



# Formulating Optimal Farm Plans with Child Farm Labour Reduction for Arable Crop Farmers in Akwa Ibom State, Nigeria: An Application of Linear Programming and T-MOTAD Models

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## Authors' contributions

*This work was carried out in collaboration between all authors. Author CEO designed the study, wrote the protocol and supervised the work. Authors UJU and KCI carried out all laboratories work and performed the statistical analysis. Author KKS managed the analyses of the study. Author UJU wrote the first draft of the manuscript. Author KCI managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

This study formulates optimum farm plans with child farm labour reduction in the face of risk and uncertainties for arable crop farmers in Akwa Ibom State. Both primary and secondary data were used for the study. A structured questionnaire was employed to obtain information from one hundred and fifty (150) stratified randomly selected arable crop farmers in rural communities of Akwa Ibom State. Linear Programming and Target-MOTAD (Minimization of Total Absolute

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Deviation) models were used to analyze the data. Eleven major crop enterprises were identified as the existing crop plans in the study area with average net return of N275247.03 for the State, The value of the normative (Plan IV) (single goal optimum net return) for an average farmer was N514110.4, indicating an increase of 86.78%, over the existing plans (Plan 1) This plan recommended the cultivation of four crop enterprises Cassava/Melon (Ca/Me) (0.10 ha), Cassava / Melon / Cocoyam (Ca/Me/Cc) (1.11 ha), Yam / Maize / Pumpkin (Y/Mz/) (0.61 ha), and Yam / Maize / Cocoyam (Y/Mz/Cc) (0.34ha)The net returns in the two risk efficient plans II and III were N467506.2 and N455565.8 respectively. This showed an increase of 69.84% and 65.51% above the existing plan and a decrease of 9.06% and 11.39% below the profit maximizing plan IV. The alternative risk efficient farm plans II and III prescribed the cultivation of Cassava/Melon/Cocoyam (Ca/Me/Cc) (0.52 ha, 0.52 ha), Cassava / Melon (Ca/Me) (0.10 ha, 0.11 ha),Cassava / Maize / Pumpkin (Ca/Mz/P) (0.83 ha, 0.79 ha), Yam / Maize / pumpkin (Y/Mz/P) (0.23 ha, 0.21 ha), and Yam / Maize/ Cocoyam (Y/Mz/Cc) (0.33 ha, 0.32 ha). Capital was the only limiting resource in the study area. The study showed that farmers existing level of returns were not optimal. It is recommended that the farmers adopt the prescribed farm plans in the study to improve their farm income and minimize risk. Farmers should be assisted and encouraged to form cooperative societies and other functional groups to raise capital and provide farm labour during critical farm operations. The existing laws on free and compulsory education and the child right act in the State should be strengthened and enforced to ensure that children are not withdrawn from schools for farm work.

*Keywords: Linear programming; T-MOTAD; resource allocation; yield variability; normative plan; Total Absolute Deviation (TAD).*

## 1. INTRODUCTION

### 1.1 Background Information

Linear programming model is use to prescribe normative farm plans under a condition of certainty for optimum returns as the only objective. As the world of reality and farm environment is marked by uncertainty due to variability in yield and prices, formulating farm plans in a risky environment with condition of certainty becomes inappropriate. Multiple objectives have been discovered as crucial factors for consideration in explaining the resource allocation behavior of food crop farmers other than single all-encompassing objective of profit maximization. Such multiple objectives may include farm household food security, maximum gross farm income, limited extent of post-harvest losses and minimum variability in yield and so on. These objectives are in line with safety-first principle that is always interested in household survival or minimizing the probability of experiencing a shortfall in income below a target level as adopted in this study.

The Millennium Development Goals (MDGs) of the United Nations encapsulate increasing resource productivity in agriculture as part of its set objectives with key measurable indicators. It recommends that States should embark on

projects that target the rural areas, where the bulk of agricultural activities take place, and should first explore potential impediments to growth and development of the rural areas. The absence of high technical input (human knowledge and technologies) which is a major precursor of low productivity has been described as the outcome of promoting child labour at the detriment of educational development [1]. Agricultural child labourers work on all types of undertakings, ranging from family farm (small, medium and large-sized) corporate-run farms, plantations and agro-industrial complexes [2]. Child farm labour according to [3] is defined as any farm activity in which children (less than 18 years) are engaged that warrants loss in school days or time. It means all farm or farm related activities that the opportunity cost is schooling for children between 7-17 years. It excludes involvement in house chores or after school paid or unpaid activities. Child labour in agriculture is a global phenomenon and is found in all regions of the world including Nigeria. According to [4], an estimated 246 million children around the world carryout work that harms their well-being, hinders their educational development and future livelihoods. Also, Seventy percent (70%) all child labourers work in agriculture while many children have traditionally been employed in family enterprises. As majority of work in rural areas are agricultural, nine out of ten working children in

rural areas are engaged in agriculture or similar activities [5].

Child labour remains a major source of concern in Nigeria in spite of legislative measures taken by government at various levels [6]. To reduce or combat child labour, some States in Nigeria had initiated and implemented free and compulsory education policy and this has increased the enrolment in public schools. However, for the poor rural households the cost of a child's education is not equal to zero when there is free education. Many parents are still unable and disheartened to send their children to schools when direct costs of uniform, transportation to and from school, books and writing materials need to be supplied from the meager family income [7]. These immediate and direct costs of schooling also lower the likelihood of the child ever entering school.

Akwa Ibom State has advocated and actually implemented the free and compulsory education policy. As a result the enrolment rate in public primary and secondary schools has increased tremendously. Although children from some of the poor households are enrolled in schools, they tend to do seasoned employment and carryout household responsibilities as farm hands [5]. In Akwa Ibom State, where majority are predominantly farmers, children even from birth are taken to the farm. Work is allocated to each member of the family depending on their ages and by this process, parents believed they are training their children to be accomplished farmers. There is widespread evidence of child farm labour in Akwa Ibom State, especially when the rural farmers rely heavily on family labour for their farming activities. Poverty is one of the major causes of child labour. [8,9] asserted that poverty in Nigeria is essentially a rural phenomenon as most of the impoverished people, about 70 percent live in rural areas where they derive their livelihood from farming.

A typical farmer anywhere in the world has limited level of resources and the farmer is faced with the problems of myriads of choices for allocating farm resources between crop and animal enterprises so as to optimize production objectives. Also, by making efficient utilization of the available resources and combining the enterprises in an optimal manner [10]. These resources can be allocated efficiently only through effective planning guided by proper scientific planning tools for agriculture. As rightly pointed out by [11] a farmer is faced with multi-

dimensional objectives some of which are competitive. The farmer's decision problem is that of picking the enterprise combinations which optimize his overall achievements. The principle of combining enterprises in farm management is often confronted with the problem of what enterprise should be taken up, how far the farmer should go in combining the enterprises with another or replacing an enterprise. This depends partly on the interrelationship between different enterprises and the price of products and inputs [12]. In farm planning, the farmers have two alternative decision criteria. One is to allocate resources so as to maximize cash returns to fixed farm resources; while the other is to allocate resources so as to maximize utility by striking some balance between increasing expected income and minimizing income variability to reflect risk behavior [13]. In the first case, deterministic linear programming model can be used to derive the profit maximizing solution. However, the principal criticism leveled against using deterministic model such as linear programming model as planning tool relates to the embodied assumption that all coefficients are determined with perfect knowledge [13,14].

In the second case concerning risk behavior, farmers are expected to be risk averse and to maximize utility. Risk programming models, have therefore, recognized the importance of risk in agricultural planning and had led to the development of a normative decision theory based on inclusion of stochastic elements in whole farm planning models. The framework for this study is based on incorporating such stochastic elements to agricultural farm planning in a risky environment. Linear Programming had been used in agriculture since the 1950s and has provided prudent solutions to whole farm planning problems [15]. In this context, the works of [16-19,10,20] is worth citing. Other study that applied Linear programming and T-MOTAD model to generate risk efficient farm plans for arable crop farmers at different ecological zones in Nigeria include [21,22,23].

Farms eventualities classifiable as risk include year to year variability in crop yields that are normally associated with fluctuations in weather. The variability in yields and income due to risk can therefore be minimized by measures designed to alter production plan. These measures include farm insurance programme, diversification policies, production or contractual basis, maintaining flexibility in production and maintaining liquidity or access to sufficient liquid

funds in order to capture changes required as a result of additional knowledge or market information. All these measures involve costs and hence influence the farmers return. Agricultural production decisions are generally made subject to the interaction of many factors and these often result in returns displaying high variability or farm income which are unstable [24]. Given these scenario an optimal farm plan with risks consideration in farm business should be formulated.

Identifying a farm plan that minimizes risk under our socio economic and ecosystem with farm output and returns displaying high variability is a difficult task for small-scale farmers. [10] documented that if the limited resources available to the numerous small-scale farmers that produce bulk of the food consumed in Nigeria are to be used efficiently optimum farm plans must be formulated for them by region or locality. The concern of this study is that the optimum farm plan in other parts of Nigeria may not be suitable for farmers in Akwa Ibom State and that the result of such studies may be mis-specified if the small scale farmer make production decisions in the face of risk and child farm labour prevalent in the rural areas in the State.

## **2. RESEARCH METHODOLOGY**

### **2.1 Study Area**

The study was carried out in Akwalbom State, Nigeria. The State is located in the South-South geopolitical zone of Nigeria. It lies between latitude 4°31 and 5°31 North and longitude 7°35 and 8°25 East. Akwa Ibom State is bounded in the South by Atlantic Ocean, in the North by Abia State, East by Cross River and West by River State. The State has a total land area of 7,246 square kilometers and a shoreline of 129 km on the Atlantic Ocean to the South. It also has about 85% of the estimated 3,920,208 population comprising of 2,044,510 males and 1,875,698 females living in the rural areas [25].

The climate is tropical, marked by two distinct seasons, the dry (November-March) and the wet (April – October) seasons. Annual rainfall ranges between 2220 mm in the Northern part of the State and up to 3000 mm in the South. From the Saline water swamp forest in the South to the rain forest in the North, the land is suitable for extensive agriculture.

The state is divided into 31 administrative units called Local Government Areas (LGAs) which are grouped into six (6) agricultural zones of; Ikot Ekpene, Uyo, Oron, Etinan, Eket and Abak. Agriculture is the major occupation of the people and almost all the families engage in farming either as primary or secondary occupation. The ecological zone of the state favours the growing of tree crops, roots, tubers, cereals and vegetables. These crops are grown in small holder plots usually in mixtures of at least crops. The main food crops are Cassava, Yam, Cocoyam, Plantain, Maize and Vegetables.

### **2.2 Sample Size and Sampling Technique**

A multi-stage stratified random sampling technique was used in selecting the respondents for this study. The six agricultural zones as structured by Akwalbom State Agricultural Development Project (AKADEP) was the sampling frame. First three of the six zones of the Akwalbom Agricultural Development Project namely: Etinan, Eket and Abak zones were purposively selected to capture the three senatorial districts of the state. The second stage involved listing all the Local Government Areas in each of the three agricultural zones earlier selected to form a separate sampling frame. From each of the three zones, two Local Government Areas were randomly selected. This gave a total of twelve (6) Local Government Areas that were selected across the State for the study. The third stage involved purposive selection of a farming community (a village) from each of the Local Government area. A farming community was purposively selected to avoid selecting an urban area where farming is taken as a secondary occupation. This gave a total of six (6) farming communities (villages). Lastly in each of the six villages, a list of farm households was compiled with the assistance of village heads and AKADEP. Extension Agents for the area, these lists served as respective sampling frames for the villages. From each village, 25 farming households were randomly selected for the study. On the whole, a total of 150 Arable Crop farmers were selected for the study.

### **2.3 Sources and Types of Data**

For the purpose of this study, both primary and secondary data sources were used. The primary data was obtained through the use of structured questionnaires for the selected arable crops farmers. Secondary data were obtained from Akwa Ibom State ADP, the Central Bank (CBN)

and other publications relevant for the study that were relevant for the study.

## 2.4 Analytical Techniques

This study employed, Linear Programming (LP) and Target Minimization of Total Absolute Deviation (T - MOTAD) models for data analysis.

## 2.5 Specification of T-MOTAD

Since T-MOTAD is a modification of linear programming model, it uses the same objective function and is specified in this study as follows:

$$Max. E(Z) = \sum_{j=1}^n P_j X_j - \sum_{j=1}^n W_r H_j - \sum_{j=1}^n r M_j - \sum_{j=1}^n K_j Q_j - \sum_{j=1}^n V_j - D - R \quad (1)$$

The objective function seeks to maximize expected farm income which is the total expected gross income less the total costs of production which include the cost of human labour, capital borrowing (interest), marketing, other variable costs, depreciation on fixed cost items and rent on land.

Where;

$E(Z)$  = Total net farm income of the farm in naira comprising:

$$\sum_{j=1}^n P_j X_j = \text{Sum of returns from all the enterprises}$$

$$\sum_{t=1}^n W_r H_j = \text{Total cost of labour employed in the farm operations for all enterprises}$$

$$\sum_{t=1}^n r M_j = \text{Total cost of capital borrowed for the farm business for all enterprises}$$

$$\sum_{t=1}^n K Q_j = \text{Total marketing cost of produce sold for all enterprises}$$

$$\sum_{j=1}^n V_j = \text{Total cost of material variable inputs eg. agro chemicals and manure for all enterprises}$$

$X_j$  = level of the  $J^{\text{th}}$  crop activity in hectare;

$P_j$  = Price of unit of output of the  $J^{\text{th}}$  crop activity in naira;

$W_r$  = wage rate per unit of human labour in naira;

$H_j$  = Number of human labour employed for the  $J^{\text{th}}$  farm activity;

$r$  = Rate of interest for capital borrowed for the farm activity;

$M_j$  = Capital borrowed in Naira for the  $J^{\text{th}}$  farm activity;

$K_j$  = Marketing expenses per unit of the product sold;

$Q_j$  = Level of crop products sold for the  $J^{\text{th}}$  farm activity;

$V_j$  = other variable cost items e.g. fertilizer, organic manure, agro chemical etc.;

$D$  = depreciation on fixed cost items e.g. farm tools and implement;

$R$  = rent for land.

Subject to:

$$\sum_{j=1}^n X_j \geq b_1 \text{ (Land)} \quad (2)$$

Which implies that the total amount of land (hectares) required to produce the crops must not exceed total available land ( $b_1$ ) for the crops.

$$\sum_{j=1}^n a_{3j}X_j \geq b_4 \text{ (Hired Labour)} \quad (5)$$

$$\sum_{j=1}^n a_{1j}X_j \geq b_2 \text{ (Family Labour)} \quad (3)$$

Which implies that the total mandays of human labour required to produce the crops must not exceed the total human labour available ( $b_2, b_3$  and  $b_4$ )

$$\sum_{j=1}^n a_{2j}X_j \geq b_3 \text{ (Child Farm Labour)} \quad (4)$$

$$\sum_{j=1}^n a_{4j}X_j - M_j \geq b_5 \text{ (Capital)} \quad (6)$$

Which implies that the total capital required to produce the crops must not exceed the total amount of capital ( $b_5$ ) available. (Owned and borrowed).

$$\sum_{j=1}^n a_{5j}X_j \geq b_6 \text{ (Risk in 2007; deviation in naira)} \quad (7)$$

$$\sum_{j=1}^n a_{6j}X_j \geq b_7 \text{ (Risk in 2008; deviation in naira)} \quad (8)$$

$$\sum_{j=1}^n a_{7j}X_j \geq b_8 \text{ (Risk in 2009; deviation in naira)} \quad (9)$$

$$\sum_{j=1}^n a_{8j}X_j \geq b_9 \text{ (Risk in 2010; deviation in naira)} \quad (10)$$

$$\sum_{j=1}^n a_{9j}X_j \geq b_{10} \text{ (Risk in 2011; deviation in naira)} \quad (11)$$

$$\sum_{j=1}^n a_{10j}X_j \geq b_{11} \text{ (Risk in 2012; deviation in naira)} \quad (12)$$

$$\sum_{j=1}^n a_{11j}X_j \geq b_{12} \text{ (Minimum absolute deviation; } 0 - M) \quad (13)$$

$$\sum_{j=1}^n a_{12j}X_j \geq b_{13} \text{ (Minimum cassava in tons)} \quad (14)$$

$$\sum_{j=1}^n a_{13j}X_j \geq b_{14} \text{ (Minimum fluted pumpkin in tons)} \quad (15)$$

$$\sum_{j=1}^n a_{14j}X_j \geq b_{15} \text{ (Minimum Yam in tons)} \quad (16)$$

$$\sum_{j=1}^n a_{15j}X_j \geq b_{16} \text{ (Minimum Cocoyam in tons)} \quad (17)$$

$$\sum_{j=1}^n a_{16j}X_j \geq b_{17} \text{ (Minimum Maize in tons)} \tag{18}$$

$$\sum_{j=1}^n a_{17j}X_j \geq b_{18} \text{ (Minimum Melon in tons)} \tag{19}$$

$$X_j, H_j, M_j, K_j \geq 0 \tag{20}$$

This implies that all decisions variables must be non-negative.

$$\sum_{j=1}^n = \text{summation of } j\text{th crop activities (j = 1 to n)}$$

### 2.6 Input-Output Coefficients (Technical Coefficients)

A technical coefficients, otherwise called an input-output coefficient,  $a_s$  denote the unit of resource requirement of an activity. In this study, the input coefficient was referred to the requirement of a crop activity in respect of the inputs of different resources. The input-output coefficient with respect to land is given by the  $a_{1j}$  in equation (2) and it represents the amount of land required to produce a  $j^{\text{th}}$  crop process. For human labour, the input-output coefficients are denoted by the  $a_{2j}$ ,  $a_{3j}$ ,  $a_{4j}$  and they referred to the amount of human labour in mandays used in producing the  $j^{\text{th}}$  crop process. The  $a_{5j}$  represent the amount of capital used for the production of the  $j^{\text{th}}$  crop process. The input coefficients for the entire farm enterprises on all the selected farms were calculated on the basis of the actual quantities of different resources used. For those crop activities annual averages of the input assuming constant prices over time, were used. The input-output coefficients were the annual averages for all farmers selected in the State.

### 2.7 Labour Utilization Profile with Child Farm Labour reduction in the State

The analysis of the total child farm labour used in the study area was 14.43 mandays as child farm labour contribution to the farm. This is quite large when converted to hour's equivalent and weighted for conventional mandays of 8 hours. Conventionally 1/3 of an adult manday is 8 hours of a child's working hours. [3] recommended 2 hours per day as available time for children to be used for farm work. This is still not proper if their school hours are not to be compromised. There is no available time for children to work in the farm during school days. This study worked out a maximum of 4 hours on Saturdays (one day a

week) as available time for children to be used in the farm without jeopardizing their education. This will sum up to 8 mandays for the farm period of one year. The 8 mandays maximum is used as a constraint (The Right Hand Side) in the model to generate the prescribed normative farm plans.

The result of the farm plan as shown in Table 1, indicated that the total cropped area under the existing plan (plan I) was 6.05 hectares, and ₦275247.03 was the net return that accrued to an average farmer in the State who embarked on this plan. For a single goal of profit or net return maximization (plan IV) with a reduced child farm labour as prescribed, the average farmer in the State should allocate his resources in such a way that the 4 crop enterprises shown in the table are produced according to their land allocations. The recommended allocation pattern under this plan depicts the most important enterprise that enters the model, to be, cassava / melon / cocoyam (Ca/Me/Cc 1.11 ha) followed by yam/maize / pumpkin (Ym/Mz/P 0.61ha), yam / maize / cocoyam (Ym/Mz/Cc 0.34 ha) and lastly by cassava / maize (Ca/Mz 0.10 ha). A striking feature of this plan is that it prescribed the highest net return of ₦514110.4 (86.78% and 12.85%) over the existing plan I and risk minimized plan III. When compared with plans II and III, it recommended the allocation of larger portion of land for crop combination involving yam. It was discovered that yam promises high returns that is highly variable (risky) in the area. Since this plan is all about profit/net returns maximization, it could favour the inclusion of yam mixed crop enterprises. Risk minimized plans with a reduced child farm labour II and III that were generated for the rural farm households in the state recommended more enterprises to be included in the plan. The optimum farm plans II and III prescribed the allocation of 5 crop enterprises. For plan II, the allocation pattern

depicted the most important enterprises as cassava / maize / pumpkin (Ca/Mz/P 0.83 ha), cassava/ melon/ cocoyam (Ca/Me/Cc 0.52 ha), Yam / maize / cocoyam (Ym/Mz/Cc 0.33 ha), Yam/Maize/pumpkin (Ym/Mz/P 0.23 ha) and cassava/melon (Ca/Me 0.10 ha). Plan III also allowed more enterprises into the programme. The plan recommended allocation pattern in order of importance, based on land allocation as; cassava / maize / pumpkin (Ca/Mz/P 0.79 ha) cassava / melon / cocoyam (Ca/Me/Cc 0.52 ha), Yam / Maize / cocoyam (Ym/Mz/Cc 0.32 ha) then Yam / maize / pumpkin (ym/Mz/p 0.21 ha and cassava/melon (Ca/Me 0.10 ha). The net returns in the two risk efficient plans II and III were N467506.2 and N455565.8 respectively. This showed an increase of 69.84% and 65.51% above the existing plan. This result satisfies the objective function and constraints (resource and risk constraints) in the model. The result showed a decrease of 9.06% and 11.39% below the profit maximizing plan IV. This decrease can be considered as a risk premium. Plan IV is most likely to be adopted by risk neutral or risk preferred farmers while plans II and III are recommended for risk averse farmers.

### 2.8 General Observation of the Characteristics of the Optimal Plans

The above plans, show similar characteristics, it can be observed that smaller incomes are recommended with greater concern for risk. Therefore less risky crop combination like cassava / maize / pumpkin occupied more areas. Similarly, to contain risk, less risky crops

occupied significant area of land in the risk efficient plans II and III. Plan IV for the three zones, indicated higher incomes hence, high risky crops like yam combinations with larger land allocations were selected. This result is consistent with that of [26]. For plans II and III that the concern is for both income and risk, to attain higher income level, the crops that were selected and given more land allocations were those with high potential for more income and less yield variability. For the selected crop enterprises, it was observed that cultivated areas were reduced as return and risk increases. The large portion of land allocated for Ca/Mz/P enterprise selected in plans II to IV could be explained by the fact that its income generating potential was high enough to sufficiently off set the Mean Absolute Deviation which is minimized in the model. The results also show that by optimizing and including better crop combinations, farmers can get more returns at the same or even at a lower level of risk.

### 2.9 The Resource use Pattern Analysis, Shadow Prices and Excluded Activities of Plan II for Farmers in Akwa Ibom State

An examination of the resource utilization pattern in Table 2 reveals that only one of the specified resources was fully utilized. The shadow price for the fully utilized resource was N8.35. This implied that the value of the programme will increase by N8.35 if additional unit of the resource was used. This result is similar to that of [27] who reported that capital was the only

**Table 1. Results of basic linear programming and T-MOTAD models for Arable crop farmers in Akwa Ibom State**

	Farmers existing Plan I	Risk efficient Plan II	Farm plan Plan III	Linear programming Plan IV
Net Return	275247.03	467506.2	455565.8	514110.4
Ca/Mz	0.98 (16.20)			0.10 (4.63)
Ca/Me/Cc	0.61 (10.08)	0.52 (25.87)	0.52 (26.67)	1.11 (51.39)
Ca/Mz/Me/Cc	0.44 (7.27)			
Ca/Me	0.86 (14.21)	0.10 (4.98)	0.11 (5.64)	
Ca/Mz/P	0.72 (11.90)	0.83 (41.29)	0.79 (40.51)	
Ca/Mz/Me	0.92 (15.21)			
Ym/Mz/P	0.31 (5.12)	0.23 (11.44)	0.21 (10.77)	0.61 (28.24)
Ym/Mz/Me	0.20 (3.31)			
Ca/Ym/P	0.26 (4.30)			
Ym/Mz/Cc	0.24 (3.97)	0.33 (16.42)	0.32 (16.41)	0.34 (15.74)
Ca	0.51 (8.43)			
Total cropped area	6.05 ha	2.01 ha	1.95 ha	2.16 ha

**Source:** Computed from Linear Programming result. Figure in parenthesis are the percentage cropped area



**Table 2. Summary result of the resource use pattern analysis and excluded activities of Plans II – IV for farmers in Akwa Ibom State**

Non basic activities	MOC shadow	Unused resources	Level/Amount	Full used resource	Shadow price
<b>Plan II</b>					
Ca/Mz/Me	9023.07	Land	4.42	Capital	8.7
Ca/Mz	2796.73	Family labour	5.58		
Ca/Mz/Me/Cc	25707.76	Hired labour	6.98		
Ca/Y/Te	46716.3	Child farm lab	2.35		
Y/Mz/Me	14334.17				
Ca	36353.7				
<b>Plan III</b>					
Ca/Mz/Cc	9023.07	Land	4.42	Capital	8.35
Ca/Mz	2796.73	Family labour	5.58		
Ca/Mz/Me/Cc	25707.76	Hired labour	6.98		
Ca/Y/Te	46716.3	Child farm lab	2.35		
Y/Mz/Me	14334.17				
Ca	36353.7				
<b>Plan IV</b>					
Ca/Mz/Me	9638.93	Land	4.27	Capital	9.10
Ca/Mz/Me/Cc	23561.31	Family labour	5.53		
Ca/Mz/Te	13324.32	Hired labour	9.41		
Ca/Y/Te	27742.35	Child farm lab	5.24		
Y/Mz/Me	14164.65				
Ca/Me	54205.57				
Ca	19623.98				

*Source: computed from Linear Programming result.*

limiting resource to attain optimal farm plan in sweet potato cropping system for farmers in Offa Oyun Local Government Area of Kwara State. The non-fully utilized or non-limiting resources for the state included land 4.42 hectares, family labour 5.58 mandays, hired labour 6.98 mandays child farm labour 2.35 mandays. This means that these resources were in excess of the actual needs of the household in the study area. It also implied that the optimum farm plan under this model cannot be affected if these unused resources were discarded.

The non-basic activities included the following: Cassava / maize / melon, cassava / maize, cassava / maize / melon / cocoyam, cassava / yam / pumpkin, yam / maize / melon and sole cassava. The non-basic activities have the marginal opportunity costs (MOC) or income penalties of N9032.07, N7296.73, N25707.76, N46716.3, N14334.17 and N36353.7 for the aforementioned excluded activities respectively. The MOC signifies by how much the program value will reduce if any of the non-basic activities which did not enter the programme is forced into the programme. The most detrimental of all the excluded activities were cassava / yam / pumpkin

followed by sole cassava and the most competitive was cassava / maize.

## **2.10 The Resource Use Pattern Analysis, Shadow Prices and Excluded Activities of Plan III for the State**

The only object of discrepancy between Plan II and III was the programme value. Plan III had the same amount of marginal opportunity costs or income penalties of its excluded activities with that of plan II. As previously discussed, Plan II should be preferred to Plan III since it will generate the highest return if cassava/maize which was the most competitive activity is forced into any of the plan.

## **2.11 The Resource Use Pattern Analysis, Shadow Prices and Excluded Activities of Plan IV for Farmers in the State**

The resource use pattern of Plan IV as shown in the above table (Table 2) reveals that capital was the only limiting resource in the state. The shadow price for capital was N9.10. This implied that the returns of the farmers will increase by

₦9.10 if additional unit of capital was used. The non-fully utilized or non-limiting resources under this plan include land (4.27 hectares), family labour (5.53 mandays), hired labour (9.41 mandays), and child farm labour (5.24 mandays). This showed that these resources were in excess of the actual needs of the households in the State. It also implied that the optimum farm plans would not be affected if the quantities of the unused resources were discarded.

The excluded activities were; cassava / maize / melon, cassava / maize/ melon/ cocoyam, cassava / maize / pumpkin, cassava / yam / pumpkin, yam/ maize /melon / cassava / melon and sole cassava. The non-basic activities under this plan have the shadow prices of ₦9638.93, ₦23561.31, ₦13324.32, ₦27742.35, ₦14164.65, ₦54205.57 and ₦19623.98 respectively. The shadow price of the excluded activities showed by how much the value of the programme would reduce if any of excluded activities was forced into the programme. The most detrimental of all the excluded activities were cassava / melon followed by cassava / yam / pumpkin while the most competitive was cassava / maize / melon.

### 2.12 Sensitivity Analysis/ Programming

The sensitivity of the plans to changes in wage rate and available capital were observed. The two variables were chosen because of their critical importance to farm operations in the study area. Capital was identified as the only limiting resource in the area while labour cost took the largest share in the total cost of production in the State. The effect of increasing wage rate by 25%

on the optimal value was observed. Also, available capital was increased by 25% and the effects on the optimal values observed.

### 2.13 Effect of Increasing Wage Rate by 25%

Table 3 presents the changes in the value of the plan when wage rate was increased by 25 percent. From the table, Plan III was highly sensitive to an increase in wage rate. It indicated 14.21% reduction in net return as shown in the table above. Similar sensitivity was obtained [19,20]. This result was expected as labour cost contributed a significant part to the total cost of production and costs normally bring down net return. These results inform the need to control wage rate and cost of labour in the study area. If wage rate is not checked, it may affect child farm labour use as poor farming households may fall back on their under aged children as veritable labour resource to avoid the high cost of hired labour. More so, with their low financial resource, they may not be able to afford the high cost of labour. This will ultimately affect their level of production.

Table 4 presents the effect on the value of the programme when capital was increased by 25 percent. As shown in the table, the plan was also sensitive to increase in capital. Also, the activities that appeared in plans, II, III and IV remained unchanged. This result however supports the call for a financial support to small scale farmers to boost their farm production and income. As earlier stated for maximization problem, an

**Table 3. Comparing the optimum net return when wage rate was increased by 25%**

State	Previous optimum	Present optimum	Decrease (₦)	% Change
Plan II	467506.2	416926.7	50579.5	10.82
Plan III	455565.8	390823.1	64742.7	14.21
Plan IV	514110.4	466865.1	47245.3	9.19

*Source: Computed from linear programming result.*

**Table 4. Comparing the optimum net return when capital was increased by 25%**

	State			
	Previous optimum	Present optimum	Increase	%Change
Plan II	467506.2	503327.4	35821.2	7.66
Plan III	455565.8	479446.6	23880.8	5.24
Plan IV	514110.4	549517.3	35406.9	6.89

*Source: Computed from linear Programming result*

increase of a limiting resource would increase the value of the programme [14]. Capital was identified as the only limiting resource and hence constrained the attainment of the plan. This result is consistent with [28] who showed that an increase in amount of available capital increases the plans return.

### 3. SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study prescribed farm plans with child farm labour reduction that would provide the arable crop farmers in Akwa Ibom State improved income. The result has showed that farm resources in the study area were not optimally allocated. The farmer's existing plans, the profit maximizing and risk efficient farm plans have important implications for strategies to improve food crop production in the study area. A more generalized allocation pattern for all farmers in the state despite differences in resource endowment across farm zones as revealed by the study showed that farmers should allocate their resources to cultivate cassava / melon / cocoyam (Ca/Me/Cc), cassava / maize / pumpkin (Ca/Mz/P), yam / maize / pumpkin (Ym/Mz/P) and cassava/maize/melon (Ca/Mz/Me) The beautiful thing is that most of the common crops found in the State were included. All the normative plans did not favour the cultivation of sole cassava and mixture of too many crops (4 crops).

The farm plans that were generated are efficient and they indicated optimum enterprise combinations, optimum farm income and optimum resource use and allocation. The study has demonstrated the importance of incorporating risk when modeling farm plans for crop farmers in tropical agriculture. It showed that farm income will be overestimated if risk is not included in subsistence farm models. Hence, it can be concluded that appropriate combination of enterprises in crop farming would not only help to increase net farm income but can also enable efficient utilization of available resources. The farmers are therefore advised to adopt any of the recommended enterprise combinations or plans that best suit their situations. Arable crop farmers in the State should adopt the risk efficient plans as formulated in this study. The prescribed enterprise combinations would lead to the maximization of farmer's net returns. The additional income will enable parents to provide other school requirement like books, writing materials, uniforms and school sandals, ensures

that their children are not withdrawn from school to work in the farm and at the same time minimizes yield variability (risk). The normative farm plans should be integrated into the AKADEP technology package to the arable crop farmers in the State. Cost of seed yam was found to be very large, this constraint the cultivation of yam, apart from the high risky nature of yam in the study area. Programme to massively produce seed yam like yam miniset technology should be pursued. Given that capital was the only limiting resource in the study area, government should introduce policies that will enhance credit access to farmers in the study area. Evidence available from this study indicated that farmers employ more of their manual labour to different farming operations. There should be a concerted effort by government to introduce and intensify the use of less labour intensive technology in the study area. This measure would ensure that all children in farm communities are in classrooms at all times during schools hours.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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