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# OPTIMUM COMBINATION OF MULTPLE FARM ENTERPRIESES AMONG SMALLHOLDER FARMERS IN NIGER STATE, NIGERIA

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## ABSTRACT
The study was conducted to determine the Optimum Combination of Multiple Farm Enterprises among Smallholder Farmers in Niger State, Nigeria. Multi-stage sampling technique was used to select respondents across the farm enterprises from the three agricultural zones of Niger State. Data were collected through interview schedule and structured questionnaire administered to 198 sampled farmers through a cost route approach, and analyzed using the linear programming model. The model was applied to each enterprise combination. The study revealed that all enterprise combinations had increase in the returns of the optimum plan over that of the existing plan. To maximize gross margin, the model recommended cultivation of 0.41 ha of yam, 2.6 ha of melon/sorghum and 0.38 ha of melon and sorghum for the crop enterprise, while the crop/livestock/fishery enterprise had yam/cowpea (1.96ha) along with the production of 5.83 heads of livestock recommended. The crop/fishery farmers are to cultivate 0.33 ha of maize/cowpea, 1.17 ha of maize/melon and to produce 0.22 of 100 fishes to maximize gross margin. The result further indicated labour and capital borrowed as the major factors of production limiting the attainment of profit maximization across the State. The study therefore recommended that, farmers should adopt the prescribed optimum farm plan developed according to the respective enterprise combinations to enable them effectively use their available resources to increase productivity and income.
**Keywords:** Combination, Enterprise, Farm, Optimum and Smallholder

## INTRODUCTION
Agriculture in Nigeria contributed about 23 percent to the Gross Domestic Product (GDP) of the country in 2021 (FAO, 2023). Despite dominance of the agricultural sector in the economy of Nigeria, food is not supplied at affordable prices for the average citizen due to the challenges hampering the productivity of the sector. Among such challenges are low technology and high production cost which have also led to increased food importation. According to Shitu (2017), Nigeria has rich agricultural, natural and human resources, but its major weakness is in mobilizing these resources to diversify its economic base, achieve self-sufficiency and food security, and reduce poverty.

Farm planning is a veritable tool in enterprise combination, as the most profitable alternative enterprises are selected in the planning process by organizing the available land, labour and capital resources into a proper combination (Reddy and Ram, 2005). Farm production planning is a complicated process as the input-output relations, cost- price ratio and farmer's preferences are taken into cognizance. However, the problem of production planning is addressed as a common problem of optimization (Stamenkovska *et al.,* 2013). Optimization is a common approach to solving problems of production planning in the sense of optimal resource allocation, given the changing conditions that farms face (Stamenkovska *et al*., 2013). Its concept is well entrenched in the fundamental principle guiding the analysis of various complex

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decisions or allocation problems as it offers a certain degree of philosophical elegance that is hard to dispute (Luenberger and Ye, 2015). More than 90% of the agricultural output are accounted for by smallholder farmers cultivating less than two hectares of land (Chiaka *et al*., 2022). These farmers are faced with limited and fixed resources which necessitate the selection of enterprise combination that will maximize income from the given set of resources. They find themselves also 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. These smallholder farmers often lack control over decisions that affect them as their demand for local services and farm input are not promptly responded to by the appropriate agencies (Chiaka *et al*., 2022). Hence, the influence of smallholder farmers on agricultural policy and budgets is extremely low. Their vulnerability to hunger is exacerbated by high food prices, as most of them become net food buyers at the end of the day. The need to optimize the use of available resources for farm enterprises is therefore crucial.

For optimum agricultural production the proper use of required inputs and available resources as well as right combination of enterprises is necessary. However, the ubiquitous problem faced by farmers is how crop and livestock enterprises should be combined, considering the amount of labour and capital available to obtain a maximum profit on a given acreage (Alotaibi and Nadeem, 2021). Consequently, it is also imperative to plan the farm enterprises more optimally to achieve maximum profit. Identifying the best farm plan is a difficult determine the optimum combination of farm enterprises for small-scale farmers with low levels of literacy. 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 (Olasunkanmi *et al.,* 2015; Alotaibi and Nadeem, 2021). Tanko *et al.* (2011) formulated a prototype enterprise combination involving only arable crops in Niger State. The objective of the study was to determine the optimum combination of farm enterprises in Niger State.

## MATERIALS AND METHOD

The study area, Niger State of Nigeria 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 constituting about 10% of Nigeria's total land mass, out of which 70% are arable (Niger State Policy on Agriculture, 2020). Based on the annual growth rate of 3.4% it was estimated that the population would be about 5,556,200 people in 2018 (Niger State Policy on Agriculture, 2020). Annual rainfall of the State ranges from 1600mm in the South to 1100mm in the Northern part lasting for about 120 to 150 days respectively with an average monthly temperature range of about $23^0$C to $29^0$C (Niger State Policy on Agriculture). The State is divided into three Agricultural Zones based on their agricultural activities. Agriculture is the predominant source of livelihood engaging about 85% of the population.

### Sampling Technique and Sampling Size

Data for this study were mainly from primary sources collected from farmers who were selected using multi-stage sampling technique. The three Agricultural Zones in the State, namely, Zones I, II and III were considered for the study. The first stage involved random selection of three Local Government Areas (LGA) from each of the three Agricultural Zones in the State. Lavun, Lapai and Agaie LGAs were randomly chosen from Zone I; Bosso, Shiroro and Paikoro LGAs from Zone II and Mariga, Mashegu and Wushishi LGAs from Zone III. In the

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second stage, two communities were randomly selected from each of the LGAs giving a total of eighteen communities. The third stage involved random selection of 10% farmers for each of the enterprise undertaken from each community. A total of 198 farmers; comprising 166 crop, 18 crop/livestock/fishery and 14 crop/fishery farmers were sampled. Data for this study were obtained through the limited cost-route approach that is, the farmers were tracked monthly during the year 2016 farming season, particularly for the information that has to do with crop production in order to obtain accurate information concerning the activities carried out on their farms from land preparation to harvest. The researcher was assisted by well-trained enumerators in data collection. Prevailing market price was used to estimate potential gross returns.

**Analytical Technique**

The analytical tool used was the Linear Programming (LP) Model. Linear Programming is a mathematical technique widely used to determine the best resources allocation among competing demands (Konstantinos *et al.*, 2022). The objective function of the linear programming model was to maximize the total gross margin of producing enterprises less the costs of production, including marketing expenses. The farm household seeks to maximize an objective function by planting various combinations of arable crops either in mixtures or as sole alongside selected livestock (small ruminant) and fisheries enterprises. The model is specified mathematically as follows and applied to each enterprise combination separately (that is crop, crop/livestock/fishery and crop/fishery enterprises): The model is specified mathematically as:

Max Z =

$\sum_{j=1}^{n} C_i X_j$ ..1 …(1)

Subject to:

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

$x_i \geq 0 \ldots 3$

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

Xi = 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

## RESULTS AND DISCUSSION

The results are presented based on each separate enterprise combination. The summary of the existing and optimum farm plan, gross margin, excluded activities and penalty cost and marginal value product (MVP) of the enterprise combinations identified in the study area are presented in Tables 1 to 10.

**Existing and optimum enterprise combinations**

Tables 1, 2 and 3 shows the identified existing and optimum plans for the enterprise combinations for crops, livestock and the fishery enterprises in Niger State. The result identified nine soles and fifteen mixed cropping patterns for the crop enterprise giving a total of twenty-four cropping patterns. Crop/livestock/fishery enterprise had six existing crop patterns (three soles and three mixed) in addition to livestock and fishery whereas the crop/fishery enterprise had five cropping patterns (two soles and three mixed) along with the fishery production in the study area.

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The model recommended yam as the only sole crop, to be cultivated on 0.41 hectare; melon/sorghum and melon/millet on 2.6 and 0.38 hectares respectively as the optimum plan for smallholder farmers who engage only on crop production. The crop/livestock/fishery enterprise had only one mixed crop and the livestock enterprise recommended in the optimum plan; while crop/fishery enterprise had two mixed crops along the fishery production in the optimum plan.

It is observed for all the enterprise combinations except for the crop enterprise which had only one sole crop in the optimum plan, the other enterprises do not have sole crop in their optimum plan. This implies that mixed crops were in a better off position for the farmer to yield more returns than the sole crops. This finding is similar to those of Adewumi *et al*. (2020): Jirgi *et al.* (2018) and Okpanachi *et al.* (2022) who in their separate studies attested that mixed cropping was of greater benefit to the farmer than the sole crop farming.

**Gross Margin in the Existing and Optimum Plans.**

The gross margin as computed for the existing and optimum plans for the various enterprise combinations are presented in Tables 4. The findings revealed that all the enterprise combinations had increase in the gross margin of the optimum plan over that of the existing plan. The gross margin per hectare obtained from the optimum plan were 106.35%, 21.60% and 104.32% increase over the existing plan for the crop, crop/livestock/fishery and crop/fishery enterprises respectively. This implies that for each of the enterprise combinations smallholder farmers in the study area have the aptitude to increase their returns but have been operating far below optimum plan.The result correlated with the works of Ibrahim *et al*. (2021): Adewumi *et al.* (2020) and Tanko and Baba (2010) who have done researches in similar area and got increase in the returns of the optimum plan over the existing plan. Furthermore, this finding tends to be in conformation with the attestation made by Kontatinos *et al.* (2022) that results from LP model provides significant improvement over existing farm plan.

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

| Farm activity | Existing plan | Optimum plan |
|---|---|---|
| Maize | 1.11 | - |
| Melon | 0.88 | - |
| Millet | 0.90 | - |
| Sorghum | 1.92 | - |
| Yam | 1.28 | 0.41 |
| Soya Bean | 1.00 | - |
| Groundnut | 0.79 | - |
| Cowpea | 1.13 | - |
| Rice | 1.10 | - |
| Maize/Sorghum | 1.36 | - |
| Maize/Cowpea | 1.25 | - |
| Maize/Yam | 1.05 | - |
| Maize/Millet | 1.50 | - |
| Maize/Groundnut | 2.00 | - |
| Maize/Soya Bean | 1.40 | - |
| Melon/Sorghum | 1.00 | 2.60 |

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| | | |
|---|---|---|
| Melon/Millet | 1.00 | 0.38 |
| Millet/Groundnut | 0.63 | - |
| Millet/Sorghum | 1.33 | - |
| Sorghum/SoyBean | 2.00 | - |
| Sorghum/Groundnut | 0.83 | - |
| Sorghum/Yam | 1.00 | - |
| Yam/Cowpea | 1.50 | - |
| Maize/Sorghum/Cowpea | 1.57 | - |

Source: Field survey (2016)

**Table 2: Existing and optimum plan of crop/livestock/fishery enterprise in hectares**

| Farm activity | Existing plan | Optimum plan |
|---|---|---|
| Maize | 1.00 | - |
| Yam | 1.00 | - |
| Groundnut | 1.00 | - |
| Maize/Cowpea | 1.00 | - |
| Yam/cowpea | 1.00 | 1.96 |
| Maize/sorghum/cowpea | 2.00 | - |
| Fish | 365.83 | - |
| Livestock | 2.13 | 5.83 |

**Source:** Field survey (2016)

**Table 3: Existing and optimum plan of crop/ fishery enterprise (hectares)**

| Farm activity | Existing plan | Optimum plan |
|---|---|---|
| Maize | 0.75 | - |
| Rice | 0.5 | - |
| Maize/Cowpea | 1.00 | 0.33 |
| Maize/Melon | 1.00 | 1.17 |
| Maize/Groundnut | 0.20 | - |
| Fish | 395.45 | 0.22 |

Source: Field survey (2016)

**Table 4: Gross margin for existing and optimum plans**

| Enterprise | Existing Plan | Optimum Plan | Difference | % Difference |
|---|---|---|---|---|
| Crop | 194,556.00 | 401,459.30 | 206,903.30 | 106.35 |
| Crop/livestock/fishery | 192,466.60 | 234,034.80 | 41,568.20 | 21.60 |
| Crop/fishery | 95,773.83 | 195,683.60 | 99,909.77 | 104.32 |

Source: Field survey (2016)

**Shadow price of excluded activities from the optimum plans**

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. 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

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indicated in Tables 5, 6 and 7. The summary of the results in the Tables show that for crop farmers 21 cropping activities were excluded from their existing plan with Sorghum/groundnut having the least shadow prices of ₦36,388.66, Crop/livestock/fishery farmers had maize/sorghum/cowpea with the least shadow price out of the 4 excluded cropping activities, fish production was also excluded with a shadow price of ₦457.33 while the crop/fishery enterprise three activities excluded from its existing plan. The implication however as explained by Reddy and Ram (2005) is that the higher the value of the shadow price of an excluded activity the lower its chances of being included in the optimum plan and vise visa, hence those activities indicated with the lowest shadow prices have more chance to be included in their respective Optimum plans.

**Marginal Value Product of resource in the optimum plans**

The Marginal Value Products (MVP) are also known as shadow prices or income penalty in relation to the resources used. A shadow price of any particular resource when greater than zero implies a shortage in supply of the resource relative to its demand. If the MVP of a resource is zero, it then 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).

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

| Excluded activities | Shadow price (₦) |
|---|---|
| Maize | 111,676.70 |
| Melon | 40,636.20 |
| Millet | 286,686.30 |
| Sorghum | 165,685.30 |
| Soya Bean | 156,719.30 |
| Groundnut | 88,867.20 |
| Cowpea | 898,127.00 |
| Rice | 115,875.70 |
| Maize/Sorghum | 231,677.60 |
| Maize/Cowpea | 187,170.40 |
| Maize/Yam | 77,148.30 |
| Maize/Millet | 69,344.95 |
| Maize/Groundnut | 90,035.34 |
| Maize/Soya Bean | 162,787.20 |
| Millet/Groundnut | 79,968.08 |
| Millet/Sorghum | 128,102.60 |
| Sorghum/Groundnut | 36,388.66 |
| Sorghum/soybean | 81,437.27 |
| Sorghum/Yam | 193,094.80 |
| Yam/Cowpea | 546,146.80 |
| Maize/Sorghum/Cowpea | 476,339.10 |

Source: Field survey (2016)

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**Table 6: Shadow prices of excluded activities from the optimum plan for crop/livestock/fishery enterprise**

| Excluded activities | Shadow price (₦) |
|---|---|
| Maize | 178,525.00 |
| Yam | 113,725.00 |
| Groundnut | 63,080.00 |
| Maize/Cowpea | 135,550.00 |
| Maize/Sorghum/Cowpea | 50,530.00 |
| Fish | 457.33 |

**Source:** Field survey (2016)

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

| Excluded activities | Shadow price (₦) |
|---|---|
| Maize | 162,347.80 |
| Rice | 24,200.00 |
| Maize/Groundnut | 65,200.00 |

**Source**: Field survey (2016)

**Marginal value product of resources used**

The results as presented in Tables 8, 9 and 10 show by how much the value of the programme will change if the available resource with excess supply is being increased by one unit for each of the enterprise combination. However, the crop enterprise had labour for second weeding, bullock and machine labour; and fertilizer in excess supply. The labour used for second weeding, feeding and cleaning as well as machine labour and capital were found to be the limiting resources in the crop/livestock/fishery enterprise while labour requirement for weeding and harvesting were in shortage alongside fertilizer and capital for the crop/fishery enterprise. This implies that all surplus resources were non-limiting in achieving maximum profit in the study area and therefore to maximize gross margin such resources should not be in further use for the production activities. The finding was in consonant that of Sulaiman *et al*. (2021) who reported that inefficiency is a product of improper utilization of inputs.

**Table 8: Marginal value product of resources used by crop enterprise in Naira**

| Resources | Shadow prices | Surplus |
|---|---|---|
| Land | 13,187.81 | 0.00 |
| Labour (Land preparation) | 750.00 | 0.00 |
| Labour (Planting) | 500.00 | 0.00 |
| Labour (1st Weeding) | 750.00 | 0.00 |
| Labour (2nd Weeding) | 0.00 | 6.68 |
| Labour (harvesting) | 500.00 | 0.00 |
| Bullock Labour | 0.00 | 0.71 |
| Machine Labour | 0.00 | 4.22 |
| Seed | 74.69 | 0.00 |
| Agrochemical | 21,339.86 | 0.00 |
| Fertilizer | 0.00 | 195.34 |
| Borrowed | 0.10 | 0.00 |

Source: Field survey (2016)

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**Table 9: Marginal value product of resources used by crop/livestock/fishery enterprise in Naira**

| Resource | Shadow price | Surplus |
|---|---|---|
| Land | 0.00 | 1.54 |
| Livestock | 0.00 | 9.56 |
| Fish | 0.00 | 983.00 |
| Labour (Land Preparation) | 0.00 | 1.83 |
| Labour (Planting) | 0.00 | 2.79 |
| Labour (1st weeding) | 0.00 | 0.86 |
| Labour (2nd weeding) | 750.00 | 0.00 |
| Labour (harvesting) | 0.00 | 2.93 |
| Labour (Pond preparation) | 0.00 | 3.15 |
| Labour(feeding) | 250.00 | 0.00 |
| Labour(cleaning) | 250.00 | 0.00 |
| Bullock Labour | 0.00 | 1.50 |
| Machine Labour | 5,500.00 | 0.00 |
| Feed | 0.00 | 27,238.52 |
| Seed | 0.00 | 1,027.88 |
| Agrochemical | 0.00 | 279.54 |
| Fertilizer | 0.00 | 39.38 |
| Capital Borrowed | 0.10 | 0.00 |

Source: Field survey (2016)

**Table 10: Marginal value product of resources used in crop/fishery enterprise**

| Resources | Shadow prices | Surplus |
|---|---|---|
| Land | 0.00 | 1.00 |
| Fish | 0.00 | 1,167.96 |
| Land preparation | 0.00 | 1.17 |
| Planting | 0.00 | 0.84 |
| 1st weeding | 750.00 | 0.00 |
| 2nd weeding | 750.00 | 0.00 |
| Harvesting | 499.98 | 0.00 |
| Pond preparation | 0.00 | 3.13 |
| Feeding | 0.00 | 1.72 |
| Bullock Labour | 0.00 | 0.03 |
| Feed | 0.00 | 139,125.80 |
| Seed | 0.00 | 1.17 |
| Agrochemical | 0.00 | 1.33 |
| Fertilizer | 1,154.00 | 0.00 |
| Capital Borrowed | 0.10 | 0.00 |

**Source:** Field survey (2016)

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## CONCLUSION AND RECOMMENDATIONS

This study has developed a prototype that prescribed specific enterprises combination that would generate maximum profit for the area under study. It was observed that crop mixture had greater prospect than the sole crops, also it was found that all enterprises combinations have the potentials to increase gross returns but, resources were not optimally allocated which could serve as hindrance to the attainment of optimum profit.

Farmers in the study area should adopt the optimum farm plans prescribed according to their enterprise combinations as this would enable them to make efficient use of their available resources, increase production and consequently their incomes. In addition, they should try to reduce the excessive use of those resources identified as surplus in this study and extend such resources to other areas that will generate additional income.

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