Chapter 1

INTRODUCTION

1.1 Background

The study reported in this dissertation is an analysis of the profitability of alternate crops suited to the Ampaem locality of Ghana, given variations in lake water levels and drawdown conditions, with a view to evaluating the optimal crop combinations and identifying any factors which may have hindered the expansion of agricultural utilisation of the drawdown along the Volta Lake. Amaugo (1979, p. 1) defines reservoir drawdown area as the land which is intermittently flooded and later exposed according to the reservoir management operation. This is the usual definition in the study, and it is a normal feature of reservoirs the filling of which depends on periodic source of flood water. Drawdown can also be defined as the area of land between the maximum high water level of the lake and current water level; this definition is employed in the parametric analysis.

The study is of importance because Ghana is striving to become self-sufficient in food production. According to Ewusi (1981), imports of food items, including tinned tomatoes, groundnut oil, maize and rice to satisfy domestic consumption have been a drain on the scarce foreign exchange which is needed to finance capital for investment and economic growth. For this reason the expansion of food crops is seen to be a realistic strategy. However, rainfall in Ghana has been lower than average for the past ten years, and this has contributed to low agricultural production (Economic Survey: 1980-83). Also, for most areas around the Volta Lake the rainfall is erratic and distribution is poor.

The author observes that one resource which can contribute to self-sufficiency in food production, in the country, is the Volta Lake which has come about as a result of the construction of a dam on the Volta River in 1963-65. The dam which cost 142 million cedis (US$49.7 million)[1] was constructed by private investors of an aluminium smelter utilising a large proportion of the resultant hydroelectric power. According to Killick (1978) the Volta Dam is the largest man-made Lake in the world. Table 1.1 below shows some of the physical characteristics of the Volta Lake. The Lake was created primarily to generate hydroelectric power. The secondary functions of the Lake are:

(a) to accumulate water for irrigated agriculture along the shores,
(b) to promote inland fishing, and
(c) to generate a route for inland water transportation to link up the southern and northern parts of the country.

The Volta River Authority (VRA), a public corporation, manages the Volta Dam and the Lake. Since 1968 the Volta Lake Research and Development Project (VLR & DP) has had as one of its functions the promotion of the lakeshore agriculture, including drawdown farming.[2] Given the task of feeding the nation under adverse rainfall conditions, lakeshore irrigated agriculture can be regarded as a burning issue which should occupy a central position among the functions of the Lake. Therefore it is surprising that less than 4 000 ha[3] of the 80 000 ha of drawdown land around the Volta Lake have been used for farming. Undeniably only a small portion of the lake's agricultural potential has been tapped.

1.2 The Problem

The crops which have been recommended by the Volta Lake Research and Development Project (VLR & DP) for growing in the drawdown include those shown in Table 1.2. The crops grown vary with regions and people. In the Ampaem area, for instance, the recommended crops include maize, onions, tomatoes, groundnuts, cowpeas and okro. It is observed, however, that the drawdown farmers are

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1 Source: VRA Annual Report, 1970, Financial Statements C & D.

2 Source: Official Papers, VRA, Head Office, Accra.

3 An Estimated figure, Irrigation Development Authority, Accra.

Table 1.1

Some Physical Attributes of the Volta Lake[1]

Attribute	Value
Maximum water level (usually in October/November)	84.15 m a.s.l.
Minimum water level (usually in June/July)	81.41 m a.s.l.
Total capacity of reservoir	148 million m^3
Maximum length (from Akosombo to Yapie)	400 km
Surface area	8450 sq. km.
Shoreline	8911 km
Volume of water at 84.15 m a.s.l.	148 million m^3 (approx.)
Volume of water at 84.41 m a.s.l.	143 million m^3 (approx.)
Ratio of shoreline to length of lake	12:3
Maximum depth	68-70 m (at Ajena)

[1] Compiled from VRA offices at dam site, Akosombo.

Table 1.2

Feasible Drawdown Crops[1]

Cereals	Legumes	Vegetables	Root Crops
maize	groundnuts	tomatoes	cassava
sorghum	cowpeas	garden eggs	sweet potato
		aubergine	
		okro	
		onions	
		peppers	

[1] Source: 1981-82 Progress Reports, Agronomy Section, VLR & DP.

cultivating mainly tomatoes and maize. The question is raised as to whether the feasible enterprises (crops) are organised in an optimal way by the Ampaem farmers. There is no doubt that the basis of peasant farmers' decision-making is a critical factor in the formulation of agricultural policy in a developing country like Ghana. If farmers operate efficiently, implying that profits are maximised, then incomes can only be increased by introducing improved methods of production; if farmers do not act efficiently, it may be desirable to reallocate resources within agriculture. Thus the author is concerned with the best way of using the drawdown land. A suitable programme for the utilisation of the drawdown has to be developed.

There is also the challenging task of working out how to deal with the variability in land supply for the different crops as a result of variations in lake water level.

1.3 Objectives of the Study

The objectives of the study are:

(a) To find the optimal cropping plan at the different drawdown conditions as a result of flooding/rainfall. Farmers in the drawdown area have to be assisted in selecting the most economic crops given the variability in the lake water level.

(b) To suggest recommendations based on the findings in (a) which would help to improve drawdown farming in the Ampaem area in particular, and lakeshore agriculture in Ghana.

1.4 Hypotheses

The two hypotheses are:

(a) Optimal cropping plan will offer no profit increase over the existing crop combination.

(b) Farm plans will remain the same under different drawdown conditions.

1.5 Outline of the Study

After the introduction in Chapter 1, a brief description of agriculture in Ghana is given in Chapter 2.

The need for reservoir drawdown farming forms the topic of discussion in Chapter 3, while the project area is examined in Chapter 4.

Chapter 5 contains a discussion of the methodology of the study. The theoretical background is briefly reviewed. Some farm planning methods are introduced and linear programming (LP) as a procedure for the selection of enterprise/activity mix at the farm management level is brought to light. This is followed by a brief discussion on parametric linear programming as a modification of LP. There has been the need to employ parametric analysis in the second part of the problem concerning variability in the supply of drawdown land. Data collection and sources will also be given in this chapter. The structure of the LP model is the topic of discussion in Chapter 6.

In Chapter 7, the results of the study are presented for subsequent discussion. The LP solution obtained for the basic farm model is described in the first section of the chapter, while the effect on the solution of variations in the supply of drawdown land is explored in the second section of the chapter.

Finally in Chapter 8, concluding remarks and policy implications from the study are presented.

Chapter 2

AGRICULTURE IN GHANA

Ghana is situated right in the centre of West Africa, and it is the first colonised black African state to achieve political independence in March, 1957. Figure 2.1 shows the map of Ghana with the Volta Lake, as well as the location of Ghana on the map of Africa. To the east of Ghana lies Togo, beyond which are Benin and the Republic of Nigeria. On the west is Ivory Coast, while the Republic of Upper Volta is on the North. In the south the country borders upon the Atlantic Ocean. The southern coast extends between latitudes 4½°N at Cape Three Points and 6½°N in the extreme east, and is thus not far from the equator. The coastline, which is about the distance across the widest part from east to west, measures about 531 Km between longitude 1½°E and longitude 3½°W. From the coast, the country extends inland to about latitude 11½°N, covering a distance of about 672 Km from south to north.

The total area of the country is 239 460 Km^2 out of which 29 000 Km^2 are under cultivation and 11 000 Km^2 are under waters (Economic Survey, 1977-80). Ghana has a population of 12 million[1]. Accra, with a population of just under one million, is the capital city and also the seat of government.

2.1 Topography and Weather

The country abounds in arable land and about 70 per cent of the total population live in the rural areas with cultivable and fertile land. The 1977-80 Economic Survey revealed that about 23 million hectares of land are suitable for agricultural purposes, but only about 3 million hectares are under cultivation. Physically the country is divided into three main regions. These are the Coastal Plain, the Akwapim and Togoland Ranges with the highest point of Ghana, the Afadjato (884m) and the Northern Plains. Drainage is by the White Volta (the principal river) and its tributaries, the Red Volta, the Black Volta, Oti and the Afram. Other important

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1 Source: Estimated mid-year (1982) Population, Central Bureau of Statistics, Accra.

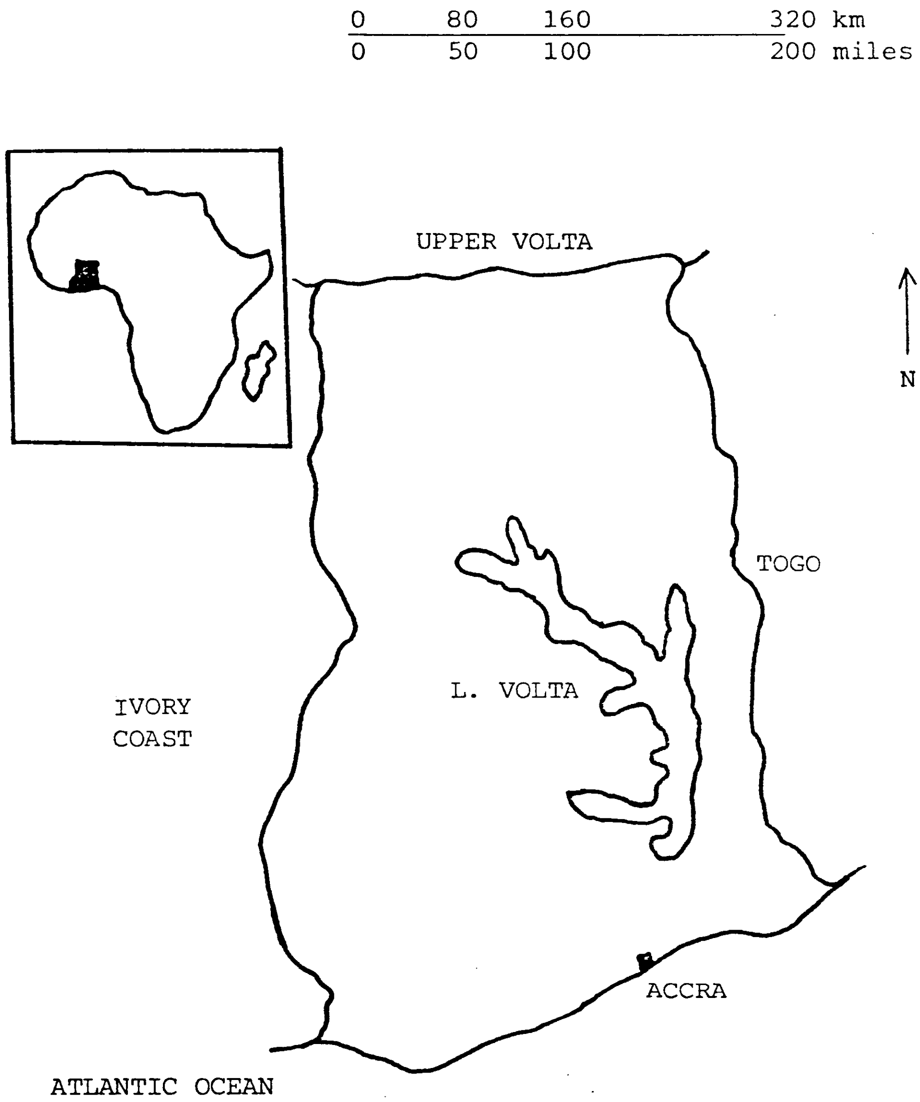

Figure 2.1 Map of Ghana with the Volta Lake, and the Location of Ghana on the Map of Africa.

rivers are the Pra, Tano, Ofin, Ankobra, Densu and Todzie. The two largest lakes are the man-made Volta lake, and Lake Bosumtwi which is situated 32 Km south-east of Kumasi.

2.1.1 Climate

Ghana is situated in the belt of tropical and equatorial climates (i.e. between latitudes 4½°N and 11½°N), however it is the former climate which dominates. High temperatures abound, with little variation from year to year. Average maximum temperatures are highest in March over most of the country, and average minimum temperatures are lowest in August over the whole country. The annual range of mean temperatures increases from the southern to the northern parts of the country.

Rainfall is markedly seasonal in character. Characteristics are heavy rainfall in May-June and September-October, and the period of no rain in January-February. At all places there is great variability in monthly and yearly totals. It is quite common for an entire month in a so-called rainy season to be without appreciable rainfall. January is a dry month throughout the country, although the driest month in the eastern coastal district is August. According to an Official Handbook (1977) average annual rainfall is greatest in the Ahanta-Nzima area (south-west) where Esiama has an average of 215 cm. From this area, rainfall decreases to north and east. The northern frontier area receives between 100 cm and 112.5 cm of rainfall; the driest part of the country is in the south-east where Accra has rainfall of only 82.5 cm while parts of the plains behind the city may receive even less.

Generally relative humidities are highest in the south, and during the night and the early morning. Harmanttan is the name given generally to the north-easterly winds which reach Ghana from the Sahara area which is their place of origin. These winds bring very hot days with, however, cooler nights than usual, and low relative humidities.

2.1.2 Vegetation

The principal factors which operate on vegetation are:

(a) climatic,

(b) physiographic,

(c) edaphic - i.e. pertaining to the nature of the soil, and

(d) biotic - i.e. depending on the activities of living organisms including man; for instance, vegetation destruction for farming, mining and agricultural purposes.

Climatic factors are usually considered to be of the greatest overall importance, and much of the present natural vegetation is essentially related to rainfall. Thus in the order of decreasing rainfall the following types of vegetation are identified in Ghana (Official Handbook, 1977):

(a) Closed or high forest,
(b) Guinea savanna woodland,
(c) The Sudan zone,
(d) The coastal scrub and grassland formation, and
(e) The strand and mangrove belt vegetation.

2.1.3 Soils

There are considerable differences between the soils of the forest, interior savanna and the coastal savanna belts which form the three major soil zones in the country. Such a classification is normal because soil formation can be regarded as a function of climate, vegetation, parent material, relief, drainage and age.

2.2 Nature of the Economy

Szerezewski (1965) observes that structural transformation occurred in the Ghanaian economy at the turn of the century, with the introduction of cocoa and the opening up of gold and other minerals. Thus the Ghanaian economy is dualistic in the sense that two distinct sub-economies co-exist. On the one hand, there is a small capital intensive modern sector involving enclave type of mining and industrial activities. On the other hand, there is a large peasant-based agricultural and traditional sector which is relatively untouched by the development of the modern sector. Between these two sub-economies, the linkages continue to be generally tenuous. However, in recent years the economic crisis which is centred mainly around the modern sector, has some serious repercussions on the traditional sectors as well.

Some selected economic indicators are contained in Table 2.1 which show that the growth of the economy has been oscillating since 1974. The output in 1980 fell below its level in 1974 by 15.6 per cent. A 13 per cent decline in the economy in 1975 was followed by a further 4.7 per cent decline in 1976. In 1977, there was a slight recovery; even though the 2.8 per cent increase could not offset population growth estimated at 2.9 per cent per annum. In 1978 there was a more satisfactory growth of 4.2 per cent. The recovery of the economy in 1977 and 1978 was, however, not sustained and real output fell by as much as 8 per cent in 1979. Rigid price controls led to a decline of the consumer price index by 24.96 per cent between May and September, 1979. Table 2.1 shows that in 1980 prices continued to rise, albeit at a decreasing rate. The key monetary and external indicators also rose in 1980. While exports and imports at 1980 prices rose by 3.1 per cent and 23.9 per cent respectively, money supply registered an increase of 34.8 per cent. Considerable capital in-flow helped to improve the foreign exchange reserves from $169.8 million in 1979 to $327 million in 1980.

2.3 Agriculture

Ghana's economy is mainly based on agriculture and about 70 per cent of the country's labour resources are employed in agriculture. Sheep, goats and poultry provide a good deal of food. There are various fruit trees such as avocado-pears, oranges, pawpaw, bananas, which in many cases grow wild in the forest. Farming is largely in the hands of peasant farmers with holdings averaging about 3 ha per farm family; they use mainly hoes and cutlasses. Usually crops are grown either for consumption by the farmer's family (subsistence agriculture) or for sale on national and international markets (cash crop production). In the rural areas, the subsistence sector of agriculture is large. According to a Household Economy Survey (1974-75), the consumption of own produce accounted for about 38 per cent of the consumption of food by the rural population.

The recent recession is due to reduction in output of agriculture, forestry and mining whose shares in Gross Domestic Product (GDP) have correspondingly fallen (see Tables 2.2 and 2.3). Thus the

Table 2.1

Some Selected Economic Indicators, 1974-80[1]

	1974	1975	1976	1977	1978	1979	1980
Real GNP at 1975 prices	6005	5241	5046	5185	5404	4971	5070
Consumer price index, 1977-100	22.8	29.6	46.2	100.0	173.7	267.3	401.2
Money supply	709.8	1039.3	1473.6	2386.4	4088.4	4630.8	6058.4
Government revenues[2]	804.8	814.8	1074.6	1382.9	2621.5	3843.5	7400
Government expenditures	1161.5	1438.6	1954.2	3175.2	3763.1	4756.1	3800
Exports	2214.1	2403.2	2279.6	2446.3	2460.2	2930.6	3020.1
Imports	2256.4	2174.2	2371.2	2365.5	2310.3	2128.4	2636.3
Foreign exchange reserves	170.5	278.1	116.5	-164.9	-180.4	169.8	327.4
External debt					3200.2	3679.5	3731.8

[1] Sources: C.B.S. Statistical Newsletter; Economic Survey 1975-76; Bank of Ghana Report of the Board of Directors for Financial Year Ended June, 1979.

[2] The figures for Government Revenues and Expenditures relate to fiscal years, e.g. 1974 is for 1974/75 fiscal year.

Table 2.2

Gross Domestic Product at Factor Cost by Industrial Origin, 1974-77

	1974	1975	1976	1977
Agriculture	3145.1	2518.2	2476.7	2362.6
Mining	110.9	104.5	100.1	97.2
Manufacturing	674.5	735.9	703.6	723.6
Construction	299.4	235.6	239.3	270.2
Utilities	34.5	32.6	36.9	36.7
Transport and Communications	203.4	206.0	167.9	190.8
Commerce	748.6	613.3	564.7	574.7
Government Service	352.8	433.0	438.5	578.0
Other Services	329.4	308.3	284.0	297.3
Total GDP at Factor Cost	5898.6	5187.4	5011.7	5131.1

Source: Ewusi (1981, p.5).

Table 2.3

Structure of the Economy-Percentage Distribution of GDP by Industrial Origin, 1974-77

	1974	1975	1976	1977
Agriculture	53.3	48.5	49.4	46.0
Mining	1.9	2.0	2.0	1.8
Manufacturing	11.4	14.2	14.0	14.1
Construction	5.1	4.6	4.8	5.3
Utilities	0.6	0.6	0.7	0.7
Transport and Communications	3.4	4.0	3.4	3.8
Commerce	12.7	11.8	11.3	11.2
Government Services	6.0	8.3	8.7	11.3
Other Services	5.6	6.0	5.7	5.8
Total GDP at Factor Cost	100.0	100.0	100.0	100.0

Source: Computed from Table 2.2.

agricultural sector comprising foodcrops, cocoa, cash crops other than cocoa, forestry, livestock and fishery has been and continues to be the mainstay of the economy. According to Ewusi (1981), agriculture forms about 50 per cent of the Gross National Product (GNP). The available data shown in Tables 2.4 and 2.5 however, indicate that 1980 and 1981 output of most major food items fell below their levels of 1974. Cocoa continues to dominate the economy, and according to an Economic Survey (1977-80) contributes about 12 per cent to the GDP (with about 17.0 per cent of the nation's labour force), and around 60 per cent to export earnings. However, of late, unfavourable developments have brought about a general decline of the cocoa industry.

Successive Ghana governments have, at various times, prepared agricultural development programmes with a view to ensuring abundant supply of food and raw materials for the country's industries and for export in order to earn foreign exchange. The governments have also recognised the need to diversify the export base. With precarious foreign exchange position, it seems realistic for the country to rely more on its own internal resources. But presently the production of food crops cannot cope with the population growth rate which is put at 2.9 per cent per year. Hence the domestic production is now being supplemented by imports. The commodity composition of imports for the 1974-76 period is given in Table 2.6 as an example. According to Huddlestone (1983), Africa's total food grain imports (i.e. commercial and food aid) increased steadily from an average of 1.9 million tons in 1961-63 to 3.1 million in 1969-71, 4.6 million in 1976-78 and 9.2 million in 1981.

2.4 Technology

Agriculture in Ghana is predominantly rainfed and so there is little or no tradition of irrigated agriculture. As such many Ghanian farmers helplessly watch their crops wilt without making the slighest effort to save them by watering, using either a bucket or a watering can, even though there could be an available source of water. However, the drought of the past decade has set the Ghanaian

Table 2.4

Agricultural Production: 1974-81 (thousand metric tons)

	1974	1975	1976	1977	1978	1979	1980	1981
Cereals	890.1	671.5	689.0	639.0	540.0	780.0	716.0	725.0
Starchy staples	7990	5462	4435	4995	4105	3927	4349	4116
Cocoa	385.1	397.3	326.7	277.4	268.2	280.8	277.2	246.5

Source: Quarterly Digest of Statistics, September 1982.

Table 2.5

Production of Major Food Crops: 1974-80 (thousand metric tons)

	1974	1975	1976	1977	1978	1979	1980
Maize	485.7	343.4	286.4	469.0	386.0	370.0	424.0
Rice	73.2	71.1	69.8	56.0	79.0	69.0	78.0
Millet	154.4	121.9	144.4	187.0	119.0	68.0	82.0
Guinea corn	176.8	135.1	188.5	210.0	138.0	97.0	132.0
Cassava	3606.1	2398.0	1818.9	2332.0	1850	n.a.	n.a.
Yam	849.5	709.2	574.9	397.0	n.a.	n.a.	n.a.
Plantain	2024.1	1245.7	1255.6	1455.0	n.a.	n.a.	n.a.

Source: Ministry of Agriculture, Unpublished Data from files.

Table 2.6

Imports Classified by Main Commodity Groups (Million Cedis)

	1974		1975		1976	
	Value	%	Value	%	Value	%
Food and Live Animals	336.2	14.9	250.0	11.5	284.5	12.0
Beverages and Tobacco	18.1	0.8	15.2	0.7	28.5	1.2
Crude Materials Inedible except Fuels	67.7	3.0	67.4	3.1	83.0	3.5
Mineral Fuels	374.5	16.6	360.9	16.6	353.3	14.9
Animals and Vegetable Oils, and Fats	36.1	1.6	23.9	1.1	28.5	1.2
Chemicals	295.6	13.1	302.2	13.9	372.3	15.7
Manufactured Goods classified chiefly by materials	528.0	23.4	497.9	22.9	448.2	18.9
Machinery and Transport Equipment	507.7	22.3	545.7	25.1	647.3	27.3
Miscellaneous Manufactured Articles	65.4	2.9	69.6	3.2	75.9	3.3
Miscellaneous Commodities N.E.S.	27.1	1.2	41.3	1.9	49.8	2.1
Total	2256.4	100.0	2174.1	100.0	2371.2	100.0

Source: C.B.S., Preliminary Economic Survey, 1977/79.

rainfed farmer thinking about how to overcome the vagaries of the weather, and he is no more prepared to accept drought as an act of God which man should not attempt to counteract.

There is enormous scope for harnessing the rivers and lakes of the country for year-round agricultural activity, but so far the success of agricultural operations has largely depended on rains. The government recognises water as essential resource to the successful implementation of any agricultural development programme particularly with regard to crops, livestock and fish farming development, as contained in the Two-year (1980-81) Crash Programme. Irrigation is also good for crops which do better in the dry period. For instance, the hazy harmattan condition in the dry period is quite a suitable weather for tomato cultivation in Ghana; but that requires irrigation. The Irrigation Development Authority (IDA) was established in April, 1977 to embark on massive irrigation programme with a view to ensuring increase in food production all round the year. But the development and use of irrigation facilities have not, unfortunately, made adequate impact on food production in the country. Therefore one wonders whether Ghana governments have really given irrigation the much needed attention. Paulino (1983) contends that virtually 100 per cent of the increase in food production in West Africa since 1960 has come from expanded harvest area, lending support to the thesis that yield-increasing technology is not available for food crops in most of West Africa.

In recent years, in Ghana, a few large scale commercial farms have been developed both in public and private sectors, and these farms require foreign exchange for the importation of machinery and equipment such as combine harvesters and tractors. It is observed that the growth of these commercial farms has been slow, and the structure of the agricultural sector in the country as a whole has not changed appreciably during the last decade. Thus there seem to be little support among political leaders, intellectuals and donors for an agriculture-led development strategy which, by necessity, requires a consistent and sustained investment in agriculture in order to generate and to maintain a reliable food surplus that is a precondition for economic development.

2.5 Some Impediments to Ghanaian Agriculture

The constraints which have impeded the growth of the agricultural sector in Ghana include the following (Economic Survey, 1977-80):

(a) Credit. Peasant farmers, who constitute about 95 per cent of the agricultural workers, scarcely have any access to institutional credit. The financial resources of these farmers are usually inadequate, and loans from money lenders are obtained at relatively high interest rates.

(b) Input supply. The supply of essential inputs like cutlasses, fertilizer and pesticides is often inadequate. Also the available supplies are usually not delivered in time due to poor road conditions and lack of transport facilities. Thus a good deal of valuable agricultural inputs are wasted on account of improper distribution system and inadequate storing facilities.

(c) Extension. The agricultural extension services are not very effective due to the low morale of the staff, inadequacy of transport facilities and agricultural inputs.

(d) Land-tenure. The land-tenure system makes it very difficult for new farmers and landless people to resort to agriculture.

(e) Transport. Generally there is lack of effective system of transporting farm produce. Therefore a good deal of farm produce cannot be evacuated to marketing centres, and this results in big losses to farmers in many areas of the country.

It is observed that the contribution of the public sector to the total agricultural production of the nation is relatively small. The two major corporations which are engaged in crop production are the Food Production Corporation (FPC), and the Ghana State Farms Corporation (GSFC). The FPC has major plans now to lay emphasis on increasing production of maize, rice and cassava, thus shifting emphasis from producing smaller quantities of numerous crops. But the corporation faces many problems which are similar to the above-mentioned constraints. The GSFC is the largest single government enterprise engaged in large scale farming. The Corporation deals with oil palm, coconut, rubber, cashew, cola, maize, rice and sorghum. During the two years 1979 and 1980 together, the corporation produced 9 100 tons of palm fruits, 236 000 tons of coconuts, 4 700 bags of maize and 1 000 tonnes of cassava; however, out of the 4 858 ha of arable land of the Corporation, only 810 ha are cultivated.[2]

2.6 Conclusion

In the earlier sections the overall physical and economic resources of Ghana was over-viewed. It was noted that whilst seasonal rainfall may be erratic the consistent temperature and nature of the soils present a favourable situation for irrigated agriculture. As considerable food is imported there is scope for increased food production. In the succeeding chapter the scope and nature for irrigated drawdown farming in Ghana is reviewed.

[2] Source: Summary Review of Economic Condition, 1977-80.

Chapter 3

RESERVOIR DRAWDOWN FARMING AND REVIEW OF WORK DONE

3.1 Introduction

With the building of the giant hydro-electric power project (in 1963-65) at Akosombo, some 116 km from the estuary of the Volta River, the whole system has been turned into an artificial lake, holding back the waters of the river behind the giant dam. The dam and associated works, which cost a total of ¢142 million, were financed by equity investments by the Ghana government (¢59 million), and loans from the World Bank (¢48 million) and the US and UK governments (¢35 million).[1] The lake, which is shown in page eight, (p.8) covers an area of 8 502 km^2, and has a storage capacity of 148 million m^3 of water. Oyedipe (1974) observes that the formation of the lake resulted in the flooding of some 739 villages of various sizes, scattered over 8 515 km^2 of land which was inhabited by some 79 000 people of different ethnic, social, religious and occupational backgrounds. Eventually the flood victims were resettled in 52 planned settlement townships by the Volta River Authority (VRA).

The VRA, as a statutory body, was established in 1961 under the Volta River Development Act - Act 46 of that year. According to the Ghana (1977) Official Handbook, the Act empowers the Authority to supply power to:

(a) any government department or public corporation responsible for the supply of electric power to the public,

(b) the township of Akosombo, and

(c) any other consumers, at voltages not lower than 11 KV, and in quantities not less, on the average in any period of 24 hours, than 4 800 KW-hr or its equivalent in terms of energy.

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[1] Source: VRA Annual Report, 1970, Financial Satements C & D.

The Authority is also charged with the control and safe-guarding of the health and well-being of the inhabitants of the lake-side area. Other functions of the Authority are:[2]

(a) the development of the fishing potentialities of the Volta Lake and the utilization of the Lake as a route for commercial transportation,

(b) the settlement of persons displaced by the formation of the Volta Lake,

(c) the administration of the township of Akosombo as a local government Agency, and

(d) the research, in conjunction with other agencies, into the development prospects and problems of the Lake, including hydro-biological studies, public health and shore-line agriculture.

The last function brought about the formation of the Volta Lake Research and Development Project (VLR & DP) which is now a division of the VRA.

The VLR & DP came into operation in January, 1968 with the specific research into the development prospects and other problems of the Lake. The fields covered by the Project are:

(a) social, agricultural and economic aspects;
(b) fishery and hydrobiological aspects; and
(c) public health aspects.

Studies are made to develop the Lake margins and to assist the displaced people during the transition period of being resettled, as well as the general development of the resources of the Lake. Assistance is also given for the implementation of the farms planned for the settlements.

3.2 The Drawdown Phenomenon on the Lakeshore

Drawdown is the area which is covered by water when the lake rises and is then exposed when the lake recedes. Drawdown farming

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[2] Source: Official Papers, VRA, Akosombo.

started spontaneously among the resettled communities around the Volta Lake. Apparently it has been an old practice, particularly with the people resettled from the lower Volta River shores who experienced the seasonal floods on the Volta River before the dam was created.

However, not much work has been done in the drawdown area. Amametekpor (1970) and Ahn (1970) give a description of the soils in certain specified parts of the Volta drawdown area, and estimate from contour maps that the size of the drawdown area is about 85 425 ha. Using data on the cumulative area exposed in the drawdown area from November 1969 to August 1970, Laryea (1973) also shows that:

(a) the maximum area exposed in 1970 was 116 599 ha which remained exposed from mid-June to mid-August (see Figure 3.1 below),

(b) thereafter, the whole area was rapidly inundated within a period of two months (i.e. mid-August to mid-October),

(c) the drawdown area is exposed gradually and for farm management purpose, the last sowing should be done not later than the middle of May so that sufficient time would be available for harvesting to be completed before the area is flooded again. Nuamah (1978) also mentions that the total exposable drawdown area is 121 457 ha, and he says that 80 972 ha are cultivable. The suitable land areas are said to occur mostly on the western bank of the Lake.

The life span of any dam depends, among other things, on the rate of siltation of the dam. Cultivation with implements lossens the soil and pulverises it, giving the soil a good tilth when it is judiciously carried out. But it is possible that the pulverised soil material from widespread cultivation of the drawndown area would be predisposed to erosion. Incidentally erosion experiments by the VLR & DP have revealed that erosion in the Volta basin is quite minimal because:

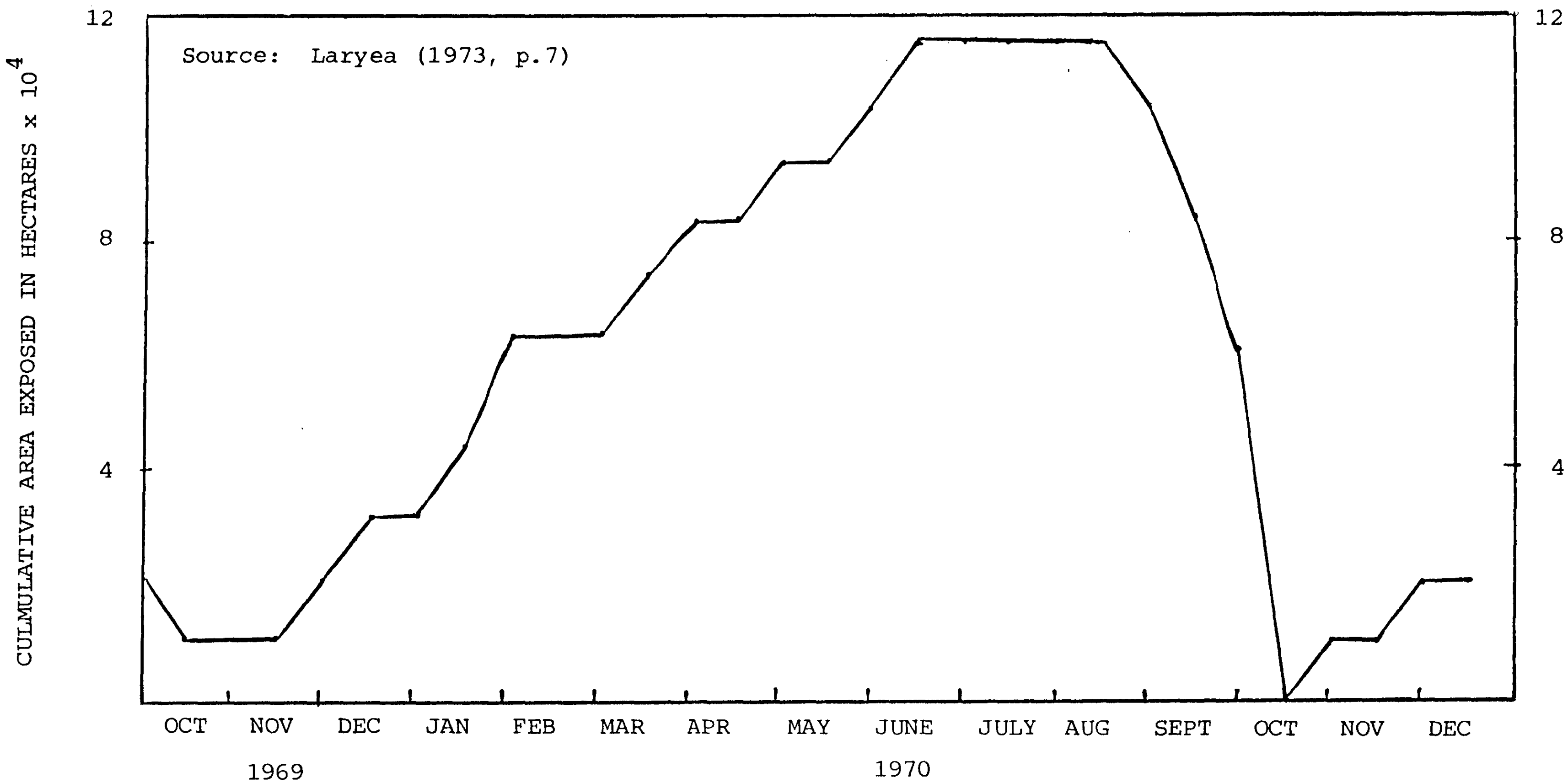

Figure 3.1 Cumulative Area Exposed at the Drawdown Area with Time in Months, for Part of 1969 and the Whole of 1970.

(a) the infiltration rate of the soil is high,

(b) the soil has a stable structure so that it does not slake or disperse upon wetting with water, and

(c) most areas of the drawdown have very gentle slopes (1-2 per cent) such that water flow on the soil surface is slow and gradual.

The VLR & DP has also been able to show the effectiveness of farm practices like contour banking, grassed terracing etc. in reducing erosion at the drawdown. However, another area of study which the Project can look at is the deposition pattern of particles by the floods as and when they occur. This study is of interest because it has been observed that both fine and coarse sand particles are being deposited at the shores of the Lake. If this continues a 'sand dune' which will raise the elevation of the drawdown area due to deposition of sand particles would be to decrease the size of the drawdown area.

The need for supplementary irrigation has been recognised in the drawdown area. The VLR & DP, as a result of irrigation studies, has introduced multi-purpose two wheeled tractors for use in the drawdown area. The average cost of one machine with standard accessories is about 110 000 cedis, and the machines have to be imported. These machines are mostly small-scale machines which have two power take-offs (P.T.O.), one above the other. The top P.T.O. is for pumping water and the lower one is for coupling implements like the rotovator, the planter, trailer and ridger. They are 10-13 horsepower diesel engines capable of irrigating about 7 ha of cropped land at seven days frequency. The drawdown therefore becomes in favour of small-scale irrigation farming the economics of which is the core of the present study. The Agronomy section of the VLR & DP has conducted trials and experiments within the Ampaem area and other places in the lake basin which have shown:

(a) a tremendous response in irrigation and its effectiveness, and

(b) a high degree of acceptance of irrigation practice by the farming community.

It is expected that substantial benefits to the industrial and agricultural growth of Ghana will be derived from the successful exploitation and development of the Volta Lake basin. Eicher (1983) mentions that on the basis of a large amount of empirical data on small holders and large scale farming, there is convincing evidence that a smallholder/smallherder road to development should form the cornerstone of policies, strategies and projects to achieve both agricultural growth and equity goals in developing countries. Thus small-scale farming should be given the much needed attention in these countries including Ghana, of course. The use of large four wheel tractors has not been visualised on the drawdown because their size and cost of operation on virtually small areas would prove uneconomical. Again the advantages of reduced or minimum tillage by the small tractors should not be lost sight of, especially given that the soils in the drawdown are relatively shallow. In support, Makeham and Malcolm (1981) point out that, of late, scientists and producers are seeking alternative means of production to the conventional tillage practices, in order to:

(a) protect the soil from wind and water erosion,
(b) maintain soil structure,
(c) increase the flexibility of the cropping system, and
(d) counter the problem of rising fuel and machinery costs.

Apart from zero tillage, the only broad alternative remaining is reduced or minimum tillage which is a characteristic of these small tractors. It should be mentioned, however, that the purchase of machinery is often a major decision for the Ghanaian small farmer because it usually involves some investment. But even the few farmers who can afford the small machines realise that the machines are hard to come by in the country.

It has been demonstrated by the VLR & DP that usually when the Lake water recedes, a lot of water referred to as 'residual moisture' remains in the soil which is able to cause plants to grow for 40 to 60 days without additional moisture. This unique property of the drawdown is important because only supplementary irrigation will be needed in dry areas, like the Ampaem area, to ensure full crop growth. For land preparation in the drawdown area, the VLR & DP has shown, through research, that it is necessary to clear weeds in advance in the path of the rising water for the following reasons:

(a) the dead plant material will make the soil rich in plant food materials and will also make the soil hold on to water for a longer period,

(b) clearing of weeds after the Lake water had receded will expose the soil to the sun and cause quicker loss of water through evaporation before the crop is planted,

(c) if the weeds are cut from the upland towards the Lake, the minor rains will cause seeds to grow again and one will be compelled to weed a number of times.

So it is quite an advantage to hoe from the edge of the water upwards towards the upland.

The drawdown has also become an important concept in Nigeria. Amaugo (1979) examines the agricultural utilization of the Kainji Lake drawdown in Nigeria, and he concludes that some benefits may be derived by farming reservoir drawdown areas, some of which cover vast areas of originally good farm lands.

Drawdown cropping is intensive and can no longer be a matter of merely sowing and harvesting. Decisions have to be made on varieties, weed control, pest control, water, fertilizer, sowing depth, rate of spacing, rotations, labour, machinery, cultivation, soil moisture, timeliness and general cropping plan(s). Thus the drawdown will continue to be an interesting area of study by scientists and researchers.

3.3 Factors Affecting the Agricultural Use of the Drawdown Area

Factors which may influence the decision to use the reservoir drawdown area for agricultural purposes include climatic factors in the reservoir area, extent of the drawdown area and availability of other farm lands, management of the reservoir operations, type of crops to be grown and pest problems in the area.

The prevalent climatic conditions after the drawdown area is exposed determine whether crops planted there can survive or not. It also influences farmers' decision to use the drawdown and the extent to which the farmers may be disposed to cultivate the land which is exposed. In the Volta Lake area, the reservoir begins to recede in November when the weather is dry and most farmers are not engaged in other activities.

Coupled with the climatic factors in determining the use of the drawdown area is the availability of other farm lands. If there is scarcity of farm lands in the upland areas, farmers might be induced to use the drawdown area which remains exposed during the rainy season. Farmers might also use the drawdown area even where there are upland farm lands, if there is the possibility of obtaining higher yields in the drawdown area. End-of-season crop reports of the Volta Lake drawdown area show that higher yields are obtained in the drawdown area with less application of fertilizer than in the upland area even during the rainy season. The 1980/81 tomato season in Table 3.1 serves as an illustrated example in the Ampaem area (in the dry season).

The reliability of the reservoir management operations in regulating the filling and emptying of the reservoir determines the extent of the successful utilization of the drawdown area for agricultural purposes. Interviews with engineers at the Volta Dam site revealed that the movement of water level, since the creation of the dam, has taken its natural course because there has not been the need to regulate the incoming flood and the water spilled. Otherwise farmers may risk planting crops in the drawdown area through unrealiable regulation (i.e. filling and emptying of the Lake).

The problem of pest damage of crops in the drawdown area is of considerable importance in the agricultural utilization of the area. In the Volta Lake where the drawdown cultivation takes place at a time when there are few growing crops around and most of the surrounding vegetation is dry, pests can concentrate on the comparatively small area of cultivated drawdown lands.

Table 3.1

Average Yield and Cash Returns to Farmers (Tomato: 1980/81)

	Drawdown area	Upland area
Farm size (ha)	0.50	0.50
Yield (kg)	4 950	3 431
Gross returns (@ ¢3.60/kg)	17 820	12 352
Total cost of production (¢)	375	1 203
Net revenue (¢)	17 445	11 149

Source: Ofei-Mensah (1981), End of Tomato Season Report, VLR & DP.

3.4 Forms of Agricultural Utilization

The reservoir drawdown area may be developed for different forms of agricultural activities. Under favourable climatic and suitable soil conditions, the area may be developed for drawdown cultivation, which is defined as the cultivation of the land which is flooded and later exposed, in such a way that the cultivation starts soon after the Lake water begins to recede and continues, keeping pace with the receding Lake water. In the Volta Lake, drawdown cultivation begins in November, when the Lake water begins to recede and continues till May when the lowest cultivable contour is exposed. The last crop is therefore harvested in August before the subsequent flooding.

Another form of agricultural use may be referred to as 'draw-up' farming. In this case, the area is planted up with the crop when the Lake water is rising so that the area which is planted is eventually submerged, but the crop continues to grow above the surface of the water. This practice is possible with crops which can stand the required standing water, for example deep water or floating rice varieties. However, the seedlings have to get well-established before the submergence of the area. The VLR & DP has experimented with elongated rice or floating rice, received from the IRRI in the Philippines. This is grown in the path of advancing water within certain contours where they would not be submerged. The crop is then harvested during the recession period. This practice has not caught up with the farmers yet.

Under the adverse climatic conditions which prevail in the Volta Lake area, drawdown crops planted in November may suffer from water stress before they reach maturity in the dry season. Similarly wet season crops in the drawdown area may suffer the adverse effect of the persistent drought in the Lake area. In each case, it is possible to sustain the crops over the period of stress by supplementary irrigation. Small movable pumps may be placed at the edge of the receding lake water to pump water onto the crop fields. Thus rainy season cultivation of the reservoir drawdown area is possible if it remains exposed during the rainy season and long enough to allow the crops to mature. It is especially beneficial where there is scarcity of cultivable land around the Lake periphery or where the soil fertility difference is in favour of the drawdown area as Kaul and Rao (1960) speak of the Tilaiya Reservoir in India.

The drawdown area can be used to improve livestock farming. Several grass species grow luxuriantly under submergence and are exposed or brought to the reach of livestock as the Lake water recedes. This has not been tried with the Volta Lake basin yet. However, in the Kainji Lake drawdown area, in Nigeria, Amaugo (1979) observes that cattle and other livestock (sheep and goat) graze the exposed grasses in a manner which may be described as drawdown grazing, since it keeps pace with the receding lake water. As a result of the residual soil moisture, other plant species, including legumes, quickly regenerate after the drawdown land is exposed. Kaul (1974) and Sinderus (1974) suggest the use of the drawdown areas for forage crops production as an alternative to its use for crop production. Since there is regular water supply, the drawdown area may be able to sustain a regulated number of livestock; and as has been suggested (Amaugo, 1979) the partial use of the drawdown area for livestock farming can fit into a well planned all-year-round agricultural utilization of a multi-purpose reservoir area.

3.5 Advantages of Drawdown Cultivation

In this chapter, the discussion, so far, suggests that some advantages may be derived from drawdown cultivation depending on the climatic and other factors prevalent in the reservoir area. In the Volta Lake, the possible advantages can be summarized as follows:

(a) the agricultural engagement of the farmers during the dry season when most of them would have been engaged in non-agricultural activities; thus the period for food production and employment of labour is prolonged.

(b) the possibility of harvesting dry season crops in the drawdown area much earlier than rainfed crops, and at a time of scarcity of food in the market.

(c) the non-requirement of elaborate capital expenditure on machinery for development of the drawdown area or for the construction of permanent structures as compared with other large-scale irrigation projects which may be taking place in the same area.

Apart from the Volta Dam, there are proposals for the construction of more dams, primarily for the generation of hydro-electric power in Ghana. It is anticipated that the various river basin development authorities might take advantage and develop the resultant reservoir drawdown areas for various uses including agriculture production. Reservoir drawdown agriculture will also be in line with government policy of self-sufficiency in food production given the irregular pattern of rainfall in the country.

3.6 Conclusion

It is evident that there is ample scope for increasing agricultural production from the drawdown land of Lake Volta and similar areas. However, the picture painted was a broad scale one. In the succeeding chapter a specific area of drawdown land is examined, with a view to assessing the extent to which the conclusions that can be drawn from Ampaem can be extended to other areas.

Chapter 4

THE PROJECT AREA

4.1 Introduction

The Ampaem area is on the Afram Wing of the Volta Lake; as such it is also said to be in the Afram Plains. The area lies in the Nkawkau District in the Eastern Region of Ghana. The Ampaem area is one of the eight zones of the lake where there is drawdown. Figure 4.1 below shows the Volta Lake and the Ampaem area. It has been estimated by the VLR & DP that the drawdown in the area is about 5 000 ha.

In this study attention has been focussed on the Ampaem area because, among other things, the economic and technical opportunities available to farmers are better documented for the area. Tamakloe (1970) did some sociological survey of the place, and Atubra (1977) in his agricultural survey also provides some information about the area. The environmental conditions are broadly uniform throughout the drawdown area along the Lake; hence there can be general applicability of deductions from the analysis.

4.2 Ecology of the Area

The ecology (climate, vegetation, people etc) of the Ampaem area has been drastically changed since the Lake formation. It was once agriculturally very productive area but now suffers frequent and severe droughts. This has led to a chain of deteriorating effects on family income and therefore livelihood. The effect of drought has brought a noticeable change in the farming activities of the people whose lands were inundated by the Lake and were resettled in small communities around the Lake. As noted earlier, 80 000 people were involved in this resettlement scheme out of which about 6 500[1] live in the Ampaem area. The average family size in the area is seven, i.e. man and wife plus five children. In 1969,

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1 Source: Oral discussions with social leaders and government officials in the Ampaem area.

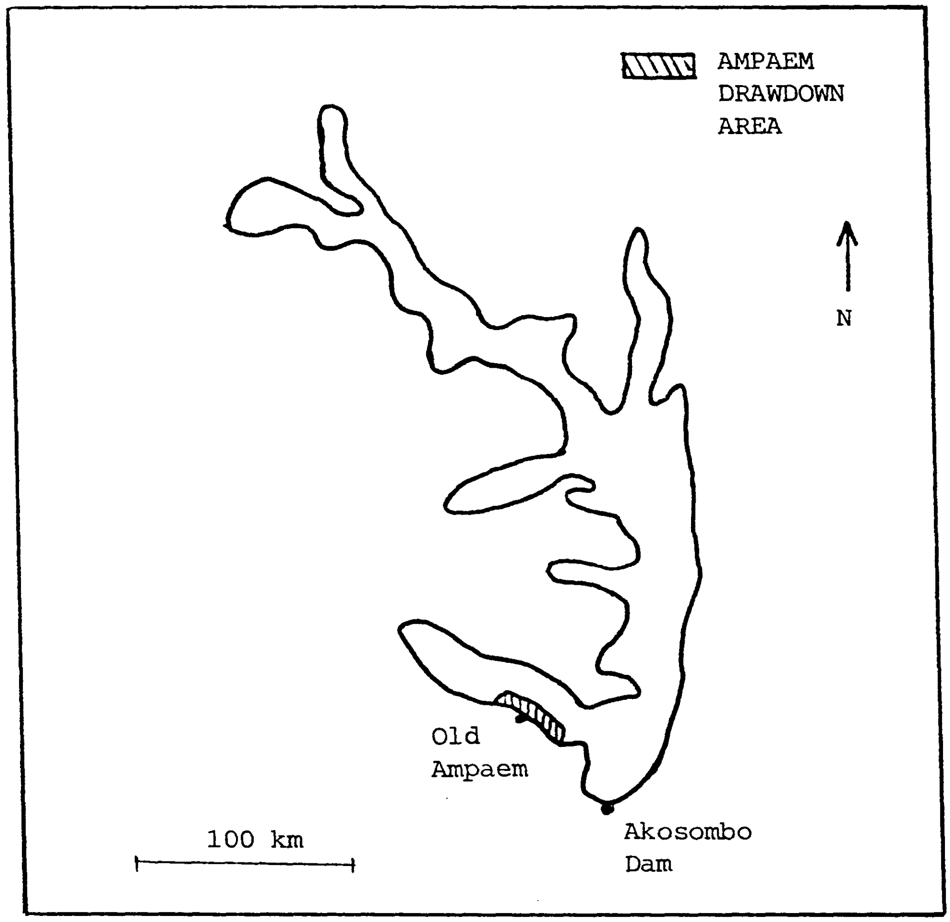

Figure 4.1 The Volta Lake Showing the Ampaem Area.

the area was declared drought stricken by the Ministry of Agriculture. During the author's interview, some people in the area attributed the severe drought to the creation of the Lake which had annoyed the River gods of Volta, Afram and the other tributaries.

Rainfall in the Ampaem area follows two seasonal patterns in May-June and September-October as depicted by Figure 4.2 below for 1976 and 1977. A period of no rain usually occurs in January-February. It should be mentioned, however, that rainfall in the area is limiting with haphazard distribution. The mean annual maximum temperature is 32°C and the critical relative humidity is recorded at 18 per cent. Wind speeds are medium but strong in March-June each year. The wind direction is predominantly southerly but south-east and north-east direction is also encountered.

Two main types of vegetation are identified in the Ampaem area as follows (Atubra, 1977):

(a) Derived or secondary forest - where the vegetation has lost its original structure through the activities of man, such as farming and fire. Usually there are few tall trees, and the undergrowth is made up of creepers and short trees.

(b) Savanna Grassland - which is made up of grasses like Andropogon gayame, Imperata cylindrica and Pasrahun orbiculare, with isolated thickets. The drawdown area is dominated by Echuncchica prycmidalis.

The farm lands lie between the Afram Range at the south and the Volta Lake. The Ampaem area is at the leeward side of this mountain, and farm activities along the mountain are therefore minimum. The land then slopes gradually to the Lake. Farm lands lie close to the Lake and are mostly fields with low gradients. Mostly the soils in the area are sandy loam.

4.3 Occupation of the People

The majority of the people in the area earn their livelihood through farming in the drawdown and the adjacent upland areas. A survey conducted in the area by Atubra (1977) before the drawdown

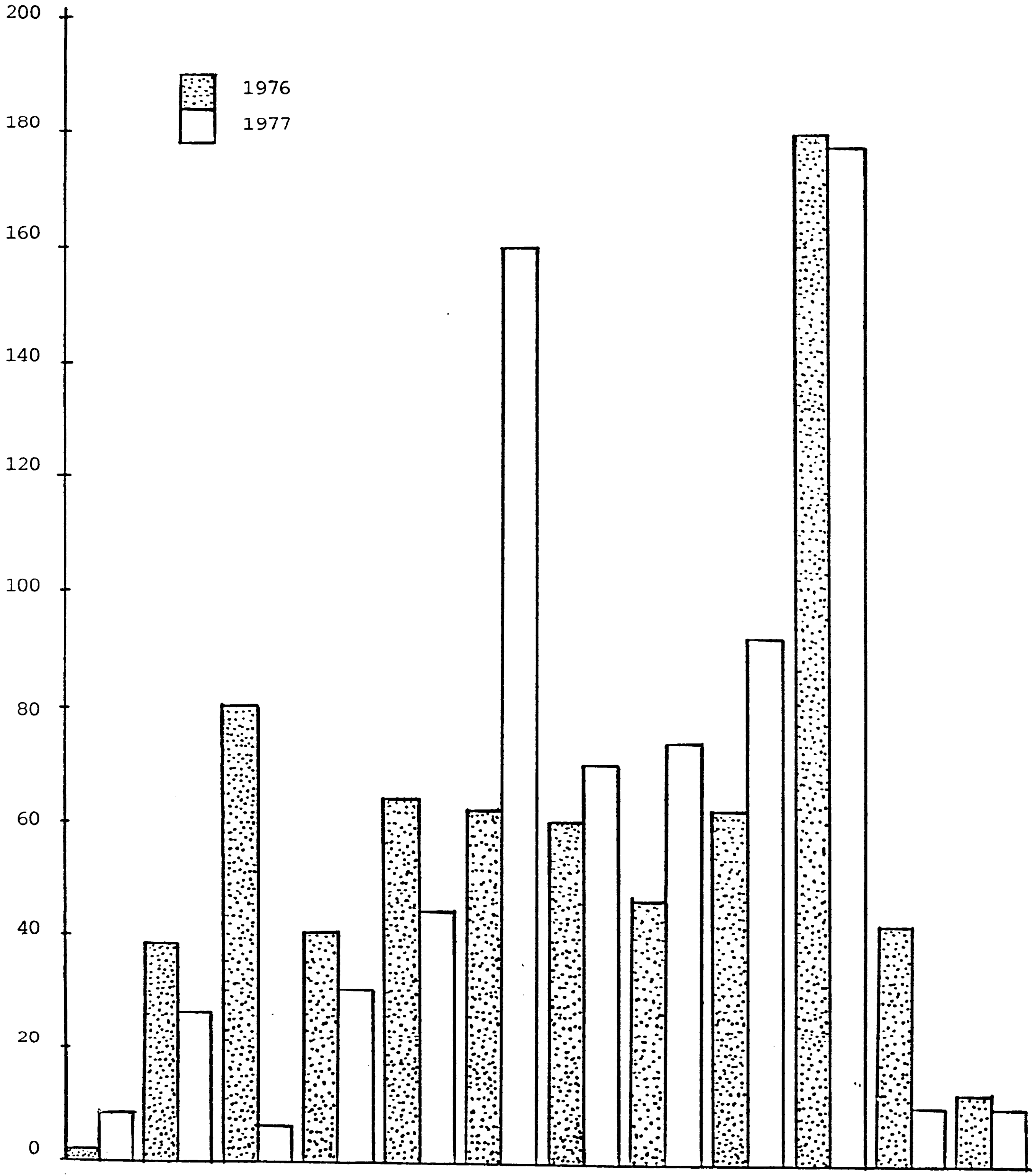

Figure 4.2 Rainfall Histogram for the Ampaem Area: 1976-77.

irrigation scheme showed that the average farm income was below 2 000 cedis and crop yields were below the average in the country. Four categories of people, in terms of occupation, are identified as shown in Table 4.1 with their per cent composition. Given the persistent crop failure, due to drought, some farmers engage in fishing in the Lake as a means of supplementing their income. The fishermen are mainly people from the Ewe and Ada Communities who have settled close to the Lake. They normally obtain their food requirements by exchanging fish for foodstuffs which farmers bring to the open market on market days.

4.4 Cropping Programme

Since 1974 the Agronomy section of the VLR & DP has carried out agronomic studies into cropping patterns, fertilizer use, disease control and plant protection, the most feasible irrigation pumps, etc. in the area. Through demonstration and trials the Project has recommended the following crops which do well in the drawdown area:

(a) Cereal - maize.
(b) Legumes - groundnuts, cowpeas.
(c) Vegetables - tomatoes, Okro.

The periods during which the crops can be grown are contained in Table 4.2. The interview revealed that enterprises are combined in various ways by most farmers as an attempt to secure better family income against crop failure. These farmers effect intercropping which is the practice of growing two or more different crops together or in association on the same piece of land. Intercropping can have its advantages; for instance, if a legume is used it can provide additional nitrogen for use by the non-leguminous crop. Different harvesting times can also ensure a more continuous supply of foodstuffs over a longer period of time. Furthermore pests and disease attacks are minimized because of selectivity which guards against total crop failure.

Almost all farmers in the project area grow only maize and tomatoes even though five crops have been recommended presently. Maize which is normally grown for home consumption occupies up to 50 per cent of the farmer's 2.5 ha farm; it is the staple crop.

Table 4.1

Occupation in the Area

Occupation	Composition (%)
Farming	55
Fishing	10
Farming and fishing	20
Farming and activities other than fishing	15
Total	100

Source: Atubra (1977).

Table 4.2

Crop Growth Periods

Season	Planting month	Harvesting month
Off (dry)	November	January
	February	April
Normal (wet)	May	July

Tomatoes are grown for sale and can occupy up to 75 per cent of the total farm area. Approximately 30 per cent of total agricultural production in the area is retained for home consumption, and the bulk of it comes from maize. This is in line with a Household Economy Survey (1974-75) which revealed that the consumption of own produce accounted for about 38 per cent of the consumption of food by the rural population. In the project area, other food items like plantain, cassava, cocoyam and fish are bought from other non-drawdown farmers outside the area who bring their produce to the market on market days. Over 60 per cent of food consumption requirement by the drawdown farmers is satisfied in this fashion. Thus one aspect of the present study seeks to help the farmers to come by optimal cropping plan(s) in the area. This can help the farmers to maximize their profits given the available resources, and also help to increase the general production of some, if not all, of the recommended crops in the Ampaem locality. The declining nature of the production of the five recommended crops, in the country, is depicted by Table 4.3 below. The area under crops (in thousand hectares) is shown in parenthesis in Table 4.3. It is noted that crop production from 1975-81 is below that in 1974.

4.5 Land tenure

The government acquired enough upland area for the Ampaem resettled communities for farming purposes. Each farm family owns 3 ha of land, and does not pay any rent for using it. However, in recent years, it is observed that most farmers have virtually abandoned the upland areas because of the persistent drought in the area. The popular land now is the drawdown because of the residual moisture in the soil which can sustain crops for an average of 40 days. Another thing is the supplementary irrigation on a small scale, in the drawdown area, which has caught the attention and interest of the farmers. As a consequence the drawdown area, which is under the auspices of the VRA, is being demarcated into plots for use by the resettled communities at no cost. Each family plot measures 250 m on the near upland or to the east and 100 m

Table 4.3

Production of the Recommended Crops, 1974-81

	1974	1975	1976	1977	1978	1979	1980	1981
Maize	485.7	343.4	286.0	274.0	218.0	380.0	382.0	378.0
	(424.9)	(319.7)	(273.2)	(256.0)	(205.0)	(358.0)	(410.0)	(372.0)
Tomatoes	104.7	90.4	100.0	103.0	104.0	125.0	..[1]	..
	(22.7)	(19.0)	(22.1)	(16.0)	(22.0)	(27.0)	..	..
Okro	252.0	159.5	108.0	92.0	93.0	110.0	..	..
	(51.0)	(32.4)	(23.3)	(24.0)	(20.0)	(27.0)	..	..
Groundnuts	156.5	110.8	113.0	81.0	83.0	107.0	..	..
	(110.9)	(101.9)	((91.4)	(85.0)	(71.0)	(92.0)	..	..
Cowpeas	16.7	16.2	17.0	14.0	11.0	9.0	..	..
	(148.6)	(147.0)	(162.8)	(157.0)	(118.0)	(121.0)	..	..

[1] .. means not available

Source: Ministry of Agriculture, Economic Planning and Research Services.

(which can be more or less depending upon drawdown conditions) towards the Lake or the west. This comes up to an average of 2.5 ha of drawdown per farm family. The rationing of land suggests that there is some pressure on the use of drawdown land since not all the resettled farmers can be accommodated on the limited land within the settled areas. Farmers who want more land may have to go long distances, probably away from the project area. Renting of drawdown land is also possible among farmers. Shared-cropping is another land tenure arrangement where by the produce realised from an area cultivated is shared between the land owner and the farmer in the ratio of two parts to one part (2:1) respectively.

4.6 Irrigation and Water Source

The availability of land in the Ampaem area cannot be adequately measured in terms of area only. It is true that the quantity of land is a factor governing farm output; however, the inherent quality of land can be of even greater importance, particularly where farmers lack the techniques or resources necessary to improve its nutrient status and productivity. For instance, small farmers on irrigated, fertile land able to practice double or even tripple cropping, can hardly be compared to farms of similar size without access to irrigation. This aspect is especially important for farms in the Ampaem area where there is low and variable rainfall. This area is at a particular disadvantage because even a relatively large farm area cannot guarantee a sufficient or stable source of food under these climatic conditions. For instance, since some farmers do not have simple water pumping machines to enable them to supplement the water requirement, yields obtained from drawdown crops are below the average in the country.

Incidentally the VLR & DP has carried out irrigation studies in the area, and has shown that the desired cycle of irrigation in the area is 5-6 days, applying about 50 mm of water per cycle and working preferrably between 10-12 hours at the most for most crops. The source of water is the Volta Lake (see Figure 4.1 above) which is presently a permanent and quite an important source. The Lake is characterised by changes in level usually between a high of 83 m occuring in about November each year and a low of 80 m in about June/July. That is, it recedes from November reaching the lowest level in June/July in succeeding year. For gradients between 1-2 per cent, the rate of flooding varies between 0.4 - 0.5 m/day, and recession is about 2-3 m/day. The cultivable drawdown lands are usually of these gradients.

4.7 Capital

Capital requirement in the area is usually in the form of cash and farm/irrigation machinery. Cash is usually needed for hiring labour during land preparation, planting and harvesting, whilst pumping machines are needed to draw up water from the Lake for irrigation purposes. The only Agricultural Development Bank (ADB) in the area is located in a town (Kwahu-Tafo) which is about 50 km from the project area. Farmers pay an interest of 10 per cent for short-term loans from the bank. Most farmers complained about the inadequacy of the loans from the bank, and some of them obtain extra loans from relatives and friends. It is also observed that lack of irrigation machinery is retarding the progress of farmwork in the area.

4.8 Infrastructure

There are four elementary schools in the Ampaem area, and about 20 per cent of the total population are school-going (aged 6-20 years). Seasonal absence from school is common because of labour needs on the farms. Some extension services are also provided by the Ministry of Agriculture and the VLR & DP, but these are not enough. The literacy level in the area is about 50 per cent.

Health services are not well developed, and there is only one private clinic in the whole area. One government hospital is located in the nearest town about 50 km from the project area. Rural sanitation is not well developed, and water supplies are direct from the Lake which is not safe for drinking unless treated. There is incidence of water-borne diseases and mosquito-borne diseases such as malaria. Attempts are being made to rehabilitate the piped-water system in the area.

Most of the houses in the area have been built by the government for the resettled communities, and they are made up of concrete with galvanised iron roofs. The houses and surrounding yards are usually kept clean. The houses are within walking distance from most farms.

The roads in the area are in fair to poor condition. In all there are about five privately-owned vehicles in the area which provide a link between these settled villages and the neighbouring towns. However, during crop harvesting times market (middle) women from various parts of the country hire additional vehicles to cart foodstuffs from the area, and this improves the transportation in the area.

4.9 Conclusion

It has been shown that despite the considerable problem of access to markets, finance and general economic infrastructure the Ampaem area is well suited to the expansion of food production. Before considering the recommended changes which emerge from the study a review of methodology is presented in the next chapter.

Chapter 5

THE METHODOLOGY OF THE STUDY

5.1 Introduction

Insofar as planning usually involves the allocation of limited resources between alternative ways of achieving a goal or objective (such as maximising farm income), it is possible to accept Barnard and Nix's (1979, p. 3) identification of three elements in planning. They are:

(a) an objective,

(b) scarce resources, and

(c) alternative ways of using the resources to attain the objective.

The above elements are a component of mathematical programming methods. At the farm level, Dillon and Hardaker (1980) suggest the implementation of such techniques through gross margin (GM) analysis, simplified programming (SP), and linear programming (LP) and its extensions. These techniques are briefly reviewed in the following sections, and their applicability to the problem under review assessed.

5.2 Farm Planning Methods

5.2.1 Gross margin (GM) analysis

The objective of GM analysis is to develop a farm plan which will result in the highest total gross margin (TGM). The GM of an enterprise or activity is its gross income less its variable costs. According to Castle et al. (1972) activity specifies a particular method of producing a crop or operating a livestock enterprise. For instance, in the present drawdown problem irrigated and non-irrigated tomatoes are considered as different activities but the same enterprise; thus an enterprise denotes the production of a particular commodity or a group of related commodities for sale. Also gross income represents the value of the output of the farm or of an enterprise or activity within the farm while variable costs represent those costs which are directly attributable to an enterprise or activity and which vary in direct proportion to the size of the enterprise or activity. Therefore TGM is the sum of the GMs of all the enterprises or activities in the farm plan.

Holmes and Buffier (1975), identify the following procedures in GM analysis:

(a) Select the activity with the highest GM per unit of one resource (e.g. GM/ha), and expand it to the maximum level permitted by the planning constraints.

(b) Introduce other activities one by one to the plan, in order of decreasing GM/ha, until further increases in TGM cannot be achieved without violating the planning constraints.

As a technique, GM analysis is quite easy and cheap and could be completed in a short period for some farms. Thus the advantages of the method lie in its simplicity and directness. It requires only the ability to draw up activity or GM budgets and to identify planning constraints.

However, since the method employs only one choice criterion, the factor selected may not be the most limiting. Another shortcoming of GM analysis is that intermediate activities cannot be included separately in the analysis; intermediate activity denotes the production of a commodity which is not sold directly but becomes an input for other activities on the farm, e.g. the production of grazing crops and pastures. Also, in GM analysis, the implications of changing circumstances, such as relative prices, cannot usually be recognised in the method. Finally Dillon and Hardaker (1980) point out that it may be difficult for the analyst to deal with new or unusual situations, and this can lead to inappropriate or even infeasible recommendations.

In spite of the above-mentioned shortcomings, some practical farm work is usually done using GM planning. However, SP or LP and its extensions are, at times, preferred.

5.2.2 Simplified programming (SP)

The aim of SP is to select the combination of activities which maximises TGM, subject to the available farm resources or limitations. Resources are allocated among the activities according to the highest GM per unit of each resource used up, and not solely land as is often in GM analysis.

The procedures which are usually used in SP may be summarised as follows (Young and Rickards, 1978):

(a) Draw up an initial table showing the activities to be considered, the GM/unit of these activities, the resource constraints to be accounted for, and the demands placed on these resources per unit level of each activity. Activity maxima and/or minima will also have to be noted.

(b) Determine the maximum feasible level for each activity.

(c) The activities and constraints should be examined to see whether any can be eliminated.

(d) Rank the undominated activities according to the GM of each per unit requirement of each resource.

(e) Activity selection is then carried out by choosing one of the resources as a key constraint.

SP has an advantage over GM analysis for problems in which a number of resources, rather than one in particular, are limiting to production. Therefore farm plans which result from SP can be more informative and realistic than GM analysis. Thus with SP, plans can be said to be, at least, close to optimum, and no computer is required in the analysis.

However, SP has some limitations. Firstly, it is more time consuming than GM analysis. Secondly, like GM analysis, the selection criteria for plan development cannot handle intermediate activities per se. Lastly, its application to large problems, with a large number of variables, would be tedious; the chance of arithmetic errors would be high, and the possibility of the plan diverging considerably from the optimum might be high unless further substitution is done. Due to these computational difficulties, LP which can employ computer facilities is, at times preferred to SP, and this is one reason why LP has been used in the present analysis.

5.2.3 Linear programming (LP) and the selection of enterprise/activity mix

Applied to farm planning, LP can be used to determine the combination (mix) of activities which maximises or minimises an objective function. For instance, given the drawdown problem with an objective of maximising TGM, the LP model can be defined as:

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

subject to a set of linear constraints:

$$\sum_{j=1}^{n} a_{ij} X_j \ (\leq, =) \ b_i \text{ for } i = 1, 2, \ldots\ldots, m,$$

on the variables:

$$X_j \geq 0, \ j = 1, 2 \ldots\ldots, n,$$

where,

X_j is quantity of activity j (j = 1, 2, ..., n),
Z is total gross margin,
C_j is the gross margin per unit of j (j = 1, 2, ... n),
b_i is amount of each of m resources available (for i = 1, 2, ..., m),
a_{ij} is amount of resource i consumed per unit of activity j (j = 1, 2, ..., n).

The C_j, a_{ij} and b_i are the parameters of the LP problem that are assumed to be known constants. However, this assumption may not be valid when planning under risk. Programming methods which accommodate risky constraints are usually known under the generic name of stochastic programming. This was not considered in the present study which is a problem of variability in land supply rather than risk in land use.

5.2.4 Some advantages of linear programming (LP)

For farm management research purposes, some advantages of LP are noted. Firstly the optimising characteristic of LP is an important advantage over SP. Another advantage of LP is that it can employ the power of modern computers to process large amounts of data efficiently, and in this case the model can be made as large as seems appropriate. Again Dillon and Hardaker (1980, p. 66) point out that some LP computer programmes provide facilities for efficient processing of variants of the basic model. The implication is that the effects on the optimal plan of changing key assumptions about prices, yields or other rates of performance can be examined. The accuracy and speed inherent in the use of computers for LP problems also need mentioning. LP can provide the following additional useful economic information which are not typical of either SP or GM analysis (Makeham and Malcolm, 1981):

(a) The extra income which would result if an additional unit of a limiting resource were available, i.e. the marginal value or marginal return from one extra unit of a limiting resource.

(b) The decrease in TGM which would occur if one unit of non-basic activity were forced into the plan, i.e. the opportunity cost (profit foregone) from choosing an activity which was not originally selected in the plan by LP.

(c) The sensitivity of the optimum plan to changes in the prices of basic activities or the availability of limiting resources.

Thus with LP, both allocation and valuation problems are solved at the same time.

It is for these numerous advantages of LP, as a planning technique, that LP has been used in the study instead of other techniques like SP or GM analysis. However, LP is not without some limitations; this is the subject of discussion in the next section.

5.2.5 Some disadvantages of linear programming (LP)

The availability of suitable computing facility can be limiting with LP. Again the validity of the answers obtained by LP depends on the availability of data employed and on the skill with which the real circumstances of the farm have been represented in the planning model. If the input data are incorrect or inappropriate, the answers obtained will also be wrong. Therefore users of LP need to have some operational experience with the technique making it difficult to convince farmers about its use. The amount of time and cost involved can also be large; for instance, the cost of consultation. The comments also apply to GM and SP.

Finally some of the assumptions of LP like linearity, divisibility, additivity and single-valued expectations have been the most criticised. In recent years, however, various extensions of LP have been developed with a view to overcoming some of these limitations. In the subsequent section, some of the extensions of LP are discussed.

5.2.6 Extensions of linear programming (LP)

Hardaker (1978) suggests that where non-linearities are held to exist, it may be possible to represent these adequately as a number of linked linear segments. Special integer programming methods have been developed to handle the difficulties associated with the assumption of divisibility of activities and resources in LP. It may be argued that profit maximisation alone is not an adequate criterion for explaining farmers' decisions especially when some amount of risk is involved. Thus a major limitation of the LP method is that it is based on the assumption that all planning coefficients are single-valued, which implies that, at least in ordinary use, no account is taken of risk. However, following the development of LP for whole-farm planning, attention has been directed to finding realistic ways of incorporating risk into programming models. It is generally accepted that most small farmers are risk averse. Therefore when yields, prices or other planning coefficients are uncertain, risk programming methods become appropriate for farm planning. Among the variety of risk programming methods employed in agriculture is quadratic risk programming which accounts for risk in activity gross margins. Methodologies for handling risk at the individual farm level have been developed. For instance, if information about the probability distribution of stochastic components is available, the E,V decision criterion (Freund 1956; Heady and Candler 1958; Markowitz 1959) or the related E, σ (Baumol 1963) can be used. Camm (1962) uses quadratic risk programming to deal with risk in the functional coefficients. Hazell (1971) advocates for the use of MOTAD programming in small-farm planning. In India MOTAD had really been applied to small farms (Schluter and Mount, 1976). Cocks (1968) also develops discrete stochastic programming to handle stochastic elements in functional, right-hand side and/or input-output coefficients, but he notes that discrete stochastic programming, while flexible in principle, often requires very large matrices for real-world problems. Trebeck and Hardaker (1972) investigate the spatial diversification of beef production using a model comprising both simulation and LP components. They conclude that such composite models are valuable for the analysis of sequential stochastic decision processes not presently amenable to solution by stochastic programming alone. The validity of the LP assumptions has also been discussed elsewhere (Barnard and Nix, 1979, pp. 364-8), together with the measures that may be needed on occasion to overcome their shortcomings. Therefore LP can still be regarded as a practical planning tool. After all most of these assumptions are common to the other techniques like SP and GM analyses.

At this point, it should be noted that the drawdown problem under investigation is that of variability in the lake water level rather than risk. The proposition is that the drawdown farmer will have some knowledge about the area (hectares) of drawdown to be exposed which will depend upon the amount of rainfall/ flooding before making decisions. The assumption here is that, the area of drawdown exposed is inversely proportional to the lake water surface elevation at the beginning of the cropping year. Changes in reservoir water elevation as a result of different rainfall patterns in the period 1973-83 have to be compared in order to establish this relationship. Then, at the beginning of the cropping year in November, the farmer can rely on the lake water level to predict the maximum drawdown area to be available for cropping. This is where Parametric Linear Programming (PLP), which will be discussed in the subsequent section, comes into the analysis.

5.2.7 Parametric linear programming (PLP)

There is the opportunity to employ parametric methods, which are well developed for LP. The present study also faces the challenging task of working out how to deal with the seasonality in land supply for the different crops as a result of variation in lake water level. Therefore it becomes necessary to modify LP to what can be termed Parametric Linear Programming (PLP) in order to solve the problem in totality. According to Hardaker (1971), PLP is a form of post optimality analysis. Its matrix is the same as for LP, the only difference is that one or more items in the right-hand side or objective are allowed to vary. In the present case the resource whose supply level is altered continuously over a complete range is drawdown land.

The necessary computer routines for PLP are readily available as most commercial LP packages incorporate parametric routines whereby selected coefficients in the initial right-hand side or objective may be varied continously over some chosen range, and all relevant solutions in that range are printed out. An example of such packages is BGPP which is used in the present study. BGPP is a computer package for solving LP problems. According to Hardaker and Pearse (1980) the method of solution by the BGPP programme is the ordinary simplex algorithm incorporating both primal and dual routines. It offers a straight LP simplex solution together with either parametric right-hand side or objective function, range values and up to eight character row and column names.

5.2.8 Applications of linear programming (LP), and why it has been chosen for this study

The typical decision problem confronted by management groups in various setting is the optimum allocation of scarce resources. In that regard, LP has been successfully applied to a wide spectrum of problems across many different fields. According to Lee et al. (1981) agriculture, business and industry, and military have been the most extensive uses of the method. Desai (1963) concluded in his study, that farmers in West India did not allocate their resources efficiently. Using a LP model he showed that incomes could be greatly increased if farmers specialised more in high-income crops. LP has also been used for planning irrigation and other settlement schemes (Hardaker, 1978).

Upton (1973) observes that new mathematical techniques involving the use of computers have been used in studying farm management problems in recent years; however, he also notes that apart from LP, such techniques are not in widespread use in Africa. This implies that there is considerable scope for use of LP in solving generalised problems for advisory purposes in most developing countries, including Ghana. A linear programme prepared for a typical model farm can provide useful guidelines for offering advice on a number of similar farms. There is reasonable homogeneity in soil type, topography and climate in the Ampaem drawdown area as well as other drawdown areas along the Volta Lake. Therefore LP has been used to obtain solutions to modal or representative farm situations in order to guide planning on individual farms in the Ampaem area.

It may be argued that the methodologies for handling risk are generally more descriptive of individual farm behaviour than LP models, such as the one used in this study, that maximise expected income. Risk has been ignored in the present study because it is assumed that the problem under investigation is that of variability in drawdown land area rather than risk. The validity of this assumption will be demonstrated in the next chapter. Hardaker (1978) also points out that the computer routines for quadratic risk programming are generally limiting, giving rise to the use of linear approximations.

Another point which is worth mentioning is the assumption of perfectly elastic demand functions for the crops in the study. The possible existence of international markets, mostly in neighbouring countries, is used by the author to justify this price-taker asssumption. However, Duloy and Norton (1975, p. 593) points out that for a large class of agricultural commodities, the spread between CIF and FOB prices may be 20 per cent or more, and therefore domestic product demand functions become relevant in price determination. He further identifies the advantages of incorporating product demand functions into a planning model designed for the purpose of analysing policy alternatives, rather than assuming exogenously determined product prices as: (a) allowing the model to correspond to a market equilibrium, (b) allowing the model greater flexibility, and (c) permitting an appraisal of the distribution between consumers and producers of benefits accruing from changes in output. The author shares these views with him; however lack of time and data, during the field trip, did not allow the author to consider this aspect of the problem.

Thus, generally, sensitivity analyses have been employed in the study to help overcome these shortcomings.

5.3 Conclusion

It has been shown that farm planning technologies are all dependent on the data base - the conclusions presented stand or fall on its adequacy. GM and SP analysis may be less susceptible to wrong conclusions because of the close association of the analyst with the data manipulation, an association which is lost in a computer analysis such as LP. Nevertheless the richness of the LP method has required its selection. The necessary problem formulation is described in the next chapter.

Chapter 6

STRUCTURE OF THE LINEAR PROGRAMMING (LP) MODEL

The LP model which was used in the analysis is described in the following sections. The general structure and the salient features are discussed. The basic model was designed to reflect, as closely as possible, the farmers actual situation in the 1982-83 cropping year.

6.1 Outline of the Matrix

A linear programme matrix was constructed to produce income maximising plan(s) for the recommended crops given resource constraints. The model represents one annual production cycle and may therefore be regarded as static. However, some activities and constraints were differentiated into smaller periods adding a time dimension to the model.

The initial matrix of the LP included all the available activities with their variable costs and/or prices per unit, and all the constraints on these activities. For each constraint, the level of the constraint was shown, as was the per unit requirements of (or contributions to) that constraint for each activity. Table 6.1 shows, in outline, the initial matrix[1] of the proposed crop combination which is used to represent the production, selling and consumption alternatives open to a drawdown farm household unit in the Ampaem area. The tableau comprises 27 rows including one objective function row and 26 constraints. Also in the tableau are 30 columns of activities and one right-hand side column. This initial tableau was modified later, to allow for parametric variation in the proportions of land supply. Input-output coefficients and resource levels were calculated from data obtained in farmer interviews.

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1 The initial matrix of the existing crop combination will be discussed later in this chapter.

Table 6.1

<u>Outline of the Initial Matrix for the Proposed Crop Combination</u>

	Crop Production (10)	Labour (10)	Consumption (5)	Selling (5)	RHS
OBJECTIVE					
Land (6)					
Labour (10)					
Consumption (5)					
Product (5)					

6.2 The Activities in the Matrix

Table 6.1 above shows how the activities in the matrix are classified. Five different crop types are included in the model; they are maize, tomatoes, okro, groundnuts and cowpeas. Within each crop type there are divisions according to the presence or absence of irrigation. The data in Appendix I tell that the five crops have similar planting times and growth periods in the year, especially when irrigation is effected in the drawdown area. Therefore there is not much differentiation of these crop production activities which are contained in the first 10 columns.

The second group of activities listed in Table 6.1 relates to the hiring of extra labour (i.e. 10 activities). Unemployment level in the Ampaem area is high, and it is assumed that a farmer can come by labour if the need arises.

The next 5 activities in the tableau represent food consumption activities. The contribution of the five crops to the specified food needs of the family is represented, and each activity is constrained in its level to provide an appropriate diet.

Selling opportunities are represented by the final group of 5 activities in Table 6.1. These involve the five crops which are grown on the drawdown farm.

6.3 The Constraints in the Matrix

The classification of the constraints included in the matrix is also provided by Table 6.1. The objective function is that of maximising net revenue after variable costs have been met. This is because often it is TGM that is maximised in farm planning. The gross margin budgets for the five crops are contained in Appendix II.

The land area is set at a level of 2.5 ha for the basic model, and this corresponds to the average size of a family farm in a normal[2] rainfall season when the length of drawdown exposed

[2] Studies by the VLR & DP have shown that in the normal/average season, when about 100m of drawdown length is exposed, the maximum lake level is 83.46m (a.s.l.) as in 1974-75 (see Table 6.5). However, for the past decade the maximum lake level has been decreasing consistently each season, implying that the drawdown area has been expanding.

is 100m; the width of drawdown is constant at 250m for each farm. It is assumed that each crop activity can use the land resources for the same period and there are no further constraints in relation to land use. Thus initially the drawdown land was fixed at 2.5 ha to obtain an optimal farm plan. One aspect of the problem was to establish a relationship between the maximum water level and area of drawdown land exposed in order to define a range of values for the drawdown land for the parametric analysis. This will be examined in section 6.5. Five constraints relate to the specification of crop rotation as the drawdown farmer sees it. Thus the matrix shows the maximum amount of each of the 5 crops he is prepared to grow on the 2.5 ha land, on relative basis. The breakdown is contained in Table 6.2 below. For instance, most farmers would like to devote about 50 per cent of the total area (i.e. 2.5 ha) to maize (preferably in the wet season).

There is no earlier study to show that there is surplus labour in any month. Therefore labour constraints are included for each of the 10 months, November to August of drawdown farming. The labour available to a farm holding is put at two full-time adults. This represents a family size of 2 adults and 5 children where only the man works full-time. Assuming 20 working days, 2 men would supply 320 m-hr (40 man-days) of labour a month. However the lake begins to fill up in August, and family labour supply is assumed to be 160m-hr (i.e. 20 man-days) for that month. The arrangement makes allowance for social and other activities. Farmers who maintain other upland farms disclosed that they could only work extra hours (i.e. overtime) on those farms if the need arises. This is because of the importance they attach to drawdown farming; hence the amount of labour allocated to the drawdown enterprise is about constant.

The next 5 constraints account for the food consumption needs, i.e. the quantities of the five crops produced and consumed. The family food needs are specified annually in terms of recommended levels of energy and protein intake. The caloric value of one kilogram of each crop is shown in Table 6.3 as well as their

Table 6.2

The Rotational Constraint

Crop	Maximum area (ha)	Percentage of total area (%)
Maize	1.25	50
Tomatoes	1.75	70
Okro	1.00	40
Groundnuts	1.38	55
Cowpeas	1.13	45

Table 6.3

Caloric Value and the Contribution of the Crops to Minimum Food Needs

Crop	Caloric value/kg[1] (Energy + protein)	Contribution to Food Needs (%)	Contribution to Food Needs (X10^3 Kcal)
Maize	3630	70	769.2
Tomatoes	190	2	22.0
Okro	200	2	22.0
Groundnuts	5790	20	219.8
Cowpeas	680	6	65.9
Total		100	1098.9

[1] Source: Ilaco (1981).

contribution to the minimum food needs. In terms of energy, a family of 2 adults and 5 children are equivalent to 4.5 adults, and this is based on the labour conversion factors of: 1 man-day = 1.25 woman days = 2 child days[3]. The assumption here is that the amount of labour put in farm work is directly related to the energy expended. According to Malasis (1975), the total calories needed/adult/day is 2230 Kcal. Therefore calories needed/family/day in the Ampaem area is 10 034 Kcal (i.e. 2230 x 4.5). This brings the total calories needed/family/year to 3663 x 10^3 out of which 30 per cent (i.e. 1098.9 x 10^3) is supplied by the five crops in the proportions shown in Table 6.3. About 70 per cent of the family food needs consist of food items like plantain, cassava, cocoyam, yam and fish, and all these are purchased in the open markets.

The remaining 5 constraints account for the quantities of the 5 main agricultural products that are produced.

6.4 Matrix for the Existing Crop Combination

One aim of the study is to compare the TGMs of the two optimal plans involving the existing and proposed crop combinations. Therefore an initial matrix, which is similar to that in Table 6.1, was constructed for the existing crop combination as contained in Table 6.4 below. In this model only the two popular crops, maize and tomatoes, are considered; whereas all the 5 recommended crops (i.e. maize, tomatoes, okro, groundnuts and cowpeas) were part of the previous model.

Accordingly the number of rows and columns were reduced to 17 and 18 respectively (see Table 6.4). It should be noted that, with regard to minimum food needs, the proportional contribution from maize and tomatoes was maintained in the two matrices. Thus in the existing crop combination an extra 28 per cent energy contribution from okro, groundnuts and cowpeas was taken up by maize and tomatoes in the ratio of 70:2.

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[3] These conversion factors have been used in many farm management studies (e.g. Core, 1973) where an adult male is assumed as a man between the age of 16 and 59 years.

Table 6.4

Outline of the Initial Matrix for the Existing Crop Combination

	Crop Production (4)	Labour (10)	Consumption (2)	Selling (2)	RHS
OBJECTIVE					
Land (3)					
Labour (10)					
Consumption (2)					
Product (2)					

In order to effect a fair comparison, the matrix for the proposed crop combination was later on revised to study the effect, on the optimal plan, of energy needs from only maize and tomatoes.

6.5 Variability in Drawdown Land Supply

The drawdown area available for cultivation each year depends on a number of factors. Firstly, it depends on the maximum lake level for that year. This is significantly influenced by rainfall in the catchment area. Second is the rate of recession, which is influenced by evaporation and use of water at Akosombo for power production. At given locations, the drawdown size and utilisation depends on the flatness of the area, the amount of residual moisture, and the nature of soils. The VLR & DP has shown that for gradients between 1-2 per cent, the rate of flooding varies between 0.4-0.5 metres/day and the rate of recession is about 2-3 metres/day. The cultivable drawdown lands are known to be of these gradients. Also the residual soil moisture depends on soil texture which is about the same in the Ampaem area and most parts of the lakeshore. Since there is not much variation in the rate of recession, the rate of evaporation and the use of water for power production are accordingly assumed to be constant in the Ampaem area. Thus the main factor which affects the drawdown area available for cultivation is identified as the maximum lake level for the cropping year which, in turn, depends on the amount of flooding/rainfall in that year.

The initial assumption was that the amount of drawdown land exposed was inversely proportional to the maximum lake level at the beginning of the cropping year. Changes in the Volta Lake surface elevation as a result of different rainfall patterns, between 1974 and 1984 were compared in order to validate this assumption (see Table 6.5). By plotting the values in Table 6.5, Figure 6.1 was obtained which shows that there is a direct relationship between the Volta Lake surface elevation and rainfall for the planting period (i.e. between November and May). That is, between 1974 and 1984, as the annual rainfall in the Ampaem area decreases,

Table 6.5

Volta Lake Surface Elevation (metres above national level datum)

	1973/74	1974/75	1975/87	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
November	83.43	83.46	83.41	82.02	80.32	79.16	81.70	81.17	78.95	75.48	72.98
December	83.16	83.25	83.12	81.94	79.88	78.82	81.10	80.78	78.49	75.11	72.73
January	82.80	82.91	82.75	81.57	79.36	78.38	80.69	80.25	78.01	74.61	72.42
February	82.41	82.55	82.35	81.20	78.88	77.89	80.28	79.73	77.48	74.11	72.18
March	82.04	82.19	81.96	80.73	78.36	77.39	79.75	79.22	77.10	73.25	71.92
April	81.70	81.85	81.57	80.25	77.88	76.88	79.23	78.69	76.45	72.86	71.75
May	81.34	81.47	81.24	79.79	77.59	76.43	78.73	78.23	76.00	72.86	71.57
June	81.51	81.30	81.02	79.39	77.56	76.16	78.34	77.75	75.57	72.63	
July	81.79	81.26	80.95	79.05	77.58	76.53	77.94	77.50	75.28	72.62	
August	82.14	81.75	80.84	78.87	77.83	78.05	78.06	77.82	75.02	72.65	
September	82.74	82.26	80.85	79.39	78.26	79.66	79.47	78.55	75.25	72.89	
October	83.43	83.32	81.21	80.30	78.89	81.46	80.96	79.13	75.64	73.23	

Source: VRA Offices, Akosombo.

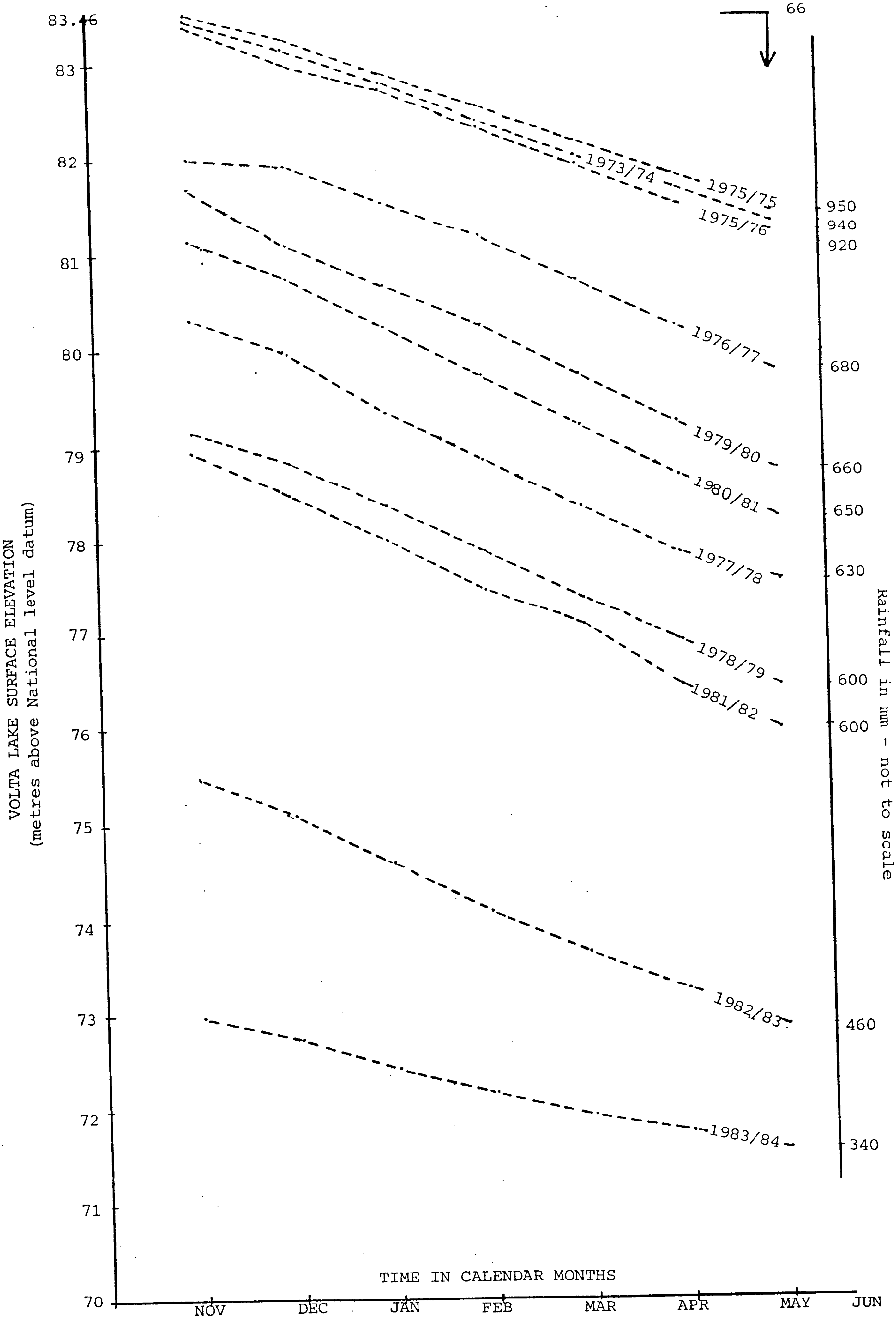


Figure 6.1 Graph of Lake Surface Elevation (and Rainfall) against Time.

Table 6.6

Total Drawdown Area Exposed for Farming

Cropping year[1] (Nov-Aug)	Total annual rainfall in the area (mm)	Fall of water (m)	Drawdown area exposed (ha)
1974-75	950	1.99	2.49[2]
1973-74	940	2.12	2.65
1975-76	920	2.22	2.78
1976-77	680	3.67	4.59
1979-80	660	4.73	5.91
1980-81	650	5.23	6.54
1977-78	630	5.87	7.34
1978-79	600	7.03	8.79
1981-82	600	7.46	9.33
1982-83	460	10.60	13.25
1983-84	340	11.89	14.86

1 In the order of decreasing rainfall.

2 This is considered as the normal drawdown area for farming per family.

the lake level also decreases. The downward sloping lines in Figure 6.1 also implies that the rate of recession of lake water is about constant. This supports the findings of the VLR & DP, and in this study the slope of the drawdown land is taken as 2 per cent.

For very low slope percentages (1-5%), the slope of the drawdown land can be defined as,

$$\text{Slope (\%)} = \frac{\text{Fall of Water (m)}}{\text{Length of ground (drawdown) (m)}} \times \frac{100}{1} \qquad (6.1)$$

therefore,

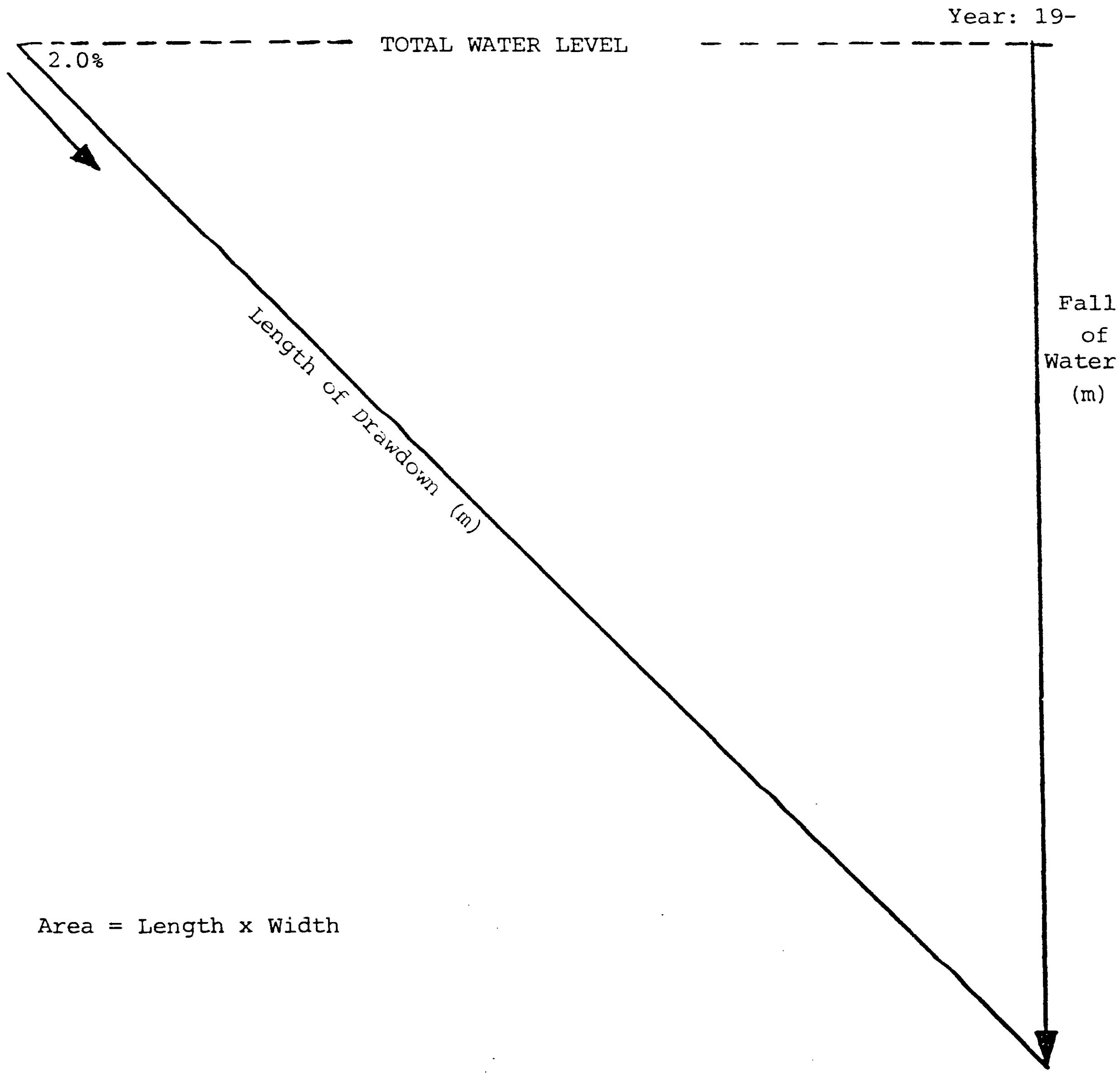
$$\text{Length of drawdown} = \frac{\text{Fall of water}}{\text{slope}} \times \frac{100}{1} \qquad (6.2)$$

and,

$$\text{Area of drawdown (ha)} = \text{Length} \times \text{Width} \qquad (6.3)$$

This mathematical relationship is illustrated by Figure 6.2 below. Equation (6.3) was used to compute the area of drawdown exposed as the lake level falls. It should be noted that the width of each drawdown farm measures 250 m. The result for the cropping year(s) together with the corresponding rainfall in the area, are summarised in Table 6.6. Then values for the fall of water in Table 6.6 were plotted against the corresponding values for the drawdown area. The result was a perfect direct relationship as shown in Figure 6.3. Thus if the change (i.e. fall or rise) in lake water level can be computed from the maximum (total) water level at the beginning of the cropping year, then the drawdown area to be exposed for farming can also be predicted. Having established this important relationship, a range of values, i.e. between 0.70 ha and 11.57 ha was defined for the parametric analysis. This range takes into account the maximum capacities of the small-scale irrigation machines in the Ampaem area. However, the farmer is not at a disadvantage if the area of land exceeds the maximum capacity of the irrigation machine.

The BGPP programme also solves LP problems with parametric right hand side which allowed for parametric variation in the



Area = Length x Width

Figure 6.2[1] Derivation of Area of Drawdown.

1 Figure is not drawn to scale.

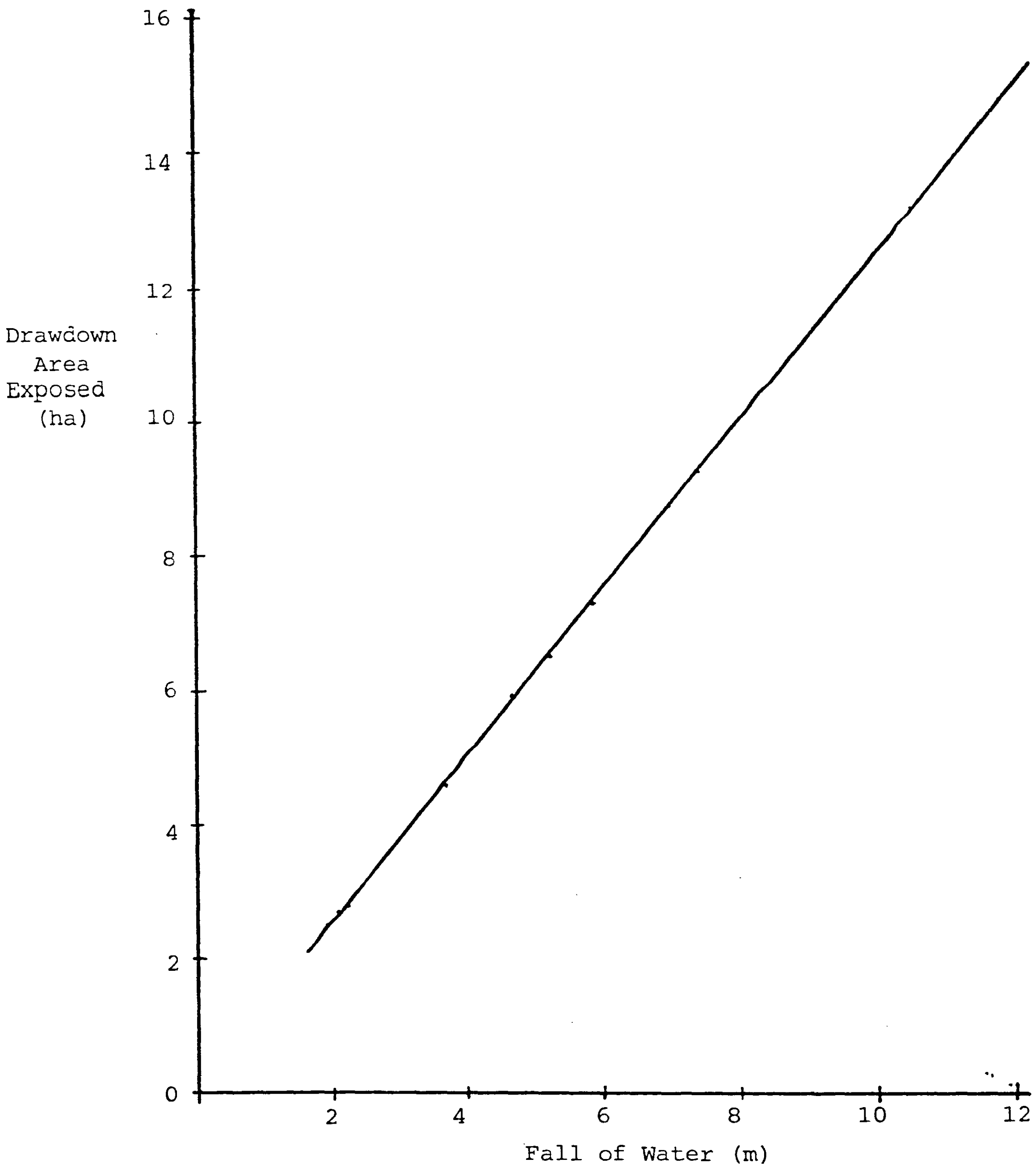


Figure 6.3 Graph of Drawdown Area Exposed Against Change in Lake Water Level.

proportions of drawdown land supply. Therefore the constraints of the LP model had to be modified as,

$$\sum_{j=1}^{n} A_{ij} X_j \ (\leq, =)\ b_i + \lambda e_i \ ,$$

where e_i is a column vector.

The parameter λ can vary from 0 towards $+\infty$ and each change-of-basis solution for non-zero increments of λ are printed.

6.6 Sensitivity Analysis

A sensitivity analysis of varying the price of groundnuts and then tomatoes (i.e. selling activities in the selected plan) parametrically was studied for advisory purposes. In either case, an additional objective function row was introduced, and the original objective function was redefined as,

$$Z = \sum_{j=1}^{n} (C_j + \lambda d_j)\ X_j \quad ,$$

where d_j is a row vector.

Also the parameter λ can vary from 0 towards $+\infty$ and each change-of-basis solutions for non-zero increments in λ are printed.
The matrix for the selected plan was slightly modified to accommodate a price range of up to ¢15.00/kg of groundnuts and up to ¢4.00/kg of tomatoes for the sensitivity analysis.

6.7 Data Collection and Sources

In this farm management study, an effort was made to obtain information about the real drawdown farm situation in the Ampaem area. The author made a trip from Australia to Ghana between 6th April and 7th June, 1984 for that purpose. In all seven villages in the area were chosen for the study. They are:

(a) Dedeso;

(b) Old Ampaem;

(c) Kwahu Amanfrom Resettled Community:- Dokomang, Mankron, Apaaso, Battors; and

(d) Amarte.

It is noted that four of the villages have come together to form what is called Kwahu Amanfrom Resettled Community. The study was restricted to the seven villages as a result of short time period, limited resources, and their importance in the Ampaem area.

Data requirement falls under the following broad heads:

(a) The amount and quality of fixed resources and other constraints.

(b) The outputs of the feasible enterprises together with their requirements of fixed and variable resources.

(c) Prices of inputs and outputs.

Also husbandry data were collected on the individual crops together with information on the frequency of rainfall and lake water levels. Detailed information on the five crops under consideration is given in Appendix II.

Two methods of data collection were employed namely, Farm survey and Field study which are discussed in the following sub-sections.

6.7.1 Farm survey

Dillon and Hardaker (1980) identify three main methods by which farm survey data can be gathered as:

(a) direct observation;
(b) interviewing respondents;
(c) records kept by respondents.

The second method, i.e. interviewing respondents, is the one employed in the study. Interviews were conducted by the use of questionnaires, and the head of one farm family was interviewed in each of the seven villages. The farm family interviewed was selected at random from each village. Data so collected were put together to define a representative farm model for the Ampaem drawdown area. It should be mentioned that the author derived much co-operation from the interviewees.

6.7.2 Field study

Kearl (1976) refers to "field study" also as "area familiarisation" or "reconnaissance study", and it is more of an informal study of a particular area or problem. Given the shortness of time some of the materials for the study consisted of statistical data and descriptive information which were obtained from the following sources:

(a) Volta River Authority (VRA), Akosombo and Accra.

(b) Volta Lake Research and Development Project (VLR & DP), Akosombo.

(c) Irrigation Development Authority, Accra.

(d) Ministries of Agriculture.

(e) Food Research Institute, Accra.

(f) Ministry of Finance, Accra.

(g) Ministry of Economic Planning, Accra.

(h) Central Bureau of Statistics, Accra.

(i) Ministry of Works and Housing, Accra.

Others sources of data are:

(j) Oral discussions with other farmers, farm workers, fishermen, social leaders and government officials.

(k) Various publications from the University of Ghana, Legon.

6.8 Conclusion

The sources of the data, its expression in a LP framework and the extensions necessary to take care of some variability have been discussed in the sections above. The results are presented and discussed in the next chapter.

Chapter 7

RESULTS AND DISCUSSIONS

With the LP method certain important economic measures associated with the optimal plan are determined. Hardaker (1971) points out that an inspection of the following features of the LP output will generally provide valuable pointers to the best long-term economic development of the farm business:

(a) the stability of the proposed plan, which is measured in terms of the change in the gross margin of each enterprise needed to bring about a change in the levels of the activities in the optimal solution;

(b) an assessment of the productivity of the farm resources, and an evaluation of the importance of the various planning constraints.

In the following sections, the results obtained from the analysis of the LP model of the drawdown farm production are discussed.

7.1 Results for the Basic Model

As noted earlier, the computer output represents a solution to the drawdown problem, and the following information is provided in the results:

(a) total farm gross margin,
(b) the amount and range of the basic activities,
(c) the marginal value products (M.V.P.) and range of the resources fully used, and
(d) the marginal opportunity costs (M.O.C.) of the non-basic activities.

The items or parts of the items which are relevant to the study are discussed in the sections which follow.

7.1.1 The resultant cropping plans

To test the first hypothesis, there had been the need to compute the total gross margins (TGMs) for the following cropping patterns in the Ampaem drawdown area:

(a) the existing crop combination which considers only maize and tomatoes (Section 6.4),

(b) the proposed crop combination which considers all the five recommended crops, namely, maize, tomatoes, okro, groundnuts and cowpeas (Section 6.1), and

(c) the modified proposed crop combination which considers all the five crops but allows only maize and tomatoes to contribute to minimum food needs (Section 6.4).

All other things remain the same in the cropping patterns. The idea is to effect comparison of the resultant farm plans in order to provide a guide to the farmers in the choice of their crops. Thus the first hypothesis of the study is to show whether the proposed cropping plan will offer profit increase over the existing crop combination. Just looking at the TGMs, the results indicate that the proposed cropping plan is more profitable than the existing cropping plan as depicted by Table 7.1. The TGM for the existing cropping plan is ¢65100, while that for the proposed plan is ¢67300. The difference between the two TGMs is 3.4 per cent over the TGM of the existing plan. When the proposed plan was modified to allow only maize and tomatoes to contribute to the minimum food needs - i.e. for the sake of fair comparison - the associated TGM was ¢69120 showing an improvement of 6.2 per cent over the existing cropping plan.

The 6.2 per cent increase in TGM and the fact that cowpeas and okro are contributing to only food needs in the original proposed plan (see Table 7.1) have convinced the author to accept the modified proposed plan as the optimal plan for the Ampaem drawdown area. Hence in the subsequent discussions the selected optimal plan (i.e. the modified proposed plan) will be solely referred to.

7.1.2 The activities in the optimal plan

The information in this section is concerned with the levels and range of those activities which are included in the optimal plan or solution as shown in Table 7.2 from the results. Given

Table 7.1

The Resultant Cropping Plans

Basic activities	Amount		
	Existing plan	Proposed plan	Modified proposed plan
Irrigated maize (ha)	0.75	0.06	0.08
Irrigated tomatoes (ha)	1.75	1.17	1.17
Irrigated okro (ha)	..[1]	0.02	..
Irrigated groundnuts (ha)	..	1.20	1.25
Irrigated cowpeas (ha)	..	0.04	0.00
Jan. hired-labour (m-hr)	40.0	..	..
Feb. hired-labour (m-hr)	192.0	175.3	174.6
Apr. hired-labour (m-hr)	96.0	77.5	77.3
July hired-labour (m-hr)	312.0	261.2	260.0
Aug. hired-labour (m-hr)	12.0	21.2	294.3
Tomatoes consumed (kg)	160.5	115.8	160.5
Okro consumed (kg)	..	110.0	..
Groundnuts consumed (kg)	..	38.0	..
Cowpeas consumed (kg)	..	96.9	..
Selling maize (kg)	2330.7	..	..
Selling tomatoes (kg)	17164.6	11494.8	11381.8
Selling okro (kg)	..	..	0.0
Selling groundnuts (kg)	..	2938.2	3087.6
Selling cowpeas (kg)	..	..	..
Total Gross Margin (TGM)	65100	67300	69120

[1] .. means that activity has not been included in that particular plan.

Source: Compiled from computer output.

Table 7.2

The Amount and Range of the Basic Activities in the Optimal Plan

Basic activities	Amount	Range		
Irrigated maize (ha)	0.08	-66602	TO	6012
Irrigated tomatoes (ha)	1.17	-226	TO	14
Irrigated groundnuts (ha)	1.25	-14	TO	226
Irrigated cowpeas (ha)	0.00	-34822	TO	4595
Feb. hired-labour (m-hr)	174.6	-4.7	TO	0.3
Apr. hired-labour (m-hr)	77.3	-7.1	TO	0.4
Jul. hired-labour (m-hr)	260.0	-2.4	TO	0.1
Aug. hired-labour (m-hr)	21.3	-0.9	TO	7.5
Maize consumed (kg)	294.3	NO LIMIT	TO	10.7
Tomatoes consumed (kg)	160.5	NO LIMIT	TO	4.0
Selling tomatoes (kg)	11381.8	-0.02	TO	0.00
Selling okro (kg)	0.0	-7.00	TO	1.11
Selling groundnuts (kg)	3087.6	-0.01	TO	0.09

Source: Computer output.

Table 7.3

Marginal Opportunity Costs (M.O.C.) and Cost of Production of the Non-basic Crop Production Activities

Non-basic activities	M.O.C. (¢)	Cost of Production (¢)
Non-irrigated maize	19 029	1250
Non-irrigated tomatoes	18 712	1328
Non-irrigated okro	20 236	863
Non-irrigated groundnuts	16 286	1550
Non-irrigated cowpeas	14 339	1645

[1] Source: Computer output.

that the optimal plan is more profitable than the existing cropping plan, it is assumed that the drawdown farmer will go in for the former. One of the purposes of the discussion in this chapter is to try and convince the farmer that he has made the right choice.

It is observed in Table 7.2 that thirteen activities are included in the optimal plan. For the crop production activities (i.e. the principal activities), the irrigated crops are selected over their non-irrigated counterparts. This result is expected when the contribution of the two crop categories (i.e. irrigated and non-irrigated) to the TGM is taken into consideration. The marginal opportunity cost (M.O.C.), which is a reduction in the total cost of production that would be required before a non-irrigated crop would enter the optimal solution - assuming no changes in other coefficients - supports this (see Table 7.3). It is noted that the cost of production of each of the non-irrigated crops is below ¢3000 whereas the M.O.C.s are each above ¢10 000. Therefore the results in Table 7.3 imply that the cost of production of each non-irrigated crop would have to be less than zero for that activity to enter the plan. Therefore it is highly unlikely that non-irrigated crops would be grown in the drawdown area. In the Ampaem area, it is generally accepted that cropping under irrigation will normally pay more than that under rain-fed condition, given the drought nature of the area. Therefore, given the chance to choose between irrigated and non-irrigated crops, there is no doubt that the farmer would like to go in for the production of irrigated crop(s) if he has the right inputs including, of course, irrigation equipment.

The level of each selected activity is also contained in Table 7.2. For the crop production activities, the implication is that the farmer has to consider the crops in the order of their relative importance inherent in the areas (hectares) they are to occupy as follows: groundnuts, tomatoes, maize. It is observed that cowpeas and okro are at zero levels implying that they are just about to be considered in the plan. Therefore, in reality, the optimal plan may also be referred to as a 'three-crop plan'. Areas of up to 1.25 ha, 1.17 ha and 0.08 ha are to be considered respectively for groundnuts, tomatoes and maize. With that arrangement, up to 3088 kg of groundnuts and 11 382 kg of tomatoes can be produced for sale while maize is to be produced solely for consumption together with some quantity of tomatoes. Cash realised from sales will contribute to the TGM which will, in turn, be used by the farmer to satisfy other family commitments.

It is expected that most drawdown farmers would be satisfied to have, at least, the two popular crops in the plan with maize still as the main contributor to food needs and tomatoes as a cash crop. It may be recalled that food consumed in this way, through the five crops, will satisfy about 30 per cent of the total family food needs in the Ampaem area. The farmer has to buy other food items like plantain, cassava, cocoyam, yam and fish from the local markets. A major change in the plan which some drawdown farmers may want to question about is the inclusion of groundnuts as a major crop to be grown for sale. Most of the drawdown farmers grow only tomatoes and maize, and it seems to the author that these farmers have failed to specify an appropriate crop rotation to maintain soil fertility. This is where groundnuts becomes important as a legume crop, and can, with advantage, be incorporated in the rotation system. The roots of these legume crops usually spread in the soil, loosening it and because they are organic matter, encourage bacteria activities. Also the nodule bacteria on these plants can accumulate nitrogen which can be taken up by the other crops. Expanding the selling activities is also in line with the Ghana government policy of diversifying the export base if there should be surplus in crop production. The farmers have to be aware of the advantage of different harvesting times to ensure a more continuous supply of foodstuffs over a longer period of time. Again pests and disease attacks are minimised because of selectivity which guard against total crop failure. Finally groundnuts can be used in vegetable oil production, it is observed that vegetable oil is quite expensive and not easy to come by in Ghana.

With regard to hired labour, July and February are the most limiting periods (see Table 7.2 above). Farm operations in the four labour periods (included in the plan) are shown in Table 7.4 below for the Ampaem drawdown area. There is no doubt that harvesting is a major operation requiring much hired labour in February and July. Apart from that much weeding is done in July before the onset of the floods as a drawdown principle. Also an operation like land preparation will need some hired labour. Hence the results are quite expected as in the plan for the Ampaem area.

It is also observed in Table 7.5 that labour supply is not fully used in November, December, March, May and June. These labour periods are usually for fertilizer application, and disease and pest control. Therefore the result suggests that the unused labour is in excess supply and could, with advantage, be discarded or contracted.

The range values associated with the basic activities in Table 7.2 show the incremental changes to the gross margin coefficient of that activity for which the current solution remains optimal. Also the range values imply that other sub-optimal solutions are possible where, although activity levels are different, TGM will be almost the same as that of the optimal solution. Thus if the matrix were re-run with the relevant price and yield changes incorporated in turn, a choice of several solutions would be obtained. Generally it is observed in Table 7.2 that large changes in values are required to bring about a change in the plan, and the information thus becomes important to the drawdown farmer from an economic point of view.

7.1.3 Resources which are fully used

Table 7.6 relates to the fully used resources and operative planning constraints. It shows the marginal value products (M.V.P.) of those resources or constraints that are fully utilised in the solution - assuming all other coefficients are unchanged. For instance, all 2.5 ha of drawdown land are used up in the plan, and the value 24 900 is the M.V.P. of drawdown land. According to Hardaker (1971) this measure can equally be regarded as the shadow price or M.O.C. of the disposal activity associated with

Table 7.4

Farm Operations in Four Labour Periods in the Ampaem Area

Period	Farm Operations
February	Harvesting and produce handling
April	Land preparation
July	Harvesting and weeding
August	Harvesting

Source: VLR & DP, Akosombo; Farmer Interviews.

Table 7.5

The Amount of Labour Supply Unused

Labour supply unused	Amount (m-hr)
November labour supply	160.0
December labour supply	50.7
March labour supply	114.6
May labour supply	248.0
June labour supply	56.0

Source: Computer output.

Table 7.6

Resources Fully Used and their Marginal Value Products (M.V.P.)

Resources fully used	M.V.P.	Range		
Land (¢/ha)	24900	-0.16	TO	0.03
Jan. labour supply (¢hr)	7.1	-4.2	TO	18.7
Feb. labour supply (¢hr)	7.5	NO LIMIT	TO	174.6
Apr. labour supply (¢/hr)	7.5	NO LIMIT	TO	77.3
Jul. labour supply (¢/hr)	7.5	NO LIMIT	TO	259.9
Aug. labour supply (¢/hr)	7.5	NO LIMIT	TO	21.3
Maize consumption needs (kg/kcal)	3.0	-14.607	TO	1068
Tomato consumption needs (kg/kcal)	21.1	-2163	TO	31
Maize product (¢/kg)	10.7	-4024	TO	294
Tomato product (¢/kg)	4.0	-11381	TO	NO LIMIT
Okro product (¢/kg)	7.0	0.0	TO	NO LIMIT
Groundnuts product (¢/kg)	15.0	-3088	TO	NO LIMIT
Cowpeas product (¢/kg)	14.8	-2881	TO	0.004

Source: Computer output.

land or the particular resource (constraint). That is to say that an extra hectare of land will permit another ¢24 900 GM to be generated. The range gives the incremental changes to the RHS coefficient for which the M.V.P. holds good.

These M.V.P. indicate the relative worth of the five products in the plan. The results in Table 7.6 show that the value, in terms of prices, of maize and cowpeas have gone up a bit, while the prices of tomatoes, okro and groundnuts remain constant. However, the increased worth of maize is confined to its maximum contribution to food needs as depicted by the range. Groundnuts and tomatoes are to be produced at very high levels to satisfy both cash and food requirements. Thus an important aspect of the computed M.V.P. is that they indicate the relative importance of the various planning constraints. Such scarce resources could, if possible, be used in a more technically efficient manner, or perhaps be expanded in the longer term. In this case the higher the level of the M.V.P. of a scarce resource in relation to the cost of acquiring more of it, the greater the likelihood of such acquisition being worthwhile. This likelihood is further increased if the range in its M.V.P. indicates that a large amount could be added before its M.V.P. would start to fall. The reasoning here is that as more and more is added, the stage is eventually reached where it ceases to be scarce and its M.V.P. falls to zero. In the drawdown problem it is observed, with the help of Table 7.6, that land has a relatively high productivity of ¢24900 per ha. This suggests that it would be worth looking into the possibility of obtaining more land. The range values indicate that the M.V.P. of land would change if the supply of land increased by more than 0.03 ha or decreased by 0.6 ha. The range also indicates the extent to which farm size could vary without altering the existing activities in the optimal plan. The effect of variability in the availability of drawdown land on both the combination of crops, the area sown to each crop and the effect on farm income is discussed in section 7.2.1.

7.2 Results with Parametric Drawdown Land Supply

The second part of the study has employed overwriting techniques to obtain a number of solutions to describe the way the optimal plan is affected by changes in drawdown farm size as a result of flooding or variation in lake water level. This will provide a clue to the second hypothesis which is investigating whether the optimal plan will remain the same under different drawdown conditions. The results[1] of the parametric analysis show that, apart from the activities which are directly concerned with food consumption needs, the levels of the other basic activities in the plan have changed with changes in the drawdown land supply. It is observed from the computer output that labour-hiring variables have been gradually introduced into the plan as the drawdown area increases. It is true that the crop production and selling activities do not change with increasing land supply. Therefore in terms of strictly cropping patterns, it may be argued that no change has occurred. However, the levels of groundnuts and tomatoes as both production and selling activities have increased with increase in land supply. Since the different drawdown conditions are reflected in the variation of drawdown land supply, then the results of the parametric analysis indicate that the optimal plan will change under different drawdown conditions.

One aim of the parametric analysis is to provide guidelines for the drawdown farmer at the beginning of the cropping year when the lake water begins to recede. It may be recalled that a direct relationship has been established between the maximum lake level at the beginning of the cropping season and the total area of drawdown land exposed for farming in the Ampaem area. Thus intermediate plans can be found from plotting the resulting key plans. In the following sections the consequences of varying the size of the drawdown farm, along with appropriate adjustments in the cropping restriction will be demonstrated.

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1 The essential sections of the computer print-out of the results will be shown in the subsequent discussion.

7.2.1 Parametric analysis of activity levels

In the parametric analysis there is only one variable resource which is drawdown land. The computer output consists of optimal solutions for the following land areas: 0.70 ha, 1.26 ha, 1.53 ha, 1.92 ha, 2.33 ha, 2.36 ha, 2.53 ha, 2.96 ha, 3.86 ha, 5.13 ha, and 11.57 ha as depicted by Table 7.7. Thus a range of 0.70 ha and 11.0 ha can be defined for drawdown land supply for planning purposes. The average maximum capacity of the small-scale irrigation machines in the Ampaem area is 7.00 ha which falls within the defined range.

By plotting the values in Table 7.7, the relationship between activity levels and drawdown land area is illustrated by Figure 7.1. It is observed that the level of maize has remained the same throughout the planning horizon. This implies that maize has been included in the plan only for its contribution towards farm family food consumption requirements. Thus changes in drawdown land supply have directly altered the levels of tomatoes and groundnuts which are to be produced for sale. Accordingly the levels of the two selling activities have steadily increased with increase in land supply as shown in Table 7.8. Also Figure 7.1 shows that at the point of intersection of the two lines, when the drawdown land supply is 2.8 ha, the areas (ha) to be considered for the two crops are the same - i.e. 1.4 ha each. After that point groundnuts has taken the place of tomatoes as the more dominant/profitable crop in the plan.

The changes in land supply have also altered the levels of hired labour in the optimal plan as depicted by Table 7.9 below. As the land supply increases the demand for hired labour also increases. It is observed that hired labour is not utilized in any period when the land supply is 0.70 ha. Hired labour is first introduced in July when the land supply is 1.26 ha, and 69 m-hr are actually used when the land area increases to 1.53 ha. This is followed by hired labour in February when land supply is 1.92 ha. Eventually hired labour has been used in 9 out of the 10 periods when land

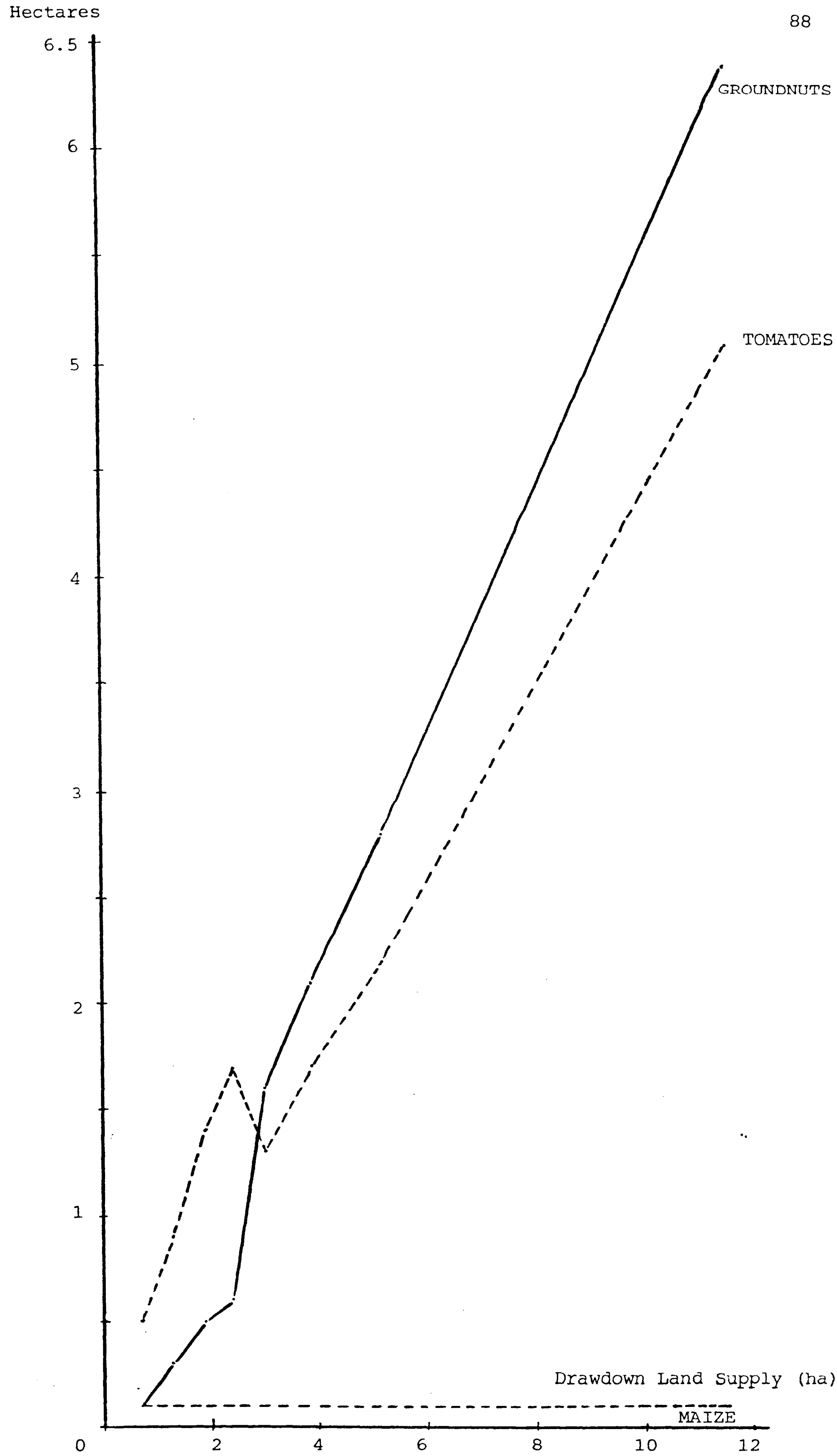

Figure 7.1 Parametric Programming Results for the Drawdown Farm - Activity Levels.

Table 7.7

Activity Levels for Different Drawdown Areas

Drawdown land area (ha)	Activity levels (ha)		
	Maize	Tomatoes	Groundnuts
0.70	0.08	0.49	0.13
1.26	0.08	0.88	0.29
1.53	0.08	1.07	0.38
1.92	0.08	1.35	0.49
2.33	0.08	1.63	0.61
2.36	0.08	1.65	0.62
2.53	0.08	1.06	1.39
2.96	0.08	1.25	1.63
3.86	0.08	1.65	2.12
5.13	0.08	2.22	2.82
11.57	0.08	5.12	6.37

Source: Compiled from computer output.

Table 7.8

Changes in the Selling Activities Associated with Changes in Land Supply

Drawdown land area (ha)	Selling activities (kg)	
	Tomatoes	Groundnuts
0.70	4 690	311
1.26	8 586	728
1.53	10 464	928
1.92	13 166	1 217
2.33	15 956	1 516
2.36	16 201	1 542
2.53	10 285	3 439
2.96	12 191	4 020
3.86	16 184	5 237
5.13	21 849	6 956
11.57	50 564	15 722

Source: Compiled from computer output.

Table 7.9

Changes in Hired Labour Associated with Changes in Land Supply

Land supply (ha)	Hired labour (m-hr)									
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
0.70	-	-	-	-	-	-	-	-	-	-
1.26	-	-	-	-	-	-	-	-	0	-
1.53	-	-	-	0	-	-	-	-	69	-
1.92	-	-	-	82	-	0	-	-	168	-
2.33	-	-	-	166	-	67	-	-	270	0
2.36	-	-	-	174	-	73	-	-	279	2
2.53	-	-	0	175	-	78	-	-	256	26
2.96	-	0	54	259	-	146	-	0	354	57
3.86	-	97	167	436	0	288	-	85	561	122
5.13	0	233	328	688	104	489	-	218	854	215
11.57	407	927	1143	1961	630	1510	0	985	2340	684

Source: Compiled from computer output.

supply is 11.57 ha. The only period which does not use any hired labour is May, and it is observed that only some minimum planting is effected in that month in the Ampaem drawdown area. Thus the results can be a useful guide to the farmer, given the different drawdown conditions (i.e. lake water levels), when planning his labour schedule(s).

7.2.2 Parametric analysis of total gross margin (TGM)

The computer print-out of the changes in TGM associated with corresponding changes in drawdown land supply is contained in Table 7.10. By plotting the values in Table 6.10, the relationship between the total value of the objective function and total land for the drawdown farm is illustrated (see Figure 7.2). For instance, when the land supply is 2.5 ha the TGM is about ¢69 000 which agrees with the value for the optimal plan; and when the land supply is 5.0 ha the TGM is about ¢128 000. On the maximum feasible area of 11.57 ha, the total value of the objective function is ¢273 100. Thus as the land supply increases the TGM also increases, although at a decreasing rate, the main effect being an expansion in groundnuts and tomatoes production.

The fall in the computed M.V.P. of drawdown land with increasing land area explains why the TGM has been increasing at a decreasing rate. This trend is probably due to the increased reliance on hired labour as the land area increases.

7.3 Sensitivity Analysis

The results of the sensitivity analysis to study the effect of a fall in the price(s) of the two selling activities (i.e. groundnuts and tomatoes) on the area (hectares) of the two crops to be grown by the farmer are presented in Tables 7.11 and 7.12 respectively for groundnuts and tomatoes. For the purpose of illustration, the values in Tables 7.11 and 7.12 are plotted respectively in Figures 7.3 and 7.4. It is assumed that the farmer is likely to expand the area to be considered for either tomatoes or groundnuts in the plan if the price of the crop increases in the future. Therefore this may not pose any problem to him. On the other hand, a fall

Table 7.10

Changes in GM Associated with Changes in Land Supply

Drawdown land supply (ha)	TGM (¢)
0.70	18 000
1.26	35 500
1.53	43 400
1.92	54 100
2.33	64 700
2.36	67 700
2.53	69 900
2.96	80 500
3.86	101 400
5.13	130 200
11.57	273 100

Source: Compiled from computer output.

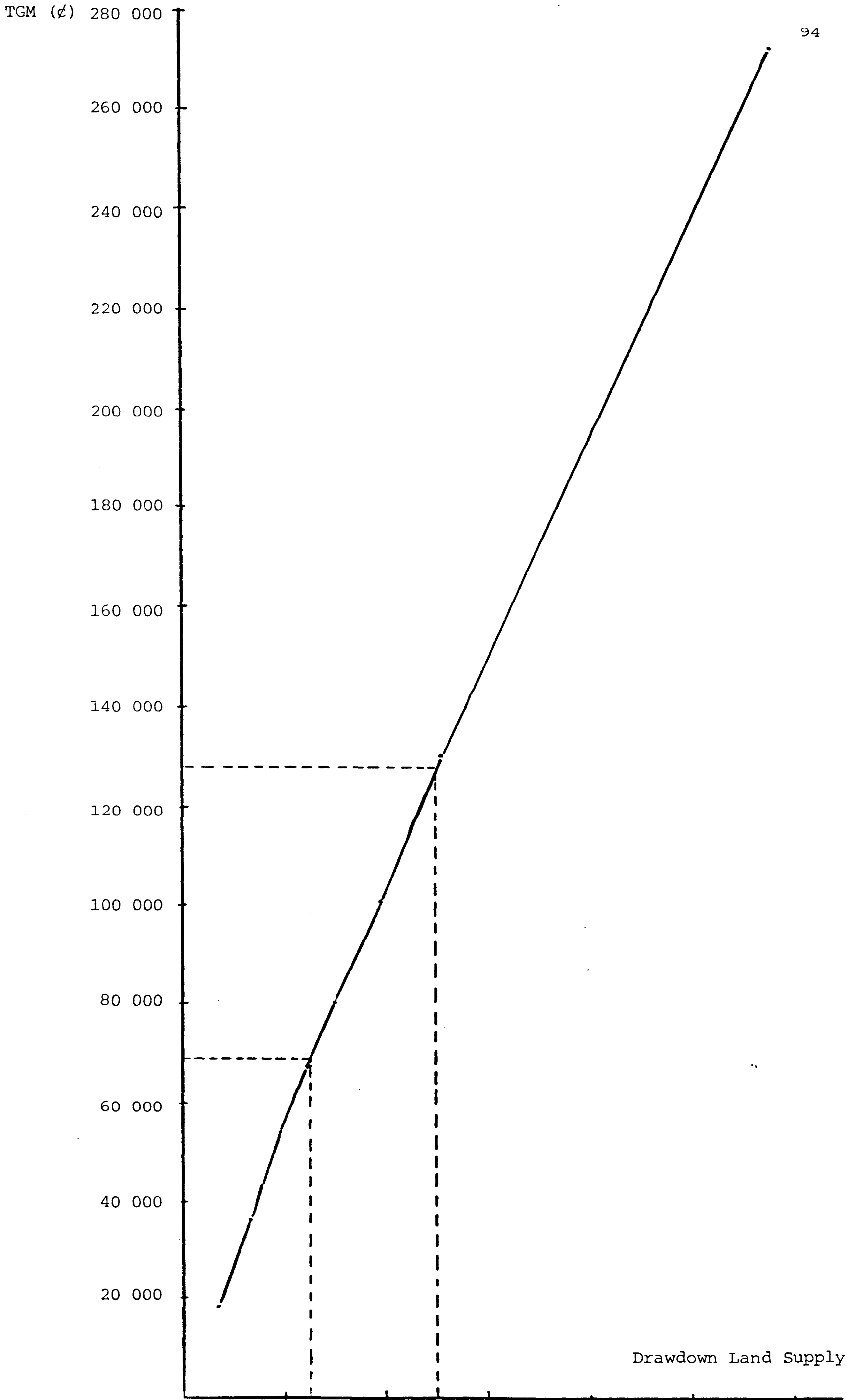

Figure 7.2 Parametric Results for the Drawdown Farm - TGM.

Table 7.11

Sensitivity Analysis for the Groundnut Crop

Price of groundnuts (¢/kg)	Area under groundnuts (ha)
0.00	0.00
13.14	0.67
14.99	1.25
15.09	1.38

Source: Compiled from computer output.

Table 7.12

Sensitivity Analysis for the Tomato Crop

Price of tomatoes (¢/kg)	Area under tomatoes (ha)
0.00	0.02
3.51	1.04
3.98	1.17
4.00	1.75

Source: Compiled from computer output.

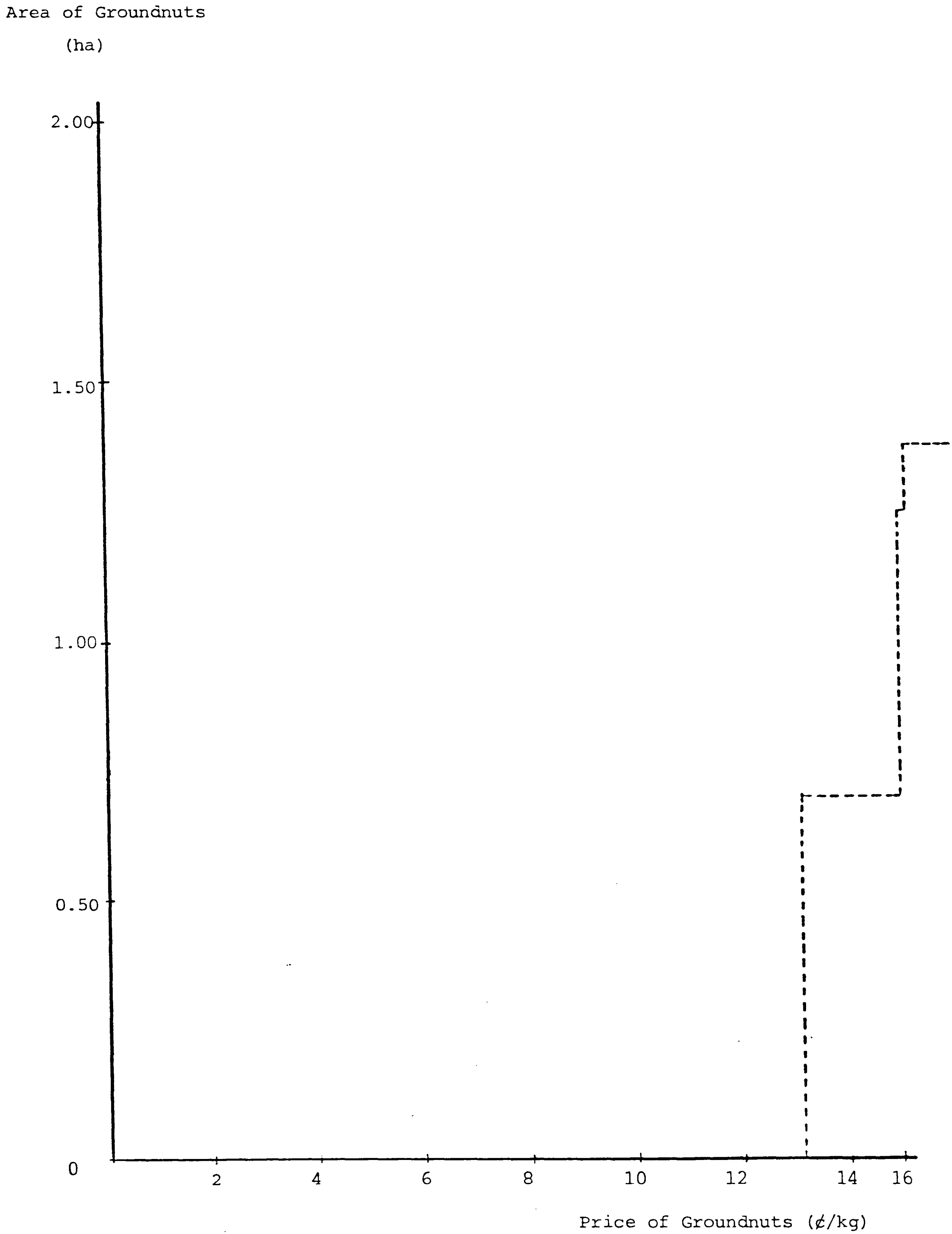

Figure 7.3 Results of Sensitivity Analysis for the Groundnut Crop.

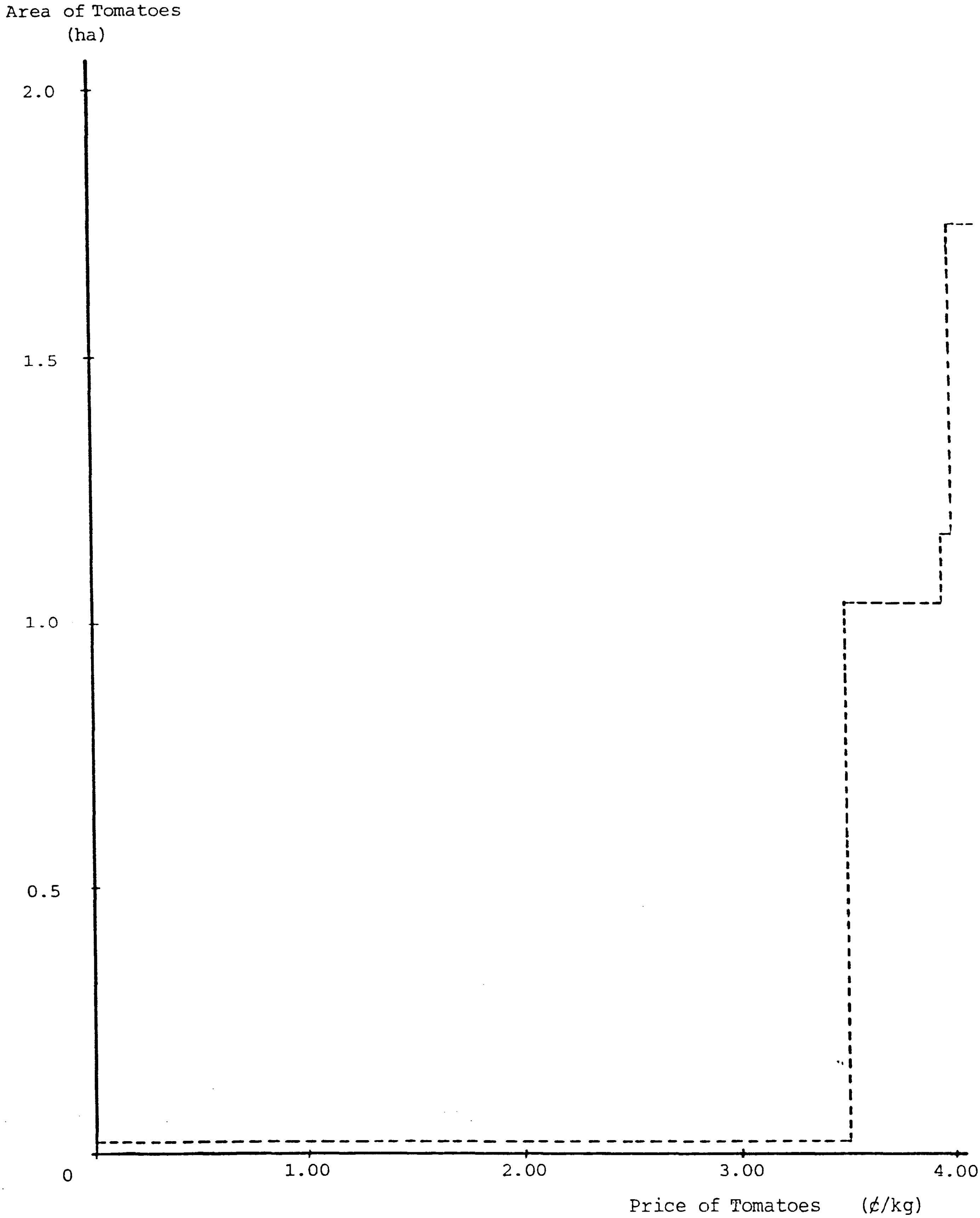

Figure 7.4 Results of Sensitivity Analysis for the Tomato Crop.

in the price of either crop can be a concern to the farmer. In this case there is the rational tendency for him to control the production of the particular crop. The results of the sensitivity analyses can guide the farmer in such a situation.

In the case of groundnuts, if the farmer can realise a price of ¢15.09/kg and above, then he can efficiently allocate 1.38 ha of the farm area (i.e. 2.5 ha) to groundnuts (see Figure 7.3). This is what the optimal plan can mean to the farmer because in the optimal plan the price of groundnuts is ¢15.00/kg which is the farm gate price in the Ampaem area. For a small price fall of ¢0.10 (i.e. from ¢15.09/kg to ¢14.99/kg) the farmer has to reduce the area under groundnuts by 0.13 ha (i.e. from 1.38 ha to 1.25 ha). A further price fall ranging between ¢14.99/kg and ¢13.14 of groundnuts means the farmer can efficiently allocate only 0.67 ha of land to groundnuts. Thereafter any price fall of groundnuts puts the area to be allocated to the crop at zero. A similar interpretation can be given to the tomato crop since the results of the two sensitivity analyses follow a similar pattern (see Figures 7.3 and 7.4).

Chapter 8

CONCLUSION AND POLICY IMPLICATIONS

8.1 Conclusion

Based on the results and discussions, some concluding remarks can be made from the study. It has been shown that the optimal cropping plan will offer profit increase over the existing crop combination. The implication is that the drawdown farmer has to consider three crops in order to satisfy both his cash and part of his food consumption needs. The two cash crops are groundnuts and tomatoes while maize becomes the main subsistence crop. The major difference between the proposed optimal plan and the existing crop combination is the inclusion of groundnuts in the former as a cash crop. The advantages of groundnuts as a legume crop, in crop rotation, may convince the farmer to consider the crop for growing.

The study has helped to design a guiding programme/schedule for cultivating the drawdown under different drawdown conditions as a result of flooding/rainfall. A direct relationship has been established between the maximum lake level, which depends upon the amount of flooding/rainfall in a particular season, and the total drawdown area to be exposed for farming. Initially, in the parametric analysis, tomatoes has proved to be a dominant crop as the area of drawdown increases. However, after a certain point, groundnuts has taken over from tomatoes and generally groundnuts has become the most profitable crop. Undeniably if the bulk of the 5 000 ha of drawdown in the Ampaem area is devoted to groundnuts and tomatoes, farmers could face some risk if the prices of the two crops fall in the future as supported by the sensitivity analysis. The idea of the sensitivity analysis is to guide farmers, especially those who can form reasonable price expectations, in the efficient allocation of land to the two crops.

It may still be argued that in the aggregate sense, it would seem irrational to devote the total drawdown along the Volta Lake to only groundnuts and tomatoes because of a possible price decline as a result of high production. In that light, there are more sophisticated models which can introduce price and demand effects in the LP model (Duloy and Norton, 1975). However, in deference to Occam's razor[1], a simpler method has been used in the analysis for two reasons; firstly due to lack of data on endogenous prices and yields as well as estimates of the interdependence among products in demand, and secondly as a way of avoiding possible complications. Thus for the present study, and especially in the Ampaem locality, a perfectly elastic demand schedule has been assumed for groundnuts and tomatoes because of export recognition of the crops. In terms of storage there is not much problem with groundnuts as the most profitable crop. The crop can also be processed into vegetable oil for local consumption and export. Tomatoes is the second important crop after groundnuts, and in the dry season when the bulk of tomatoes production in Ghana is limited to the drawdown area and other areas with perennial source of water, supply is likely to meet only local consumption. Again tomatoes can be exported in its puree form. The author is also of the opinion that as additional crops are introduced, through research, to the drawdown area in the future, the cropping plan may change in favour of the production and sale of many crops at relatively reasonable levels. Such diversification of the cropping pattern could be an effective strategy for averting risk if the yields and revenues of some of the alternative crops are negatively correlated. Some policy recommendations are also suggested in the next section of this chapter which may be useful in alleviating the problem of any possible overproduction. Thus some amount of caution may have to be exercised with the use of the results especially in the light of future demand of the two crops.

The results have also indicated that attention should be given to irrigated agriculture in the Ampaem area. This is because of the poor contribution of the non-irrigated crops to the total farm gross margin, and not a single non-irrigated crop has been included

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1 "Appeal may be made to a working rule known as Occam's razor whereby the simplest possible descriptions are made used until they are proved inadequate". (Richardson, 1956, p. 1247).

in the farm plan. The central policy implication of those arguing for allocative efficiency in traditional agriculture has been the need for new technology. The results with irrigation and non-irrigation in the analysis lead the author to a similar conclusion. It was observed during the study/survey that lack of small irrigation machines and credit, among other inputs, have retarded the progress of work on most drawdown farms in the Ampaem area. Probably this is one reason why only a small portion of the agricultural potential of the drawdown has been tapped. If irrigation is accorded the needed attention in the drawdown areas, sufficient food could be produced for local consumption, and any surplus could be exported to, at least, neighbouring countries like Togoland and Upper Volta. The smuggling of some of these food items to some neighbouring countries where they attract even higher prices is an indication of the existence of markets for the crops.

8.2 Policy Implications

The study has brought about some policy implications in connection with drawdown irrigated farming along the Volta lakeshore, and general agriculture in Ghana. Thus the following policy recommendations which, the author thinks, are in line with the government's basic objective of increasing food production are made:

(a) Farm inputs

The efficiency of the operations of the Ministry of Agriculture is to be improved in this regard. For instance, efforts could be made to ensure that inputs such as cutlasses, hoes, fertilizers, improved seeds and insecticides are made available at existing agricultural stations in the lakeshore area and other stations of the Ministry of Agriculture to enable them to operate effectively as farm supply centres. In addition import licence could be made available to the Ministry for the importation of adequate inputs, including irrigation pumps, for distribution to producers.

(b) Irrigation

The government could take concrete steps towards the development of drawdown irrigated agriculture, and attention could be paid to the use of pumps to lift water from the Volta Lake, rivers and other perennial sources for irrigated farming. The small-scale irrigation pumps look quite simple and the possibility of manufacturing them locally could be exploited. For instance, one or two factories could be established for that purpose and any surplus output could be exported to places like Nigeria where drawdown irrigation farming is also practised. Otherwise these machines will have to be imported. Attention could also be paid to the completion of land development of some of the on-going irrigation projects where the water resources are already harnessed for irrigation farming.

(c) Incentives

Farmers could be offered attractive prices as well as assured market opportunities for their goods. It is observed that market (middle) women are playing an important role in that regard in the Ampaem area. In addition an Agricultural Prices Committee could make recommendations for input prices to be fixed and announced well ahead of the planting season. Appropriate price incentives will help the flow of resources into productive sectors and agricultural production in general will be increased.

(d) Credit

The importance of credit to farmers should be recognised by the government. The existence of only one bank (i.e. the Agricultural Development Bank) in the Ampaem area is an inconvenience and a setback to the farmers because most of them have to travel long distances to reach the bank. This calls for the establishment of rural banks especially in areas along the Volta Lake. Interests on loans from such banks should be attractive to farmers, and the banks could also play a role in providing some farm inputs, like machinery, directly to farmers.

(e) Post-harvest facilities

The Ministry of Agriculture could look into the management aspects of the conservation of agricultural produce. Provisions could be made for storage facilities to store locally produced food for periods ranging from 3 to 9 months to ensure their sustained supply at all seasons. Factories which utilise the crops as raw materials could be activated or expanded if necessary. For instance, the two tomato factories in the country need resuscitation. In this way surplus tomatoes, in the puree form, could be canned as a substitute for imports, and also for export to other countries - most likely neighbouring countries. As a short-term measure, efforts could be made at improving on-farm storage through increase extension education on improved farm storage methods. These could be supplemented by a well planned transportation and haulage system which will be ready at call to cart produce to needy areas.

(f) Extension

Undeniably agricultural extension has not been given the much needed attention in Ghana. For instance, some drawdown farmers seem to ignore the advantages of clearing weeds in advance as weeds are usually cut from upland towards the lake which is against the drawdown principle. Lack of extension services poses a very important problem because there will be no use to devise a cropping pattern, if farmers are not made aware of its benefits to them. Through extension education farmers may appreciate the importance of groundnuts as a legume for nitrogen fixation. From the farm survey it seems to the author that the adoption rate of the drawdown concept is low for most farmers in the Ampaem area. This may be another reason why only a small portion of the drawdown agricultural potential has been utilised. Therefore the Ministry of Agriculture could intensify its efforts to educate farmers to adopt improved agricultural practices.

(g) Land Tenure

Presently the drawdown land is being demarcated, at no cost, to farmers. However, as the drawdown area becomes popular and lucrative there is the possibility of competition for land in the future. The VRA, in conjunction with the Ministry of Agriculture and the elders of the various resettlement communities, could work out some regulations which would help to prevent land disputes and misuse.

(h) Research and development

Research bodies like the VLR & DP could be encouraged and assisted to conduct further research/experiments into: (i) crop development and production at the drawdown area and the Volta lakeshore in general; (ii) livestock production at the drawdown; and (iii) problems like erosion and siltation which can arise as a result of extensive drawdown cultivation, with the possible remedies. Also in making aid and development negotiations abroad, the government should bear in mind that given the important link between scientific research and agricultural development, a developing country like Ghana should be actively supported in her efforts to establish her own national research system(s). In doing so, the country can put an end to a scientific dependence on the industralised world, as well as build a national team of trained scientific personnel. This is the essence of the so-called appropriate technology and, for instance, the design and manufacture of small irrigation pumps could fit well in this approach.

(i) Infrastructure

The study has revealed that the infrastructure of the Ampaem area and other places along the lake are not well developed. As an incentive to farmers to work hard, the government could take a positive step towards the welfare of the farming communities. Hence the goal should not only be increase agricultural output but also to: (i) increase rural employment; (ii) improve health and nutritional levels; and (iii) expand educational opportunities in the area.