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OPTIMAL FARM PLANS FOR ARABLE CROP ENTERPRISES UNDER LIMITED RESOURCE CONDITION IN NIGER STATE, NIGERIA

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ABSTRACT

This study was designed to determine the optimal plan for arable crop farm enterprises in Niger State, Nigeria. Primary data were collected during the 2009 cropping season using multi-stage random sampling technique and used for the analysis. Linear Programming model was used for optimizing gross margins. The results revealed a considerable divergence between the existing and optimum plans. Farm resources were not optimally allocated and after optimization, gross margins could be increased. Cereal-legume cropping patterns showed dominance in both the existing and optimum plans. As a result of inter variation in resource management, the gross margins were higher in the optimal (₦87,322.89/ha) as compared to the existing plan (₦63,800.25/ha). The optimum plans prescribed more of cash-crop-based enterprises. The results suggested increasing farm sizes while the study recommends strong financial support, farm advisory services and adequate supply of modern inputs at fairly competitive prices to arable crop farmers in the study area.

Keywords: Optimum plans; Gross margins; Limited resource; Arable crops; Linear programming.

INTRODUCTION

Nigeria has a total land area estimated at about 98.3 million hectares out of which about 71.2 million hectares accounting for about 70% are cultivable while only about 34 million hectares accounting for one third of total land area are under cultivation (Onyenweaku *et al.*, 2008). Although the large population and the demand for food are obvious, taking advantage of the abundant arable land requires optimal allocation of the meagre resources at the disposal of the resource poor farmers who provide for the majority of the nation's food need and in this way restrain a repetition of the past experiences where the nation had to resort to massive food importation leading to rising food import bills (Adedipe *et al.*, 1999).

According to Ibrahim (2007), the study of farm management involves three successive stages: analysis of the present position of the farm business; interpretation of the

present position for indication of possible improvements; and preparation of an acceptable course of action for improvement of the farm business. Most farm management studies in Nigeria have been concerned with analysis of existing performance in the arithmetic fashion, usually of groups of sample farms selected under certain criteria. Some studies (Okezie and Okoye, 2006; Fasasi, 2006; Sanusi and Salimonu, 2006; Rahman *et al*., 2005), attempted production function analysis showing the marginal conditions of resource use with respect to production of individual or selected enterprises. Few others (such as Ayoola and Adedzwa 2006; Okezie and Ude, 2006) used budgeting techniques to evaluate economic benefits of alternative crop production systems. Such types of analysis do not specify what the optimum combination of enterprises under given restraining conditions would be. Expansion of such enterprises may also be constrained by physical, economic, social and environmental constraints (Alam, 1994; Alam *et al*., 1995; Schipper *et al*., 1995; Stonehouse, 1996; Sama, 1997; Adejobi *et al*., 2003; Alford *et al*., 2004). In addition, such studies are only descriptive and very partial in nature by addressing only the existing aspect in the organization and operation of the crop farm enterprises. Farmers' profit cannot be maximized without optimum cropping patterns, which ensure efficient utilization of available resources. The use of Linear Programming makes it possible to devise equilibrium solution, which include the specification of products levels as well as factor and product prices (Hassan *et al*., 2005). It is therefore imperative to use the techniques of mathematical programming and the methods of budgeting in the planning process of the farm.

Developing optimum farm plan for small-holder farmers could lead to the resolution of the food crises given that the Nigerian farmer does not seem to exploit fully the opportunities for capital formation, improved resource base, higher productivity, innovation and improved management techniques (Olayemi, 1980). The farmer is faced with the challenge of rationing his scarce resources among intended activities as well as optimizing the result of the rationing (Olayemi and Onyenweaku, 1999). This requires the choice of appropriate mix of crop activities to achieve a well defined technical relationship between inputs and outputs (Sama, 1997). This therefore creates an allocation problem. Up to now, little attention has been devoted to the role of farm planning in the resolution of the food crisis and raising income earnings of smallholder farmers. Formulating optimum farm plans for small holder farmers could lead to the resolution of the food crisis and consequently improve the living standards of small holder farmers. The need to provide such suitable farm plans and education on the importance of the efficient use of scarce land and other resources taking into cognizance other motives of production imposed on the farmers by their socio-economic and cultural environment is obvious. Agricultural production planning apart from shedding light on efficient utilization of resources in the farm, makes possible the charting of those courses of action for attaining maximum net returns. Identifying the best farm plan is a difficult task for any farmer, but it is especially difficult for small scale farmers with little or no formal education. Thus, if agricultural policy is to be relevant and to raise the income levels and subsequently the living standards of the many small-scale farmers who produce the bulk of the food consumed in the country, optimum farm plans must be formulated for them by region or locality. These plans could also help policy-makers predict farmers' responses to policy alternatives thereby sharpening the policy decision-making process. Studies in optimum resource allocation in a regional framework using the linear programming approach have been attempted in many countries (Tajuddin, *et al*., 1994, Alam, 1994; Schipper *et al*., 1995; Alam *et al*., 1995;

Sama, 1997; Dipeolu *et al*., 2000; Adejobi *et al*., 2003 Tanko, 2004, Hassan, 2004; Hassan *et al*., 2005; Shahidullah, *et al*., 2006).

This study is an attempt to determine the optimal farm plans for arable crop enterprises under limited resource condition in the study area.

MATERIALS AND METHODS

Study Area

The study area is Niger State of Nigeria. The State is located in North-central Nigeria 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 and a population of 4,082,558 people (Wikipedia, 2008). Agriculture is the predominant source of livelihood; 80% to 90% of the population reside in farm households. Mixed farming is widely practiced. The animals provide energy for ploughing, while their droppings are used for manuring the soil. Thus, the animals aid in mechanization and encourage intensification of land use. The State is well suited for production of a wide variety of crops such as yam, cassava, maize, millet, rice, cowpea, tomato, etc because of the favourable climatic condition. The annual rainfall is between 1100 and 1600mm with average monthly temperature ranging from 23˚C to 37˚C (NSADP, 1994). The vegetation consists mainly of short grasses, shrubs and scattered trees. The State covers a land area of 80,000 square kilometers or 8 million hectares constituting 8 percent of the total land area of the country. About six million hectares, representing 85% of the total land area is arable. (NSADP, 1994).

Sampling Technique

The sampling frame for this study comprised of all the arable crop farmers in Niger State. Primary data were used for analysis. Respondents were chosen using multi-stage random sampling technique. The three Agricultural Development Project (ADP) Zones in the State, namely, Bida, Kontagora and Kuta were considered for the study. The first stage involved random selection of two LGA's each from the ADP zones as follows: Lavun and Bida were randomly chosen from Bida Zone, Mariga and Kontagora from Kontagora Zone, as well as Shiroro and Paiko from Kuta Zone. In the second stage, two villages were selected randomly from each of the LGA's giving a total of twelve (12) villages. The third stage involved random selection of thirty five (35) farm households from each of the villages bringing the total sample size to 420 respondents. Structured questionnaire was used to elicit relevant information from respondents. Extension Officers resident in each of the locations and trained enumerators assisted the researchers in data collection. The limited cost-route approach of data collection was used in data collection. Data collection lasted for five months (i.e., August-December, 2009).

Data collected for this study include input information such as farm size in hectares, human labour input in man days, animal traction input in cattle days, tractor hiring in number of hours utilized, quantity of fertilizers in kilogrammes, cost of agrochemicals in naira, depreciation on farm tools and equipment etc., production input and output prices, socio-economic characteristics of farmers such as years of schooling, farming experience, age, household size, etc. as well as output information.

The Empirical Model

The objective function is to maximize total gross margin of producing the crops less costs of hired human labour, bullock labour, hired tractor/power tiller, capital borrowing and marketing. The model is similar to the one adopted by Ibrahim (2007), but refined to aid in the attainment of the study objective. The linear programming model is specified as follows:

$$\text{Maximize } Z = \sum_{j=1}^{n} P_j X_j - \sum_{t=1}^{n} WhL_t - \sum_{t=1}^{n} WbK_t - \sum_{t=1}^{n} WdR_t - \sum_{k=1}^{n} P_k Y_k - \sum_{t=1}^{n} rM_t - \sum_{t=1}^{n} Oc_t \quad \text{---} \quad (1)$$

(Objective function)

Subject to:

$$\sum_{j=1}^{n} {}_{1js} X_j \leq L_{s\ (s=1,2)} \quad \text{---} \quad (2) \text{ (Land restriction)}$$

$$\sum_{j=1}^{n} a_{ij} X_j \leq a_i \quad \text{---} \quad (3) \text{ (Human labour restriction)}$$

$$\sum_{j=1}^{n} b_{ij} X_j \leq b_i \quad \text{---} \quad (4) \text{ (Bullock labour restriction)}$$

$$\sum_{j=1}^{n} c_{ij} X_{jt} \leq c_i \quad \text{---} \quad (5) \text{ (Tractor hiring restriction)}$$

$$\sum_{j=1}^{n} d_{ij} X_j \leq d_i \quad \text{---} \quad (6) \text{ (Capital restriction)}$$

and $X_j, a_i, b_i, c_i, d_i \geq 0$ --- (7) (Non-negativity of decision variables)

Where; Z= Total gross margin of the farm in Naira; C_j = Gross value of output per hectare of the j^{th} crop activity in Naira; X_j=Unit of the j^{th} crop activity in hectares; Wh = Wage rate per unit of hired human labour in Naira; L_t = Number of hired human labour in t^{th} period; Wb = Wage rate per unit of bullock labour in Naira; K_t = Number of hired bullock labour in t^{th} period; Wd = Wage rate per unit of tractor/power tiller; R_t = Tractor/power tiller hired in t^{th} period; P_k = Marketing expense per unit of the product sold in t^{th} period; Y_k= Units of crop products sold in t^{th} period; r = Rate of interest for six months; M_t = Capital borrowed in Naira in t^{th} period; L_s=Total available land in hectares for the crops with (s) restrictions; Oc_t = Other costs (such as fertilizer, agrochemicals, improved seeds, e.t.c); a_{ij} = Input coefficient of human labour (in mandays) for j^{th} crop activity in t^{th} period. b_{ij}=Input coefficient of bullock labour for j^{th} crop activity in t^{th} period; c_{ij}= Input coefficient of tractor hiring used in producing one hectare of j^{th} crop activity in t^{th} period; d_{ij}= Input coefficient of capital used in producing one hectare of j^{th} crop activity in t^{th} period and $\sum$ = Summation of j^{th} crop activities (j =1 to n).

Activities in the model and the price co-efficient "P_j"

The activities in the models can broadly be grouped into crop production activities, labour (human, bullock, tractor) hiring activities, capital borrowing and product selling activities. The crop production activities are broadly grouped into sole crops and crop mixtures. For each of the crop production activities the unit of activity is one hectare. The price coefficient "Pj" of a production activity in the model is the gross margin per hectare (total revenue less total variable costs of production). For a human labour hiring activity, the price coefficient is the ruling wage rate (naira per man day). The price coefficient of a bullock labour hiring activity is the wage rate per cattle day in naira. The price coefficient of a tractor hiring activity is the wage rate per hour of tractor hiring. For a capital borrowing activity, the price coefficient is the prevailing market rate of interest, while for a selling activity, the price coefficient is the marketing expense per unit of the product sold. The selling activity facilitates the sale of the final output realized from the various cropping activities. Each production activity may have more than one selling activity depending on whether such activity is sole or mixed. Transfer activities (rows) provide a vehicle whereby the services or output of one activity may be transferred in the model to another activity. Hence, to ensure fuller utilization of capital and labour, capital and labour transfer activities were incorporated in the model. They ensure the transfer of capital and labour from one period to another period provided it is profitable.

Input coefficients

The input coefficients refer to the requirement of a crop activity in respect of the inputs of the different resources measured on per hectare basis (unit of land). The input coefficients for all the crop activities were calculated on the basis of the actual quantities of different resources used for those crop activities. For instance, the input-output coefficient for human labour are denoted by ajt's and they refer to the amount of human labour in man days used in producing a hectare of the j^{th} crop activity in t^{th} period. The input-output coefficients (aij's) are the averages for all the farmers in each category.

Resource restrictions in the Model

Five restrictions were incorporated in the model. These are: Land (with two restrictions, namely highland and lowland); human labour (with five restriction periods, namely: land preparation, planting, first weeding, second weeding and harvesting); bullock labour (with two restriction periods of first weeding and second weeding respectively); tractor hiring (three restriction periods of May, June and July) and capital (with three restriction periods, namely: April-June, July-September and October-December).

RESULTS AND DISCUSSION

Socioeconomic Profile of Respondents

A summary of the statistics of farmers in the study area is presented in Table 1.

Table1. Summary of descriptive statistics of socioeconomic characteristics of the respondents

Variable	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	27.00	67.00	43.63	9.89	97.96
Household size	3.00	14.00	9.18	2.64	6.97
Farm size	0.01	4.00	0.98	1.00	1.00
Education	0.00	12.00	6.18	4.05	16.48
Labour	35.00	220.00	99.66	31.91	1018.74
Experience	10.00	35.00	24.01	5.39	29.15
Ext. Contact	1.00	3.00	2.02	0.77	0.60

Source: Field survey, 2009.

The results (Table 1) show that a typical farmer sampled is about 44 years old, married, had nine family members, had attained at least primary level of education and cultivated 0.98 hectares of land. A typical farm household head had 24 years of experience in farming and had at least two contacts with an extension agent during the 2009 cropping season. A typical respondent with access to credit received at least ₦12,000.00 as agricultural loan. The preponderance of experienced farmers in the state will fast track the decision making process. Previous experience enables the farmer set realistic time and cost targets by identifying production risks and constraints with ease. A large family size provides a ready source of cheap family labour. Small holder farmers over rely on meagre household resources and would strive to ensure minimum usage of paid labour as a result of the paucity and dearth of resources (Tanko and Mbanasor, 2006). Education plays a crucial role in technology dissemination and adoption. The ability of the farmer to cope with complexities of new innovations, the intricacies of the product and factor markets increases as the level of education increases. Smallness of cultivated land is a common feature in small holder agriculture. Farmers usually own several plots devoted to crops in scattered locations.

Yields and Value of Output

The averages of yield figures per hectare, value of output per hectare and farm prices of the various commodities in the different locations of the study area are presented in Table 2. The results indicate that crops grown in mixtures gave lower yields as compared to those in sole stands. The reasons are obvious. Firstly, there is competition among crops for space, light and nutrients in mixed stands and secondly, population densities of individual crops are lowered generally when planted as mixtures than as sole stands. However, despite the low yields from mixed stands, the gross returns per hectare from multiple cropping are higher than those from sole crops, because the low yields may be off-set by the yields of other crops present in the mixture. Intercropping can thus be rationalized on the basis of higher gross returns per hectare and per unit input of labour, higher profitability and considerable biological inputs into the soil especially by leguminous crops from which other crops gain (Tanko and Mbanasor, 2006).

Table 2: Yield per hectare, value of output per hectare and farm prices of some selected arable crops in Niger State, Nigeria

Arable Crop Enterprises	Average Yield Per Hectare (tons) (1)	Price/kg in(₦)	Price/ton in ₦ (2)	Average Value of Output/Ha (tons) (1)x(2)
1. Maize	1.870	52.73	52,730	96,605.10
2. Cowpea	0.682	98.17	98,170	66,951.94
3. Sorghum	0.812	47.05	47,050	38,204.60
4. Groundnut	0.828	62.00	62,000	51,336.00
5. Rice	1.564	42.58	42,580	66,595.12
6. Yam	1.978	109.46	109,460	216,511.88
7. Melon	0.453	85.43	85,430	38,699.79
8. Sweet potato	1.501	95.45	95,450	143,270.45
9.Cassava	1.993	67.85	67,850	135,225.05
10.Maize/Cowpea				
Maize	1.370	52.73	52,730	72,240.10
Cowpea	0.382	98.17	98,170	37,500.94
11.Maize/Groundnut				
Maize	1.370	52.73	52,730	72,240.10
Groundnut	0.620	62.00	62,000	38,440.00
12.Maize/Sorghum				
Maize	1.376	52.73	52,730	72,556.48
Sorghum	0.618	47.05	47,050	29,076.90
13.Maize/Groundnut/Cowpea				
Maize	1.276	52.73	52,730	67,283.48
Groundnut	0.528	62.00	62,000	32,736.00
Cowpea	0.484	98.17	98,170	47,514.28
14.Sorghum/Maize/Cowpea	0.412	47.05	47,050	19,384.60
Sorghum	1.170	52.73	52,730	61,694.10
Maize	0.482	98.17	98,170	47,317.94
Cowpea				
15.Millet/Cowpea				
Millet	1.438	44.97	44,970	64,666.86
Cowpea	0.480	98.17	98,170	47,121.60
16.Yam/Maize				
Yam	1.628	109.46	109,460	178,200.88
Maize	1.076	52.73	52,730	56,737.48
17.Sorghum/Cowpea				
Sorghum	0.812	47.05	47,050	38,204.60
Cowpea	0.480	98.17	98,170	47,121.60
18.Melon/Okra				
Melon	0.453	85.43	85,430	38,699.79
Okra	0.336	100.42	100,420	33,741.12
19.Sorghum/Cowpea/Groundn				

Sorghum	0.614	47.05	47,050	28,888.70
Cowpea	0.382	98.17	98,170	37,500.94
Groundnut	0.620	62.00	62,000	38,440.00
20.Sorghum/Groundnut				
Sorghum	0.619	47.05	47,050	29,123.95
Groundnut	0.728	62.00	62,000	45,136.00

Source: Computed from Field Survey Data, 2009.

Average Gross Margin

The gross margins for the existing and optimum plans for a representative farmer under different capital situations are presented in Table 3.

Table 3: Gross margins per hectare realized by farmers in the borrowed and limited capital situations

Gross margin/ha Existing plan(₦)	Gross margin/ha Optimum plans(₦)	Increase over existing plan(₦)	% increase over existing plan
63,800.25	87,322.89	23,522.64	26.94

Source: Field survey data, 2009.

Results (Table 3) indicate that optimum plans resulted in an increase in gross margins over the existing plan by 26.94%. Marked disparity in gross incomes was witnessed in the farms. This was occasioned by disparity in resource endowment, technical and managerial competencies. Similarly, Bajwa (1978) also found that optimal cropping pattern solution increased income by 2.2% as compared to the existing plan for small farmers in Punjab, Pakistan, India. Further lending credence to this finding, Nadda (1978) applied linear programming technique in the Himachal, Pradesh, India. The model suggested that by growing fewer crops, income would increase as compared to crop diversification followed under the existing situation.

Farm Resource Allocation

The existing land use in terms of hectarage allocation for the various basic activities are presented in Table 4. The most predominant cropping pattern was Maize/Groundnut which accounted for about 11.21% of total cropped area in the highland situation. The next important cropping pattern was Maize/Groundnut/Cowpea which occupied 9.46% of total cropped area. The cropping patterns adopted by the farmers is indicative of their resource endowment. The patterns tended more towards commercial/cash crop production. Cereal-legume based cropping enterprises dominated the farming systems. Mixed cropping is founded on sound biological principles.

The results after optimization in Table 4 show that melon/okra was the most dominant cropping pattern in the highland situation which occupied about 67.70% of total cropped area. The next cropping pattern prescribed by the optimum plan was sorghum/cowpea/groundnut under the highland situation which accounted for about 24.70% of total cropped area. A third crop enterprise, namely, maize/cowpea occupying

7.60% of total cropped area under highland situation was included in the optimized plan. The optimum plans also devoted the total cropped area to mixed cropping enterprises. For while in the existing plan farmers devoted about 35.18% of total cropped area to sole crop enterprises, none was prescribed by the optimum plans.

Generally, the optimum plans prescribed fewer crops as compared to the existing plan. This finding is similar to the finding of Hassan *et al* (2005). They applied the linear programming technique in the Punjab region, India and found that overall, crop acreage in the optimal solution decreased by 0.37% as compared to the existing acreage. A similar study conducted by Tanko (2004) in Kebbi State, Nigeria, also indicated a divergence between the optimal and existing plans. Under the existing technology, crop mixtures were found to be in better competitive position as compared to sole crop enterprises.

Table 4: Existing and optimum cropping patterns under borrowed and limited capital situations in Niger State, Nigeria

Cropping patterns	Existing plan	Optimum plans
1. Maize (HL)	0.95	0.00
	(6.66)	
2. Cowpea (HL)	0.62	0.00
	(4.34)	
3. Sorghum (LL)	0.87	0.00
	(6.10)	
4. Groundnut (HL)	0.99	0.00
	(6.94)	
5. Rice (LL)	0.45	0.00
	(3.15)	
6. Yam (HL)	0.80	0.00
	(5.61)	
7. Melon (LL)	0.28	0.00
	(1.96)	
8. Sweet potato (LL)	0.00	0.00
9.Cassava (LL)	0.06	0.00
	(0.42)	
10.Maize/Cowpea (HL)	0.89	0.32
	(6.24)	(7.60)
11. Maize/Groundnut (HL)	1.60	0.00
	(11.21)	
12. Maize/Sorghum (HL)	0.34	0.00
	(2.38)	
13.Maize/Groundnut/Cowpea (HL)	1.35	0.00
	(9.46)	
14.Sorghum/Maize/Cowpea (HL)	0.91	0.00
	(6.38)	
15.Millet/Cowpea (HL)	0.67	0.00
	(4.70)	

16.Yam/Maize (HL)	0.70 (4.91)	0.00
17.Sorghum/Cowpea (LL)	1.01 (7.08)	0.00
18.Melon/Okra (HL)	0.04 (0.28)	2.85 (67.70)
19.Sorghum/Cowpea/Groundn (HL)	0.90 (6.31)	1.04 (24.70)
20.Sorghum/Groundnut (HL)	0.84 (5.89)	0.00
Total cropped area	14.27 (100.00)	4.21 (100.00)
% Sole crops	35.18	0.00
% Crop mixtures	64.82	100.00

Source: Computed from field survey data, 2009; Figures in parentheses are the respective percentages.

A summary of activities included in the optimum plan is presented in Table 5. The results show that three crop enterprises, namely Maize/Cowpea(0.32ha), Melon/Okra(2.85ha) and Sorghum/Cowpea/Groundnut(1.04ha). This finding further justifies the smallholder farmers' insistence on mixed as against sole cropping enterprises. Mixed cropping is justified on the basis of higher gross returns per hectare, hedging against crop failure and considerable input into the soil nutrient status by crops in the mixture. Other activities included are capital borrowing and selling activities for Maize, Cowpea, Sorghum, Groundnut, Melon and Okra. The maximum gross margin attainable by a typical farmer in the sample location is ₦87,322.89.

Table 5: Summary of activities included in the optimum plan

No.	Activity name	Unit of activity	Optimal value/Activity levels
1.	Maize/Cowpea	Hectares	0.32
2.	Melon/Okra	Hectares	2.85
3.	Sorghum/Cowpea/Groundnut	Hectares	1.04
4.	Capital Borrowing	Naira	1,823.50
5.	Maize selling	Naira	606.80
6.	Cowpea selling	Naira	113,877.20
7.	Sorghum selling	Naira	49,160.59
8.	Groundnut selling	Naira	64,781.22
9.	Melon selling	Naira	243,475.50
10.	Okra selling	Naira	297,759.50
	Max. Objective		₦87,322.89

Source: Computed from field survey data, 2009.

The resource use levels in the optimized plan are presented in Table 6. The results indicated that only the two classes of land, namely, highland and lowland with shadow prices of ₦10,142.69 and ₦13,840.71 respectively posed as factors limiting the attainment

of the objective function. The results indicated that land acted as a constraint to production. Other resources were in surplus supply. This is similar to Alam *et al*.(1995) who also found that land acted as a constraint in crop production in Bangladesh. Results (Table 6) further indicated the status of the resources utilized either as loose (non-limiting) or tight (limiting) respectively.

Table 6: Resource use level in the optimized plan

No	Constraints	Status	Original value	Shadow price	Slack or surplus
1.	Human Labour (Land preparation)	Loose	175.00	0.00	75.77
2.	Human Labour (Planting)	Loose	162.00	0.00	55.34
3.	Human Labour (First weeding)	Loose	186.00	0.00	29.54
4.	Human Labour (Second weeding)	Loose	180.00	0.00	75.74
5.	Human Labour (Harvesting)	Loose	150.00	0.00	42.59
6.	Land I (Highland)	Tight	1.16	10,142.69	0.00
7.	Land II (Lowland)	Tight	2.85	13,840.71	0.00
8.	Bullock labour	Loose	21.00	0.00	14.16
9.	Tractor Hiring	Loose	8.50	0.00	8.50
10.	Transfer row maize	Loose	0.00	0.00	0.00
11.	Transfer row cowpea	Tight	0.00	0.05	0.00
12.	Transfer row sorghum	Tight	0.00	0.10	0.00
13.	Transfer row groundnut	Tight	0.00	0.05	0.00
14.	Transfer row millet	Tight	0.00	0.06	0.00
15.	Transfer row rice	Tight	0.00	0.05	0.00
16.	Transfer row yam	Tight	0.00	0.07	0.00
17.	Transfer row melon	Tight	0.00	0.11	0.00
18.	Transfer row potato	Tight	0.00	0.09	0.00
19.	Transfer row cassava	Tight	0.00	0.10	0.00
20.	Transfer row okra	Tight	0.00	0.07	0.00

Source: Computed from field survey data, 2009.

Results of Sensitivity Analysis

The emerging farm plans were subjected to sensitivity analysis to observe the sensitivity of the optimum plans to changes in a predetermined variable, namely, cultivated land area by a typical respondent was increased by one hectare, that is from 1.16ha to 2.16ha in the programming matrix. The results are presented in Table 7.

Table 7: Comparison of the optimum gross margins when land was increased by one hectare for each of the two classes of land

Optimumgross margin from plans I(₦)	Optimum gross margins from present plan (₦)	Increase in farm income (₦)	Percentage Change
87,322.89	99,343.02	12,020.13	13.77

Source: Field survey, 2009.

Increasing the area under cultivation resulted in the following cropping enterprises namely, millet/cowpea (0.028ha), melon/okra (3.094 ha) and sorghum/cowpea/groundnut (0.728ha) being included in the optimum plan. This is an improvement over plan I whereby total land allocated to crops was lower on a comparative basis suggesting that prospects abound if cultivated land is increased. Results in Table 7 also show that optimum gross margin increased from ₦87,322.89 to ₦99,343.02, representing an increase of 13.77% over the initial plan (plan I). Large farm sizes coupled with efficient utilization of resources and appropriate management practices should translate into increased outputs and/or farm income.

CONCLUSION

This study has shown that given the existing level of technology, farm resources were not optimally allocated. Furthermore, cereal-based cropping enterprises laced with legumes showed dominance in both the existing and optimum plans. The observed differences in gross margin of investigated farms was mainly attributable to optimization. Under the existing level of technology and resource availability, crop mixtures were in a better competitive position than sole crops. Gauging the sensitivity of the plans to increase in land under cultivation indicated that agricultural land acted as a constraint to production. This is likely to hamper production activities of farmers.

Based on the findings of this research, certain policy instruments and their implications are identifiable. The existing land use pattern was found to be sub-optimal, thereby suggesting more scope for farm management. The prototype combinations of enterprises could be found useful in the extension education package of Niger State Agricutural Development Project (ADP) and the Niger State Fadama Coordination Office (NSFCO). Effective extension programmes and farm advisory services that will educate the farmers on efficient allocation of resources should be further strengthened. This has the propensity to improve the livelihoods of the smallholder farmer, curb the incidences of widespread hunger, unemployment and poverty. The optimum combination of enterprises, in addition to increasing gross margins were also capital intensive as capital investments were observed even at higher rates of interest. Adequate supply of agricultural credit, modern production inputs at fairly competitive prices should be made available to practicing farmers. Results also show that increasing the area under cultivation resulted in increase in gross margins. This suggests that more arable land should be employed in crop production. There is need to give special attention to minor crops in developing improved varieties with higher profitability, dissemination of technology to the farmers and improvement in the post harvest processing and utilization. For the goals of food security, increased income and reduced farm production costs, farmers should allocate farm resources as prescribed by the plans.

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