Management Decision Options in Allocating Crop Farming Households' Resources in the Drier Savannah Zone of Nigeria: A Multi-Objective Programming Approach

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Abstract
The most daunting management task facing the household is the decision on how to efficiently allocate its limited resources among its multiple production goals, which are conflicting. This paper developed an optimal enterprise management option that would ensure efficient utilization of household's scarce resources to meet its production goals of food security, adequate income, and minimum expenditure on labour. Using multistage sampling technique, 400 households were randomly selected and household production and other socio-economic data were analyzed using Goal Programming (GP) model. The GP results revealed that only 4 of the 18 basic cropping activities identified entered the program. The activities and their hectarage allocations in order of importance were Millet/Maize/Rice (1.20 ha), Maize/Guinea corn/Cowpea (0.94 ha), Millet/Cowpea (0.16 ha), and Maize/Cowpea/Millet (0.04 ha). An important feature of this management option was that cereal-based mixed cropping had a relatively more significant effect on household needs for food, income, and reduced expenditure on labour than any other activity in the programme. This option would utilize a minimum cost of ₦6485.2 ha^{-1} to meet more than 75% of household production goals. Furthermore, land and hired labour were not limited resources. It is recommended that for the goals of food security, increased income, and reduced farm production costs to be achieved by households in the study area, farming households should practice appropriate cereal-based crop enterprise combination.

Key words: Management option, Resources, Crop enterprise, Farming household.

INTRODUCTION

In the normal traditional household setting of Africans, the most daunting management task facing the household as exemplified by its head is the decision on how to efficiently allocate its limited resources among its multiple production(objectives) goals, which

are often conflicting. In most cases, the households usually have limited resources to meet their most common production goals (objectives) of food security, adequate income, and minimum expenditure on labour (Aromolaran, 1992).

Over the years, there have been arguments on the assumption of profit maximization as the sole or overriding objective of the small farmer. It has been argued that the traditional farm is better viewed as a component of the farm household economic system, consisting of both the farm family and the farm-firm, in contrast to its being an independent economic unit. The farming system is embedded in the household economy, which integrates both production and consumption and it is shaped by the multiple goals that are operative in the system (Norman *et. al.*, 1982).

This has given rise to multiple-objective decision models, which incorporate more than the traditional profit maximization objective. Mathematical programming models are widely used for this purpose. In many real life situations, a decision maker is often faced with the problem of attaining a set of objectives within the limits of the constraints imposed by the stock of available resources, production processes and the exogenous environment. This type of problem is known as a multi-objective or multiple-criteria problem. The ability of the household to be able to make an appropriate decision on how to efficiently utilize its resources affects it in all economic ramifications in terms of poverty reduction and social welfare. To this end, this study developed a management option that ensures optimal household production systems that will meet household conflicting objectives of poverty reduction, food sufficiency and minimal expenses on labour. This will assist in improving the welfare of the household vis-à-vis reducing wastages in the use of its resources.

Conceptual Framework

Over the years there has been the difficulty of getting a consensus definition of household. Aside from this theoretical question of defining household, the practical problem exists that household composition and structure are highly variable over time. To circumvent this theoretical bottleneck, the study adopted the definition based on the United Nations framework, in which Scoones (2000) defined household as an institution based on arrangements by persons, individuals or groups for living together. A household could be

viewed as a unit or groups eating from the same pot, even though some members may not be related, as distinct from the family, members of which are related.

The rural farming household is therefore viewed as a group of people living together and carrying out production and consumption activities together in a rural environment. For the purpose of this study, the farming household is assumed to maximize a utility function:

$U = f(X_a, X_m, X_l)$.....(1)

Where the commodities are own produced staples (X_a), a market-purchased good (X_m) and leisure (X_l). Utility is maximized subject to a cash income constraint:

$P_mX_m = P_a(Q-X_a) - w(L-F)$.....(2)

Where P_m and P_a are the prices of the market purchased commodities and the own produced staples, respectively. Q is the household output of the staples(such that $Q-X_a$ is its marketed surplus), w is the market wage, L is total labour (family and hired) input, and F is family labour input (such that if L-F, is positive, labour is hired and if negative, off farm labour is supplied) (Singh *et al.*, 1986).

The farming household also faces some other constraints. It cannot possibly allocate more time to leisure, on-farm production, or off-farm employment than to the total time available to the household:

$X_l + F = T$..... (3)

Where T is the total stock of household time. The household also faces a production constraint or production technology that depicts the relation between inputs and outputs:

$Q = Q(L, A)$.....(4)

Where A is the household fixed quantity of land. Here, various complexities that could arise from inclusion of other variable inputs such as fertilizer and pesticide have been ignored. It is also assumed that only one crop is being produced and that family labour and hired labour are perfect substitutes and can be added directly. In neoclassical economic theory, production is also assumed to be riskless. In addition, it is also assumed that the three prices in the model (P_a, P_m and w) are not affected by various actions of the household. That is, a household is assumed to be a price-taker in the three markets apart from income; these include land and time available for production. But these three constraints (i.e. income, land and time) can be collapsed into a single constraint. Substituting the production constraint for Q and the time constraint into the cash income constraints for F in equation 2, we have a single constraint of the form:

$P_mX_m + P_aX_a + wX_l - w.T = \Pi$ ...(5)

Where,

$\Pi = P_aQ(L, A) - wL$.....(6)
The expression in equation 6 is a measure of farm profits (Π). From equation 5, the left hand side shows the total household "expenditure" on three items (the market-purchased commodity, the household's purchase of its own output, and the household's purchase of its own time in the form of leisure). The right hand side is a development of Becker's concept of full income in which the value of the stock of time (wT) owned by the household is exclusively recorded. The extension for agricultural household includes a measure of farm profits (P_aQ-wL) with all labour valued at the market wage as a result of the assumption of price-taking behaviour of households in the labour market.

Equation (5) can therefore be written in another form:
$P_mX_m + P_aX_a + wX_l = Y^*$.....(7)
Where Y^* is the value of full income associated with the profit maximizing behaviour of the household. Maximizing utility subject to this new version of constraint requires a first order condition.

Since household members have to make choice among goals competing for limited resources, the concept of "livelihood security" becomes very important in the analysis of the household resources, production and exchange activities, poverty, basic needs, and consumption. Thus, equations 1 and 7 formed the basis for the study of rural farming households' management decision option in allocating resources reported in this study.

RESEARCH METHODOLOGY

Study Area

The study was carried out in Kebbi State in the north-western geo-political zone, Nigeria between February 2003 and October 2004. The area falls into the dry savannah ecological zone of Nigeria with an average annual rainfall of between 650mm and 1100mm. The vegetation largely comprises drought resistant grasses, legumes and shrubs. There are two distinct seasons, (the rainy and dry seasons) with the dry season being longer than the rainy season. Because of the long dry period, Fadama (a form of irrigation) is a prominent practice in the study area to supplement for rain-fed crop production. Also, the ecology supports livestock (particularly large and small ruminants) production in terms of the climate and the vegetation. The State is divided into four Agricultural Development Project zones namely Argungu, Bunza, Zuru and Yauri.

The commonly cultivated crops in the state include maize,

sorghum, millet, rice, cowpea, and fruits and vegetables. The area is famous for traditional arts and crafts, beads, swords and glass-ware, and it is the site of the famous Argungu Fishing Festival, one of the most popular tourist attractions in Nigeria.

Sampling Procedure

The sampling technique adopted in the study was multi-stage sampling technique. The first stage was the random selection of 10 Local Government Areas (LGAs) from all the four ADP zones. The number of LGAs selected from each of the zones was proportional to the total number of LGAs in each of the four ADP zones.

The second stage involved the random selection of 10 villages from each LGA to make a total of 100 villages sampled in the study area. In the third and final stage, 400 households were randomly selected from the villages earlier selected in proportion to their population. The essence of wide coverage of the villages and reduced number of households per village was to cover as much variations in household production characteristics as possible in the study area; because it was envisaged that there may not be much intra village variances compared with inter village variances.

Sources and Types of Data

Primary data were largely used in this study but a few secondary data were also collected. The primary data were collected from selected rural farming households through the use of pretested and structured questionnaires with the help of trained ADP enumerators. The data collected covered the socio-economic and demographic characteristics of farm households, agricultural production data and household consumption expenditure.

Socio-economic and demographic data collected included those on age and gender of heads of households, their marital status, household size, years of farming experience, occupational status of heads of households, educational level of heads of households, types and values of assets possessed (e.g. houses, vehicles, etc), sources of health care services, sources of water supply, sources of loan/credit facilities, and membership of cooperative societies.

Agricultural production data collected covered total farm size, number of farm sites operated, types of farm enterprises, farm expenses, quantities of commodities produced, quantities of own produced food consumed

and quantities marketed, access to farm inputs, farm labour utilization and so on (Adejobi, 2004).

Household consumption demand data collected included those on total household expenditure, food expenditure, non-food expenditure, quantities of various foods purchased and quantities of various foods consumed and quantities and values of various non-food goods and services purchased and consumed, such as furniture, clothing, footwear, transportation.

Secondary data for this study were mainly obtained from the Annual Reports of the Kebbi State Agricultural and Rural Development Agency (KARDA). Data were collected on the common objectives and ranking of house-holds' production goals, while population data were collected from the State's office of the National Population Commission (NPC).

Analytical Tool

The goal-programming (GP) model was used to determine the optimum combination of house-hold production activities that would take households out of food insecurity. The GP method minimizes deviations of actual values of objectives from their expected values, the weighted goal programming (WGP). The model is expressed as follows, following Njiti and Sharpe (1994)

$$\text{Minimize } Z = \sum_{i=1}^{n}\left(W_i^{+}d_i^{+} + W_i^{-}d_i^{-}\right) \quad \ldots\ldots 8$$

Subject to: $AX - Id^{+} + Id^{-}$ BX ($\leq$ = $\geq$) C $X_{ij} \geq 0$ (j = 1, 2, …, m) d_i^{+}, d_i^{-} ≤ 0 (i = 1, 2, …, n)

In which:

Z = objective function

W_i^{+}, W_i^{-} = the numerical differential weights assigned to the deviational variables d_i^{+}, d_i^{-} of goal i. d_i^{+}, d_i^{-} = the vectors (n.1) of the negative and positive deviations of goal i.

A = the (n.m) matrix which represents the relationship between the decision variable vector, X (m.1) and the goal vector, G (n.1). Practically, the decision variables vector represents inputs, which are transformed by matrix 'A' to produce desired outputs. I = the identity matrix.

B = the (c.m) matrix of coefficients which relate the decision variables to constraint vector, C (c.1).

n = number of goals.

m = number of decision variables

c = number of constraints.

The deviational variables (d_i^{+}, d_i^{-}) were derived from the households' characteristics. It was assumed that the main objectives pursued by any household in the study area are as follows:

i. to provide adequate food to ensure at least minimum calorie

for the household throughout the year.

ii. to earn adequate monetary income to at least meet minimum household financial needs.

iii. to maximize utilization of family labour through minimum use of paid labour.

It was on the basis of these objectives that the optimality of the system was assessed. The production system was said to be optimal only if it is capable of providing an adequate caloric intake for the family throughout the year, and producing adequate monetary surplus to allow the household to acquire goods that were not produced on the farm. These were the assumed minimum requirements for taking household out of poverty (Manyong and Degand, 1995).

For the three objectives assumed, the indicators were as follows:

(i) The indicator for adequate caloric intake came from the WHO/FAO recommendations, which gave some indicators for adequate caloric intake (FAO, 1974; Food Basket, 1995).

(ii) The monetary income indicator corresponded to a minimum of 56% of the average household expenditure in the study area which corresponds to an earlier determined poverty line for households in the study area (Adejobi, 2004).

The labour saving indicator was represented by desired level of cash expenditure on paid labour in the study area.

The structure of the objective function is further described in Table 1. The objectives were prioritized based on the view of households in the study area. The households were of the opinion that food security in terms of adequacy comes first, followed by balanced diet. The third and the fourth on the priority ranking were accumulation of monetary income and limited expenditure on paid labour through efficient utilization of family labour. Pre-emptive weights were also attached to these objectives based on the ranking with the first objective carrying the highest weight.

Major activities included in the model were as follows:

1. Maize and Rice 2. Millet and Guinea corn 3. Millet and Cowpea 4. Guinea corn and Maize 5. Mize Cowpea and Rice 6. Guinea corn and Groundnut 7. Millet ,Guinea corn, Cowpea and Groundnut 8. Millet, Maize and Rice 9. Mize, Guinea corn and Cowpea 10. Rice, Sorghum and Groundnut 11. Sorghum, Rice, Millet and Onions 12. Cowpea, Rice and Groundnut 13. Guinea corn Cowpea and Rice

14. Millet, Guinea corn and Rice 15. Millet, Groundnut and Guinea corn 16. Millet, Rice and Vegetable 17. Sorghum, Groundnut, Pepper and Maize 18. Millet, Maize, Bambaranut and Sugarcane 19. Cassava, Maize and Groundnut 20. Sweet potato, Pepper and Carrots.

Table 1. Tabular Representation of the Objective Function Structure of the Basic Linear Goal Programming Model for the Average Farm Household.

Objectives of Farm Production	Goal Statements: Achievement of	Objective Function Statement: To minimize	Deviation Variable in Objective Function	Priority Level	Pre-emptive Weights
1. Farm Household Food Security	i. minimum maize intake ii. minimum millet intake iii. minimum cowpea intake iv. minimum rice intake	Underachievement Underachievement Underachievement Underachievement	d- d- d- d-	1 1 1 1	7 7 7 7
2. Limited Cash Expenditure on Labor	i. specified level of expenditure on labour	Overachievement	d^+	4	4
3. Gross Farm Income	i. Desired level of farm income	Underachievement	d-	3	5
4. Nutritional Well being	i. minimum calorie intake	Underachievement	d-	2	6

Source: Constructed after field survey by ranking goals and attaching relative weights to them (Adejobi, 2004).

RESULTS AND DISCUSSION

Common Objectives of Farm Production and their Priority Ranking

One of the core objectives of this study is to develop an optimal enterprise combination that would (i) ensure adequate food to meet at least the minimum calorie requirement of the household throughout the year, (ii) provide adequate monetary income to at least meet minimum household financial needs, and (iii) allow maximum utilization of family labour through minimum use of paid labour. These are the three most important goals of household farm production as arrived at from an earlier survey carried out by the Kebbi State Agricultural and Rural Development Agency (KARDA). However, there were other relatively minor production objectives of households as presented in order of priority ranking in Table 2.

From Table 2, it is observed that the first three out of the six identified objectives in the study area were the most wide-spread among rural households. The most important of the household production objectives was meeting the minimum food requirements of households (95% of households), while meeting household's social obligations was found to be the least important production objective (23.5% of households).

In developing the optimal enterprise combination, the first three production objectives were considered to be the most important to the farmer and the most relevant to this study. The three other less important objectives are not considered not only because of their relative unimportance but also because they are not relevant to the scope of this study.

Table 2: Ranking of Common Objectives for Farm Production Among Households in the Study Area

Rank	Objectives	Number of Households Ranking	Percentage of all Households
1	Adequate food to meet at least minimum calorie for the household throughout the year	950	95.0
2	Adequate monetary income to meet minimum household financial needs	870	87.0
3	Maximization of the utilization of family labour through minimum use of paid labour	780	78.0
4	Provision of stable employment for household member throughout the year	755	75.5
5	Limited expenditure on maintenance of soil fertility	413	41.3
6	Fulfilment of social obligations by households	235	23.5

Source: Kebbi State Agricultural and Rural Development Agency Annual Report, 1999

Prevalent Crop Mixtures among the Sampled Households in the Study Area

Table 3 shows the relative importance of the major crops grown by the sampled farmers in the study area, which indicated that the basic cropping patterns prevalent in the study area were subsumed in the crop combinations numbered 1 to 20 in the table. The results of analysis showed that guinea corn /maize, millet/guinea corn, millet/cowpea, millet/maize /rice, and millet/guinea corn/rice were the five most important crop combinations, when the percentage of farmers involved in their production was the criterion for evaluation. However, the order of ranking of the crop enterprise combinations changed when the criterion of percentage of land put under cultivation of each crop enterprise combinations was used. With this criterion, guinea corn/ groundnut, guinea corn/ maize, millet/ cowpea, millet /guinea corn/ cowpea, and millet/guinea corn were the most important in that order.

The results presented in Table 3 support the following inferences:

i. Sole cropping was found not to be practised by the sampled farm households in the study area.
ii. The dominant cropping patterns were all cereal based because of the climatic condition of the study area, which supports the production of cereals.
iii. Although, 20 cropping combinations were identified, only the first 18 listed in Table 3 were included in the goal-programming model. The last two were not included because less than 10 percent of the sampled households practised them.
iv. While guinea corn / maize enterprise was the most common cropping enterprise, guinea corn/groundnut had the highest proportion of total land devoted to it. This suggests that guinea corn is a very important crop in the study area.
v. Whether the percentage of farmer involved or the percentage of total land cultivated was used in ranking the crop combinations, guinea corn/ maize and millet/cowpea crop combinations still came out as the most important crop mixtures cultivated by farm households in the study area.

Basic Optimal Farm Plan from Linear Goal Programming (LGP) Results

This section presents the optimal farm plan generated under the assumption that meeting farm family goals is the underlying

Table 3: Relative Importance of Crop Mixtures in the Cropping System of Sampled Households

	Crop Combination	No. of Farmers Planting crops	Percentage of Total No. of farmers	Total area Under crop (ha)	Percentage of Total Area	Average Area Under Crop (ha)
1	Maize and Rice	140	35	115	4.99	0.82
2	Millet and Guinea corn	201	51	134.74	5.85	0.67
3	Millet and Cowpea	185	46	202.37	8.78	1.09
4	Guinea Corn and Maize	260	65	211	9.16	0.80
5	Maize, Cowpea and Rice	146	37	115.74	5.02	0.70
6	Guinea Corn and Groundnut	80	20	213	9.24	2.66
7	Millet, Guinea Corn Cowpea and Groundnut	98	25	101.37	4.40	1.03
8	Millet, Maize and Rice	177	45	92	3.99	0.52
9	Maize, Guinea corn and Cowpea	102	26	138.7	6.01	1.35
10	Rice, Sorghum and Groundnut	87	22	92	3.99	1.06
11	Sorghum, Rice, Millet and Onions	78	20	94	4.08	1.21
12	Cowpea, Rice and Groundnut	115	29	91	3.95	0.79
13	Guinea corn, Cowpea and Rice	97	24	104.74	4.55	1.08
14	Millet, Guinea corn and Rice	178	45	90	3.91	0.51
15	Millet, Groundnut and Guinea corn	142	36	102	4.43	0.72
16	Millet, Rice and Vegetable	88	22	94.74	4.11	1.08
17	Sorghum, Groundnut, Pepper, Maize	100	25	84.40	3.66	0.84
18	Millet, Maize, Bambaranut and Sugarcane	77	19	79.37	3.44	1.03
19	Cassava, Maize, Groundnut	38	9.5	71	3.08	1.87
20	Sweet Potato, Pepper, Carrots	29	7.3	76.7	3.33	2.64

Source: Field survey, 2004

behavioural principle guiding management decision of the farmers in their resource use and allocation.

The objective function was to minimize the positive and negative deviations attached to the goals. Since weighted goal programming approach is adopted, weights were attached to the goals in order of importance, with the most important goal having the highest weight, so as to increase the likelihood that the most

important goals would be met (Brown et. al, 1990; Aromolaran, 1992). In this study, the most important goal was meeting the minimum household food requirement per year as shown earlier in Table 2 and a weight of 7 was attached to it, while the least important goal was minimum cash expenditure on labour with a weight of 3.

In addition to minimizing the positive and negative deviations, following Njiti and Sharpe (1994), the cost of production associated with each of the 18 enterprise included in the programme was also minimized.

The activities numbered 1-18 in Table 3 were included in the programme. All the activities were crop enterprises and were mostly cereal base. The basic cropping activities that entered the programme are presented in Table 4.

Table 4: Basic Cropping Activity and their Hectarage Allocations

Basic Activity	Hectarage (ha)
Millet/Cowpea	0.16
Maize/Millet/Cowpea	0.04
Millet/Maize/Rice	1.20
Maize/Guinea corn/Cowpea	0.94
Programme value	6485.16

Source: Data Analysis, 2004

From Table 4, out of the 18 basic activities included in the model, only 4 of them enter the programme. The 4 activities include:

i. Millet and Cowpea mixed
ii. Maize, Cowpea and Millet mixed
iii. Millet, Maize and Rice mixed, and
iv. Maize, Guinea corn and Cowpea mixed.

The programme value of 6485.16 was obtained, which means that for the optimum farm plan, an average farm household will incur a cost of ₦6485.1. It is shown that the average farmer should allocate resources in such a way that only the four crop enterprises (or basic activities) shown in Table 4 are produced, and according to their hectarage allocations. The recommended allocation pattern depicts Millet/ Maize/Rice (1.20ha) as the most important enterprise, followed by Maize/Guinea corn/Cowpea (0.94 ha), then by Millet/Cowpea (0.16 ha), and lastly by Maize/ Cowpea/ Millet (0.04ha). Together, they account for about 60 percent of the total land holding in the study area.

The basic activities are defined as those enterprise combinations that entered the programme, while those that did not enter the programme, or rather, excluded activities are the non-basic activities. The non-basic activities include maize/rice, millet/ groundnut, guinea corn/ maize, guinea corn/groundnut, millet/ guinea corn/ cowpea/ groundnut, rice / sorghum / groundnut, rice/ sorghum/ groundnut, sorghum/ rice /millet / onion, cowpea / rice/ groundnut, guinea corn/ cowpea/ rice, millet/ guinea corn/rice, millet /groundnut/guinea corn, millet/rice/ vegetables, sorghum sorghum/ groundnut/pepper/maize, and millet /maize/bambaranut/sugarcane. These non-basic activities and their marginal opportunity costs (MOCs) are presented in Table 5.

Table 5: Excluded Activities and their Marginal Opportunity Costs (MOC)

Excluded activity	Marginal Opportunity cost (MOC)
Maize/Rice	₦3672.46
Millet/Groundnut	₦1796.35
Guinea corn/Maize	₦2426.04
Guinea corn/Groundnut	₦2481.97
Millet/Guinea corn/Cowpea/Groundnut	₦398.34
Rice/Sorghum/Groundnut,	₦2770.48
Sorghum/Rice/Millet/Onion,	₦2785.61
Cowpea/Rice/Groundnut	₦192.69
Guinea corn/Cowpea/Rice, ,	₦681.37
Millet/Guinea corn/Rice	₦688.65
Millet/Groundnut/Guinea corn,	₦3096.77
Millet/Rice/Vegetables,	₦1825.68
Sorghum/Groundnut/Pepper/Maize,	₦4831.60
Millet/Maize/Bambaranut/Sugarcane	₦3912.99

Source: Data Analysis, 2004

The MOC shows by how much the programme value will increase if a unit of the non-basic activities (excluded real activities), which did not enter the programme, were forced into the programme. That is, the optimal cost of production will increase by the margin equal to the MOC value of each excluded activity for each unit of the excluded activity forced into the programme.

The two excluded activities with the highest cost penalty, in

this regard were sorghum/ groundnut/pepper/maize and millet /maize/ bambaranut/sugarcane with MOCs of ₦4831.6 and ₦3913 respectively. On the other hand, the excluded real activity with the least cost penalty was cowpea/rice/ groundnut, with MOC of ₦192.7.

Resource Allocation and Use Pattern

The resources employed by the farm-family in its crop production activities include land, family labour for period I (May/ July), family labour for period II (August/October), hired labour for period I (May/July), hired labour for period II (August/October) and cash on material input. The allocation and use pattern of these resources are presented in Table 6.

An examination of the resource utilization pattern reveals that only 4 of the specified resources were fully utilized in arriving at the optimal solution. These resources include family labour for period I, family labour for period II, hired labour for period

Table 6: Resource Allocations and Use Pattern

Resource	Use status	Slack	Shadow price (MVP)
Land	Not fully utilized	2.33 ha	-
Family labour I	Fully utilized	-	10.44
Hired labour I	Fully utilized	-	11.53
Family labour II	Fully utilized	-	5.11
Hired labour II	Not fully utilized	44.65 mandays	-
Cash on material input	Fully utilized	-	16.00

Source: Data Analysis, 2004

I, and cash on material input. The shadow prices for the fully utilized resources were 10.44, 5.11, 11.53, and 16.00 respectively; this implies that the cost of production will decrease by ₦10.4, ₦5.1, ₦11.5 and ₦16.0 respectively if additional units of such resources are used.

The non-fully utilized resources include land (2.33 ha) and hired labour for period II (44.65 mandays). These show that these resources were in excess of the actual needs of the household in the study area. Though there are indications of land fragmentation in the study area due to land tenure system that is a prominent feature of land in the study area, however, land is not yet a constraining factor to households' agricultural (crop)

production in the study area.

Production and Goal attainment by Farm-Household

The issues of production and goal attainment address the extent to which a household is able to satisfy its basic production goals, given a definite preference structure and the actual amounts of constraining resources available.

Table 7 reveals that about 78 percent of the goal components were achieved. It shows that, given the optimal solution and given that the farmer follows the recommended enterprise combination, most of the goals as preferred by an average farm family in the study area would be achieved. Although there were some deviations exhibited by some goals in the programme (particularly minimum income deviations for periods I and II, as well as labour cash expenditure deviations), the deviations were small.

Table 7 Production and Goal Attainment

Subsets of Goals	Target	Optimal plan value	Underachieve-ment	Overachieve-ment	Degree of attainment
Maize intake	1200 Kg	1200	0	0	Achieved
Millet intake	980 Kg	980 Kg	0	0	Achieved
Cowpea intake	851 Kg	851 Kg	0	0	Achieved
Rice intake	544 Kg	544 Kg	0	0	Achieved
Calorie required	1403700 Kilocal	1403700 Kilocal	0	0	Achieved
Income period I	₦7503.00	₦7473.00	₦30.00	0	Not achieved
Income period II	₦4040.200	₦4040.200	₦0.00005	0	Not achieved
Cash on Labour	₦8200.00	₦7925.00	275.00	0	Achieved
Cash on material input	₦3539.00	₦3539.00	0	0	Achieved

Source: Computer printout of Goal programming Models

CONCLUSIONS AND RECOMMENDATIONS

It was concluded from the programming results that only 4 (i.e. Millet/Maize/Rice, Maize/ Guinea corn/Cowpea, Millet/ Cowpea and Maize/Cowpea/ Millet) of the 18 major cropping activities identified in the study area entered the programme. Resource utilization pattern revealed that only 4 of the specified resources were fully utilized in arriving at the optimal solution. Furthermore, about 80 percent of the average household's production goals were met by the optimal plan derived from the goal programming model.

The goal programming results suggested that the goals of food security, increased income, and reduced farm production costs would be achieved by households in the study area through an improved crop enterprise combination involving 1.20 hectares of Millet/Maize/Rice, 0.94 hectare of Maize/Guinea corn/ Cowpea, 0.16 hectare of Millet/Cowpea, and 0.04 hectare of Maize/Cowpea/Millet. That is, the average household farm size should be about 2.34 hectares. It follows, therefore, that a cereal-based cropping pattern is most desirable in the study area. Furthermore, excessive land holding and hired labour use particularly in the low production period as well as indiscriminate crop-mix should be discouraged in the study area.

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