FARM PLANNING FOR OPTIMUM ENTERPRISE COMBINATIONS FOR SMALLHOLDER FARMERS IN AGRICULTURAL ZONE ONE (I) OF NIGER STATE, NIGERIA

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ABSTRACT

Farmers are often faced with a need to select the optimum level of input use, least cost combination of input and the most profitable combination of enterprises from possible multiple enterprises that could be produced on the farm. This study derived a prototype model for planning optimum enterprise combinations for smallholder farmers in Agricultural Zone One (I) of Niger State. Multi-stage sampling technique was used to select respondents comprising crop, livestock and fish farmers in the Zone. The data for this study were collected through interview schedule and structured questionnaire administered to 224 sampled farmers through a cost route approach. Data collected were analyzed using the linear programming model to maximize gross margin from various combination of arable crop, fishery and selected livestock (small ruminant) enterprises. The study showed that out of 17 cropping patterns identified in the cropping enterprise, only 2 were prescribed in the optimum plan yielding a gross margin of ₦154,933.30 per hectare; about 70% increase over the existing plan. The Crop/Livestock enterprise had an optimum return of 405.59% over the existing plan with a recommendation of 2.51ha devoted to cultivation of melon/sorghum and the production of 5 small ruminants (either goat or sheep). Consequently, for the Crop/Fishery enterprise, melon/maize (1.80 ha) and 5.85(100 fishes) were recommended to yield a gross margin of ₦53,029.46 which is 94.98% increase over that of the existing plan. The linear programming solution further indicated labour and capital borrowed as the major factors of production limiting the attainment of profit maximization across the enterprises. The study therefore recommended that, farmers should adopt the prescribed optimum farm plan developed to enable them effectively use their available resources to increase yield and income.

***Keywords**: Enterprise Combination, Farm Planning, Linear Programming, Smallholder Farmers*

INTRODUCTION

In Nigeria, agriculture contributes about 23% to the Gross Domestic Product of the country, provides employment for about two-thirds of the nation's workforce thereby constituting the mainstay of the country's large rural community (Food and Agriculture Organization [FAO], 2023). As the human population continues to increase, agriculture seems not to be fulfilling its vital role of feeding the human race, providing other essential agricultural commodities and generating stable incomes. Nigeria's agriculture is characterized by resource-poor smallholder farmers with about 90% of the total agricultural output generated by households which on average cultivate about two hectares of land (Nchuchuwe and Adejuwon, 2012). These smallholder farmers whose farm enterprises in most cases include livestock are unable to efficiently allocation their scarce resources through optimum enterprise combination, to make year round provision for the household, accumulate monetary income and minimizing expenditure on labour, (Igwe and Onyenweaku, 2013).

Farm enterprise combination is an essential relationship in agricultural production economics involving the allotment of available resources among two or more enterprises (Egbodion and Ada-Okungbonwa, 2012). Integration which is also a form of enterprise combination is done to recycle resources efficiently; different countries have developed different ways to accomplish this, hitherto a common feature of the system is the combination of crop and livestock enterprises; other forms of integrated farming include aquaculture (Shamim, Fouzia and Momota , 2011).

Integrated enterprise combination, which will offer farmers optimum results is a decision they often take by trial and error method, the outcome of which is usually uncertain (Ohajianya and Oguoma, 2009; Olasunkanmi, Adedeji, Otunnaiya, Soluade and Ogunjobi 2015). Smallholder rural farmers also tend to rely on traditional methods such as experiences, intuition and comparison among neighbour to make decisions which do not guarantee the optimal result (Tanko and Onyenweaku, 2009). It cannot be neglected that smallholder farmers are faced with limited and fixed resources which necessitate the selection of enterprise combination that will maximize income from the available set of resources. These farmers are also faced with a need to select the optimum level of input use, least cost combination of input and the most profitable combination of enterprises from a large number of possible enterprises that could be produced on the farm. Hence, the need to optimize the use of available resources for farm enterprises is crucial as identifying the best farm plan is a difficult task for small-scale farmers with low levels of literacy. It is however imperative to plan the farm enterprises more optimally to achieve maximum profit. Researchers (Adeniyi and Adesina, 2014; Ohajianya and Oguoma, 2009, Sofi, Ahmed, Ahmad and Bhat, 2015; Ibrahim, Oformata, Jirgi and Adewumi, 2019;

Adewumi, Tanko, Ibrahim and Yisa, 2020; Okpanachi, Tanko, Ibrahim and Adewumi, 2022) over time have made effort to determine optimum farm plans for farmers mostly on cropping enterprises, but little evidence exist on combination of crop, livestock and fishery enterprises. Tanko, Baba and Adeniji (2011), formulated a prototype enterprise combination involving only arable crops in Niger State, but there still lack study on optimum enterprise combination involving various farm enterprises in Niger State, a research gap which this study sought to fill.

Farm planning can assist the farmers in allocating the available resources in an optimal manner. Formulating optimum farm plans for smallholder farmers could lead to resolution of food crisis and consequently improve on living standards of smallholder farmers. If the limited resources available to the many small-scale farmers in Nigeria are to be used efficiently, optimum farm plans must be formulated for these farmers by region or locality. This study is therefore poised to develop optimum combination of crop, livestock and fishery enterprises. Findings emanating from this study will provide necessary information for formulating effective policy by the policy makers and will also be valuable to both new entrants and practising farmers. Also, agricultural project administrators and researchers will benefit immensely from this study as its output can be used as a baseline for future research in similar area. The optimum farm plans developed could also form part of the teaching content of extension service delivery in the state.

METHODOLOGY

The study area is Agricultural Zone (I) of Niger State, Nigeria. Niger State is located in north central Nigeria and falls within the Guinea Savanna ecological zone of the country. It lies between Latitudes 8°20′ N and 11°30′ N and Longitudes 3°30′ E and 7°20′E with a total land area of 76,363 square kilometers. The climatic condition of Zone (I) favour the cultivation of crops including maize, rice, sorghum, cowpea, melon and groundnut. Livestock production is dominated by small-holders with predominant livestock enterprises comprising of sheep, goat and poultry raised under semi-intensive management systems. People of this Zone are predominately farmers and traders.

The sampling frame for this study comprised of the smallholder farmers who are into crop, livestock and fishery enterprises in the Agricultural Zone (I) of Niger State. Data for this study were mainly from primary sources collected from farmers who were selected using multi-stage sampling technique. The first stage involved random selection of three Local Government Areas (Lavun, Lapai and Agaie LGAs) out of the eight LGAs within the Zone.

Two communities were then selected randomly from each of the LGAs giving a total six communities. The third stage involved random selection of 10% farmers for each enterprise undertaken from each community bringing the total number of sampled farmers to 224.

Data Collection

Interview schedules were conducted to obtain cross-sectional data for 2016 production season from the farmers in the study area through a limited cost-route approach, which was obtained through the assistance of well-trained enumerators. Output was measured per 100kg bags for grains while for tubers it was based on 100 tubers as a unit. In the case of mixed cropping, the average output of each crop was determined on yield per hectare basis and applied to the total hectares. Information about the farm size was obtained from the farmers. Prevailing market price was used to estimate potential gross returns. The livestock small ruminant (sheep and goat) were selected for this study and were considered as a single enterprise since their mode of production is similar, likewise, only cultured fish was considered.

Analytical Technique

The analytical tool used for this study is linear programming. It is an optimizing technique, which is used widely to allocate resources optimally in order to increase the production (Bhatia and Bhat 2019). The basic linear programming model was specified to maximize gross margin for each enterprise that is, crop, crop/livestock and crop/fishery enterprises separately to determine the most optimal activity combination under the limit of the resource constraint as specified within the enterprises.

The model is specified mathematically as: Max Z =

$$\sum_{j=1}^{n} C_i X_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Subject to:

$$\sum_{j=1}^{m} a_{ij}\ x_i \ \leq\ b_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$x_i \ \geq\ 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where: i=1,2,3,….m; j=1,2,3,…n

Z = Gross Margin; C_i = Gross Margin per unit of each activity in the enterprise; X_j = Decision Variables to be maximized these are activities or enterprises to be engaged. a_{ij} = the amount ‘‘a’’ of the resource ‘‘i’’ used in the production of one unit of ‘’j’’; b_i = the level ‘’b’’ at which resources ‘’i’’ is available m = number of activities in the programme.

RESULTS AND DISCUSSION

Crop Enterprise

Existing and optimum enterprise combination of crop enterprise

The existing plan of smallholder farmers who engaged solely in crop farming is revealed in Table 1. Seventeen cropping patterns were identified which were made up of nine sole crops and eight mixed crops. None of the crops grown as sole entered the optimum plan whereas for those grown as mixed, melon/sorghum and sorghum/groundnut entered the plan with a prescribed 0.65 hectare and 1.55 hectares respectively. This result is in consonant with the findings of Adewumi *et al*., (2020) who also studied seventeen crop enterprises of both sole and mixed crops with none of the sole crops making it into the optimum plan. Also similar studies by Adewumi, (2017), Jirgi, Adewumi, Yisa and Okpanachi, (2018) and Okpanachi *et al*., (2022) with similar findings attested that mixed crop enterprises are more likely in a competing position to yield more benefit for the farmer than the sole crop enterprises.

Table 1: Existing and optimum plan of crop enterprise (hectares)

Farm Activity	Existing plan(ha)	Optimum plan(ha)
Maize	0.88	-
Melon	0.38	-
Millet	1.00	-
Sorghum	0.97	-
Yam	1.00	-
Soya Bean	1.50	-
Groundnut	0.63	-
Cowpea	0.50	-
Rice	0.88	-
Maize/Yam	1.05	-
Maize/Groundnut	2.00	-
Maize/Soya Bean	1.25	-
Melon/Sorghum	1.00	0.65
Millet/Groundnut	0.63	-
Sorghum/Soybean	2.00	-
Sorghum/Groundnut	0.83	1.55
Yam/Cowpea	1.00	-

Source: Field survey, 2016

Gross margin among the plans for crop enterprise

The result in Table 2 showed that the gross margin in Naira per hectare for the existing plan was estimated at ₦90,851.38 for the crop enterprise, whereas that of the optimum plan was ₦154,933.30 which is higher than that of the existing plan of the farmer with a 70.53% increase. This result agrees with Tanko and Baba (2010) who carried out a similar study in Niger State.

The result further showed that mixed crop enterprise yielded more returns than sole crop enterprises for those purely into crop production in the study area.

Table 2: Gross margin for existing and optimum plans for crop enterprise

Enterprises	Existing plan (₦)ha	Optimum plan(₦)ha	Increase over Existing plan (₦)ha	% Increase
crop	90,851.38	154,933.30	64,081.92	70.53

Source: Field survey, 2016

Shadow price of excluded activities from the optimum plan of crop enterprise.

Shadow prices are the income penalties that would be experienced by a farmer who forcefully introduces an activity which has been excluded by the optimum solution of a linear programming result (Reddy and Ram, 2005). It indicates the amount by which the value of the programme would be reduced if an activity was used in place of another or forced into the plan. Included activities usually have zero shadow prices while only excluded activities have positive shadow prices as indicated in Tables 3. The higher the value of the shadow price of an excluded activity the lower its chances of being included in the optimum plan. The summary of the results in Table 3 indicate that for crop farmers in the study Zone, 15 crops were excluded from their existing plan with Sorghum/Soybean having the least shadow prices while Yam/Cowpea had the highest shadow prices of ₦8,273.90 and ₦387,640.50. Hence, Sorghum/Soybean have better chances to be included in the plan.

Table 3: Shadow prices of excluded activities from the optimum plan for crop farmers

Excluded Activity	Shadow Prices(₦)
Maize	136,090.30
Melon	23,184.90
Millet	12,276.75
Sorghum	23,667.86
Yam	147,942.60
Soya Bean	56,673.79
Groundnut	20,0734.60
Cowpea	12,644.05
Rice	171,507.90
Maize/Yam	269,546.00
Maize/Groundnut	68,758.29
Maize/Soya Bean	177,286.00
Millet/Groundnut	29,452.40
Sorghum/soybean	8,273.90
Yam/Cowpea	387,640.50

Source: Field survey, 2016

Marginal value product of resource in the optimum plan of crop enterprise.

The Marginal Value Products (MVP) are also shadow prices relating to the resources. A shadow price of any particular resource greater than zero implies a shortage in supply of the resource relative to its demand. Hence, further use of that resource increases the potentials in the production of a particular product. If the MVP of a resource is zero, it implies that the resource is in excess supply and therefore should not be in further use for the production of the activities (Reddy and Ram, 2005).

The result in Table 4, show by how much the value of the programme will change if the available resource with excess supply is being increased by one unit. It was revealed that for crop farmers in the Zone, land, machine labour and seed were in surplus supply resulting in their zero MVP hence should not be further increased in the production of the activity. On the other hand, other category of labour, agrochemical, fertilizer and capital borrowed were completely used up by the programme. Additional unit usage of these resources will lead to increase in the optimum value of the enterprise (gross margin) by the corresponding shadow prices.

Table 4: Marginal value product of resources used by crop farmers in Naira

Resources	Shadow prices(₦)	Surplus(₦)
Land	0.00	1.99
Land Preparation	750.00	0.00
Labour (Planting)	500.00	0.00
Labour (First Weeding)	749.99	0.00
Second weeding	750.00	0.00
Labour (Harvesting)	500.00	0.00
Machine Labour	0.00	0.58
Seed	0.00	333.23
Agrochemical	6,325.00	0.00
Fertilizer	502.39	0.00
Capital Borrowed	0.10	0.00

Source: Field survey, 2016

Crop and Livestock

Existing and optimum enterprise combination of crop/livestock enterprise

Table 5 summarizes the result for the optimum plan for farmers that combine the production of crop and livestock in the Zone.

The existing plan has six mono-crops, ten mixed cropping pattern and livestock enterprise. None of the sole crops were included in the plan and for the mixed crops only Melon/Sorghum was included with a prescription of 2.51 hectares of land for production and five heads of livestock. Igwe and Onyenweaku, (2013) who also studied optimum combination of crop and livestock found that sole crops have weak competing power when combined with mixed crops and livestock production.

Table 5: Existing and optimum plan for crop/livestock farmers (hectares)

Farm Activity	Existing plan(ha)	Optimum plan(ha)
Maize	0.85	-
Sorghum	0.75	-
Yam	0.80	-
Groundnut	0.50	-
Cowpea	0.43	-
Rice	0.72	-
Maize/Sorghum	0.83	-
Maize/melon	1.00	-
Maize/Millet	1.50	-
Melon/Sorghum	0.50	2.51
Melon/Millet	1.17	-
Millet/Groundnut	0.75	-
Millet/Sorghum	0.50	-
Sorghum/Soybean	3.00	-
Sorghum/Groundnut	0.81	-
Sorghum/Yam	1.00	-
Livestock	3.67	5.00

Source: Field survey, 2016

Gross margin among the plans for crop/livestock farmers

The result in Table 6 also revealed the gross margin for the crop/livestock farmers in Zone. The result shows that the optimum plan had a tremendous increase of 405.59% over the existing plan, indicating a relatively higher gross margin than that for crop farmers in the same Zones, the inclusion of livestock to the enterprise could explain for such increase as reported by Olasunkanmi *et al.*, (2015) who stated that practising mixed farming with livestock increases profitability. Obasi, Nwaiwu, Korie and Tim-Ashama, (2016) also affirms that crop/ livestock system of mixed farming offer the highest return on farm businesses.

Table 6: Gross margin for existing and optimum plans for crop/livestock enterprise

Enterprises	Existing plan(₦)ha	Optimum plan(₦)ha	Increase over Existing plan(₦)ha	% Increase
Crop/livestock	122,419.20	618,939.70	496,520.50	405.59

Source: Field survey, 2016

Shadow price of excluded activities from the optimum plan of crop/livestock enterprise.

The result revealed that Farmers who engage in a combination of crop and livestock as an enterprise had 15 excluded activities as shown in Table 7. Rice as a sole crop as the highest shadow price of ₦364,332.10 while Maize/Sorghum had the least shadow price of ₦31,605.84 with a higher chances of being included in the programme.

Table 7: Shadow prices of excluded activities from the optimum plan for crop/livestock enterprise

Excluded Activity	Shadow prices(₦)
Maize	256,491.50
Sorghum	124,644.50
Yam	143,470.00
Groundnut	196,082.50
Cowpea	289,756.20
Rice	364,332.10
Maize/Sorghum	31,605.84
Maize/melon	242,657.50
Maize/Millet	88,015.84
Melon/Millet	168,847.50
Millet/Groundnut	156,742.50
Millet/Sorghum	94,682.51
Sorghum/SoyBean	102,317.50
Sorghum/Groundnut	137,892.70
Sorghum/Yam	349,732.50

Source: Field survey, 2016

Marginal value product of resources in the optimum plan of crop/livestock enterprise

The MVP obtained in the optimum plan for crop/livestock farmers is presented in Table 8, indicating that livestock capacity, labour for land preparation and first weeding as well as bullock and machine labour with feed, seed, agrochemical and fertilizer in are in excess supply in the production process. Continuous usage of these resources will hamper the attainment of the goal of the farmer to maximize gross margin.

Crop and Fishery Enterprise

Existing and optimum enterprise combination of crop/fisheries enterprise.

The optimum plan for the crop and fishery enterprise is summarized in Table 9, the existing plan had only Rice as a sole crop and Maize/Melon as a mixed crop along fish farming. The optimum plan for the farmers prescribed 5.85 fishes and Maize/Melon (1.8 ha). Rice production was not included in the plan. As observed in the earlier findings in this study for both the crop, and crop/livestock enterprises sole crops were not included in the optimum plans. This is congruent to a similar study carried out by Igwe and Onyenweaku, (2013) indicating that sole crops are weak in competing with other enterprises among small scale farmers.

Table 8: Marginal value product of resources used by crop/livestock farmers

Resources	Shadow Prices(₦)	Surplus(₦)
Land	167,832.50	0.00
Livestock	0.00	14.57
Labour (Land Preparation)	0.00	0.44
Labour (Planting)	500.00	0.00
Labour (First Weeding)	0.00	2.55
Labour (Second weeding)	749.99	0.00
Labour (Harvesting)	499.99	0.00
Labour (Feeding)	250.00	0.00
Labour (Cleaning)	250.00	0.00
Machine Labour	0.00	4.89
Seed	0.00	55.99
Agrochemical	0.00	140.75
Fertilizer	0.00	166.83
Capital Borrowed	0.10	0.00

Source: Field survey, 2016

Table 9: Existing and optimum plan of crop/fishery farmers in hectares

Farm Activity	Existing plan(ha)	Optimum plan(ha)
Rice	2.50	-
Maize/Melon	1.00	1.80
Fish	330.00	5.85

Source: Field survey, 2016

Gross margin among the plans for crop/fishery farmers.

The value of the programme shows an increase of 94.98% on the existing plan with the cultivation of 1.80ha of maize/melon and production of fish as presented in Table 10. This suggest that introduction of fishery enterprises alone could bring positive prospect to farm enterprise.

Table 10: Gross margin for existing and optimum plans for crop/fishery farmers

Enterprises	Existing plan(₦)ha	Optimum plan(₦)ha	Increase over Existing plan(₦)ha	% Increase
Crop/Fishery	27,197.96	53,029.46	25,831.5	94.98

Source: Field survey, 2016.

Shadow price of excluded activities from the optimum plan of crop/fishery enterprise.

Table 11 shows the shadow prices the excluded activities from the existing plan for farmers combining crop and fish production. Rice as the only sole crop was excluded from the optimum plan with a shadow price of ₦47,240.00. Indicating that the value of the programme will be reduced by ₦47,240.00 if the farmer forcefully add rice enterprise to the programme.

Table 11: Shadow prices of excluded activities from the optimum plan for crop/fishery farmers

Excluded Activity	Shadow prices(₦)
Rice	47,240.00

Source: Field survey, 2016

Marginal value product of resources in the optimum plan of crop/fishery farmers

The MVP of farmers who engaged in combination of crop/fishery enterprise in the study area are summarized in Table 12. The farmers were limited by labour during the period of first weeding and harvest; agrochemical and capital with shadow prices of ₦750, ₦500, ₦5,580 and ₦0.1 respectively.

Table 12: Marginal value product of resources used in crop/fishery enterprise

Resources	Shadow Prices(₦)	Surplus(₦)
Land	0.00	0.20
Fish	0.00	984.15
Labour (Land Preparation)	0.00	2.60
Labour (Planting)	0.00	1.60
Labour (First Weeding)	750.00	0.00
Labour (Second weeding)	0.00	1.20
Labour (Harvesting)	500.00	0.00
Feed	0.00	120,662.90
Seed	0.00	6.00
Agrochemical	5,580.00	0.00
Fertilizer	0.00	70.00
Capital Borrowed	0.10	0.00

Source: Field survey, 2016

CONCLUSION AND RECOMMENDATIONS

From the study it is concluded for all enterprises, that resources were not optimally allocated which could serve as hindrance to the attainment of optimum profit. Hence, it is recommended that farmers in the study area should adopt the optimum farm plan according to their enterprise combinations. The optimum farm plans prescribed 0.65ha for melon/sorghum and 1.55ha for sorghum/groundnut cultivation for the Crop enterprise. Crop/Livestock enterprise should cultivate 1.55ha of melon/sorghum and keep 5 heads of either goat or sheep. While the Crop/fishery enterprise should adopt the cultivation of maize/melon on 1.80ha and produce 5.85(100) fishes as this would enable them to make efficient use of their available resources, increase production and consequently their incomes. Likewise for the resources, land, seed and machine labour were found to be in surplus for the Crop enterprise, The Crop/livestock enterprise had excess number of livestock kept; labour for land preparation and first weeding including machine labour, quantity of seed, agrochemical and fertilizer used were in surplus. Whereas for the Crop/fishery enterprise land, number of fishes produced; labour for land preparation, planting and second weeding; quantities of feed, seed and fertilizer used were also in excess supply. Hence, farmers should extend the use of these resources that have been identified as surplus under the associated enterprise combination to other income generating activity.

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