type of movement is rare.

3.4 General Herd Management

Calves are restricted at night by tying them with neck loops (dangwali) which are then tied to a single rope stretched between two posts, to prevent them from

suckling their dam. The adult cattle are confined during the night in single enclosure. Trees with their leaves and branches intact are fallen and lined up to construct a fence.

Weaning is always natural when the calves are about one year old. Milking is done once or twice but one milking daily is predominant. Castration by crushing the cord is done at 4-5 years of age. Kanwa, a local mineral supplement is fed mostly in the rainy season when feed is abundant. The explanation was that Kanwa enhances appetite of animals and that it is detrimental to animals health if the animals appetite is high and feed is in short supply. The most prevalent diseases reported in the area include abortion, intestinal problems, skin diseases and liver flukes. They are treated locally or by veterinarian on occasional visits. Table 3.8 shows pattern of ownership of cattle in the study area.

Small ruminants (sheep and goats) feature very prominently in farming activities of the crop/livestock farmer in the study area. Sheep accompany cattle for grazing while goats are tethered and fed soilage (green fodder) during the planting season to avoid crop damage. It was observed that farmers are in favour of increasing their number of small ruminants. The reason is that during the recent rinderpest outbreak cattle population was reduced considerably. The farmers pointed out that

small ruminants were normally sold to meet household cash demands, thus preventing frequent sales of already declined cattle herds.

Table 3.8: Structure of cattle ownership in the study area.

Cattle range	No. of house-hold	Total No. of cattle per group	Mean No. of cattle	Percent of total
1 - 40	80	3390	42 (10.5)	62.40
41 - 80	30	1198	39.9 (10.4)	22.00
> 81	10	846	84.6 (36.5)	15.60

Figures in parenthesis are standard deviations.

Source: Field Survey, 1986/87.

The breed of goats in the area is predominantly red Sokoto (Maradi) while the sheep is of Yankasa breed. The pattern of small ruminant ownership in the study area is presented in Table 3.9.

3.5 Technology of Agricultural Production in the Study Area

Two kinds of agricultural production technology were observed in the study area. The traditional technology which is indigenous to the area has been in use for a very long time. The settling agro-pastoralists copy this technology from their Hausa landowners. Land, labour and

Table 3.9: Structure of small ruminant ownership in Giwa Area.

Range of small ruminant	No. of house-hold	Total of small ruminant per group	Mean of small ruminant	Percent of total
1 - 10	38	178.6	4.7 (2.1)	12.20
11 - 20	26	358.0	13.8 (1.8)	24.60
21 - 30	14	322.0	23.0 (1.63)	22.10
> 31	20	600.0	30.0 (16.8)	41.10
Total	98	1459.4		100.00

Figures in parenthesis are the standard deviations (SD).
Source: Computed from Field Survey, 1986/87.

local seed varieties are virtually the only inputs of their technology, although some farmers used organic manure to replenish soil fertility. Tools are essentially cutlasses and hoes.

The new technology involves the use of improved seed varieties, the application of chemical fertilizers and pesticides. This is not widely practised by the farmers because of the high cost of the improved inputs.

The use of oxen is not a new technology as such. Mixed farming system, which is sometimes referred to as the use of animal power, is widely practised in many

parts of northern Nigeria and can be described as the next cultivation technique understood by small farmers apart from hoe cultiviation (Ogungbile, 1980). In the study area however, the use of oxen is practised by the few rich Hausa farmers while very few Fulani make use of oxen. This is because the Hausas are the land owners and therefore have large areas and only keep small number of livestock relative to the Fulani. The opposite is the case for the Fulani who keeps fairly large number of animals with little crop cultivation.

CHAPTER IV

CONCEPTUAL FORMULATION OF THE LINEAR PROGRAMME MODEL

4.1 Preliminary Consideration

A farm firm as a productive unit makes decisions through the owner or manager on what to produce, how to produce and how much of each of the commodities to be produced. He then makes some profit or bears the loss which emanates from his decisions. The difference between his revenue from sales of the products and the cost of the inputs is his profit, if positive, or his loss if negative. It is generally assumed that the main objective of the farm manager is to make his profit as large as possible or his loss as small as possible. It is the attempt to satisfy this manager's objective and other minor goals that constitutes the optimization problem.

There are many mathematical and research methods developed over the years to effectively tackle and analyse the optimization problems in the theory of the firm. If the theory of marginal analysis of the firm is assumed, differential calculus and the idea of simultaneous equations are the major mathematical tools prevalent in micro-economics texts. Another mathematical tool widely applied to the optimization problem is the linear programming technique. Both the differential calculus and linear programming approaches should give

identical results to a given optimization problem. The major difference between the two approaches is in the nature of the assumptions. While the objective function to be optimized is assumed to be a continuous function of independent variables with the first and second order partial derivations in the differential calculus approach, both the objective function and the constraints are assumed to be linear functions or a set of linearly segmented functions of independent variables in the linear programming approach.

Linear programming, however, has a variety of flexibilities and can be adapted for use for non-linear relationships. Extension of linear programming includes dynamic, recursive, stockastic and quadratic methods which allow analysis of optimization problem incorporating market demand, time and probability distribution. The goal of management is entrenched in the objective function of the firm. In practical situation, especially in developing agriculture, subsistence food requirement or some subjective family objectives may override the much publicised goal of profit maximization. Different forms of objective functions will lead to different patterns of investments and consequently different rates of firm growth. This is one reasons why determination of adequate variables to measure the objective function has been a subject of controversy.

Given the assumptions concerning individual farm resources, prospective costs and returns from alternative products and family consumption, the general objective of this study is to maximise the net revenue. In order to accomplish this objective, the farm firm is assumed to have a production function which can be expressed mathematically as a relationship between quantities of inputs and quantities of outputs he produces. The theory of the firm can be adapted to the single period case where time element is not incorporated into the model. This is so because the farmers in the area of study are largely small scale operators and therefore usually plan their farming activities at the start of every planting season. Inputs are largely family owned, no credits and no records are available which could aid complexities of multiperiod analysis. Furthermore, they are mainly subsistent producers with small surpluses for sale. Their production process is made complex by growing crops in mixtures and management of different types of livestock (cattle, sheep, goats) simultaneously.

To simplify things the analysis will be limited to one period model without consideration of time element. Thus the one period production function for an individual can be represented as follows:

$$Y_j = f(T_i\ C_j\ L_j) \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where Y_j = output of product in kilogrammes

T_j = amount of land needed to produce product j in hectares.

C_j = amount of capital needed to produce j product in naira

L_j = amount of labour to produce j produce in man-hours

The net revenue or profit from the production of product j is given by:

$$\pi = P_j Y_j - (kT_j + r^{C}j + wL_j) \quad \ldots\ldots \quad (2)$$

Where P_j represents price per unit of product. k, r, w are the prices of land, capital and labour services for the single production season respectively.

If it is assumed that the farmer faces a perfectly competitive market, in both input and output markets and land constraint, then the process of profit maximisation can be set up in Lagarangian equation as follows:

$$\text{Max:} \quad \pi_j = P_j Y_j - (kT_j + r^{C}j + wL_j) \quad \ldots\ldots (3)$$

$$\frac{d\pi_j}{dT_j} = P_y \frac{dY_j}{dT_j} - k \quad \ldots\ldots\ldots\ldots (4)$$

$$\frac{d\pi_j}{dC_j} = P_y \frac{dY_j}{dC_j} - r \quad \ldots\ldots\ldots\ldots (5)$$

$$\frac{d\pi_j}{dL_j} = P_y \frac{dY_j}{dL_j} - w \quad \ldots\ldots\ldots\ldots (6)$$

Equation 3 is the objective function to be maximised. Equations 4, 5 and 6 constitute the first order derivatives of the objective function with respect to the individual inputs used in the production process.

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If equations 4, 5 and 6 are each equated to zero and the values of the inputs prices are moved to the right hand side of the respective equations, equations 4 to 6 imply that the marginal value product with respect to each input must be equal to the value of the input prices. For example:

$$\frac{d\pi_j}{dT_j} = P_y \frac{dY_j}{dT_j} - k \quad \ldots\ldots (4) \text{ then } P_y \frac{dY_j}{dT_j} = k.$$

If equations 4 to 6 are each set equal to zero and then solved simultaneously, the optimum quantities of land, capital and labour to be used to achieve the objective function of maximum profit given the constraints can be derived. Marginal rate of technical substitution (MRTS) between any two inputs can be obtained from the first order conditions. For example, marginal rate of technical substitution (which expresses the rate at which one input replaces the other in the production process as these input prices change) MRTS between capital and labour is given as follows from equations 5 to 6.

$$\frac{\frac{P_j . dY_j}{dC_j}}{\frac{P_j \; dY_j}{dL_j}} = \frac{MVPC_j}{MVP_{L_j}} = \frac{w}{r} - \quad \ldots\ldots\ldots (7)$$

Equation 7 states that the ratios of the marginal productivities of the two inputs must be equal to their price ratio.

The above expressions represent the single period

static production decision process in the neo-classical marginal sense. The validity of the above analysis is subject to the fact that the second order condition holds. The second order condition requires that the second partial derivative of each resource be negative or that the relevant bordered Hesian determinant be positive , i.e.

$$\frac{d\pi_j^2}{dC_j^2} = Pf_{11} \leq 0 \quad \text{or} \quad \begin{bmatrix} f_{11} & f_{12} & -r_1 \\ f_{21} & f_{22} & -r_2 \\ -r_1 & -r_2 & 0 \end{bmatrix} > 0.$$

4.2 Linear Programming

The problem can be formulated and solved in the context of single period linear programming. Linear programming (LP) is a mathematical technique of finding the optimal solution from a number of alternative choices. In order words it can be described as a mathematical procedure to maximise a linear objective function subject to a number of linear constraints. The technique is used as a farm planning tool in this study. In such context, the objective function is usually stated in the form,

$$Z = \sum_{j=1}^{n} C_j X_j$$

Where Z represents the returns to be maximised.

X_j's are decision variables such as the number of hectares to be produced or the amount of labour to be hired.

C_j's measure the marginal contribution of each decision variable such as the returns over variable costs (gross margins) of one hectare of crop or one head of livestock produced. The fixed conditions present on the farm are usually stated in the form of linear restrictions such as

$$\sum_{j=1}^{m} aij\ X_j - bi;\ (1 = 1, 2, \ldots m)$$

Where X_j's are as previously defined, and the bi represent the total amount of a resource available.

aij's represent how much of a resource is required for each activity unit, such as the amount of labour required to produce one hectare of a crop or one head of a livestock. Another restriction on the decision variable takes the form of:

$$X_j \geq 0$$

for all js which specify that only non-negative levels of each decision variable may be examined. Linear programming then provides a means to find the levels of the decision variables that would maximize the objective function subject to the fixed conditions on the farm and the non-negative requirements.

The mathematical framework of a linear programming matrix requires a number of important assumptions to be made about the nature of the process being represented.

These assumptions include additivity, divisibility, finiteness and linearity. However, several programming model modifications are available to handle relaxation of most of these assumptions whenever it is more realistic to do so. In this study however, it is further assumed that input-output values and resource supplies are known with certainty. Although for many purposes these assumptions may be useful simplification of reality (Etuk, 1979). Kennedy and Francisco (1974) and Upton and Casey (1974) have contended that risk considerations are important in small holder decision making and that some method of incorporating risk factor into a linear programming framework is therefore desirable.

A number of studies (Bousaard and Petit (1967), Markewits (1959), McInerneg (1969), Hazel and How (1970), Hazel (1970, 1971) among others have developed techniques to account for risk in linear programming models of the farm-firm. In the formulation of the linear programming models in this study, the risk factor is only implicitly specified by incorporating restriction to ensure that production of grain to meet minimum family consumption needs. Apart from being easily included in the complexity of a mixed crop/livestock production system, this specification is relatively undemanding in its data requirements for yield and price distribution.

The structure of a linear programming model is determined by related components, Beneke and Winterboar

(1971). The components as given before are the objective function, the activities in the model and the constraints or restrictions in the model. A detailed description of the components for the linear programming model which is used to represent the planning environment of the representative farm in the study area is given below.

4.2.1 The Objective Function

A variety of objectives have been specified for the small holder mixed crop-livestock traditional agriculture, Schults (1964) and Hopper (1965) believed that peasant farmers are profit maximisers. Wolf (1966) have indicated that peasant farmers have status objectives. Dewild (1967) contends that for many Africans, security is a more important consideration than the possibility of increasing income. Lipton (1968) seems to have a similar view. Norman (1973) found that small farmers in Zaria area used inputs in a manner consistent with a profit maximising objective. They adopted intercropping and livestock production and other practices indicative of an insurance or risk minimisation strategy. He concluded that food security and profit maximisation were relevant goals of farmers. It has been suggested that the objectives of the smallholder may include maximisation and that the objective were likely to vary over time, according to the farmers age and needs, and the external factors that influence his productive capacity (Upton, 1974). Hayer (1971) has stressed the

difficulty of deciding what it is that subsistence farmers aim for. He contends that the objective function is ambiguous and suggests ensuring an adequate food supply in drought years, producing a suitable varied diet, maximising the number of people fed, maximising the market value of output as possible alternative that could be considered. This complexity in ascertaining the objectives of small holders makes the definition of a meaningful and operational objective function a difficult problem in application of linear programming to peasant agriculture.

In this study, it is assumed that the farmers in the study area seek food security for the household as well as maximise income. Upton (1974) has indicated that there are two alternative approaches to incorporating more than one objective in a single linear programming model. One approach is to combine the various objectives into a single decision criterion such as expected utility maximisation. The other approach referred to as the lexicographic method is to employ a hirachy of objectives treating all but one as constraints. The lexicographic approach has been widely used in studies of African farmers (Low, 1974; Ogunfowora, 1972; Nwangi, 1978) and is the approach adopted in this study.

The income maximisation objective is specified in the objective functions. The security objective of producing staple food for the family is specified in the matrix as constraints to force the production of necessary

amounts of millet, guineacorn and cowpea for meeting minimum family consumption levels.

4.3 Restrictions in the Model

Farming in the study area is carried out under a number of constraints or restrictions. These restrictions, which include availability of land, family labour, operating capital, family consumption requirements and non-negativity of activity levels, are outlined as shown in Table 4.1. They are described below.

Table 4.1: Average level of existing resources.

Resources	Unit	Average Levels of Existing Resources
Land	Ha	2.50
Labour (crops)	Mhrs	2905.40
Labour (livestock)	Mhrs	3667.80
Cattle	No.	45.00
Small ruminant	No.	15.00
Cash expenses	₦	109.09
Crops (livestock)	₦	164.21
Farm income	₦	3000.00
Total* Grain Consumption	Kg	3458.70

*Total grain consumption was estimated at 70% of total grain output.

4.3.1 Land Restriction

The amount of land available for cultivation by the representative farm was about 2.5 hectares. This

consisted mostly of land owned by the household through any of the four channels outlined. There was little evidence of land selling or renting in the study area. Consequently, no provision is made in the model for any such activities.

Only upland or "gona" type of farmland is considered in the model. "Fadama" land is omitted because it was virtually absent in the study area. The land is also assumed to be homogenous in quality. The row unit is in hectares.

4.3.2 Labour Restrictions

Family labour restrictions are specified on a four-monthly basis in the model. The row unit is in man-hours. The amount of family labour available for work on the representative farm each period was assumed to be equal to the number of man-hours actually spent on the farm by family members during each period. These were estimated from the data obtained in the survey conducted.

Family labour could be augmented with hired labour. However, the amount of labour that can be hired depends on the total labour requirement relative to the amount of family labour available, the amount of hired labour available in relation to its wage rate and on the amount of operative capital available for the hiring of labour.

4.3.3 Operating Capital Restrictions

A major problem in the specification of operating capital constraints in a linear programming matrix is the difficulty in obtaining relevant data on the amount of operating capital available for farming activities. In this study, reported cash expenses of individual households are used as a proxy for the amount of operating capital. The amount of funds available for cash expenses on the representative farm was set equal to the amount estimated to have been spent on hired labour, and fertilizers for the crop production activities during the 1986-87 production season. Expenses on livestock included drugs and salt licks. These were estimated from the data obtained in the survey conducted by the author and are presented in Table 4.1.

The operating capital constraints are not specified in the model since the objective function is presented as net revenue.

4.3.4 Grain Consumption Constraints

It is assumed that representative farm seeks to achieve security by producing its own grain consumption requirements. Constraints are therefore incorporated with the model to force the production of minimum amounts of millet, guinea corn, cowpea and maize for family consumption. The required amounts were derived from

the results of the survey in the study area, Table 4.1.

4.4 Some Limitations of the Model

The description that has just been presented above does not exhaust the list of activities and restrictions that could possibly be included in a linear programming model at peasant agriculture. For example, additional levels of fertilization could be included as separate activities. The number of activities depends on the availability of data and on the objectives of the study. It is important to note that the size and complexity of a planning model may have an important influence on its usefulness. Large and complex models are costly to develop in terms of both time and money, and it is not always certain that the benefits to be derived from using a more sophisticated model (in terms of greater precision of the planning decisions derived from it) are sufficient to justify the costs. Also as one tries to build more realism into the model by increasing the number of activities and restrictions, one risks making the model so complicated that he cannot readily trace the logical connections between a change in an instrument variable and a resulting change in production.

Hardaker (1971) has advised that planning models should be kept simple in the first place, but if the results prove to be unsatisfactory in practical terms, more refinements can then be considered. This advice

dictated the philosophy underlying the approach to model formulation in this study.

This chapter has presented a detailed description of the components of the linear programming models to be employed in this study. The results of the various applications of the models are discussed in the chapter that follows.

4.5 Other Programming Methods

Other programming methods include multi-period linear programming techniques that incorporates time elements in the model, dynamic, recursive, interger and simulation. Brief details of these programming methods are presented below.

4.5.1 Multi-Period Linear Programming

The linear programming approach described above is a static or one period model. An extension of linear programming technique that incorporates time element into the model is capable of showing growth or size change from one time period to the other is the multi-period linear programming technique. Multi-period linear models are widely used in many growth studies and agricultural finance applications.

The techniques of multi-period linear programming permits the programming of activities and restrictions

for a finite number of years. Output of any one year in the programme become inputs for the following year. Thus, activities in each year represent the best or most profitable plan in terms of the specific time horizon optimum.

The variables of the multi-period model have the same interpretations as those of the basic linear programming model earlier described, except that the importance of time is emphasised in the multi-period case. The main difference is in the structure of the two models.

The matrices of a multi-period model are divided into subsets with each sub matrix depicting one year or a time period. The input-output matrix i.e. $a_{ijt} = A$ can be represented as follows:

$$A = \begin{bmatrix} A_1 & & & \\ & A_2 & & \\ & & \ddots & \\ & & & Ak \end{bmatrix}$$

where submatrix A_i contains the input-output coefficients for the time period 1, 2, ... K. Multi-period LP model contains overlapping rows and columns to permit transfer of unused resources from one period to another.

The variables C_{jt}, X_{jt} and b_{it} are vectors C, X and B respectively, in matrix notation and connote the same interpretations as defined in the regular linear programming model except that they are also divided into subvectors to reflect the period to which they belong.

Z, the value of the objective function (Z) or discounted net returns in this case, gives a simultaneous solution of the programme for all the periods taken together. Income earned in the succeeding years after the first year are discounted with the appropriate discount rate to reflect the time value for money. This technique assumes that prices, yields and technical coefficients are known or can be determined for each of the future times periods.

The condition $X_{jt} \geq 0$ guarantees that no activity is carried on at a negative level. This technique is sometimes erroneously called dynamic programming. A distinction must be made between multi-period or dynamic linear programming and dynamic programming. Basically the term dynamics involves movement through time. For a firm, dynamics deals with deriving an optimal time path from its present state which Barry (1965) calles a "terminal state". The path is optimal with respect to the firm's objectives. The time path implies the sequential nature of decision making in that decisions

in respective time periods depend on preceeding events on expectation in succeeding events. Dynamic programming is used to describe any technique suitable for solving certain multi-stage problems where time may or may not be involved. On the other hand, dynamic linear programming is an application of linear programming technique to solve problems that involve more than one time period. These two concepts differ greatly from the static analysis of profit maximisation for a given sized firm or the comparative statics of different sizes of firms.

The problem with multi-period programming analysis is the use of the concepts of net present value. Computation of net present value involves discounting of future incomes and costs by a discounting factor called the discount rate. A high discount rate gives too much advantage to projects with quick income turnover than those with longer gestation period, while a lower discount rate does the opposite. So, the choice of discount rate can influence the choice of projects. There are arguments in literature in favour of both high and low discount rates.

This technique is not used in this study because the decision making process and planning in traditional agriculture is carried out usually over one production season, such that resources and outputs are acquired and disposed of within the season. Capital borrowing activities are very low in the study area which requires

no use of a discount rate or cost of capital.

4.5.2 Dynamic Programming

Dynamic programming is an offshoot of optimal control theory. Its more popular and useful applications have been in the physical sciences where laws of motion through time and space hold for more excatly than in the social sciences. Minden (1968) has shown how dynamic programming can be used in farm growth research. The multi-stage aspect of dynamic programming easily adapts to a growth model by referring to each time period as a stage. Minden, however, noted that its use in actual growth models is severely limited because of the enormous computations required despite the fact that there is no standard logarithm as at the time of study for solving dynamic programming problems in most developing countries including Nigeria.

4.5.3 Recursive Programming

Another programming technique usually associated with dynamic programming to solve farm growth problems which incorporates time into the model is the recursive (dynamic) programming. Day (1968) developed the fundamentals of recursive programming and its application to predict crop production response. Heidhues (1966) used similar model to analyse the effects of European Economic Community (EEC) policy alternatives on different farms in northern Germany between 1964 - 65 and 1969 - 70.

Heidhues defines recursive programming as "a sequential optimizing rule with a functional relationship between any given or proceeding periods". Like dynamic programming, it uses sequential optimisation to explain behaviour. This feature makes it applicable to a wide variety of dynamic problems in economics, because recursive systems can be solved sequentially with mathematical logarithms. Starting with,given initial conditions, one can use the solutions for each period to compute parameters of successive periods (Cany, 1968). A linear recursive programming model of farm growth can be represented in matrix notation as:

Maximise C(t)x(t) = Z(t) subject to A(t)x(t) B(t)x(t) = 0.

Where Z(t) = value of the objective function in period t

C(t) = n-dimentional vector of coefficients of the objective function

X(t) = n-dimentional vector of the level of activities for period t

A(t) = n x n matrix of technical and institutional structure of production

B(t) = vector of available resources and/or potential available.

Given that we now have a series of linear programming models, one for each time period and the elements in any vector B(t) are dependent on the optimum values of the proceeding year. The relationship can be represent as:
B(t) = F(B)(t-1), X(t-1 + v(t)).

This implies that the resource restrictions in period t are determined by the resource available in the previous time period and the optimal activities (X) for the linear programming solution for the preceding time period. V(t) permits external interference in resource restrictions such as gifts, inheritance or natural disaster. Elements in C and A can vary from time to time to reflect changes in price expectations and technology.

4.5.4 Interger Programming

One shortcoming of programming technique that are already discussed is the assumption of complete divisibility of variables. The problem of indivisibility often arises in firm growth models because many activities are in actual situations not perfectly divisible. Customs, physical characteristics may dictate that the minimum level of some variables must be in discrete units. For instance acquisition and utilization of a fraction of an ox is impossible in the practical sense. Interger programming is an alternative programming technique developed to handle problems situations where all or some of the variables are restricted to interger values. If all variables are restricted to intergers, it is called pure interger problem and if only some variables are restricted to intergers, it is known as mixed-interger problem (Argwal et al, 1972).

4.5.5 Simulation Approach

Once a model has been constructed and perfected, a process of experimentation can be undertaken to provide insights into a variety of relationships (Beneke and Winterboer, 1973). This process is referred to as simulation. This approach attempts to simulate the behaviour of a farm household over time. Simulation has a number of advantages: simulation is suitable technique when the decision process is so complex that it cannot be handled by a single analytical procedures (Irwin, 1966). It is also possible to identify the effects of changes in key parameters of the system by making suitable changes in the model and observing the resultant outcome.

Furthermore, when a problem under investigation involves examination of relationships over time the data required by other techniques may not be available. A simulation model can be used to generate the necessary sequences of data on the system behaviour, which can be analysed by other techniques.

Summarising the advantages of simulation approach, Naylor (1971), has this to say:

> Although it may be conceptually possible to formulate a mathematical model describing the behaviour of a dynamic, multi-process firm operating under uncertainty, present day mathematics is simply incapable of yielding solution of this magnitude.

Naylor also argues that such circumstances will lead a researcher to resort to simulation technique in order to obtain not only a solution to such a problem of great magnitude, but also incorporate greater complexity and greater realism into the analysis than it is possible by other techniques.

The main disadvantages of simulation is that it does not guarantee an optimum solution as compared with solutions generated by the multi-period, recursive and linear programming techniques.

CHAPTER V

DESCRIPTION AND APPLICATION OF THE MODEL

The analytical technique used in this study is the single-period linear programming model. There are three basic models which are labelled A, B and C in this study. Model A represents production activities in which all the products are either sold or consumed. Model B specifies selling activities while model C incorporates crop-livestock linkages, as well as production and consumption activities. Crop residue is used to feed livestock and animal manure is used to improve soil nutrient for the benefit of the crops. Both crop residue and animal waste are regarded as resource endowments at the farmer's disposal.

In addition to the basic models there are others which are derivatives from the basic models. These are AI, AII, AIII, BI, BII, BIII, C, CI and CII. The Roman figures indicate various levels of land, labour and livestock utilization which are the major resources at the disposal of the small scale mixed farmer. Model AI increases land from 2.5 ha to 3.5 ha with cattle included as a livestock activity. Model AII maintains land at 2.5 ha but excludes cattle activities and model AIII has land at 3.5 ha without cattle.

Since the short term family cash requirements was always met by the sales of small ruminants, some sheep

or goats are usually produced to meet such family cash requirements.

One important decision a mixed farmer has to make is the allocation of labour between crops and livestock activities at the peak farming period (May, June, July, August) corresponding to period 2 in this study. One of the goals of a mixed farmer is to produce enough food to meet family's nutritional and subsistence need, some crops must be produced to meet food consumption requirements.

Model BI assumes that an increase in labour supply at the peak period is capable of solving labour shortage in this period. Model BII assumes that land is a major constraints since the agro-pastoralists have no title to land. Therefore an increase in land could enable the farmer produce enough food for his family and small surplus for sale. Model BIII assumes that if both labour and land are increased the farmer is spared the difficult decision of resource allocation between crops and livestock, hence crops and livestock output are bound to increase.

It is often claimed that one reason why a hitherto wandering Fulani has taken to settle life is to enable him utilize crop residue more efficiently for his animals and the use of manure for crop cultivation. The assumption being that the animals will not loose weight at the critical dry months of the year (February -

May). The use of maure could reduce the cost of inorganic fertilizer thereby resulting in higher net revenue.

Models CI and CII were used to test these hypothesis in which crop residue and manure were introduced as resources which the farmer can utilize to increase crop and livestock output.

The variants of the models were also used to test the stability of the basic models A, B and C and to observe changes that might take place in terms of resource use and revenue derived from resource adjustments.

5.1 Activities in the Model

Four groups of activities have been specified in this study with LP model.

(a) production (crop and livestock activities)

(b) consumption activities

(c) selling activities (crop and livestock)

(d) labour hiring activities

Capital borrowing and transfer activities are less important in the study area and hence were not built into the LP model.

5.1.1 Crop and Livestock Production Activities

The matrix of production activities of crops and livestock defined for the representative farm for the

model A is shown in appendix 1, column 1-8. The activities comprise three two-crop mixtures of guinea corn/cowpea, millet/guinea corn, maize/cowpea mixtures and sole crop groundnut production. The livestock production activities are made up of cattle, sheep, goats and milk production.

When two or more crops were interplanted in a mixture the production activities were defined in terms of the mixture rather than the individual crops in the mixture. For example labour was defined for guinea corn/millet as an enterprise. Input-output relationships were calculated for the field or enterprise as a whole. Some of the problems associated with using crop mixtures as production activities in linear programming model include estimation of the relative areas occupied by each of the crops which affect the estimation of the yields of such crops in the mixture and the possible interaction effects on the crops growing together. This problem was solved in this study by computing the average farm size in hectares and the average yield of predominant crops such as guinea corn, millet, maize and cowpea in kg, estimates of kg/ha for each crop output was calculated. It is hoped that these problems will not affect the results.

The activity units i.e. the amounts of crops and livestock production that each unit of activity represents are defined in terms of hectare for crop land and kilogrammes live-weight for livestock.

These enterprises were identified as the enterprises that most adequately depict the important production opportunities available to the small holder mixed crop and livestock farmer. Table 5.1 shows mean farm size and average number of livestock owned.

Table 5.1: Mean farm size in relation to livestock ownership.

Cattle Range	Mean farm size (ha)	Mean No. of sheep	Mean No. of goat
0 - 10	3.09	9.7	11.8
11 - 20	2.81	9.5	19.0
21 - 30	2.66	10.4	8.5
31 - 40	2.23	10.0	10.0
Above 40	1.71	20.0	14.2

Source: Field Survey, 1986/87.

There is distinction between dairy cow and beef cow therefore specific costs are also charged to dairy activities. The lactating animals at the time of survey were recorded as dairy cows for the purpose of this study. Due to difficultives in determining milk yield because milking is done by women and tradition forbids men from interviewing women, furthermore, records were not kept by farmers therefore estimates reported by Van Raay (1975) for savanna region was used to compute average milk produced. This seems reasonable because the same breeds of animals are still kept by the farmers and management is still largely traditional, therefore the use of the

estimates of milk yield as reported by Van Raay is justified. The estimate by International Livestock Centre for Africa (ILCA) in the sub-humid zone of Nigeria is put at 0.9 kg/cow per day, over a lactation period of 250 days. However, under improved management system it is possible to obtain a yield of 3.12 kg/cow per day for bunaji cow (Foster, 1960). The price for local fresh milk in the market was determined by the researcher in the absence of reliable standardisation method. Milk was bought from the sellers each market day for about one month. The amount bought was weighed each time and the estimated average price per kg was determined as ₦1.50. This was the price used for milk in this study. Table 5.2 indicates prices of commodities as obtained from the local markets in the area of study for 1987. Labour for milking was estimated at 15 minutes per animal per day for about 250 days lactation which gives 63 man hours per animal.

5.1.2 Consumption Activites

A major difference between the farm and the firm lies in the fact that the farm and the household cannot be separated. On many farms the decisions for resource allocation lies directly with household commitments. This means that not all available resources are utilized for production activities only. Therefore it is only logical in considering activities in a model such as

Table 5.2: Prices of commodities at the open market (1987).

Commodity	Price/Unit (₦)
Cattle	5/kg live wt.
Sheep	2.50 kg live wt.
Goat	2/kg live wt.
Milk/kg	1.50
Guinea corn/kg	1.00
Millet/kg	1.30
Maize/kg	1.00
Cowpea/kg	2.40

Source: Field Survey, 1986/87.

this, the consumption activities be taken into account. In this study the consumption activities is limited to farm products consumed such as crops and milk. The information on the cash expenditure for the family living expenses was difficult to obtain. This was due to the farmers unwillingness to disclose this information. Also the consumption of livestock like cattle, sheep and goats could not be readily determined.

However, Ogungbile (1980) quoting Simons (1976) reported a minimum of ₦250 required per household as a fixed consumption expenditure for a year. This is regarded as the value of grain needed for consumption in Northern Nigeria. In a study of protein intake in three villages of Zaria province by Norman (1972) the value of

grain consumed in the study was estimated as ₦1120.3 per household. In this study about 70 percent of guinea corn and millet, 50 percent of cowpea and 20 percent of maize output were estimated to have been consumed while the balance were sold. Groundnut was not consumed at all. Table 5.3 shows total crop yield in mixture and the yield of each crop in the mixture.

5.1.3 Selling Activities

In traditional agriculture the main goal is to produce food to meet family needs. However, more food in excess of family needs is often produced hence the surplus is sold at the local market. Besides, some farmers are deliberately producing certain food crops for sale to supplement their family cash needs. Consequently, there is a selling activity for crop and livestock as well as milk in the models. Table 5.4 indicates mean number of animals sold in the year of the study.

Table 5.3: Total crop yield in mixture and individual crop yield (kg/ha).

Crop Mixture	Total Yield in mixture	Yield of Individual Crops			
		GC	CP	MZ	ML
GC-CP	1150.00	850.00	300.00		
MZ-CP	1250.00		300.00	950.00	
GC-ML	2541.00	741.00			800

Source: Computed from Field Survey, 1986/87.

Table 5.4: Mean livestock sales.

Cattle Range	Cattle	Sheep	Goats
0 - 10	1.0	1.0	3.4
11 - 20	1.1	2.0	3.0
21 - 30	1.3	2.0	2.8
31 - 40	1.4	3.0	3.3
> 40	1.6	4.0	4.6

Source: From Field Survey, 1986/87.

5.1.4 Labour Hiring Activites

Labour hiring activities are actually limited to two farming periods for crops i.e. May-August which is regarded as the peak period and September-December corresponding to the period harvesting of crops. No labour is hired in the period January-April corresponding to off-farm period and none is hired at all for livestock activities. A limit is imposed on the amount of labour that can be hired because there are no landless class in the study area. Which means that most people who provide labour services will also make time to work on their own farms, therefore there is limit to the amount of labour that may be available for hire. The wage rate in the area was estimated at 90k per hour. Other forms of arrangements under which hired labour may be obtained include exchange and contract systems, however, work paid for on hourly basis was the most common. For this study all forms of hired labour are assumed to be paid for. The activity unit is one man hour.

Tables 5.5 and 5.6 show labour distribution by enterprise and farm size for crops and livestock respectively. A major difference between the Fulani and non-Fulani mixed farmers is that while the Fulani still practice some limited animal movement the non-Fulani are able to keep their livestock within the village throughout the year. It was also discovered that the non-Fulani keep a lot more crop residue than their Fulani counterparts. There is reduced labour input for livestock activities during the peak crop activities between May-September. There is no hired labour for livestock activities.

5.2 Obtaining LP Coefficient for this Study

The difficulties involved in obtaining linear programming coefficients from production function method and the prohibitively high cost of programming every farm unit have led to the use of the representative farm or more accurately the representative resource situation (Plaxico and Tweeten, 1963). Delgado (1979), referred to it as a "typical" farm. A typical or representative farm is defined as a model farm in a frequency distribution of farms in the same universe (Elliot, 1928).

Tapp (1928), commenting on the use of representative farm showed that blanket recommendations applying to all farms of a region cannot be made sufficiently specific

Table 5.5: Labour distribution by crop enterprise in man hours.

Farm size (ha)	Crop enter-prise	Period					
		Family Labour			Hired Labour		
		1	2	3	1	2	3
	GC-CP	-	380.0	240	-	-	12.0
3.89	MZ-CP	-	236.0	180	-	15.0	12.0
	ML-GC	12	140.0	127.0	-	70	9.0
	GC-CP	-	243.0	221.9	-	19.1	16.0
2.81	MZ-CP	-	167.8	116.8	-	27.0	13.0
	Ml-GC	-	121.0	114	-	11.8	9.0
	GC-CP	-	224.0	159.0	-	-	7.8
2.66	MZ-CP	-	181.0	132.6	-	-	11.3
	ML-GC	-	121.0	114	-	21.2	2.0
	GC-CP	-	180	142	-	6.5	27.4
2.23	MZ-CP	-	205	130	-	11.3	47
	ML-GC	-	67	134.5	-	4.8	3.0
	GC-CP	-	154	129	-	16	8
1.71	MZ-CP	-	105	162	-	7	6
	ML-GC	-	38	113	-	27	11

Source: From Field Survey, 1986/87.

Table 5.6: Labour distribution for livestock activities in man hours.

Range of Cattle	Jan-April	May-Sept.	Oct-Dec
0 - 10	1294	554	1403
11 - 20	1262	536	1357
21 - 30	1253	647	1285
31 - 40	1202	573	1444
> 40	1228	511	1292

Source: Field Survey, 1986/87.

and may be misleading. Whereas if farms are seggregated into groups as to type, size and activities, then more specific recommendations can be made and applied by the farmers in the group. Holmes (1923), divided Iowa State into several types of farming areas on the basis of existing enterprises. Davies (1936), classified Connecticut farms meticulously according to the amounts of labour used in the various enterprises. In the late 1930s, Black and Highell constructed composite supply schedules for milk in the New England and Midwest States of the United States of America based on budgeted responses of representative" dairy operations. Bonard (1963) noted that with the variations within the enterprise combinations among small farms, it is unlikely that a single farm model will adequately represent all the significant characteristics of any broad spectrum of farms, so that sub-strata are in fact necessary. He emphasised that studies based on farm strata cannot be

regarded as basic research. However, considerable variations did not exist within the integrated crop/ livestock enterprises in the study area, hence stratification of the sample was not necessary.

Benard and Nix (1973), have indicated that in areas where there is reasonable homogeneity in at least some of the major resources - particularly with respect to natural factors, such as soil type, topography and climate-linear programming can be used to obtain solutions to model or "representative" farm situations in order to guide planning on individual farms. The usefulness of a representative farm is limited by the way in which the representative farm is constructed. Aggregation bias is a major problem associated with representative linear programming from models and may be defined as the error in predicting aggregate output supplies or input demands, for a group of farms by using a representative farm model, rather than modelling each farm individually and summing the results (Buckwell and Hezell, 1972). There has been numerous studies on methods of minimising aggregation bias including (Lee, 1966; Buckwell and Hezell, 1972; Kennedy, 1975). All these authors agreed that if a number of farms are to be represented by a single LP model they must be technically homogenous, i.e. have identical input-output coefficients and have proportional expectation of revenue. The main issue of debate has been the relative factor endowment of farms. The method used for this

study was that adopted by Delgado (1979) the construction of a representative farm using mean values. Collinson (1972) had discussed three alternative techniques for deriving representative farm. These are:

(a) the identification of a particular farm as the typical farm;
(b) the use of an average farm derived from means of resources, input-output and net price coefficients of a sample farms as the representative farms;
(c) the synthesis of a hypothetical or composite farm from different components of the population.

The identification of a typical farm unit requires consideration of a wide range of relevant criteria. Not only is the selection of these criteria difficult, but also data on them may not be available or difficult to collect. Besides, even when the data is available, it is not easy to find a single farm whose validity could be considered typical in all respects.

An important limitation to the use of an average farm is that it brings with it the problem of aggregation bias (Collinson, 1972). This has been demonstrated by (Frick and Andrews, 1972; Day, 1963; Hartley, 1962: Buckwell and Hezell, 1972). While the synthesis of a composite farm reduces the aggregation bias, it involves

the stratification of the population on the basis of characteristics of the farms and farmers which strongly influence the particular decision under study. Farm economics research has shown that non-physical variables such as institutional restrictions, motivations, preferences, managerial ability etc. have a profound impact on farm organisation, production efficiency and earnings, and deserve being built into stratification schemes (Plaxico and Tweeten, 1963). One practical weakness of the synthesis procedures is that it is difficult to quantify several of these institutional and human factors and even more difficult to determine their distribution within a population. As Carter (1963) has pointed out, their quantification is necessary to provide a basis for stratification in sampling.

The choice of the method of representative farm depends on the purpose for which the results of the study are to be used. If the study is designed to estimate regional or national supply response, which would require that the results for the representative farm be raised to give an aggregate estimate, then methods of benchmark farm construction which minimize aggregation bias are needed. However, when the objective, as in this study, is to identify the direction of farm adjustment and estimate the degree of farmer's response to changing resources in a given area, the problem of aggregation bias and their control are not relevant, and hence the use of average farm can be justified. Even in the

estimation of aggregate production function, the benefits of a reduction in aggregate bias, achieved through a rigorous construction of benchmark farms must be balanced against the costs both in terms of time and money of reducing aggregation bias (Ogunfowora, 1972).

In the present study, the representative farm is based on data obtained from the survey conducted in 1986-87 along with the data collected by LSR in 1986. The farms in the sample were considered to be sufficiently similar with respect to the key variables that affect farm adjustment. To overcome the problem of aggregation bias in this study, the following method was adopted. One hundred and twenty of the farmers were selected at random. Sixty farmers were chosen for interview on the basis of resource endowment and duration of settlement. Since the study is concerned with small scale mixed crop-livestock farmer, respondents were also selected such that only farmers with not more than 50 heads of cattle and farm size not more than 3 hectares were qualified for interview. The representative farm for the linear programming model was then constructed from the mean values of the sixty respondents.

In this way, the high variability encountered among the small farmers in terms of resource endowment and production activities was greatly reduced. Only eight percent of the farms in the sample frame were more than

four hectares in size, about twenty-seven percent of the households owned more than forty five heads of cattle of all types and about fourteen percent owned more than thirty-five heads of small ruminants. These farms and households were excluded from the derivation of the representative farm in order to reduce the upward bias of the average farm (Etuk, 1979; Delgado, 1979). Thus the levels of the resources of the representative farm are based on the mean values of the resources of sample farms that were less than four hectares in size, less than forty-five heads of cattle and less than thirty-five heads of small ruminants.

Only one representative farm was used for the analysis so as to provide an opportunity for detailed examination of numerous problem situations of the mixed crop/livestock production systems. The representative farm approach is used in this study to indicate "average results" for a homogeneous group of farms.

5.3 Farm Resource Situation and Restrictions

Farm resources are present in limited amounts. It is necessary to define the resource endowments which can limit the optimum plan. They are:

Land

Land along with labour are generally regarded as

the two major inputs subsistent agriculture. The basic model in this study is designed for the small peasant farmer who may wish to reorganise his farm with very little or no cost but to achieve greater output. The average farm size is 2.5 hectares. The methods of land acquisition has already been discussed.

Labour

The household unit is the main source of farm labour for the peasant farmers (Warthner, 1964). The household head in addition to his physical labour is generally responsible for management of the farm operations. The average family size in the study area is 8.35. The male members of the family contribute about 80 percent of the labour input. Adult children male or female are generally responsible for grazing of animals. Labour requirement for grazing is high during the dry season which also corresponds to the off-farm season requiring no labour on the field. At the peak period, labour input for grazing is reduced to enable the adult children assist in the farm work before taking the animals out. This period also coincides with abundance of grass. Married women are confined under the puda or seclusion practised by the moslems. This is why their contribution in farm labour is very small.

Labour input is measured in man-hours. Farm labour of the farm follows seasonal pattern as mentioned earlier. Labour availability is divided into three time periods as follows:

January-February-March-April (Period 1)

May-June-July-August (Period 2)

September-October-November-Dec. (Period 3)

The first period corresponds to zero farm labour input but maximum livestock labour requirements, this period is the dry season with virtually no rainfall. At this time farmers engage in off-farm activities such as rope making for sale, building or repair of farm houses and road rehabilitation.

Period two is the busiest time of the year Ogungbile (1980), Norman (1972) found that an average farm uses 50 percent of the annual labour input at this time in Zaria area which include Giwa district, the area of study. This is why the view is generally held that the amount of labour available at this period determines the extent of farming activities that can be carried out. Major farming operations include land preparation, planting, fertilization, weeding, etc. Labour hiring is also undertaken. But there is no general pattern of labour that was apparent at the time of survey. Wage is fixed by negotiation but fluctuates between ₦3 - ₦5 per day of 8 hours per person.

The third period consists predominantly of harvesting activities, but weeding of some crops are also carried out during this period.

Capital

Capital is a major constraint to subsistent farming in the study area. The farmers cannot benefit from the formal sources of capital as they cannot provide the mandatory collateral normally required by these financial houses. The farmers rely on their savings and the local money lenders who charge large interest rates. However, in the study area borrowing activities was insignificant as most farmers interviewed did not borrow money for their operations during the survey. They however, express a desire to obtain loans for farming especially for fodder production for livestock.

Management

An important input not generally considered is management. This is true in peasant agriculture where modern methods of management is lacking. However, Upton (1973) believed that peasant farmers are good managers given their circumstances. Warrmer (1964) contends that it is managerial ability of peasant farmers that has resulted in some economic advantages which include promotion of better

utilization of the existing labour force, increase in output per head which results in equitable distribution of income. However, a major setback in the decision making process of the peasant type of farm organisation is that alternatives are not considered. Tradition is the guiding principle. Under such circumstances maximum goals may not be achieved.

5.4 Source of Data

The data that are used for the empirical analysis in this study were obtained largely from the primary sources. Three villages were selected for this study. They are: Galadimawa situated on the northern borders of Giwa District, Tsibiri which is centrally located and Mahuta which occupies the southern area of the District. A total of 120 households were listed from three villages out of which 60 farmers were selected on the basis of duration of settlement in the area. Those that have settled in the area for at least five years were selected. A representative farm was constructed from the mean values of the relevant coefficients used in this study. Given the resources available for the study, it was not possible to either include more villages or increase the number of respondents. The data collection was by questionnaire in which relevant questions were asked. The interview

was conducted at bi-monthly intervals by two trained enumerators and lasted for one cropping season (1986/87).

Each crop mixture e.g. millet/guinea corn was treated as a separate crop enterprise since it was not possible to allocate inputs, particularly labour to any particular crop constituent. On the output side, crops were completely separated into constituents since the harvesting, consumption and sales were on the basis of individual crop. For the livestock enterprises, the unit of measurement was in kilogramme (kg) live weight per animal and livestock number. In the absence of uniform standard for one unit livestock activity, this method seems appropriate. However, average weight of cattle in the study area was assumed to be about 352 kg/live weight equivalent of 1.2 LU. Average weight of small ruminant (sheep and goats) was taken as 25 kg/live weight equivalent of 0.1 LU. One tropical livestock unit is 250 kg live weight. The LU was not used because of small figures that could arise as seen in the case of the small ruminant.

5.5 Limitation of the Data

There was a general unwillingness on the part of the farmers to give accurate information about their income while they over-emphasized the cost incurred.

The recall memory process of some of the respondents may not be too accurate. The best method of interview would have been at a frequency of twice every week as against the forthnightly interval adopted in this study. This was due to resource limitations. It would have been ideal to repeat the process of data collection in the same area for at least another year for greater accuracy. However, time and other resource constraints did not permit such repetition. It is hoped that the information generated will provide a good understanding of the production process of a small scale mixed farming systems in the study area.

Finally, no generally recognised methodology has been developed for the purpose of analysing mixed farms. The large number of possible crop combinations and different types of livestock make such an analysis an extremely complex subject. Since this study is concerned with optimum combination of enterprises, a linear programming method of analysis seems to be an appropriate tool of analysis.

CHAPTER VI

INTERPRETATION OF RESULTS

This chapter presents an analysis of the results of the application of the linear programming models. The main issues are given the available resources (land and labour) and those that can be made available (adjustments in the available resources) how should small scale mixed farming production be organised and what crops and livestock should be produced? The analysis is focused on the changes in farm income and resource use that are likely to be associated with resource adjustments in a mixed crop/livestock production system.

The first optimum plan (Basic Plan A was obtained with existing resource levels. Then three alternatives using variants of the model A in which adjustments were made in farm size and types of livestock to be produced. In these sets of models selling and consumption activities were excluded.

In the next phase of the analysis, the base plan of model B was obtained. Three variants of model B in which adjustments were made in farm size and labour availability to observe the effects of these adjustments on farm income, selling activities are included.

Finally, the analysis focuses on the use of crop residue and manure in the production of crops and

livestock representing model C. The influence of adjustment in farm size on farm income was also analysed.

The linear programming output in each situation provided information on the value of the objective function of the optimum enterprise combinations the resource used with their respective marginal value of products (MVPs), the non-optimal activities with the cost associated with forcing each of them into the solution and this stability limits of the optimum plan. The validity of the optimal solution depends on the reality of the assumptions made concerning prices, technical coefficients and constraints. The optimal solution may differ from the actual practice of farmers because the linear programming model is an abstraction from reality, and some of the factors omitted from the model in the attempt to keep the model manageable may prevent the model from capturing all aspects of the farmers' behaviour in the study area.

6.1 The Characteristics of the Optimum Farm Plan Model A

Gross Margin

The characteristics of the optimum farm plan under existing resource levels model A are shown in Table 6.1. The value of the objective function or

total gross margin (TGM) is equal to ₦6205.00. The total gross margin takes into account all grains produced, whether consumed or sold. Fixed costs are similarly not considered. In general, fixed cost items in the study is very minimal so that total gross margin is equivalent to net farm income. The unpaid family labour was not also considered, so that the gross margin is by no means the cash balance after all expenses have been accounted for or profit.

Table 6.1: Optimum organization of the representative farm with existing resoruce levels, Model A.

Item	Unit	Activity Level
MZ-CP	Ha	2.00
GC-ML	Ha	0.50
GC-CP	Ha	0.00
GNT	Ha	0.00
Cattle	No.	2.00
Total Gross Margin	₦	6205.00
Land	Ha	2.50
Labour 1	Mhrs	650.00
Labour 2	Mhrs	580.00
Labour 3	Mhrs	400.00
Total Labour	Mhrs	1630.00

Source: Computed for abbreviations - See Appendix 1.

Enterprise Combination

The optimum combination of enterprise is also provided in Table 6.1. The optimal plan includes two crop mixtures comprising maize/cowpea and guinea corn/millet. All the available land was utilized. The maize/cowpea mixture was cultivated on 2.0 hectares or 80 percent of the cultivated land area. The remaining 20 percent of the cultivated land area was devoted to guinea corn/millet mixture.

Not all the crop enterprises grown by farmers in the study area are included in the optimal plan. For example guinea corn/cowpea and sole crop groundnut were not included in optimum plan. The exclusion of these crops must not be taken to mean that there will be no increase in their production, rather it signifies that at the given conditions, they are not competitive enough to be included in the income maximising plan.

For the livestock enterprises, only cattle entered the optimum plan. Sheep, goat and milk production are excluded in this income maximising plan. The nutritional importance of milk is reflected in the fact that over 80 percent of milk in various forms is consumed. Hence milk production must of necessity be produced. Similarly, short term demand for cash for family expenses is always met by the sales of small ruminant to avoid the frequent sales

312572

of cattle. Therefore in recent times due to deaths of cattle as a result of rinderpest disease outbreak, small ruminant production has actually increase in the study area.

Labour Use

The total labour use in the optimum plan was 1630 man-hours made up of 650 man-hours in period 1 (January, February, March, April) corresponding to zero cropping activities. A total of 580 man-hours of labour was utilized in period 2 which is also the peak period of farming activities. Labour bottleneck at this time is severed. And 400 man-hours used in period (September, October, November, December) corresponding to period of harvesting of crops.

Shadow Prices

The marginal value products of the resource restrictions presented in Table 6.2 are the shadow prices on the disposable activities of the linear programming model. Beneke and Winterboer (1971) have argued that the interpretation of the shadow prices on the disposal activities as marginal value products is not consistent with the exact definition of the marginal value products. The marginal value product of a resource is defined as the increases in the value of total output that is obtained from

the use of an additional unit of the resource with all other inputs held constant. This latter condition is not met in the linear programming framework because production coefficients for the activities are defined in fixed ratio of one to another. Thus an increase in the use of one input requires an increases in another. In spite of this, the shadows prices of the disposable activities are operationally useful because they provide information concerning the resource that could best be expanded to increase income. The linear programming solution holds for a specific range until other resources become limiting, at which point another organisation becomes optimal and the marginal value products of the resource change.

Table 6.2: Marginal value products of the existing resource levels, Model A.

Resource	Unit	Marginal Value Product (₦)
Land	Ha	1020.00
Labour 1	Mhrs	0.16
Labour 2	Mhrs	47.06
Labour 3	Mhrs	10.22

Source: Computed. See Appendix 1 for the abbreviations.

The marginal value products indicate the productivity of resources on the farm. They indicate the amount by which the total gross margins of the

farm would be increased by utilizing an additional unit of the resources. The marginal value of products are zero for excess or slack resources and positive for limiting resources. A high marginal value product indicates the degree of scarcity of the resources. Thus the more limiting the resource, the higher the marginal value products which have to be considered relative to the marginal factor costs of the resources. It is profitable to acquire more resource if its marginal value product is higher than its factor cost. The high marginal value product of ₦1020 for land reflects the scarcity of land or more correctly the difficulty associated with land acquisition by the agro-pastoralists. It shows that the total gross margin will be increased by ₦1020 if an additional one hectare of land was made available. Expansion of land beyond the available amount could be profitable if the marginal factor cost of land is less than 1020 Naira. Information was not available on the value of land or rent, hence the comparison between marginal value product and marginal factor cost was not possible.

Excluded Activities

The output of the linear programming routine also provides information on the activities excluded from the optimum plan. The excluded activities are the least profitable enterprises. The cost of forcing

and excluded enterprise into the solution indicates how the value of the objective function would be reduced or how income would be penalised. It reveals the competitive position of the enterprise. Sheep and goats were the least competitive.

6.2 Farm Resource Adjustments: Models AI, AII, AIII

In order to test the effect of adjustments in resources productivity, level of income and output, the variants of model A were analysed. These were models AI, AII, and AIII.

6.2.1 Optimum Farm Plan for Model AI

Model AI represents optimum farm plan in which land size was varied from 2.5 to 3.5 hectares to observe the effect of more land on total gross margin. The plan increased the total gross margin (TGM) from ₦6205 to ₦8125.00 representing an increase of ₦1920.00 or 31 percent over model A. This result indicates that a change in one unit of land changes TGM by 31 percent. It is however observed that the extra unit of land is allocated between the same crop activities as in model A. This probably indicates how important these crops are in meeting revenue maximisation as well as food sufficiency goals of the farmer. Since it was observed that guinea corn and millet are the major grains consumed while maize are mostly sold

for cash. Table 6.3 presents the optimal farm plan for model AI. Cattle still remains the only livestock activity in the plan. Again the TGM does not represent the actual cash or profit since about 70 percent of the crops is consumed by the farm family.

The marginal value product of resources used in the optimal plan for model AI is presented in Table 6.4. The value of land decreased from ₦1012 in model A to ₦876.00 in model AI, a decrease of ₦136.00. The reason is not readily obvious, it may probably be due to inability of the farmer to manage larger farm size in addition to his livestock.

The question is by how much should be the price level per unit of activity not in solution be raised to bring the activity into the optimal plan? The computer analysis shows that guinea corn/cowpea crop mixture should be sold at ₦4.50 per kg instead of the ₦3.28 entered in the matrix. The prices of sheep and goat should be raised to ₦150.00 and ₦145.00 per animal respectively instead of the existing prices of ₦80.00 and ₦60.00 respectively. This result indicates the very low competitive position of these enterprises vis-a-vis cattle activity. Milk production activity was the least competitive apparently due to its very

Table 6.3: Optimum organisation of the representative farm with land increased to 3.5 hectares, Model AI.

Item	Unit	Activity Level
MZ-CP	Ha	2.50
GC-ML	Ha	1.00
GC-CP	Ha	0.00
GNT	Ha	0.00
Cattle	No.	2.00
Total Gross Margin	₦	8125.00
Land	Ha	3.50
Labour 1	Mhrs	650.00
Labour 2	Mhrs	580.00
Labour 3	Mhrs	400.00
Total Labour	Mhrs	1630.00

Source: Computed from Survey, 1986/87.

Table 6.4: Marginal value products for Model AI.

Resource	Unit	Marginal Value Products (₦)
Land	Ha	876.00
Labour 1	Mhrs	0.90
Labour 2	Mhrs	48.69
Labour 3	Mhrs	11.46

Source: Computed from Survey, 1986/87.

low quantity produced which probably is not economic, but of very high nutritional significance, and therefore will continue to be produced by the farmer. Table 6.5 shows price increases required for activity not used.

Table 6.5: Range analysis Model AI; Price increase, quantity and equivalent yield per unit of activities not in optimum plan.

Activity	Price (₦)	Quantity		Unit of Activity		Equivalent Yield per unit	
		Kg	Nos.	Ha.	kg/l.wt	kg	kg/l.wt
CC-CP	4.50	245.7	-	0.41	-	1945.5	-
GNT	2.50	860.0	-	1.48	-	580.0	-
Sheep	150.00	-	4	-	100	-	25
Goat	145.00	-	6	-	150	-	25
Milk	2.50	493	3	1 cow	-	190 kg/animal per lactation	

Source: From Survey, 1986/87.

6.2.2 Model AII

In the plan for model AII cattle activities is excluded so as to observe the effect of this exclusion on total gross margin and to design a plan which covers these farmers without cattle. There were a number of farmers who claim to have lost their entire cattle herd as a result of the outbreak of rinderpest disease of 1982/83. There are a few others who are

just starting life but do not yet own cattle but own some small ruminant.

The farm size for model AII remained at 2.5 hectares but devoted to maize/cowpea crop mixture only in the optimum plan. In the absence of cattle activity, sheep enterprise entered the optimum plan, indicating the relative competitive position of sheep over goat activity. So it will be more profitable for the farmer to produce sheep in conjunction with maize/cowpea crop mixture. Sheep has high value than goat because of the role it plays in the muslim religion. A total gross margin of ₦4705.00 was realised, using a total of 1630.00 man-hour of labour. Table 6.6 represents optimum farm organisation for model AII. The farmer has to produce 6 sheep to realise the total gross margin in the plan. However, there is a reduced total gross margin of ₦1800.00 or 28 percent over model A.

The shadow prices or the marginal value products as earlier explained expresses the extent to which the value of the optimal plan would be reduced if the quantity of the resources, land or labour in this case, is reduced by one unit. The shadow prices for periods 2 and 3 labour are higher than the on-going wage rate, this is a reflection of labour scarcity at these periods. Table 6.7

presents the marginal value products of the resources for model AII.

Table 6.6: Optimum organisation of farm plan for Model AII.

Item	Unit	Activity Level
MZ-CP	Ha	2.50
Sheep	No.	6.00
GC-ML	Ha.	0.00
GC-CP	"	0.00
GNT	"	0.00
Total gross margin	₦	4705.00
Labour 1	Mhrs	650.00
Labour 2	Mhrs	580.00
Labour 3	Mhrs	400.00
Total Labour	Mhrs	1630.00

Source: Computed from Survey, 1986/87.

Table 6.7: Marginal value product for Model AII.

Resource	Unit	Marginal Value Products (₦)
Land	Ha	1020.00
Labour 1	Mhrs	0.90
Labour 2	Mhrs	47.00
Labour 3	Mhrs	11.66

Source: From Survey, 1986/87.

A number of activities are not included in the optimum plan not because they are not important to the farmer but because they are not competitive enough to be included in the revenue maximising plan. In this model only one crop mixture of maize/cowpea entered the optimum plan while the rest including sole crop groundnut were excluded. Table 6.8 indicates the prices at which these enterprises could enter the optimum plan.

Table 6.8: Price increase required in activities not used - Model AII.

Activity	Unit	Present value (₦)	Value Required (₦)
GC-CP	Ha	634.00	1020.00
GC-ML	Ha	860.00	1020.00
GNT	Ha	944.00	11250.00
Goat	No.	60.00	376.00
Milk	Kg	135.00	263.00

Source: Computed from Survey, 1986/87.

6.2.3 Model AIII

This model like model AII does not include cattle production activity for the reasons already stated. But unlike model AII, this model AIII has larger farm size of 3.5 hectares. The land in this model is allocated between two crop mixtures which are maize/ cowpea 2.5 hectares and guinea corn/millet 1.00 hectare.

It is observed that the optimum solution to the model once more calls for maize/cowpea crop mixture production. This crop mixture has proved dominant regardless of competitive with other crop enterprises in the event of larger farm size. The reason for this may be due to relative high price per unit of cowpea. Cowpea sells at ₦2.80/kg, maize and guinea corn at ₦1.00/kg while millet sale for ₦1.30/kg. Groundnut has continued to be omitted from the optimum plan. The reason for this could be attributable to its low yield and high cost of production involving constant spraying. In the village setting, water for spraying and its transportation may pose serious problem. In order to bring changes in cropping pattern without a reduction in the value of the objective, function, prices of activities not in the optimum plan has to increase without any increases in production cost or their output per hectare must increase.

For the livestock enterprises, sheep production activity is the enterprise of choice over goat and milk production in the absence of cattle production activity. Cattle taking the lead, followed by sheep, goat and milk production activities in that order. This therefore means that the farmer is encouraged to produce cattle and sheep for high gross margins. However, milk production will continue to be produced

for its nutritional value. This suggestions are valid under the price levels used and the existing technology.

The objective function for this plan has a value of ₦7005.00 representing the total gross margin for the optimum plan as shown in Table 6.9. This value is the market value of products from the farm whether sold or consumed. No distinction is made between products sold and those consumed. This is so because from the onset, model A and its variants did not include selling activities. There were two reasons for this, firstly, it was to take care of the very subsistent small mixed farmer who may not have surplus produce for sale. This may be true of the agro-pastoralists who may not have access to land upto even the average farm size of 2.5 hectares. This is a possibility if it is remembered that the Fulani herdsmen have no title to land. Most of them are settlers and could be evicted by their landlords any time.

Table 6.10 shows prices levels required in order to bring activities excluded from the optimum plan into the solution. As in previous models they represent shadow prices of these enterprises.

Table 6.9: Optimum farm plan for model AIII.

Item	Unit	Activity Level
MZ-CP	Ha	2.50
GC-ML	Ha	1.00
GC-CP	Ha	0.00
GNT	Ha	0.00
Sheep	No.	6.00
Total gross margin	₦	7005.00
Labour 1	Mhrs	650.00
Labour 2	"	580.00
Labour 3	"	400.00
Total Labour	"	1630.00

Source: Computed from Survey, 1986/87.

Table 6.10: Price increase required in activities not used in Model AIII.

Activity	Unit	Present Value (₦)	Value Required (₦)
GC-CP	Ha	534.00	806.00
GNT	Ha	944.00	1203.00
Goat	No.	60.00	377.11
Milk	Kg	125.00	187.00

Source: From Survey, 1986/87.

6.2.4 A Comparison of Models A, AI, AII and AIII

This section briefly compares all the models in the A series. A comparison of models A, AI, AII and AIII reveals some important points about resoruce use efficiency, this concept needs explanation. This is a measure of resource productivity. In monetary terms it refers to the returns to unit of the resource used in the production process. Thus labour efficiency is the return to one unit of labour (man-hour) used in the production process. Similarly land use efficiency is the return to one unit of land (hectare) used in the production process. These values can be compared with the average for the area to determine the relative efficiency of the resources under consideration. However, these average values were not available in the study area at the time of this research.

Resource use efficiency can be used to give an idea on the profitability of a production process. The theory is that average cost should be less than or equal to average returns. For example the average wage rate in the study area is ₦0.90 per man-hour hence all projects whose return to one unit of labour on the average is equal to or greater than ₦0.90 are considered profitable, if the relationship holds for all the resources used in the enterprise. Land use efficiency was measured in terms of crop values only.

A comparison of A, AI, AII and AIII shows that land use efficiency is highest in model AIII while labour use efficiency is highest in model AI. Both models A and AI have cattle production activities. Models AII shows lowest land and labour use efficiency. Model AII do not have cattle production activity. Showing the importance of cattle in the small scale mixed farming system. Table 6.11 shows these comparisons.

Table 6.11: Comparison of optimal farm organization of models A, AI, AII and AIII.

Item	Unit	Activities/Models Levels			
		A	AI	AII	AIII
MZ-CP	Ha	2.00	2.50	2.50	2.50
GC-CP	Ha	0.00	0.00	0.00	0.00
GC-ML	Ha	0.50	1.00	0.00	1.00
Cattle	No.	2.00	2.60	0.00	0.00
Sheep	No.	0.00	0.00	6.00	6.00
TGM	₦	6205.00	8125.00	4705.00	7005.00
Land	Ha	2.50	3.50	2.50	3.50
Total Labour	Mhr	1630.00	1680.00	1630.00	1630.00
Land use efficiency	₦/Ha	1842.00	1786.00	1688.00	1864.00
Labour use efficiency	N/Mhr	3.80	4.90	2.88	4.30

Source: From Sruvey, 1986/87.

In terms of labour resource, all the models are economically viable because all the returns to unit of labour are greater than the on-going wage rate in the study area. Although the cost of one hectare of land

in the study area was not known. It probably may not be higher than any of the values in the models for land use efficiency or return per hectare of land put under cultivation.

6.3 The Analysis of the B Model

The next phase of the analysis involves introduction of consumption and selling activities into the plan. It is true that food sufficiency is a major conern of the small scale farmer, however, small surplus may always be available for sale in the local markets. Model B is the base model reflecting the existing resource situation; model BI shows increase in labour 2, BII shows increase in farm size and BIII shows increases in both labour 2 period and farm size. All the models included selling activities. This represents a major difference between models A and B.

6.3.1 Model B

The optimum plan for model B shows that guinea corn/millet crop mixture should be produced with the existing 2.5 hectare of cultivated land. 70 percent of the crops are consumed only 30 percent are sold. A total of 475 kg live weight of cattle should be produced and sold. Giving a total gross margin of ₦3913.00. This value represents actual cash realised by the farmer since the values of crops consumed are

excluded. Table 6.12 represents optimum plan for the basic model B.

Table 6.12: Optimum plan for Model B.

Item	Unit	Activity Level
GC-ML	Ha	2.50
Cattle	Kg	465.00
GCS	"	638.00
MLS	"	600.00
GC-CP	Ha	0.00
MZ-CP	Ha	0.00
GNT	Ha	0.00
Total Gross Margin	₦	3913.00
Labour 1	Mhr	650.00
Labour 2	Mhr	580.00
Labour 3	Mhr	400.00
Total Labour	Mhr	1630.00

Source: Computed from Survey, 1986/87.

Land has continued to be an important scarce resource. In model B, the marginal value product for land is 1610 Naira. The MVP for labour for periods 2 and period 3 were ₦25.20 and ₦23.10 respectively. Table 6.13 shows the MVP for the resources under consideration in model B. As earlier explained these

Table 6.13: Marginal value products for Model B.

Item	Unit	Marginal Value Product (₦)
Land	**Ha**	1610.00
Labour 1	**Mhr**	2.14
Labour 2	**Mhr**	25.20
Labour 3	**Mhr**	23.10

Source: Computed from Survey, 1986/87.

values represent addition to total revenue resulting from the use of one more unit of the resource.

Table 6.14 presents those activities not in optimum solution because of low prices or low output or both. The table also shows the prices required so as to bring the activities into the optimal solution in model B. For example guinea corn/cowpea crop mixture and maize/cowpea crop mixture should be sold at ₦5.00/kg. It should be remembered that the crops though grown in mixtures are sold separately. It is left for the farmer to determine what the prices of each crop component should be, if he insists on the production of the particular crop mixtures. The farmer could use the present prices as a guide in determining what the prices required for the crop component should be. Similarly groundnut should sell at ₦3.50/kg instead of ₦1.80 to make it competitive.

Table 6.14: Price increase required in activities not used for Model B.

Item	Unit	Present/Price/ Unit (₦)	Price Required Per Unit (₦)
GC-CP	Kg	3.80	5.00
MZ-CP	"	3.80	5.00
GNT	"	1.80	3.50
Sheep	"	2.16	5.60
Goat	"	2.00	6.41
Milk	"	1.50	2.50

Source: Computed from Survey Data, 1986/87.

Sheep and goat should sell at ₦5.60 and ₦6.41 instead of ₦2.16 and ₦2.00 per kilogramme live weight respectively, to make them enter the optimum plan.

6.3.2 Model BI

One major characteristic of the variants of the B model was to observe the effects of land and labour adjustments on total gross margin.

When labour was increased by 100 man hours in period 2 with land at 2.5 hectares in model BI, two crop mixtures were produced while cattle production did not show any increase. Total gross margin decreased from ₦3913.00 to ₦3778.00, a decrease of ₦135.00 or 3.5 percent over model B. Table 6.15 shows optimum farm organization for model BI.

Table 6.15: Optimum farm organization for Model BI

Item	Unit	Activity Level
GC-CP	Ha	1.50
GC-ML	Ha	1.00
MZ-CP	Ha	0.00
GNT	Ha	0.00
Cattle	Kg	475.00
GCS	"	638.00
MLS	"	240.00
CPS	"	225.00
Total Gross Margin	₦	3778.00
Labour 1	Mhr	650.00
Labour 2	"	680.00
Labour 3	"	400.00
Total Labour	"	1730.00

Source: Computed from Survey, 1986/87.

The provision of extra 100 man hours of labour made it possible for two crop mixtures to be produced. Guinea corn/cowpea was allocated 1.5 hectares while one hectare was devoted to the guinea corn/millet crop mixture. This model also specifies the amounts of the crops that should be sold after the food requirements of the family have been met. It shows that 637 kg of guinea corn, 240 kg of millet and 225 kg of cowpea could be sold.

The implication of the model is that if farmers are able to finance additional labour up to 100 man-hours at the peak farming activities in period 2 without increase of farm size, this may reduce gross margin, other things remaining constant. This may be indication that labour is underutilized.

The marginal value product of resources for model BI is presented in Table 5.16 and have the same meanings as previously discussed. However, it can be observed that the marginal value product for labour in period 2 is ₦10.18 which is a relatively low figure. This means every additional unit of labour employed in period 2 adds ₦10.18 to total revenue upto a point where the marginal value product is zero.

Table 6.16: Marginal value product for Model BI.

Item	Unit	Marginal Value Product (₦)
Land	Ha	1552.20
Labour 1	Mhr	4.63
Labour 2	"	10.18
Labour 3	"	3.30

Soruce: From Survey, 1986/87.

As in other models not all activities are included in the optimum plan in BI. This is because

of either low prices, low output or both. Table 6.17 shows both the present prices and those required in order to allow the inclusion of these activities in the optimum plan.

Table 6.17: Price increase required in activities not used in Model BI.

Activity	Unit	Present price (₦) per Unit	Price Required (₦) per unit
MZ-CP	Kg	3.80	5.50
GNT	"	1.80	5.73
Sheep	"	2.16	5.78
Goat	"	2.00	6.41
Milk	"	1.50	3.00

Source: From Survey. 1986/87.

6.3.3 Model BII

In model BII farm size was increased to 3.5 hectare while labour remained at the existing level of 580 man-hours for period 2. The optimum farm plan for model BII is presented in Table 6.18.

The increase in farm size without a corresponding increase in labour increases the gross margin by ₦689.00 or 18 percent in model BII over model B. The same crop mixture as in BI entered the optimum plan in BII as well as cattle production. However,

Table 6.18: Optimum farm plan model BII.

Item	Unit	Activity Level
GC-CP	Ha	1.35
GC-ML	"	2.15
MZ-CP	"	0.00
GNT	"	0.00
Cattle	Kg	468.00
GCS	"	819.00
MLS	"	617.00
CPS	"	203.00
Total Gross Margin	₦	4608.00
Labour 1	Mhr	650.00
Labour 2	"	580.00
Labour 3	"	400.00
Total Labour	"	1630.00

Computed from Survey, 1986/87.

less cattle is produced in BII (468 kg live weight) as against 475 kg live weight in BI.

The marginal value products of resources as well as the shadow prices of activities excluded from the optimum plan are not significantly different from those in model BI. The marginal value product of labour in period 2 continues to show high value of ₦10.00. As would be expected the marginal value product for land in model BII decreased by about

₦383.00 or 10 percent as compared to model BI. This may mean inefficient land utilization as a result of relatively low labour input.

6.3.4 Model BIII

Whereas in the previous models of A variants, either labour was increased as in BI or farm size was increased as in BII, but in BIII both farm size and labour were increased simultaneously. Thus BIII differs from B in both levels of labour and land used, from BI in farm size and BII in labour input. A striking feature of model BIII is that all the three crop mixtures enter the optimal solution. These are guinea corn/cowpea with allocation of 1.50 hectares of land, maize/cowpea and guinea corn/millet were allocated 1.00 hectare of land each respectively.

It is to be noted that small quantity of millet was sold compared to other grain. This may be due to the fact that millet is a very important grain in the study area because it costs more than either maize or guinea corn on unit to unit basis. Millet is the grain of choice in the preparation of favourite dish called furra (grounded millet mixed with sour milk).

There was substantial increase in cattle production in this model. However, sheep, goat and milk production were not competitive enough to enter the optimum farm plan. As explained earlier, farmers will produce them in view of their nutritional importance and meeting short term cash requirements of the farm family.

Simultaneous increase in both farm size and labour in the critical labour bottleneck increase both crop and livestock output and consequently higher total gross margin. Table 6.19 presents the optimum farm organisation for model BIII. This is in line with the theory of economics of scale which the simultaneous expansion in all resources results in expansion in output. This is a long run situation in which no fixed resource exists. This is the production level at which all agro-pastoralists should aim at. The total gross margin reported like those in all B model variants does not include the value of produce reserved for family consumption.

The marginal value products of the resoruces and prices increase required to bring in activities excluded from the optimum plan are not significantly different from those in model BI, see Table 6.17.

Table 6.19: Model BIII - Optimal plan land and labour in period 2 increased to 3.5 ha and 680 man-hours respectively.

Item	Unit	Activity Level
GC-CP	Ha	1.50
MZ-CP	"	1.00
GC-ML	"	0.00
Cattle	Kg	617.00
GCS	"	638.00
MZS	"	285.00
CPS	"	1134.00
MLS	"	240.00
Total gross margin	₦	5502.00
Labour 1	Mhr	650.00
Labour 2	"	650.00
Labour 3	"	400.00
Total Labour	"	1730.00

Source: Computed from Survey, 1986/87.

6.3.5 Comparison of Models B, BI, BII and BIII

It will be recalled that the B model and its variants were used to observe the effect on total gross margin as land and labour resources were varied. They also included selling activities.

Model B represented the optimum plan for the existing resources of 2.5 hectare farm size and total labour of 1630 man-hours. This model also has the

lowest total gross margin of ₦3913.00 except model BII.

In model BI land size was fixed at 2.5 hectares but labour was increased by 100 man-hours over that of the basic model B. The total gross margin was decreased from ₦3913.00 to ₦3778.00, a total of ₦135.00 or 3.50 percent decrease while labour increase was 17.00 percent. These changes also influenced the results of resource use efficiency which were higher for B than BI models. Land use efficiency decreased from ₦615.0o/hectare in B to ₦561.00/hectare in BI while the corresponding figures for labour were ₦2.40/man-hour in B and ₦2.18/man-hour for BI respectively.

For model BII, labour was fixed at 1630 man-hours but land was increased to 3.5 hectares. This resulted in an increase in total gross margin of ₦645.00 over the gross margin of B and ₦830.00 over BI models. Cattle production activity dropped from 475 kg live weight in B and BI models to 468 kg live weight in BII. However, there were more crops sales in BII of guinea corn than B and BI. This shows that with increase in land without corresponding increase in labour results in reallocation of more labour in favour of cropping activity. Land use efficiency was significantly higher for model BII compared to model BI. But the differences in labour use efficiency was not significant between the two models.

When both labour and land were increased simultaneously, total gross margin was highest in model BIII. Many more crops and more cattle output were attained as compared to other models. Land use index was also higher than in other models. Labour use efficiency was clearly higher than in the other models as well.

Model BIII obviously represents a model of choice for agro-pastoral mixed small farmer with virtually no improved inputs, using traditional technology. Table 6.20 represents all the optimum farm plans for the B, BI, BII and BIII models.

Table 6.20: Comparison of optimal farm organisation of models B, BI, BII, BIII.

Item	Unit	Activities/Models Level			
		B	BI	BII	BIII
GC-ML	Ha	2.40	1.00	2.15	1.00
Cattle	Kg	475.00	475.00	468.00	517.00
GCS	"	638.00	638.00	819.00	638.00
MLS	"	600.00	240.00	517.00	240.00
CPS	"	0.00	255.00	203.00	1134.00
MZS	"	0.00	0.00	0.00	285.00
GC-CP	Ha	0.00	1.50	1.35	1.50
MZ-CP	"	0.00	0.00	0.00	1.00
Total Labour	Mhr	1630.00	1730.00	1630.00	1730.00
Land use efficiency	N/Ha	615.00	561.00	648.00	691.00
Labour use efficiency	N/Mhr	2.40	2.18	2.83	3.18
TGM	N	3913.00	3778.00	4608.00	5502.00

Source: Computed from Survey, 1986/87.

6.4 Crop-Livestock Linkages: An Important Aspect of Mixed Farming Production Systems

The practice of growing crops in mixture and raising livestock simultaneously is to a large extent confined to the less developed areas of Africa. Crop residue provides fodder for livestock feeding for most of the very dry periods of the year, while the use of grains in supplemented feeding of livestock is an age old practice (Kallal and Adamu, 1988). Animals on the other hand provide faeces and urine which supply nutrients to maintain soil fertility. They supply traction power for land tillage and transporation of farm inputs and products. Short term cash demand for the farm family is met by the sale of livestock.

This complex of interactions between crops and livestock becomes more important when considering agro-pastoral productions where the livestock and crop production units are under one management (Fig. 2). An aspect of the system often ignored is the production and utilization of crop residue during the dry critical period of the year (February, March, April). Herd and flock sizes are generally larger in the pastoral and/or agro-pastoral societies in the drier northern parts of the country. The quality and quantity of fodder on offer in these drier parts declines to very low levels in the dry season and therefore lead to general body weight loss of animals and their body conditions (Van Raay and de Leeuw, 1971).

This section focuses on the production and utilization of crop residue for feeding livestock during the critical months of February, March and April. The objective is to introduce crop residue and animal manure into the farm plan in order to observe their effect on gross margins and resource adjustment.

Estimates of crop residue yield in a representative small scale mixed farm as obtained in a regression analysis is shown in Table 6.21. Estimates of the quantity, composition and fertilizer value of dry animal faeces and average chemical composition of animal faeces grazing cereal crop residue are presented in Tables 6.22 and 6.23 respectively.

Table 6.21: Important variables and regression coefficients.

Variables	Mean	S.E.	Regression Coefficient
Farm size (ha)	2.5	0.155	-
Grain yield (kg)	3731.62	34.66	0.994*
Herd size	40.00	3.71	0.839*
Crop residue yield (kg)	14296.5	130.98	-
Constant term	-	-	5.26
Adjusted R^2	-	-	0.94

*Significantly different from 0 at .05 level.

Table 6.22: Quantity, composition and fertilizer value of dry animal faeces.

Type of animal	Number of animals	Amount of faeces deposited tons/year	Fertilizer element kg/ton of faeces		Total fertilizer element in faeces packed kg/year	
			N_2	P_2O_5	N_2	P_2O_5
Cattle	40	21.90	15.5	8.47	229.45	185.49
Sheep	10	0.73	21.50	6.28	15.70	4.56
Goats	10	0,88	25.70	7.56	22.62	6.65

Source: Computed from Kallah and Adamu (1988). "The importance of animal faeces as fertilizer".

Table 6.23: Average composition (DM) basis of faeces on animals grazing mainly cereal crop residue.

Item	Unit	Cattle	Sheep	Goats
Dry matter	%	22.04	95.00	92.94
Organic matter	"	86.57	68.05	66.44
N	"	1.55	2.15	2.57
P	"	0.37	0.27	0.33
K	"	0.65	0.89	0.82
Ca	"	2.80	1.41	1.06
Mg	"	0.30	0.50	0.36
Fe	"	0.21	0.51	0.25
Mn	(ppm)	148.52	590.96	483.83
Zn	"	148.52	171.29	115.99
Cu	"	33.66	59.96	42.42
B	"	51.53	49.50	13.50
pH	-	8.02	7.95	7.29

Source: Kallah and Adamu (1988): The Importance of Animal Faeces as Fertilizer, Ahmadu Bello University, Zaria.

6.4.1 Model C

In this section, the complementary role of crop residue and animal manure is examined. What makes the crop/livestock production system unique is in the interaction between them. Model C is used to represent such interactions. Model C is the existing resource base with land limited at 2.5 hectares and total labour of 1250 man-hour, crop residue was fed at the rate of 6 kg/cattle and 2 kg/small ruminant per day for three critical months of (February - April). Manure was applied at the rate of 240 kg/ha on the three crop mixtures of guinea corn/cowpea, maize/cowpea and guinea corn/millet.

Two other variants of model C are analysed to examine the effect of resource adjustments on gross margin. Model CI is the model with increased labour while CII increases both labour and land. Land is not limited to any fixed level in model CII. The results of the optimum solution for the models now follow.

The optimum solution for model C shows increases in both livestock and crop production. Cattle recorded high level of 850 kg live weight and sheep, for the first time is appearing in any optimum plan with cattle at the same time. Sheep shows a total of

Table 6.24: Optimum farm plan for Model C.

Item	Unit	Activity Level
GC-ML	Ha	1.50
MZ-CP	Ha	1.00
Cattle	Kg	850.00
Sheep	"	200.00
GCS	"	383.00
MLS	"	540.00
MZS	"	285.00
CPS	"	150.00
Total Gross Margin	₦	6578.00
Labour 1	Mhr	270.00
Labour 2	"	580.00
Labour 3	"	400.00
Total Labour	"	1250.00

Source: From Survey, 1986/87.

200 kg live weight. This dramatic increases in output can be attributed to the use of crop residue for feeding of livestock. Weight gains were recorded during critical dry months instead of weight losses as observed when the farmer relies on natural rangeland grazing system. Similarly crop yields were also increased as evidenced in the comparatively large quantities available for sales. This again is due to the application of animal manure on crop land. As would be expected, total gross margin has also increased

substantially. It should be remembered that the gross revenues in models B and C variants do not include products consumed. This is in contrast to model A variants where estimates of gross revenues represent all products that are either consumed or sold. The total gross margin for model C is ₦6578.00 as shown in Table 6.21. However, it must be emphasised that this revenue depends on a number of factors some of which are: ability to collect enough quantity of good quality crop residue, timely spread of manure to allow for proper decomposition and other agronomic operations. Adequate and timely labour supply is crucial. Table 6.24 presents the optimal solution for model C.

Price increases required to bring activities no in the plan to a more competitive position are shown in Table 6.25. It shows that guinea corn/cowpea crop mixture should be sold for ₦4.80 instead of ₦1.45 on the average. It should be noted that grains are not sold in mixtures though produced in mixtures. The prices are taken as an average since things like this are not obvious to the computer. Corresponding values for other activities are shown in the Table.

6.4.2 Model CI

In this model land was held constant at 2.5 hectares while labour was increased to 680 man-hours in period 2 representing a 17 percent increase. However,

Table 6.25: Price increase required to include in activities not in the optimal plan for Model C.

Activity	Unit	Present Price ₦/unit	Price Required ₦/unit
GC-CP	Kg	1.45	4.80
GNT	"	1.80	5.00
Milk	"	1.50	3.50
Goat	"	3.00	6.00

Source: Computed from Survey, 1986/87.

the optimal plan for model CI did not produce any major differences over model C, except that the total gross margin increased from ₦6578.00 to ₦6587.00 or 0.002 percent increase. This slight increase is probably due to reallocation of land among the crop activities. However, the increase is not significant, hence increase in labour alone without corresponding increase in land is counter productive. In model CI maize/cowpea was allocated 1.10 hectares of land while guinea corn/millet had land size of 1.40 hectares. Table 6.26 shows the optimal solution for model CI.

6.4.3 Model CII

In model CII constraint on land was removed to allow for maximum land use. Also labour was increased by the use of animal power for land preparation and transportation. This was to observe the effect of

removal of land and labour constraints on revenue in the agro-pastoral system. This is important now that the nomadic Fulani are encouraged to acquire land and settle. This is in line with the Federal Government Policy on livestock development as it relates to the nomads.

Table 6.26: Optimal solution for Model CI.

Item	Unit	Activity Level
GC-ML	Ha	1.40
MZ-CP	"	1.10
Cattle	Kg	850.00
Sheep	"	200.00
GCS	"	357.00
MLS	"	386.00
MZS	"	314.00
CPS	"	165.00
Total Gross Margin	₦	6587.00
Labour 1	Mhr	270.00
Labour 2	"	680.00
Labour 3	"	400.00
Total Labour	"	1350.00

Source: From Survey, 1986/87.

Under this farm plan 4.50 hectares of land was cultivated in the optimal plan and more crops were also brought into cultivation. This could be due to

expansion of resources. Livestock activities also increased. The two crop mixtures brought into the final plan are as follows: guinea corn/millet 2.5 hectares, and maize/cowpea 2.00 hectares of land. The expansion in land and labour resources resulted in 32 percent increase in total gross margin and about 15 percent apparent increase in labour input over the corresponding figures for model CI. However, in real terms less labour is used in model CII given the size of 4.5 hectares. A reduction in labour may be due to the use of work animals for some of the more tedious farm operations. Table 6.27 presents the optimal farm plan for model CII.

Table 6.27: Optimum farm plan for Model CII.

Item	Unit	Activity Level
GC-ML	Ha	2.50
MZ-CP	"	2.00
Cattle	Kg	980.00
Sheep	"	250.00
GCS	"	638.00
MLS	"	600.00
MZS	"	570.00
CPS	"	300.00
Total Gross Margin	₦	8723.00
Labour 1	Mhr	270.00
Labour 2	"	680.00
Labour 3	"	600.00
Total labour	"	1550.00

Source: From Survey, 1986/87.

The price increases required for activities not used in the plan are not significantly different from those for model C in Table 6.25.

These results tend to show that if land and labour constraints are removed, the agro-pastoral mix farming strategy could play a significant role in the drive for self-sufficiency in food and fibure.

6.4.4 A Comparison of Optimal Plans for Models, C CI and CII

A comparison of models C and CI show identical levels of resource use efficiency. Land use efficiency are ₦651.00 and ₦655 per hectare for models C and CI also labour use index are ₦5.30 and ₦4.90 for models C and CI respectively. The two models differ only in total labour input which is higher in CI with 1350 man-hours as against C which is 1250 man-hours. However although model CII shows the highest total gross margin of ₦8723, the land use index is not different from models C and CI while the labour use index for CII shows slight superiority of ₦5.63/man-hour over ₦5.30 and ₦4.90 per man-hour in models C and CI respectively. Table 6.28 shows optimal farm models C, CI and CII.

It should be noted that the total gross margin reported in the study do not necessarily represent income to the small scale mixed farmer, rather they represent what may be attained if all resources are provided and other conditions are satisfied.

Table 6.28: A comparison of optimal plans for Models C, CI and CII.

Item	Unit	Activities/Models Level		
		C	CI	CII
GC-ML	Ha	1.50	1.40	2.50
MZ-CP	"	2.00	1.10	2.00
GC-CP	"	0.00	0.00	0.00
Cattle	Kg	850.00	850.00	980.00
Sheep	"	200.00	200.00	250.00
GCS	"	383.00	357.00	638.00
MLS	"	360.00	306.00	600.00
MZS	"	285.00	314.00	570.00
CPS	"	150.00	165.00	300.00
Total Gross Margin	₦	6578.00	6587.00	8723.00
Labour 1	Mhr	270.00	270.00	270.00
Labour 2	"	580.00	680.00	680.00
Labour 3	"	400.00	400.00	600.00
Total Labour	"	1250.00	1350.00	1550.00
Land use efficiency	₦/Ha	651.00	655.00	655.11
Labour use efficiency	₦/Ha	5.30	4.90	5.63

Source: Computed from Survey, 1986/87.

CHAPTER VII

SUMMARY, CONCLUSION, POLICY IMPLICATIONS OF THE STUDY AND SUGGESTIONS FOR FURTHER RESEARCH

7.1 Summary

The present position of the Nigeria agriculture cannot be described as satisfactory. Not only has the production of basic food items failed to keep pace with the demand, the incomes of the farmers have continued to dwindle in the face of galloping inflation. Not only have these problems handicapped the capacity of the agricultural sector to contribute significantly, they have also constituted a major constraint to the development and potential growth of agro-based industries.

Lack of coordinated and relevant research in the agricultural sector is a major cause of the poor performance of the agricultural sector. The bulk of food items produced in Nigeria is derived from millions of small scale farms scattered all over the country. The majority of these farms are either mixed farms producing crops and livestock or growing crops in mixtures. Agricultural research in Nigeria however tends to emphasize specialisation in either crops or livestock as well as sole cropping as opposed to intercropping as practised by the majority of farmers.

The result is that research results are not relevant to the needs of the small scale mixed farmer.

Technological backwardness in the traditional agricultural sector has also been identified as another cause of the poor performance of the sector. In order to remove this technological limitation and therefore enhance the capacity of the sector to perform the roles expected in the fifth National Development Plan 1988-1993, the Federal and state governments have embarked on series of programmes aimed at raising the level of agricultural production technology on small scale farms. A major component of this technological campaign has been the introduction of modern inputs such as chemical fertilizers, improved seed varieties, pesticides, herbicides and improved cultural practices into the traditional farming systems.

There is a paucity of relevant quantitative information on the production strategy of the mixed crop/livestock farming system. Such information will include among others the combinations of crops and livestock that could maximise output and farm income, changes in farm income as a result of resource adjustments and efficient resource allocation. Since it is the government's intention to raise farm income, output and resource productivity in the rural areas where the majority of the small scale mixed farmers,

this information is needed to provide adequate basis for planning and policy decisions that will benefit the mixed crop/livestock farmers.

The purpose of this study is to evolve optimum farm plan, analyse enterprise combinations, changes in farm incomes, resource use and productivity and crop residue utilization for dry season feeding of livestock and the use of animal waste in a mixed crop/livestock farming system in the Giwa District of Kaduna State.

Static linear programming model provided the framework for the economic analysis of the mixed crop/livestock production system of the small farmer under the traditional technology. The model was formulated to maximise gross margin subject to meeting the minimum grain consumption requirements of the household. The activities in the model included crop and livestock production activities. The model was used to generate optimum farm plans with and without cattle production activities as shown in model A. Selling activities and resource adjustments are shown in model B and crop residue and manure utilization in model C. Comparative analysis of these basic models were used to obtain indication of the direct changes in farm income and farm resource productivities.

The data that provided the empirical base for the study were obtained mainly from primary sources. Data on milk yield had to be assembled from secondary sources consisting of unpublished data on milk yield collected by the Livestock System Research Programme of the National Animal Production Research Institute, Shika, Zaria. The major source of data for the resource endowment and the production information on the mixed crop/livestock farming systems was from a survey conducted under the Livestock System Research Programme of NAPRI. In the survey, a sample of 60 households from three villages in Giwa District of Kaduna State were interviewed. The three villages and the distribution of respondents were Galadimawa 25, Tsibiri 15 and Mahuta 20 farmers. The farmers were interviewed once every two weeks during the 1986/87 cropping season.

The results of the study indicate that cattle production is an important source of revenue. It has the potential for achieving increases in farm income. A comparison between models A, AI, AII and AIII shows substantial increases in gross margins. A and AI models have cattle production activities in their optimal plans while models AII and AIII do not have cattle production in their optimal plans. The difference in gross margin between models A and AII which differ only in terms of the type of

livestock in the optimal plan is ₦1500, representing 24 percent change between models A and AII. Model A has cattle production while AII has sheep enterprise in the optimum plans. The same results is observed between model AI and AIII in which the difference in gross margin is ₦1120 representing 14 percent change between models AI and AIII. Again, model AI has cattle activity in the optimal plan while AIII has sheep production in the optimal plan. It should also be noted that with increase in farm size, gross margin is also increased, irrespective of the type of livestock enterprise included in the optimal plan. Although models A and AI both have cattle activity in their optimal plans, yet the gross margin is higher in AI with higher farm size of 3.5 hectares as against 2.5 hectares in model A. An increase in revenue in model AI over A is ₦1920 representing 31 percent change. The same trend is seen between models AII and AIII both without cattle production activity but with sheep enterprise in their optimal plans. The two models differ only in farm size. Model AIII with 3.5 hectares of farm has ₦7005 as total gross margin as compared to AII with 2.5 hectares of farm and a total gross margin of ₦4705. This is a difference of ₦2300 representing 49 percent change.

Efficiency of factor use, measured by returns per unit of factor shows that land use efficiency decreased

slightly from ₦1842 to ₦1786 per hectare when land was increased from 2.5 in model A to 3.5 hectares in model AI. However, labour use efficiency increased from ₦3.80 to ₦4.90 per man-hour when land was increased from 2.5 to 3.5 hectares.

The cropping pattern shows very strong favour for maize/cowpea crop mixture since this mixture is appearing in the optimum models A, AI, AII and AIII. However any increase in land is devoted to guinea corn/millet crop mixture production. Sole crop groundnut and guinea corn/cowpea crop mixture were not in a better competitive position even when additional land was made available.

Three alternatives using variants of model B were defined for investigating the extent to which labour and land are limiting factors. It should be remembered that model B and its variants also included selling activities of the surplus farm products.

Model B is the optimal plan for existing resources with a TGM (total gross margin) of ₦3913. In model BI, labour was increased by about 10 percent while land remained at 2.5 hectares. TGM was decreased from ₦3913 to ₦3778 representing a decrease of 3.5 percent. This shows that land can be a limiting factor for increased farm revenue especially at the peak farming period. There were no improvements in labour and

land use efficiency in model B and BI. An increase in land from 2.5 to 3.5 hectares in model BII increased the TGM to ₦4608 about ₦695 increase over model B and by ₦830 over model BI. Although there was a slight improvement in labour use efficiency, there was a slight improvement in labour use efficiency, there was a significant drop in land use efficiency. The fact that an increase in land results in an increase in TGM and land use efficiency in model BII over B and BI shows that land is more limiting in relative terms than labour. Model BIII represents an ideal farm plan in which all resources were increased. The resultant TGM of ₦5502 is in line with the theory of economy of scale. A 40 percent increase in land results in 41 percent increase in TGM in model BIII over B a constant return to land. Farmers can increase their farm income by 41 percent with corresponding increase of 40 percent land and 6 percent labour. Again model BIII shows that land is more limiting in relative terms at the peak periods. The cropping pattern in models B and the variants were less deversified. Guinea corn/millet and guinea corn/cowpea were the crop mixtures in the optimum plans representing three types of crops in the two crop mixtures, while for model A and the variants four types of crops were represented in the crop mixtures. Unlike model A, model B had cattle activity in it and in all the variants.

The linear programming results of model C, CI, CII incorporating crop residue and animal manure show higher total gross margins over other models. Optimal plan for model C includes all the three crop mixtures as well as more livestock output compared to models A and B. Total gross margin of ₦6578 from 2.5 hectares of land, 850 kg of cattle and 200 kg live weight of sheep was recorded. Again an increase in labour without corresponding increase in land did not increase the total gross margin significantly as observed in model CI. However when all resources are increased simultaneously, the total gross margin also increased significantly as shown in model CII. In model CII a total farm size of 4.5 hectares was cultivated because animal power was utilized in some of the more tedious operations. This helped to relieve the labour bottleneck experienced at this peak farming periods.

A comparison of models C, CI and CII tend to show that land and labour use efficiency are not significantly different. This could represent the desirable levels of resource use in the small scale mixed farming production strategy. Table 6.28 shows such comparison. The interactions between crops and livestock represent a major feature of mixed farming production system. The study focused on crop residue utilization for livestock feeding during the critical months of the dry season (February, March and April) and the use of animal manure for crops.

Estimate from the result showed that the farmer needed an additional 13873 kg of crop residue in order to meet the fodder requirements of about 40 heads of cattle at critical period. This quantity of crop residue could be obtained by cultivating extra half hectare of guinea corn. Apart from meeting fodder needed by the animals, he would also have more cash to meet family expenses.

It is believed that it is easier for the small farmer to cultivate extra half hectare of land with a crop he is familiar with, and utilize the residue for his animals, than for him to attempt pasture production under the existing resources and level of technology. In the long run however, with improved resource base, pasture production is the better path to higher livestock output.

7.2 Conclusion

This study has shown that small scale mixed crop/livestock farms could be reorganised for higher output using the traditional technology. Consequently farm income has increased substantially from ₦300 per year as estimated during the survey to between ₦3778 and ₦8723 per year after planning and reorganisation.

The traditional farming systems have satisfied the peasant farmer but cannot stand up to the change

of growing population and a rapidly developing country like Nigeria. This calls for the gradual modernisation of the mixed farming system. There is therefore some justification for conducting more intensive research to increase the yields of crops and livestock within a mixed crop/livestock system of production. The results of such research could be simplified and incorporated into the Federal Government's programme on normadic education. Extension services will have to be strengthened so that improved methods and inputs could reach the mixed farmers. A deliberate liberal land policy in favour of the mixed farmer should be pursued to make land readily available to them.

7.3 Policy Implications

With the assumption that the data, the analytical framework and the unit of analysis all have reasonable degree of validity, the quantitative estimates obtained may not be the exact magnitudes but they could provide relevant insights and guidelines that would aid the understanding of the crop/livestock mixed farming production system in the improvement of traditional agriculture.

The results of the study indicate that the hitherto neglected mixed crop/livestock production system has some potential for achieving significant increases in farm income, output, resource use and

productivity through the reorganisation of the existing land, labour and livestock resources. Therefore, planning for agricultural development should henceforth focus on the design and implementation of programmes aimed at facilitating expansion in the use of these resources among the small scale farmers, practising crop/livestock integrated farming. Specifically, programmes concerned with making land acquisition and ownership as well as livestock improvement available to the small scale mixed farmers are ideal. Since the bulk of livestock resources of Nigeria is owned by the agro-pastoralists who are largely mixed farmers, there is the urgent need to strengthen livestock extension services and research into crop/livestock production strategy.

The results of the study have also indicated that labour in the peak labour demand months is a critical and limiting factor in agricultural production of mixed farmer. This is when labour has to be rationed between crops and livestock activities. The potential for achieving increase in farm income, output and resource use is substantially improved when measures are taken to break the labour bottleneck in peak periods. One such measure would be the provision of credit

opportunities for the small mixed farmers to enable them to hire the additional labour required during such periods. The farmers in the study area show the desire to obtain such credits. It is known that farmers sometimes seek and obtain credit from non-formal sources with very high interest rate. The policy of the Nigerian Agricultural and Cooperative Bank to relax the emphasis on collateral is a welcome move. Efforts should be made to extend this facility to the mixed farmers. However, given the high wage rates resulting from the absence of a landless class of labourers, and problems of low repayment rates and the diversion of credit funds to non-farming activities, the provision of credit could only be a short term solution to labour bottleneck problem.

Another means of increasing the amount of labour at peak periods would be for the farmers to put extra hours on crop production activities. This is possible because the peak periods coincide with the periods of abundance of fodder. Therefore less time could be spent in grazing livestock and the animals do not need to go too far away in search of fodder and water. Increases in family labour for work on the farms is considered feasible because of the limited prospect of off-farm employment in the study area. It is believed that good health and nutrition severely enhance the

working ability of peasant farmers to work for long hours on the farm. Programmes designed to improve the health and nutrition of small crop/ livestock farmers could increase the ability of the farmers to work for more hours. It may be necessary to make nutrition and health improvement programmes an integral part of the efforts aimed at improving the conditions in the agricultural sector.

The long term solution to the labour problem in the mixed farming situation is likely to consist of measures such as selective mechanisation of farm operations, that significantly improve the efficiency of labour utilization during peak periods. One such possibility will be the use of workbull and the ariana toolbar. The workbulls are easily obtained from the farms while a group of farmers could pull resources together to purchase an ariana toolbar. Analysis on the cropping pattern, cost outlay and financial returns would however be required.

7.4 Limitation and Suggestions for Further Studies

An important limitation of this study has been the reliance on one year's data which was regarded as a good farming year in terms of the amount and distribution of rainfall. Failure to analyse the consequences of variations in input-output coefficients

limits the scope of the application of the results of the study. The results of the study need to be complemented by the results of similar studies in other areas and in different years in order to obtain a comprehensive picture that permits broad generalisations to be made concerning the formulation of optimum farm plan for the mixed crop/livestock farming system in Nigeria.

Another limitation of the study has been the static nature of the analysis. Static models are useful for a comparative analysis of equilibrium situations such that these situations are sufficiently far apart in time to allow equilibrium to be attained. Farmers operate in a dynamic world. Unlike dynamic models, static models cannot provide detailed information about the adjustment path of crop and livestock production response from one set of policy variables to another. Such information is likely to be of greater use for policy evaluation than simple knowledge of the input-output relationships under static equilibrium conditions. Besides, the approach adopted in the study provides only partial equilibrium solutions. To expect the prices of products as well as yields and technical coefficients to remain constant is strictly a short term phenomenon. Prices and yields do change annually because of weather, technology and other supply and demand conditions.

Another limitation of the study was that there was no way to account for the differences in managerial skills and attitude to risks of the farmers in the sample whose data were used in the construction of a representative farm used in this study. In this study land or farm size is treated as if it is always found in contiguous places sufficient for the size of farm described in this study. In actual situations individual farms are made up of several fragmented little fields scattered over the area. Unless this situation changes as a result of land reforms, future studies should adjust for the error that may result from operating a farm made up of small separate fields. The use of linear programming model to analyse lumpy or chunky variables i.e. variables that are not in discrete units such as cattle, sheep and goats was yet another limitation. It might be more meaningful for further studies of this nature to consider the use of mixed interger programming model.

It is apparent that lack of attention to research, socio-economic, political factors, and an attempt for external imposition of a capital intensive economy without adequate mechanisms for involving the small scale mixed crop/livestock farmer in decisions that affect them, may hinder

reforms in the agro-pastoral sector of the Nigerian agriculture. Ideas may be introduced but the actual initiative for change should come from the people.

Despite these limitations, the results of the study provide useful insights about the likely micro-economic effects of the reorganisation of small scale crop/livestock farms in the Giwa District of Kaduna State.

REFERENCES

Abalu, G.O.I. and D'Silver, B. (1980): Nigeria's Food Situation: Problems and Prospects. Food Policy, pp. 49-60.

Abalu, G.O.I. (1986): Agricultural Development and Management in Nigeria - Major Theoretical and Practical Questions. Paper delivered to the Participants on the Senior Executive Course Nov. 9, National Institute for Policy and Strategic Studies, Kuru, March 6, 1987.

Agrawal, R.C. and Heady, E.C. (1972): Operations Research Methods for Agricultural Decisions, Iowa State University, Iowa, U.S.A.

Agrawal, G.D. (1964): Farm Planning and Management Manual, Ministry of Agriculture and Natural Resources, Ibadan, Nigeria.

Alhassan, W.S. and Obilana, A.B. (1984): Observations on Yields and Potential Feeding values of strats of grain sorghum cultivars developed in Nigeria. Unpublished Data National Animal Production Research Institute, Shika, Zaria.

Alkali, M. (1969): Mixed Farming - Needs and Potential Livestock Development in the Dry and Intermediate Savanna Zones, 1969.

Awogbade, M.C. and Hassan, U.A. (1987). Prospects and Problems of Settlement Schemes for the Nomadic Fulani in Nigeria - Case Study of Successful Schemes. Livestock and Veterinary Conference, A.B.U., Zaria, 26-30 April, 1987.

Barry, S.J. (1965): Dynamic Programming Method. Jr. of Farm Economics Vol. 42 No. 12.

Benard, C.S. and Nix, J.S. (1979): Farm Planning and Control. Cambridge University Press.

Boneke, R.R. and Winterboer, R.D. (1973): Linear Programming Applications to Agriculture. Iowa State University.

Boussard, J.M. and Pelit, M. (1967): Representing of farmers' Behaviour under uncertainty with Focus-Loss Constraint. Journal of Farm Economics, Vol. 49, pp. 569-880.

Cany, J. (1968): Linear Programming Methods. Farm Economics Vol. 42, No. 15.

Clayton, E.S. (1961): Linear Programming Matrix for Case Study Farm in Kenya. Journal of Agricultural Economics Vol. 14, No. 3.

Clayton, E.S. (1965): Economic Planning in Peasant Agriculture. Dept. of Agric. Economics. Wye College.

Collinson, M.P. (1974): Some Guindelines for Farm Economic Data collection in Rural Areas of Africa. Memeograph of ADC Seminar, Beinit.

Corby, H.D.L. (1941): Changes being brought about by the Introduction of Mixed Farming and Forest. Journal of Farm Economics Vol. 11, No. 3 pp. 106-110, December.

Dantwala, M.L. (1968): Problems of Small Farmers: The Indian Society of Agricultural Economics 46-68, Esplanado, Mausions, Bombay.

Davis, L.G. (1956): Types of Farming and Types of Farming Areas in Connecticut. Agricultural Experimental Station Bulletin 213, p. 131, 1936.

Day, L.M. (1963): Use of Representative Farms in Studies of Inter-Regional Competition and Produce Response. Journal of Farm Economics 47: 690-695.

Day, Richard (1968): Recursive Programming and Production Response Amsterdam, Netherlands, North Holland Publishing Company.

Delgado, C.L. (1979): The Southern Fulani Farming System in Upper Volta: A Model for the Integration of Crop and Livestock Production in the West African Savanna. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, U.S.A.

D'Silva, B. and Raza, M.R. (1980): Integrated Rural Development in Nigeria - The Funtua Project. Food Policy, November.

Doreen Warriner (1964): Economics of Peasant Farming - Frankcass and Company Limited, Oxford University Press.

Dunstan, S.C. (1977): Small farms in West Africa: A Descriptive Analysis of Employment. Incomes and Productivity in Sierra-Leone, February.

Eddy, E.D. (1979): Labour and Land Use on Mixed Farms in the Pastoral Zone of Nigeria. Monograph III, Livestock and Marketing in the Entente States of West Africa. Ann Arbor, Centre for Research on Economic Development, University of Michigan.

Elliot, F.F. (1928): The Representative for Idea Applied to Research and Extension in Agricultural Economics. Journal of Agricultural Economics Vol. 10, p. 486.

Erhabor, P.O. (1982): Efficiency of Resource Use Under Small-Scale Irrigation Technology in Nigeria. Purdue University Water Resource Center. Technical Report No. 148.

Etuk, E.G. (1982): A Comparative Study of Optimum Farm for Small-Farms with Traditional and New Technologies in Zaria Area of Northern Nigeria. Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.

Etuk, E.G. (1979): Micro-economic Effects of Technological Change on Small Holder Agriculture in Northern Nigeria: A Linear Programming Analysis. An Unpublished Ph.D. Thesis, Michigan State University.

F.A.O. (1963): Integrating Crops with Livestock in West Africa. Animal Health Paper No. 43, Rome.

Federal Ministry of Agriculture (1974): Second National Development Plan.

Feldman, D. (1969): Decreasing Costs in Tobacco Production - An Application of Separable Programming. University of Sussex, Institute of Development Studies, Communication Series No. 40.

Frick, G.E. and Andrew, R.A. (1965): Aggregation Bias and Four Methods of Summing Farm Supply Functions. Journal of Farm Economics 47: 696:700.

Godzama, M. (1987): An Address at the Opening of a Branch of Allied Bank Kano. New Nigerian Friday November.

Gilbert, E.H., Norman, D.W. and Winch, F.E. (1980): Farming Systems Research: A Critical Appraisal Michigan State University Rural Development Paper No.6. Department of Agricultural Economics, Michigan State University, East Lansing.

Hardakar, J.B. (1971): Farm Planning by Computer. Technical Bulletin 19, Ministry of Agriculture. Fisheries and Food, London.

Hartely, H.O. (1962): Total Supply Functions Estimated from Farm Surveys. Paper for the North Central Farm Management Research Committee.

Harwood, R.R. (1979): Small Farm Development. Westriew Press/Boulder, Colarado.

Hayer, J. (1979): A Linear Programming Analysis of Constraints on Peasant Farms in Kenya. Food Research Institute Studies on Agricultural Economics, Trade and Development, Standford University.

Hayer, L. (1967): The Economics of Small Scale Farming in Lowland Machakos, Nairobi University College, Institute for Development Studies, Occasional Paper No.1.

Hayness, D.W. (1969): The Development of Agricultural Implements in Northern Nigeria. Samaru Research Bulletin No. 65, p. 102, Samaru.

Hazel, P.B.R. and How, R.B. (1970): Obtaining Acceptable Farm Plans under Uncertainty. Papers and Reports of 14th International Conference on Agricultural Economics held at Musk, pp. 338-347.

Hazel, P.B.R. (1970): Game Theory - An Extension of its Application to Farm Planning under Uncertainty. Journal of Agricultural Economics XXL, pp. 239-252.

Hazel, P.B.R. (1971): A Linear Alternative to Quadratic and Semi-Variance Programming for Farm Planning under Certainty. American Journal of Agricultural Economics Vol. 53 pp. 53-62.

Heady, E.O. and Candler, W. (1958): Linear Programming Methods, Iowa State University Press.

Hermons, C. (1985): Modelling of Extensive Livestock Production Systems. Proceedings of the ILCA, ARO/CABC Workshop, Isreal, February 5-9.

Heidhues, T. (1966): A Recursive Programming Model of Farm Growth in Northern Germany. Journal of Farm Economics 48: pp. 668-684.

Hill, P. (1970): Rural Capitalism in West Africa. African Study Series No. 2. Cambridge University.

Holmes, C.L. (1936): Types of Farming in Iowa. Agricultural Experimental Station Bulletin 213, p. 131.

Hopkins, E. (1975): Wolof Farmers in Senegal: A Study of Responses on Agricultural Extension Scheme. Ph.D. Thesis, University of Sussex.

Hopper, V.D. (1965): Allocation Efficiency in a Traditional Indian Agriculture - Journal of Farm Economics 47(3), pp. 601-624.

Irevin, G.D. (1966): A Comparative Review of Some Farm Growth Models. Journal of Farm Economics 48, 1510-1512.

Juler, C.J. (1966): An Analysis of the Solution Tabuleau of a Standard Linear Programming Problem. Journal of Agricultural Economics Vol. XVII, No. 2, September, pp. 159-170.

Jones, W.O. (1960): Economic Man in Africa. Food Research Institute Studies Vol. 1 No. 2.

Kaufmann, R. Von (1983): Development of Integrated Crop/Livestock Farming Systems. Joint Meeting of the Panel of Experts on Development Aspect and Ecological/Technical Aspects of the Programme for the Control of African Animal Trypanasomiasis and Related Development. Addis-Ababa, 20-24, June 1983.

Kaufman, R. Von and Ingawa, S.A. (1987): Normadism in Africa and Possible Solutions. Livestock and Veterinary Conference held at A.E.R,L.S., A.B.U., Zaria, 28-30 April.

Kenedy , F. (1975): Economics of Peasant Agriculture: Miscellaneous Paper no. 35. Michigan State University, U.S.A.

Khan, H.D. (1979): Ten Decades of Rural Development Sessions from India. Michigan State University Rural Development Paper No. 1. Department of Agricutlural Economics, Michigan State University, East Lansing, U.S.A.

Kisopanides, G. (1963): Farm Planning for Increased Family Income in West Mecedonia, Greece; Journal of Agricultural Economics 15(4) pp. 645-655.

Kline, C.K. (1969): Agricultural Mechanization in Equatorial Africa. East Lansing International Institute of Agriculture, Michigan State University.

Kolhatkar, V.Y. (1964): Spot Check in Gombe, Hadejia and Kontagora Divisions, F.A.O. Socio-Economic Survey of Peasant Agriculture in Northern Nigeria. Ministry of Agriculture, Kaduna State (Mimeograph).

Lipton, M.A. (1968): The Theory of the Optimizing Peasant. The Journal of Development Studies 4: 327-351.

Livestock Systems Research, NAPRI (1989): Exposition of Activities Presented at NAPRI Seminar.

Longhurst, R., Palmer-Jones, R.V., and Norman, D.W. (1976): Problems of Determining Relevant Research Priorities for Agricultural Development in the Developing World: The Role to be Played by the Social Scientists. IAR, ABU, Zaria, Nigeria.

Malton, P.J. (1968): Income Distribution and Patterns of Expenditure, Savings and Credit Among Farmers in the North of Nigeria. Department of Agricultural Economics, Cornell University, U.S.A.

Markoritz, H. (1959): Linear Programming and Game Theory Models. Some Extensions Journal of Agricultural Economics XX, pp. 269-278.

Maylor, T.H. (1971): Computer Simulation Experiments with Models of Economic Systems. New York, John Wiley and Sons, Inc.

McDowell, R.E. and Hilderbrand, P.E. (1980): Integrated Crop and Animal Production Making the most of Resources Available to Small Farms in Developing Countries, Rockefeller Foundation Working Paper, New York.

McFarquhar, A.M.M. (1961): Rational Decision Making and Risk in Farm Planning. Journal of Agricultural Economics Vol. 14, No. 4 p. 552.

McFarquhar, A.M.M. and Evans, A. (1957): Linear Programming and the Combination of Enterprise in Tropical Agriculture. Journal of Agricultural Economics Vol. 12, No. 4, p. 474.

Mclnearnery, J.P. (1969): Linear Programming and Game Theory Models: Some Extensions. Journal of Agric. Economics Vol. 20, No. 2 p. 267.

Mighal, R. and Blank, J.D. (1951): Integrated Competition in Agricutlure - Harvard University Press, 1951.

Minden, A.J. (1968): Dynamic Programming: A Toll for Farm Growth Research, Candian Journal of Agricultural Economics 16: 18-45.

Monthly Economic and Business Digest, August 1984, Vol. 2, No. 8.

NAPRI (1986): Research Highlights on Cattle Production.

Norman, D.W. (1972): An Economic Survey of Three Villages in Zaria Province. Input-Output Studies. Samaru Miscellaneous Paper Vol. 1, No. 37, ABU, Zaria.

Norman, D.W. (1969): Mixed Farming Need and Potential Comments in Livestock Development in the Dry and Intermediate Savanna Zones, 1969 p. 45.

Norman, D.W. (1974): Crop Mixtures under Indigenous Conditions in Northern Part of Nigeria. Samaru Research Bulletin, No. 205, 1974.

Norman, D.W., Pryor, D.H. and Gibbs, C.J.W. (1979): Technical Change and the Small Farmer in Hausa-land Northern Nigeria. Rural African Employment Paper 21, Michigan State University, Lansing, USA.

Norman, D.W. (1973): Economic Analysis of Agricultural Production and Labour Utilization among the Hausas in North of Nigeria. Department of Agricultural Economics, Michigan State University.

Nurkse, R. (1955): Problems of Capital Formation in Underdeveloped Countries. Oxford, Basil, Blackwell, p. 5.

Nuru, S. (1984): The Adjustment and Integration of Crops and Livestock Systems. Proceedings of Advancing Agricultural Production in Africa. C.A.B. 1st Scientific Conference, Arusha, Tanzania, Feb.

Nuru, S., deLeeuw, P.M. and Abalu, G.O.I. (1976): The Potential for Livestock Production in the River Basin Irrigation Schemes in Nigeria. Irrigation Cropping Scheme Meeting, I.A.R., Zaria.

Nuthal, P.L. (1971): On the Analysis of a Simplex Linear Programming Solution Tableau with Reference to Net Revenue Stability. Journal of Agricultural Economics Vol. XXII, No. 1 pp. 49-60, January.

Nwokolo, S.C. (1971): The Ten Year Development Plan, 1966-1970: An Economic and Political Analysis of Agricultural Planning. Paper Read at the Annual Conference of Agricultural Society of Nigeria, held at A.B.U., Zaria 25-30, 1977.

Ogungbile, A.O. (1980): An Evaluation of Improved Sole-Crop Production Technology on Small Farms in Northern Nigeria under different farm power Sources - A Multi Period Linear Programming Approach. Unpublished Ph.D Thesis, Iowa State University, Amans, Iowa.

Ogunfowora, O. (1972): Derived Resource Demand, Product Supply in the North Central State of Nigeria. Ph.D Thesis, Iowa State University.

Ogunfowora, O., and Norman, D.W. (1973): An Optimization Model for Evaluating the Stability of Sole Cropping Systems Under Changing Resource and Technology Levels. Samaru Research Bulletin No. 217, IAR, ABU, Samaru, Zaria.

Olayewole, M.B., Adamu, A.M. and Fulani, i.J. (1979): Dry Maintenance of Ruminants on Crop Residue, Annual Reports, NAPRI, 1980.

Opeke, R.O. (1977): Toward a Theory of Agricultural Research to make Man Live. Paper presented at the 13th Annual Conference of Agricultural Society of Nigeria, A.B.U., Zaria, July 25-30.

Oram, P.A. (1973): Livestock Production and Integration with Crops in Developing Countries. Theme 3, Paper 42 Proceedings Production, Melbourne, Australia.

Otchere, E.O. et al. (1984): Livestock System Research in Giwa District, Initial Reports, NAPRI, 1985.

Plaxico, J.S. and Tweenten, L.G. (1963): Representative Farm for Policy and Projection Research. Journal of Farm Economics 45(5) 1458-1468.

Poleman, T.T. and Freebrain, D.K. (1973): Food Population and Employment, New York, Praeger.

Powell, M.J. (1983): ILCA's Research on Crop/Livestock Interactions in the Sub-Humid Zone of Nigeria. Paper presented at the Seminar on Collaborative Research in Agriculture with Australian Centre for International Agricultural Research (ACIAR), Zaria, November 14-15.

Schneir, R.M. and Darling, H.S. (1967): Power in Agricutlure in Nigeria: Today and Tomorrow. Samaru Agricutlural Newsletter, Vol. 9, No. 4 pp. 47-48, August.

Schults, T.W. (1965): Transforming Traditional Agriculture, Yale.

Stavis, B. (1978): Agricultural Research and Extension Services in China. World Development 6: 631-645.

Stewart, J.D. (1961): Farm Operating Capital as a Constraint, a Problem in the Application of Linear Programming. The Farm Economist Vol. 9, No. 110, p. 463.

Tapp, J.W. and Williard, R.E. (1928): Types of Farming in North Dakota, Washington D.C., United States Department of Agriculture Technical Bulletin 102.

Tifteen, M. (1971): Changing Patterns of Farming in Gombe Emirate, North Eastern State, Nigeria.

Upton, M. (1964): A Development of Gross Margin Analysis. Journal of Agricultural Economics. Vol. 16, No. I, pp. 111-117.

Upton, M. (1973): Farm Management in Africa: The Principles of Production and Planning: Oxford University Press, London.

Van Raay, H.G.T. and Lamboy, J.G. (1975): Rural Planning in a Savanna Region. Rotterdam University Press.

Van Raay, H.G.T. and de Leeuw, P.N. (1971): The Importance of Crop Residue and Fodder - A Resource Analysis in Katsina Province of Nigeria. Samaru Research Bulletin 139, IAR, ABU, Zaria.

Ware, T.A. (1979): Wolof Farmers and Fulani Herders. A Case Study of Drought Adaptation in the Diourbol Region of Senegal.

Wheat, J.D. (1969): Breeding and Improvement of Livestock Development in the Dry and Intermediate Zones, p. 63.

West-Sadlar, R.A. and Hagger, R.J. (1969): Pilot Dairy Farm at Shika Research Station. Samaru Miscellaneous Paper No. 32, IAR, Zaria, 1971.

Wolof, E.R. (1966): Peasants, Prentice Hall, Inc.

APPENDIX 1: PRODUCTION ACTIVITIES - MODEL A

Now No.	Objective Function (j) / Resources	Units	GC/CP -634.00	MZ/CP -1202.00	GC/ML -860.00	GNT -944.00	ML -135.00	CAT -800.00	SHE -80.00	GOA -60.00
1	Land	Ha	1.00	1.00	1.00	1.00				
2	LSTK	No.					1.00	1.00	1.00	1.00
3	LAB1	Mhr					20.00	17.00	8.00	8.00
4	LAB2	Mhr	92.00	181.00	143.00	227.00	20.00	7.00	4.00	3.00
5	LAB3	Mhr	42.00	80.00	127.00	72.00	20.00	17.00	8.00	8.00
6	GCTR	Kgm	-850.00		-741.00					
7	MLTR	"			-1800					
8	CPIR	"	-300.00	-300.00						
9	MZTR	"		850.00						
10	GNTR	"				-580.00				
11	MITR	"					-190.00			
12	CATR	"						-2.00		
13	SHTR	"							-3.00	
14	GOTR	"								-3.00
15	GCC	"	600.00		300.00					
16	MLC	"			600.00					
17	CPC	"	150.00	150.00						
18	MILC	"					100.00			

LABOUR HIRING AND CONSUMPTION ACTIVITIES - MODEL A (CONT'D.)

Row No.	Objective Function (j) / Resources	$LABH_2$ 0.900	$LABH_3$ 0.900	Sign	RHS
1	Land			=	1.50
2	LSTK			=	8.00
3	LAB1			-	480.00
4	LAB2	-1.00		-	1120.00
5	LAB3		-1.00	-	1726.00
6	GCTR				0.00
7	MLTR				0.00
8	CPTR				0.00
9	MZTR				0.00
10	GNTR				0.00
11	MITR				0.00
12	CATR				0.00
13	SHTR				0.00
14	GOTR				0.00

APPENDIX 2: PRODUCTION ACTIVITIES - MODEL B

Row No.	Objective Function (j) / Resources	Units	GC/CP 100.00	MZ/CP 150.00	GC/ML 170.00	GNT 180.00	MIL 0.80	CAT 3.50	SHE 1.00	GOA 1.00
1	Land	Ha	1.00	1.00	1.00	1.00				
2	LSTK	Kg					1.00	1.00	1.00	1.00
3	LAB1	Mhr					20.00	17.00	8.00	8.00
4	LAB2	"	92.00	181.00	143.00	227.00	20.00	7.00	4.00	3.00
5	LAB3	"	42.00	80.00	127.00	72.00	20.00	17.00	8.00	8.00
6	GCTR	Kg	-850.00		-741.00					
7	MLTR	"			-800.00					
8	CPTR	"	-300.00	-300.00						
9	MZTR	"	-850.00							
10	GNTR	"				-850.00				
11	MITR	"					-190.00			
12	CATR	"						-350.00		
13	SHTR	"							-70.00	
14	GOTR	"								-60.00
15	GCC	"	600.00		300.00					
16	MLC	"			600.00					
17	CPC	"	150.00	150.00						
18	MILC	"					100.00			

LABOUR HIRING, CONSUMPTION AND SELLING ACTIVITIES - MODEL B (CONT'D.)

Row No.	Objective Function (j) / Resources	Units	$LABH_2$ 0.900	$LABH_3$ 0.900	GCC	MLC	CPC	MILC	GCS	MLS
1	Land	Ha								
2	LSTK	Kg								
3	LAB1	Mhr								
4	LAB2	"	-1.00							
5	LAB3	"		-1.00						
6	GCTR	Kg							-1.00	
7	MLTR	"								-1.00
8	CPTR	"								
9	MZTR	"								
10	GNTR	"								
11	MITR	"								
12	CATR	"								
13	SHTR	"								
14	GOTR	"								
15	GCC	"								
16	MLC	"			-1.00					
17	CPC	"					-1.00			
18	MILC	"						-1.00		

SELLING ACTIVITIES - MODEL B (CONT'D.)

Row No.	Objective Function (j) / Resources	Unit	CPS -2.80	MZS -1.00	GNS -1.80	MILS -1.50	CATS -5.00	SHES -3.50	GOAS -3.00	Sign	RHS
1	Land	Ha								-	2.50
2	LSTK	Kg								-	480.00
3	LAB1	Mhr								-	1434.00
4	LAB2	"								-	1120.00
5	LAB3	"								-	1726.00
6	GCTR	Kg									0.00
7	MLTR	"									0.00
8	CPTR	"	-1.00								0.00
9	MZTR	"		-1.00							0.00
10	GNTR	"			-1.00						0.00
11	MITR	"									
12	CATR	"					-1.00				0.00
13	SHTR	"						-1.00			
14	GOTR	"							-1.00		
15	GCC	"								-	900.00
16	MLC	"								-	600.00
17	CPC	"								-	300.00
18	MLC	"				-1.00				-	100.00

APPENDIX 3: PRODOCTION ACTIVITIES - MODEL C[1]

Row No.	Objective Function (j) / Resources	Units	GC/CP 100.00	MZ/CP 150.00	GC/ML 170.00	GNT 180.00	MIL 0.80	CAT 3.50	SHE 2.15	GOA 2.00	Sign	RHS
1	Land	Ha	1.00	1.00	1.00	1.00					-	2.50
2	LSTK	Kg					1.00	1.00	1.00	1.00	-	480.00
3	LAB1	Mhr					20.00	17.00	8.00	8.00	-	1434.00
4	LAB2	"	92.00	181.00	143.00	227.00	20.00	7.00	4.00	3.00	-	1120.00
5	LAB3	"	42.00	80.00	127.00	72.00	20.00	17.00	8.00	8.00	-	1726.00
6	LAB W4	"	20.00	20.00	20.00	20.00					-	60.00
18	MILC	Kg					100.00				-	100.00
19	CR	"					600.00	600.00	120.00	120.00	-	9760.00
20	MA	"	240.00	240.00	240.00							

1. All other row numbers are as in Model B.

APPENDIX 4

ABBREVIATIONS USED IN THE MODELS

1.	LSTK	Livestock
2.	LAB1	Labour available for period 1 (Jan - April)
3.	LAB2	Labour available for period 2 (May - August)
4.	LAB3	Labour available for period 3 (Sept - Dec)
5.	LRS	Livestock research system
6.	GCTR	Guinea corn transfer
7.	MLTR	Millet transfer
8.	CPTR	Cowpea transfer
9.	MZTR	Cowpea transfer
10.	GNTR	Groundnut transfer
11.	MITR	Millet transfer
12.	CATR	Cattle transfer
13.	SHTR	Sheep transfer
14.	GOTR	Goat transfer
15.	GCC	Guinea corn consumption
16.	MLC	Millet consumption
17.	CPC	Cowpea consumption
18.	MZC	Maize consumption
19.	MILC	Milk consumption
20.	HA	Hectares
21.	KG	Kilogramme
22.	Mhr	Man-hours
23.	No.	Number
24.	CR	Crop residue
25.	MA	Manure
26.	GC-CP	Guinea corn-Cowpea crop mixture production
27.	MZ-CP	Maize-Cowpea crop mixture production
28.	GC-ML	Guinea corn-Millet crop mixture production
29.	GNT	Groundnut sole crop production
30.	MIL	Milk production
31.	CAT	Cattle production
32.	SHE	Sheep production
33.	GOA	Goat production
34.	GCS	Guinea corn selling activity
35.	MLS	Millet selling activity
36.	CPS	Cowpea selling activity
37.	MILS	Milk selling activity
38.	CATS	Cattle selling activity
39.	SHES	Sheep selling activity
40.	GOAS	Goat selling activity
41	LABWA	Labour from work animals

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