Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.3, No.18, 2013

Optimum Combination of Farm Enterprises among Smallholder Farmers in Umuahia Agricultural Zone, Abia State, Nigeria

Kelechi Igwe[1*] Christian Onyenweaku[2]

1. Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, P. O. Box 2, MOUAU Post Office Umudike, Abia State, Nigeria
2. Department of Agricultural Economics, Michael Okpara University of Agriculture, P. M. B. 7267, Umuahia, Abia State, Nigeria

* E-mail of the corresponding author: kayceigwe@gmail.com

Abstract
Farm households in Umuahia Agricultural zone of Abia State engage in crop farming with few of such farmers combining their semi-commercial farm business with livestock enterprises most of which are poultry and non-ruminants. A representative sample of thirty farmers drawn from a sampling frame from Umuahia Zonal office of Abia State Agricultural Development Project was used to solve a gross margin maximization problem for an average farmer in the area. Results showed that one sole crop farm enterprise, two crop mixtures and two of the selected livestock enterprises should be produced to maximize gross margin in the prescribed combination. The extent to which land availability, labour use and wage rate affected gross margin was tested for sensitivity analysis; land availability when increased by 25% resulted to 13.48% increase in the gross margin, labour use when increased by 25% led to an increase of N15,159.90, representing about 3.04% of N499,229.90 obtained as the optimum gross margin while wage rate when reduced by 50% resulted to increase of about 6.16% in the original plan. Land I (Arable land), human labour I (land preparation and planting), human labour I (2nd weeding), human labour I (harvesting) and human labour II (feeding) were the limiting factors of production for attainment of the objective function out of the 14 resource constraints in the model. The study recommends that more arable land and labour saving technologies should be employed in farm production and also calls for private sector driven extension services in the study area.
Keywords: Optimum plan, farm enterprise, existing plan, gross margin, Linear Programming, Umuahia

1. Introduction

Generally, mathematical programming tools have been employed variously covering wide range of activities like crop farming, mixed farming, horticultural crops, livestock alone, various breeds and varieties, all sorts of combinations of different activities (Mehta, 1992). In a regional/inter-regional framework, linear programming approach has been used for studies in optimum resource allocation and resource requirements in many countries (Alam *et al.*, 1995; Sama, 1997; Alam, 1994; Onyenweaku, 1980; Shipper *et al.*, 1995). Within Nigeria, application of linear programming models to farm enterprises in various states has also been reported (Osuji, 1978; Tanko, 2004). However, arable crop based farms or the livestock component particularly animals whose production cycles last within a year are yet to be fully targeted. Hassan *et al.* (2005) reported that the use of LP makes it possible to devise equilibrium solution, which include the specification of products levels, factor and product prices. The prototype enterprise combination expected from this study shall thus assist in answering many resource allocation problems that would enhance farm productivity.

Achieving self-sufficiency in food crops among other things requires that, for the indigenous food crop in which Nigeria has a comparative advantage over other nations of the world, significant increases are experienced given the prevailing socio-cultural and economic circumstances of Nigeria. Effective combination of measures aimed at increasing the level of farm resources and making efficient use of the food sub-sector is one of the strategies advocated to achieve significant increases in food production (Heady, 1952). Developing optimum farm plan for small-holder farmers for this category of food crops could lead to the resolution of the food crises given that the Nigerian farmer does not seem to exploit fully her opportunities for capital formation, improved resource base, higher productivity, innovation and improved management techniques (Olayemi, 1980). Given that the small holder farmer is faced with the challenge of rationing his scarce resources among intended activities as well as optimizing the result of the rationing, he must make the choice of approximate mix of crop activities and analysis of planning of mixed enterprises to achieve a well defined technical relationship between inputs and outputs (Olayemi and Onyenweaku, 1999; Sama, 1997). This therefore creates an allocation problem which the findings of the study have addressed for the selected enterprises in Abia State.

In spite of all the food crop production programmes of FGN over the years, the food deficit has exacerbated leading to rapid increases in domestic food prices and increased importation of food which the worsening position of the balance of payments in recent years could no longer sustain (Tanko, 2004). There is need for the practicing farmers who suffer from a dearth of valuable information and are struggling to optimize their

objective function subject to their resource constraints given a complex mixture of many variables to be planed for (Igwe *et al*., 2013). To this end, the determination of the optimum cropping plan and selected livestock enterprises would be helpful. Given the resource restraints and possible alternative combinations to choose from how best to allocate resources to optimize gross returns to achieve the highest possible returns would be determined by the status of the factors of production. By either increasing or decreasing any of the resources the optimum mix of the activities and value of the programme could be evaluated when the nature of the competition of the activities in entering the plan or otherwise is established. Farm planning decisions would be made when the optimum plan is compared with the existing crop-livestock farm plans for the respondents.

2. Methodology

2.1 Study Area

Abia State has about thirty eight (38) blocks, two hundred and twenty eight (228) circles and one thousand, eight hundred and twenty four contact farmers, with each farm family consisting of about 5-10 members who are mainly small-scaled farmers (Oriaku, 2008). There are three agricultural zones in the State. Because of nature of data and nearness to the researcher, Umuahia Agricultural zone was chosen as the study Area. Umuahia zone is made up of Umuahia North, Umuahia South, Ikwuano, Isiala Ngwa North, Isiala Ngwa South and Osisioma Local Government Areas (Oriaku, 2008). There is no striking variation in the climate of all the Local Governments within the zone.

Within the rural communities of the zone just as it is in Ohafia zone, the male youths engage in off-farm activities such as 'Okada' riding, the middle-aged who do not fancy that engage in hunting while petty trading is predominant among the women folks, who major in foodstuffs and fruits (Igwe *et al*., 2013). The Umuahia Main Market and the Industrial Market Ahiaeke are two major markets that impart on the economy of the Zone. Mixed crop agriculture is characteristic of the agriculture of farm households within the agricultural zones of Abia State (Igwe *et al.*, 2011).

2.2 Sampling Procedure

This study aimed at examining the optimization of selected farm enterprises employed LP model. Data were collected from a sample size of 30 respondents accomplished by a multi-stage sampling technique. This first stage was choosing Umuahia zone. The second stage involved listing all the blocks in the zone and randomly selecting a block. The third stage involved the circle level, whereby three circles were selected from the chosen block. This gave a total of three circles. The fourth stage involved selecting a village (farming community) from each of the three circles.

The farm household which is made up the man, his wife and other dependents was the primary unit from which data used for the study were collected. Ten potential farmers were identified with the assistance of the village heads and the extension agents in each of the three villages namely Umugbalu, Amawom, and Amaoba, so chosen. A total of thirty respondents who engage in crop farming and may combine arable crop farming with poultry, piggery or fisheries production enterprises assumed to be the major livestock enterprises undertaken in the study area were interviewed for the study. A list of these farmers derived from the Agricultural extension officer in the zone constituted the sampling frame for the farmers.

2.3 Analytical Technique

Linear programming and Descriptive statistics were used in the analysis of the data. The linear programming model that developed a prototype optimum enterprise combination pattern for sole crop and crop mixes as well as for the selected livestock mixes that maximize gross margin of crop farms and animal farms together in the study was employed. The linear programming problems are usually characterized by the large number of solutions that satisfy the basic conditions of each problem and the selection of a particular solution as the best solution to a problem depending on the overall objective that is implied in the statement of the problem (Igwe, 2012).

The objective function set for the study for the crop and livestock enterprises was to maximize the return over variable cost (gross margin), where the return represented the product term of average yield of enterprise and its unit price patterned following Igwe and Onyenweaku (2013) which derived its inspiration from Osuji (1978) and Uddin *et al.,* (1994) with modification that involved incorporation of the livestock enterprises. In order to maintain uniformity, the output prices were taken as the harvest price and input prices as the actual market prices at the time of application of inputs following Alam *et al*. (1995) and Tanko (2004).

The general deterministic LP model of the study is a gross margin maximization model designed to find out the optimum solutions. Following Igwe *et al*. (2013) the model is specified mathematically as:

$$\text{Maximize } Z = \sum_{j=1}^{m} P_j X_j - \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij} X_{ij} \quad \ldots 1$$

Subject to:

$$\sum_{j=1}^{n} a_{ij}X_j \leq b_i \quad \ldots 2$$

$X_j \geq 0$ ... 3

Which implies that all decision variables must be non-negative

$\sum f_k X_j \geq F_{ic}(min)$ (minimum subsistence farm-family tuber/cereal crop requirement) ... 4

$\sum f_{kc} X_j \geq F_{ia}(min)$ (minimum subsistence farm-family protein requirement) ... 5

Where: i = 1, 2....m; j = 1, 2, ... n

Z = Gross margin of total output, X_j = Decision variable, for instance the number of hectares the farmer devoted to the production of a crop or a combination of crops or a combination of crops or livestock capacities produced by farm, P_j = The gross value per hectare of the jth activity be it crop or per livestock capacity for livestock enterprises, C_{ij} = Cost per unit of ith input used in the production of the jth activity, X_{ij} = Quantity of ith input in jth activity, a_{ij} = the amount ''a'' of the resource ''i'' used in the production of one unit of ''j'', b = level of available resources, b_i = the level ''b'' at which resources ''i'' is available, m = number of activities in the programme, f_k = food production in tons/hectare of k^{th} tuber/cereal activity, f_{kc} = livestock production in tons per livestock capacity of kc^{th} protein activity, $F_{ic(min)}$ = Minimum quantity of tuber/cereal crops required by the farm family per annum in tons (ic=1,2,3...n) and $F_{ia}(min)$ = Minimum quantity of protein required by farm family per annum in tons (ia = 1,2,3,...n)

2.4 Resource Restrictions in the Model

Land, labour input, minimum tuber/cereal crop requirement and minimum protein requirement in terms of livestock products were incorporated in the model. The minimum requirement accounts for the crops or livestock needed to fulfil home consumption required by subsistence farmers who are less market oriented. This assumption is inconsonance with Alam *et al*. (1995), who affirmed that family food supply is a possible constraint in farm planning. On land constraint, all the farmers are assumed to be operating rain fed agriculture at variance with Alam *et al*. (1995) and Tanko (2004).

2.4.1 Land and Livestock Capacities

Only one type of land restriction was classified for crops. For the livestock enterprises, livestock capacities were used as proxy to define size of farm. The other restrictions in the model included particularly for the selected livestock enterprises were that each poultry enterprise be it broiler or layers was fixed at a capacity of 500 birds; egg production was fixed at a capacity of 1000 crates; pig enterprise was limited to a capacity of 15 pigs; and the fish enterprise limited to a capacity of 1000 fish. These classifications were in consonance with those of Igwe and Onyenweaku (2013) and Igwe *et al*., (2013).

2.4.2 Labour Activities

Labour input was classified as human labour across enterprises. Labour activities were not separated into family and hired labour but were treated together. However, labour was classified into two broad classes accounting for crops and livestock enterprises assumed to be grouped into four periods in each class respectively.

The first labour category was defined for crops as human labour requirement 1 defined thus: Land preparation and planting (abbreviated HLa1 LPP); First weeding (abbreviated HLa1 1^{st} weeding); Second weeding (abbreviated HLa1 2^{nd} weeding); Crop Harvesting (abbreviated HLa1 CHarvesting)

Wage rate which is the remuneration per man-day made to labour in cash and in kind was determined by taking the mean for the number of observations. In line with convention, one man-day corresponds to 8 working hours.

The second labour category was defined for livestock as human labour requirement 2 defined as Livestock Feeding (abbreviated HLa11 Feeding), Cleaning (abbreviated HLa11 Cleaning), Sorting (abbreviated HLa11 Sorting) and Harvesting (abbreviated HLa11 Harvesting)

Wage rates differed in both human labour categories according to periods as well as nature of farm operations. It was observed that for the crop enterprise category, wage was highest during land preparation and planting relative to other periods while sorting and harvesting had higher wage rates for the livestock category relative to feeding and cleaning. Irrespective of livestock capacities the mean wage rates were determined based on the number of observations.

2.4.3 Capital

Given that the respondents generally were small scale farmers who were peasants or at best semi-commercial and who did not finance their farm business by formal capital borrowing, no provision was made for capital borrowing in the model. The level of capital available to the farmers was constrained to the amount used in buying seeds, other material inputs and as well as paying for labour when need arises. Given that labour expenses and other costs of production have been taken care of in the model, the issue of capital was not considered in the model. Capital thus included working capital required in meeting day to day farm or production expenses such as purchasing of seeds, and other agronomic inputs such as fertilizers, manures and insecticides. The farmers relied on proceeds from previous harvests and were involved in other off farm

activities which made it possible for them to meet their capital need in their small scale farming activities as observed in related studies (Igwe *et al*. 2013).

3. Results and Discussion

3.1 Socio-economic Characteristics of Respondents

The summary of the socio-economic characteristics is presented in Table 1.

Table 1: Summary of Descriptive Statistics of Some Selected Socioeconomic Characteristics of Respondents in Umuahia Zone

Variable	Sample Size	Minimum	Maximum	Mean	Standard Deviation
Age	30	20.00	70.00	54.23	11.74
Sex	30	0.00	1.00	0.87	0.35
Marital Status	30	0.00	1.00	1.00	0.26
Education	30	0.00	22.00	10.60	5.16
Experience	30	10.00	45.00	29.47	12.25
Household Size	30	1.00	10.00	5.87	3.16
Off-Farm Income	30	25,000.00	750,000.00	78,020.00	1.44E+10

Source: Field Survey, 2009/2010

The study showed that the mean age was 54 years for Umuahia. This was less than the mean age for the same categories of farmers in Aba Agricultural zone (Igwe *et al*., 2013). Agricultural work in the study area not being mechanized is labour intensive as in all the zones in Abia State (Igwe and Onyenweaku, 2013; Igwe et al., 2013). Therefore, it is expected that the farmers within this age can readily provide a lot of physical strength required for farm work. Age is expected to determine the ability of a farmer to bear risks associated with farm work. To this, Nwaru, (2004) insisted that the ability of a farmer to not only bear risk and be innovative but also, able to do manual work decreases with age. This does not mean that more youths in the area do not need to be motivated to take up agriculture to stabilize this age gap.

For the selected enterprises, the males were more into agriculture than their female counterparts in the three agricultural zones. This agrees with the findings of Olaleye (2000), that small-scale farming are being carried out mostly by males while the females involve in light farm operations such as processing, harvesting and marketing. The customs on land holding also naturally make men the legitimate landowners except where the household is headed by females (Igwe, 2012).

However, in the opinion of Kebede (2001), women appear to be more efficient than the men when it comes to frequent supervision and follow up of farm activities on the farm. An average farmer in the area can be said to be relatively literate. This trend has been observed in the generality of the farming communities in the State (Igwe *et al*., 2013). This contradicts the general view that majority of the farmers are still uneducated. Exposure to education serves as a catalyst or elixir that activates the engine of growth through efficient information acquisition and usage enhances farmers' use of improved technology and increased productivity (Amaza and Olayemi, 2000; Igwe, 2012).

The mean farming experience of the sampled farmers was 29 years. Nwaru (2004) reported that farmers count more on their experience than educational attainment in order to increase their productivity. However, Kebede (2001) opined that age could be used as a proxy for experience; a thought which Igwe (2012) has maintained should question the continued use of both variables in most regression analysis among certain researchers of the developing economies extraction and has called for a paradigm shift in econometric analysis and modelling. The mean household size of farmers in the study area was 6. Larger household size is believed to enhance the availability of family labour since it reduces labour cost in agricultural production (.Effiong, 2005). However, Okike (2000) reported that labour availability through large household sizes may not be a guarantee for increased efficiency, particularly where majority of the household members are little children. For such a situation, family labour may be underutilized given the small – scale nature of food production activities. This explained why labour use in the optimum was lower than in the existing plan.

The mean off-farm income for the sampled farmers in the study area was N78,020.00. This implies that given the average farm holding, the sampled farmers relatively have the wherewithal to support their agricultural activities in spite of the almost absence of formal capital borrowing.

3.2 Land holdings of Farmers in the Study Area

The farm size of the respondents as it relates their arable farm holdings is presented in Table 2.

Table 2: Frequency Distribution of Farmers According to the Farm size in Umuahia Agricultural Zone

Range	Frequency	Percentage
0.13 – 0.27	9	30.00
0.28-9.42	7	23.33
0.43-0.57	8	26.67
0.58-0.72	6	20.00
Total	**30**	**100**
Mean	0.43	
Standard Deviation	0.17	

Source; Field Survey Data, 2009/2010

For all the sampled farmers in Umuahia, no farmer had a farm holding of more than a hectare of farm land devoted to arable crop farming while about 30% of the farmers had about 0.27 hectares or less and only 20% had between 0.50 and 0.72 hectares.

3.3 Crop and Livestock Yields and Value of Yield per Hectare and per Livestock capacities

The yields of crops produced both as sole and as mixtures and their value of the yields as well as those of the selected livestock mainly non-ruminants and poultry combined by some of the arable crop farmers are presented in Table 3 Umuahia agricultural zone.

Table 3: Yield, Value of Output and Farm Prices of Some Selected Arable Crops and Animal Produce for Umuahia Agricultural Zone, Abia State

Enterprise Crop	Yield (tons per ha)	Price per kg	Price per ton	Value
Yam				
Yam	1.3429	194.38	194,380.00	261,032.90
Cassava/Maize				
Cassava	7.3378	30.00	30,000.00	220,134.00
Maize	4.0319	86.26	86.260.00	220,134.00
Cassava/Yam				
Cassava	7.5219	28.72	28,720.00	216,028.97
Yam	0.6486	185.34	185,340.00	120,211.52
Maize/Yam				
Maize	4.068	86.96	4,068.10	16,549.03
Yam	0.6752	210.68	210,680.00	142,251.14
Cassava/Melon				
Cassava	6.789	30.00	30,000.00	203,661.30
Melon	0.397	50.00	50,000.00	19,850.00
Cassava/Maize/Yam				
Cassava	6.6054	22.45	22,450.00	148,291.23
Maize	1.575	86.93	86,930.00	136,914.75
Yam	0.436	194.34	194,340.00	84,732.24
Cassava/Maize/Melon				
Cassava	6.290	30.00	30,000.00	188,701.80
Maize	2.968	86.75	86,750.00	257,474.74
Melon	0.06	50.00	50,000.00	3,000.00
Cassava/Melon/Cocoyam				
Cassava	6.8085	29.98	29,980.00	204,118.83
Melon	0.40	50.72	50,720.00	20,228.00
Cocoyam	1.8674	56.00	56,000.00	104,574.40
Cassava/Melon/Cowpea				
Cassava	3.457	48.92	48,920.00	169,131.22
Melon	0.2038	52.00	52,000.00	10,597.60
Cowpea	0.0252	200.00	200,000.00	5,040.00
Cassava/Maize/Yam/Telferia				
Cassava	5.875	30.00	30,000.00	176,253.00
Maize	2.4535	87.45	87,450.00	214,558.58
Yam	0.4419	194.36	194,364.21	85,889.54
Telferia	0.261	45.00	45,000.00	11,745.00

Livestock Enterprises				
Poultry	**Yield (tons per 500 birds)**	**Price per Kg**	**Price per ton**	**Value**
Broiler I	1.34	447.76	447,760.00	599,998.40
Broiler II	1.725	460.00	460,000.00	793,500.00
Layers	0.99	353.54	353,540.00	350,004.60
Egg	**Yield (tons per 1000 crates)**	**Price per Kg**	**Price per ton**	**Value**
Egg	0.82	335.37	335,365.85	275,000.00
Fish	**Yield (tons per 1000 fish)**	**Price per Kg**	**Price per ton**	**Value**
Fish I	0.85	600.00	600,000.00	528,000.00
Fish II	0.72	615.00	615,000.00	442,800
Pig	**Yield (tons per 15 pigs)**	**Price per Kg**	**Price per ton**	**Value**
Pig	0.27	671.11	671,110.00	181,199.70

Source: Field Survey, 2009/2010

3.4 Existing and Optimum Cropping/Enterprise Patterns in Umuahia Agricultural Zone

The existing and optimum enterprise patterns in Umuahia agricultural zone for the sampled farmers are presented in Table 4.

Table 4: Existing and Optimum Cropping/Enterprise Pattern in Umuahia Agricultural Zone, Abia State, Nigeria

Cropping/Enterprise pattern	**Existing plan (ha)**		**Optimum plan (ha)**	
	Size of farm	Percentage	Size of farm	Percentage
1. Yam	0.31	12.25	0.72	17.96
2. Cassava / Maize	0.25	9.88	-	-
3. Cassava/Yam	0.12	4.74	-	-
4. Maize/ Yam	0.14	5.53	0.03	0.75
5. Cassava/ Melon	0.22	8.70	-	-
6. Cassava/ Melon/Yam	0.19	7.51	-	-
7. Cassava/ Maize/ Melon	0.27	8.70	-	-
8. Cassava/Melon/ Cocoyam	0.64	25.30	-	-
9. Cassava/Melon/Cowpea	0.21	8.30	3.26	81.30
10. Cassava/Maize/Yam/Telferia	0.23	9.09	-	-
11. Pig	0.19	100	0.11	100
12. Broilers 1 Jan-May	0.36	33.33	-	-
13. Broilers 11 Aug-Dec	0.28	25.93	0.02	5.13
14. Layers/Egg- Jan-Dec	0.14	40.74	0.37	94.87
15. Fish 1-Jan-June	0.90	62.07	0.06	100
16. Fish 11 July-Dec	0.55	37.93	-	-
Total crop area	2.53		4.01	
% Sole		12.25		17.96
% Crop Mixture		87.75		82.05
Total Poultry	1.08		0.39	
% Broilers		59.26		5.13
% Layers		40.74		94.87
Total Fisheries	1.45		0.10	
		100		100
Total Pig	0.19		0.11	
% Pig		100		100

Source: Field survey, 2009/2010

Results in the zone recommended 0.72 hectare of yam, 0.02 hectare of maize/yam and 3.26 hectares of cassava/yam/cowpea while 0.11 15 pigs (1.65 pigs) and 0.17 of 500 units (85.00 birds) of broiler II and 0.06 of 1000 (60.00) fish were prescribed for the livestock counterpart. A similar study in Ohafia zone recommended 0.29 ha of yam which was less than recommended in Umuahia but had more than a single sole crop enterprise (Igwe et al., 2013). The implication therefore is that for an average farmer sampled in the state to maximize gross margin, emphasis should be on Bro 11 done between August and December and pig enterprise according to the prescribed plan in the combination with the recommended crop enterprises. Only one sole cropping pattern was recommended in the plan.

3.5 Gross Margin among various Plans

The gross margins for the existing and optimum plans for selected farmers in Umuahia agricultural zone is presented in Table 5.

Table 5: Gross Margin (in Naira) for Existing and Optimum Plans for the Selected Farmers in the Zone

Existing Plan	Optimum Plan	Increase/Decrease Over Existing Plan	Percentage %
271,150.75	499,229.90	228,079.15	84.12

Source: Field Survey Data, 2009/2010

Result indicates that optimum plans resulted in an increase in gross margin over the existing plan across the zones by 84.12% in Umuahia. The findings were high relative to values obtained among crop farmers in Niger State on raising their income level (Tanko and Baba, 2010). The introduction of livestock enterprises among the crop enterprises could explain for the relatively high optimum values relative to studies where only crop enterprises were evaluated.

3.6 Shadow Prices of Excluded Activities among Selected Farmers in the Zone

The higher the shadow price of an excluded activity, the lower is its chance of being included in the final plan. The shadow prices of excluded activities obtained as by-products of the linear programme solution for the sampled farmers are presented in Table 6.

S/N	Excluded Activity	Shadow Price (N)
1.	Cassava/Maize	48,265.16
2.	Cassava/Yam	63,563.61
3.	Cassava/Melon	119,990.70
4.	Cassava/Maize/Yam	81,769.83
5.	Cassava/Maize/Melon	20,184.30
6.	Cassava/melon/Cocoyam	31,585.41
7.	Cassava/Maize/Yam/Telferia	45,841.83
8.	Broiler I – Jan-May	42,446.14
9.	Fish II –July-December	1,763.20

Source: Computed from Field Survey Data, 2009/2010

Among the crop enterprises in Umuahia agricultural zone, cassava/maize/melon had the least shadow price of N20,184.30 while cassava/melon has the highest shadow price of N119,990.70.This lends credence to previous findings of other researchers where shadow prices of sole crops were reported to have higher than those of crop mixtures (Nwosu, 1981 and Alam et al.1995). Therefore, it should follow that the less the crop mixtures the higher the shadow prices. For Ohafia agricultural zone, the selected mixed crop enterprise was found to be in a better competitive position as compared to sole cropping and livestock enterprises.

Shadow price of sole crop was relatively higher than those of crop mixtures. This lends credence to previous findings (Adejobi *et al*, 2003; Tanko, 2004). The excluded mixed crop enterprise was found to be relatively in a better competitive position as compared to sole cropping and livestock enterprises except for cassava/maize/yam. However, fish I, done usually between January and June had the least propensity to depress income among farmers.

3.7 Shadow Prices of Available Resources in the Optimized Plans

The status therefore of the available resources in the optimized plans for Umuahia, agricultural zone is presented in Table 7.

Table 7: Shadow Prices (in Naira) of Resource Constraints in Umuahia Zone

Constraint	Resource	Shadow Price
Land I	Tight	42, 080.83
Land II	Loose	0.00
Land III	Loose	0.00
Land IV	Loose	0.00
Land V	Loose	0.00
Feed	Loose	0.00
Human Labour I (Land Preparation and Planting)	Tight	600.00
Human Labour I (1st Weeding)	Loose	0.00
Human Labour I (2nd Weeding)	Tight	350.00
Human Labour I (Harvesting)	Tight	300.00
Human Labour II (Feeding)	Tight	8.49
Human Labour II (Cleaning)	Loose	0.00
Human Labour II (Sorting)	Loose	0.00
Human Labour II (Harvesting)	Loose	0.00

Source: Computed from Field Survey Data, 2009/2010

Any resource that is abundant, that is not used up by the programme, is not a limiting resource and has a zero shadow price as it does not constraint the attainment of a programme's objective and vice versa (Olayemi and Onyenweaku, 1999; Igwe and Onyenweaku, 2013).

3.8 Minimum Staple Food/Livestock Requirements

The staple foods for farmers in the area were tubers and cereals for the crops and to meet their protein needs, certain amounts of their livestock were consumed. Results of the minimum staple and protein requirements by households (in tons) in existing and optimum plans are presented in table 8. Indication in the table is that a typical farm household required about 3.07 tons for farmers in Umuahia Agricultural zone while 0.06 tons of animal protein is required for the livestock. The optimum plans for these minimum requirements were satisfied adequately.

Table 8: Minimum Staple and Animal Protein Requirements by Households (in tons) in the Plans

Staple/Animal Protein	Existing Plan	Optimum Plan	Increase over Existing Plan
Yam	0.98	4.85	3.87
Cassava	1.29	11.26	9.97
Maize	0.06	1.16	1.10
Pig	0.03	0.27	0.24
Broiler	0.03	1.26	1.23
Layers	0.018	0.36	0.34
Fish	0.05	0.88	0.83

Source: Field Survey Data, 2009/2010

4.0 Sensitivity Analysis

The sensitivity analysis of the plans to changes in some production variables was observed. Usually as has been established by many researchers in the past, land and labour are variables of utmost interest in such analysis (Osuji, 1978; Tanko, 2004). However, given that feed was incorporated in the model for the livestock enterprises, the effect of increasing quantity of feed available by 50 percent was also observed. In the first scenario, land resource was increased by 50 percent, to see its effect on the optimum plan. In the second scenario, labour was increased by 25 percent across each period for crops and decreased by same for livestock in each zone to see their effect on the optimum plan; in the third scenario, wage was decreased by 50 percent for both crops and livestock and finally, the effect of 50% increase in the quantity of available feed on the programme was observed.

Effect of Increasing Area under Cultivation

In Umuahia agricultural zone for the farmers, the value of the objective function increased from N499,229.90 to N566,518.20 being an increase by N67,288.30, representing 13.48% over that the previous plan. It was also observed that the increase affected cassava/melon/cowpea which increased by 2 hectares, from 3.26 hectares to 5.26 hectares while other activities remained unchanged. This was contrary to what was obtained in Ohafia agricultural zone within the same planting season period, at which time, there was no increment in the optimized plan when area of land was increased by the same proportion (Igwe *et al.* 2013).

Table 9: Comparing the Optimum Gross Margins when Land was increased by 50 percent

Previous Optimum (N)	Present Optimum (N)	Increase (N)	% Change
499,229.90	566,518.20	67,288.30	13.48

Source: Computed from Field Survey Data, 2009/2010

Effect of Varying Labour Use on the Optimum Gross Margin

Labour use was increased by 25 percent of what was available across the zones for crops and decreased by the same for livestock to see their respective effect on the optimum gross margin and this is presented in table 10. Increasing labour by 25% of that available in the zone increased the value of the objective function by 3.04% which represent only about N15,159.90 increment to the initial optimum value of the objective function. The effect of varying labour use on the optimum gross margin is presented in table 10. This was slightly higher than was obtained in Aba agricultural zone, where an increase of 1.86% of the previous optimum gross margin was obtained (Igwe and Onyenweaku, 2013). It was at variance with how sensitive increase of labour had on optimum gross margin of similar farmers in Ohafia agricultural zone (Igwe *et al*., 2013).

Table 10: Comparing the Optimum Gross Margins when Labour was increased by 25 percent

Previous Optimum (N)	Present Optimum (N)	Increase (N)	% Change
499,299.90	514,389.80	15,159.90	3.04

Source: Computed from Field Survey Data 2009/2010

Effect of Varying Labour Wages on the Optimum Gross Margin

Given that high wage rate would depress gross margin, effect of reduction of wage rate by 50 percent was also examined. This is shown in Table 11. The reduction led only to a 6.16% increase of the original value.

Table 11: Comparing the Optimum Gross Margins when Wage rate was reduced by 50% across Crops and Livestock

Previous Optimum (N)	Present Optimum (N)	Increase (N)	% Change
499,299.90	529,998.50	30,768.60	6.16

Source: Computed from Field Survey Data 2009/2010

5. Conclusion

The study concludes that among smallholder farmers the allocation of resources was not optimal in the existing plan and that crop mixtures were dominant in the study area. Given that land was vividly shown to be the major limiting factor in Umuahia zone more arable land should be employed in crop production but not without consideration to improving on the environment where the farming activities are done. This calls for a quick re-structuring of the Land use Decree so that land do not continue to lie fallow for decades when it could have been given to practicing farmers as a way of empowering them to do more and contribute to increasing agricultural productivity in Nigeria.

The inclusion of livestock enterprises among selected arable crops gives a fair representation of what obtains in the zone because the generality of the farmers do not necessarily hands off from either category of enterprises completely. The combination of crop and livestock enterprises contributes in improving the gross returns to the farmers in the zone. Effective farm advisory in the efficient allocation of farm resources and appropriate enterprise patterns should be encouraged by the setting up of independent or private driven extension service organizations to compliment government's effort in extension service through the ADPs. The zone has capacity for possible use of linear programming by farmers or atleast contact farmers in the area in the near future.

Acknowledgement

The PhD work of the first author provided a window for the work and all who contributed to shape that research and or the analysis of the data particularly Drs Jude Nwaru and Tanko Likita are highly acknowledged. Mr Paul Anorue, Mr Gideon Nnamerenwa, Mr Bismark Ibeagwa and Mrs Clara Igwe who assisted in the collation of the socio-economic characteristics were helpful in the completion of the research.

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