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Linear Optimising Model for Foodcrops Enterprise selection in Ife Area of Oyo State

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Abstract

Within the environmental framework provided by the physical and socio-economic factors, a linear programming technique was used to examine foodcrops enterprise combination under different sizes of farm. The evidence showed that 2.83ha was optimal for a small sized farm, 8.50ha for medium and 22.13ha for large sized farms. Different combinations of maize, cassava and melon enterprises provided optimal incomes of ₦1,680, ₦4,793, and ₦10,331 respectively for the various farm sizes. The most serious resource constraints were labour for land clearing and preparation and, to a lesser extent, labour for weeding.

Introduction

With increased monetization of the economy, several of the traditional pursuits which formerly were regarded as a way of life and therefore were not operated within the cost-price context are now being run as business enterprises with a motive of realizing cash incomes to make a decent living. The cultivation of foodcrops which was essentially undertaken by peasant farmers primarily to meet household consumption needs, is now pursued by many farmers in most parts of Western Nigeria with the objective of making as much income as could possibly be realized in the non-farm sectors of the economy. The commercialisation of agricultural production has also been encouraged by the several cash incentives embodied in government's pricing, incomes, and subsidy policies.

However, the opportunity to make much money in any business depends to a large extent on the amount of input that has been invested in its planning. The peculiar process of agricultural production reveals that the physical environment exerts a decisive influence on the types of crops that can be grown in any area. This being so, planning for maximum income in foodcrops production must take cognisance of the physical environment.

The most important aspects of the physical environment which significantly influence agricultural production are soils, climate and vegetation. The soil types in Ife area according to Symth and Montgomery (1962) are made up of Iwo and Egbeda series. Iwo series is considered most suitable for tree crops, notably cocoa and citrus, but it is also considered suitable for annual crops. It is however not ideal for mechanical cultivation. Egbeda series is among the most fertile and is very suitable for arable cropping and mechanical cultivation.

Ife area falls within the forest vegetation zone of Nigeria, and has an annual rainfall of about 1270mm. The types of arable crops grown in the area include yam, cassava, maize, melon, cowpea ad vegetables.

The most effective approach to agricultural land use and planning lies in an intimate understanding of the natural eco-systems existing in different areas, and a careful simulation of these for resource utilization. These will ensure that productivity can be maximised, resources conserved and long-term usage made possible.

The objective of this study therefore was to use linear programming technique (Heady and Candler, 1958; Beneke and Winterboer, 1973) to determine:

(i) optimum combination of foodcrops enterprises in Ife econo-ecological environment,
(ii) optimum farm income and
(iii) the resources that pose critical bottlenecks to production expansion given different scales of operation.

These would provide information on the types of farm operations and resources at which government policy should be directed to facilitate efficient management functions for greater level of output and optimal use of resources.

Materials and Methods

The basic input-output data used in this study were generated from farm management experimental studies carried out at the University of Ife Teaching and Research Farm from 1977 to 1982. The experiments were designed to represent a mix of some improved cultural practices such as fertilizer application to maize, chemical pest control and sole cropping on the one hand, and the types of traditional cultural practices that are prevalent among the typical Nigerian farmers, on the other hand.

The product prices used to estimate the values of the output obtained consisted of those ruling in Ife markets for the period of study. The resultant values represent the respective gross margin per ha of each of the enterprises studied. Gross margin is used here as the total naira

value of output less variable costs of production. This definition enables it to be used as a measure of short-term profit.

The farm operations on which research emphasis was placed were (a) land clearing which was accomplished by human labour and land preparation which was undertaken by mechanical power, (b) planting time which was measured in mandays, (c) weeding, which was carried out with human labour, (d) fertilizer application which was used on maize enterprise alone and was done with human labour, (e) chemical spraying of cowpea, cassava, maize and melon enterprises, and (f) ridging, staking and training of vines for yam which were performed with ridgers and human labour respectively. A ratio of 1:10 was used to convert machine days to mandays.

The five enterprises studied and specified in the linear programming model are cassava (X_1), early maize (X_2), cowpea (X_3), melon (X_4), and yam (X_5). These represent the major potentially suitable food crops in Ife area.

Three sizes of farms were considered in the model, (small, medium and large) and different levels of resource restrictions were specified (Table 1).

TABLE 1: LEVEL OF RESOURCES IN THE MODEL

Resources	Resource Availability		
	Small Farm	Medium Farm	Large Farm
Operating capital (₦)	700	2,000	5,000
Labour (mandays) for land preparation	70	200	400
Labour (mandays) for planting	22	32	100
Land area(ha)	4.05	10.12	at least 20.24
Labour (mandays) for weeding etc.	90	120	300

The linear programming model may be formulated as expressed in (1) through (3):

$$\text{Maximize } Z = \sum_{j=1}^{r} PjXj - \sum_{i=1}^{n} \sum_{j=1}^{r} C_{ij}Xij \quad (1)$$

subject to

$$\sum_{j=1}^{r} A_{ij} X_j \leqslant \sum_{j=1}^{r} bij \quad bij \text{ - - - - - - - - - - } (2)$$

$$X_j \geqslant 0 \text{ - } (3)$$

where:

Z	=	Gross margin from enterprise combination.
Xj	=	Decision variables representing, for example, the number of ha planted to a crop enterprise on the farm.
Pj	=	Naira value per ha of the jth activity.
Cij	=	cost per unit of the ith input into the jth activity.
Aij	=	the amount of ith resource used in the production of one unit of jth activity.
b	=	level of available resources
bi	=	level at which resource i is available.
r	=	number of activities in the farm plan
i	=	number of resource constraints.

Results and Discussion

The results of the simplex method of solution are summarised (optimum plans with shadow prices) in Table 2. The results show that given the resources available to the small holder, 2.83ha is the optimal farm size which should be devoted to maize enterprise alone. The optimal income consistent with this is ₦1,680, which is equivalent to government salary scale GL 02. The farm size would require (a) ₦630 out-pocket operating expenses, (b) 70 mandays of labour for land clearing and preparation, (c) 7 mandays of labour for planting, and (d) 35 mandays of labour for weeding and application of fertilizer and spraying chemicals.

The shadow prices of real activities not in the optimal plan indicate the amount by which income would be reduced if they were to be

forced into the plan. Thus, for the small holding, the inclusion of one unit of yam, cowpea cassava and melon into the programme would lower income by ₦205, ₦169, ₦107 and ₦1 respectively; an indication that the first three of these enterprises are far less competitive with maize on small holder farms. However, the cultivation of melon is highly competitive with maize enterprise as its inclusion in the plan would reduce optimal income by only ₦1 per unit activity.

TABLE 2: SUMMARY OF OPTIMUM PLANS BY FARM SIZE

	Small Holding		Medium Holding		Large Holding	
Activity	**Activity Level**	**Shadow Prices ₦**	**Activity Level**	**Shadow Prices ₦**	**Activity Level**	**Shadow Prices ₦**
X_1		107		147.72	7.29*	
X_2	2.83*		4.86*		14.85*	
X_3		169		167.31		183.65
X_4		1	3.64*			15.95
X_5		205		202.98		268.70
S_1	70		7			
S_2		24		56.4		98.85
S_3	15					
S_4	3					
S_5				48		3.30
Optimum Income	₦1,680		₦4,793		₦10,331	
Total Farm Size*	2.83		8.50		22.13	

*in ha cultivated.

The shadow prices of resources are shown by the values of their corresponding disposal activities (S_1 as operating capital, S_2 as labour for land preparation, S_3 as labour for planting, S_4 as planted hectarage, and S_5 as labour for weeding, etc.). These shadow prices represent the marginal value productivities (MVP) of resources, i.e. the value contributed to income by bringing one additional unit of the resource into production. Thus, the higher the MVP of a resource, the more anxious the entrepreneur is, in acquiring additional units of this resource since it would contribute substantially to his income. The magnitude of the shadow price is consequently an indication of its limiting effect on income expansion. An examination of Table 2 reveals that S_2 is the most limiting resource with a value of ₦24 per manday of labour on the small-sized farm.

The results also show that for the medium-sized farm, the optimal farm size is 8.50ha and the optimal enterprise mix are maize (4.86ha) and melon (3.64ha) giving an optimal income of ₦4,793, an equivalent of GL 09. The farm size requires: (a) ₦1,927 out-of-pocket operating expenses, (b) 200 mandays of labour for land clearing and preparation, (c) 25 mandays of labour for planting, and (d) 120 mandays for weeding and application of fertilizer and chemical spraying.

If yam, cowpea and cassava were forced into the medium-sized optimal plan, income would be reduced per unit by ₦202.98, ₦167.31 and ₦147.72 respectively. This suggests that these enterprises are not competitive with maize and melon on this size of farm. Judging from the values of the MVP of resouces, labour for land clearing and preparation posed the greatest limitation to farm expansion with a shadow price of ₦56.4 per unit, while labour for weeding was to a lesser extent, another limiting resource.

The optimal size for the large sized farm was 22.13ha which should be planted as 14.85ha to early maize and 7.29ha to cassava. The maximum income is ₦10,331 which is the equivalent of GL 15 in terms of government salary scale. In terms of resource requirements, the large sized farm would require: (a) ₦4,718 out-of-pocket running expenses, (b) 400 mandays of labour for land clearing and preparation, (c) 400 mandays of labour for land clearing and preparation, (c) 72.31 mandays of planting time and (d) 300 mandays for weeding, fertilizer application and spraying.

The shadow prices for the large sized farm were ₦268.70 for yam enterprise, ₦183.65 for cowpea enterprise and ₦15.95 for melon. These indicate that only melon enterprise is fairly competitive with cassava and early maize enterprises on this scale of farm operation.

The shadow prices for labour on the different farm sizes present significant and interesting results with regard to what wage rates per

manday would be if all the underlying assumptions such as the operation of optimum farm plans, the prevalence of perfect competition, the absence of all market imperfections, etc. were met. With the exception of the shadow price for weeding operation on the large size holding which was found to be ₦3.30 per manday, prices were consistently much larger than the current market prices for farm labour (₦7.00 per manday). This suggests that if farmers could be guided to operate optimal farm plans, they could profitably support the payment of much higher wages to farm labour than they currently pay. This could be a way of attracting more labour to work on the farm.

Conclusion

Since this study was conducted under experimental conditions, the programme implementation under farmers' conditions need be considered. In this respect, there is the need for government to organize extension programme to provide proper guidance and training in management techniques and choice of enterprises in each acological zone. This should be supported with recommendations of modest improved cultural practices as used in the study.

In order to take care of the financial implication of the optimal plan, it is important that farmers are taught, through adult education programme, the merit of saving and investment, especially investment in income increasing technologies, so that they could mobilise at least part of the needed out-of-pocket operating expenses. The current practice is to rely solely on government credit, or in its absence, on private money lenders who usually lend on very harsh terms. While government should assist to bail farmers out of financial bottleneck, farmers themselves should accept the responsibility to provide some of the needed capital outlay.

Finally, to implement the optimal solution under field conditions, farmers would need to increase the size of their farm enterprises much more substantially than the usual less than 2 ha which they now cultivate. This can be achieved through the strengthening of the existing Federal and State government policies on provision of agricultural inputs, services and credit facilities. Additionally, organizing farmers with contiguous land into production cooperatives around agro-service centres should be encouraged. Agricultural inputs and services could then be channelled through such centres to the cooperatives at subsidized prices.

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