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Optimal Farm Plan in Rubber Tapping In Southern Nigeria

Giroh, D.Y. & E. F. Adebayo
Department of Agricultural Economics and Extension,
Modibbo Adama University of Technology, P.M. B 2076, Yola, Nigeria

Abstract

The study examined optimal farm plan in rubber latex production in southern Nigeria using structured questionnaire administered through a multi stage, purposive and random sampling techniques where a total of 300 rubber farmers were selected. Data collected were analyzed using goal programming. The result of the analysis shows that the average rubber farmer cannot fully achieve his production goals from the available resources at his disposal. The plan was able to achieve or satisfy completely two goals out of the five namely tappable rubber trees and latex production in litres. The goals of rubber production in kilogramme dry rubber and income were underachieved by 2, 264.75 kg and N13,797.70 respectively while production cost was overachieved by N274, 921.40, because it overshoot the desired level. The gross margin, dry rubber and cost of production goals did not reach their desired levels. The average rubber farmer cannot fully satisfy his multiple production goals. The study recommended that farmers should form cooperative societies and associations to enable them access production credit from commercial and Nigerian Agricultural Cooperative and Rural Development Bank. End users of research results on rubber, NGOs and the three tiers of government in the rubber producing belt should be encouraged to fund farmers' capacity building activities like farmers field days, On farm adaptive research (O FAR) trials for increased production.

Keywords: Farm, Plan, Latex, Goal programming and Slack value,

Background to the study

Commercially, natural rubber is obtained almost exclusively from Hevea brasiliensis (genus Hevea, family Euphorbiaceae), a tall softwood tree indigenous to Brazil. The world rubber industry began to develop in the 1800s, with the invention of the masticator and the vulcanization process. Demand for rubber grew rapidly with the invention of the solid and later the pneumatic rubber tyre and the high demand for rubber insulation by the electrical industry which made *Hevea brasiliensis* Muell Arg as the major source of natural rubber because of its superior latex yield over other species of *Hevea*. Natural rubber was introduced into Nigeria in 1895 from the Wickham collection of 1876. Transition period between 1876 and 1895 was the era of planting at Kew Botanical Gardens in England and Asia (Aigbekaen et al., 2000).The earliest plantation in Nigeria was planted in 1903 and by 1925 single estates of about 1000 hectares was planted. The early plantations were raised from unselected seeds with latex yield of 300 400 kg/ha/yr.

Genetic improvement of *Hevea brasiliensis* commenced in Nigeria in 1960s following the establishment of Rubber Research Station (RRS) in 1961 and became the Rubber Research Institute of Nigeria in 1973 with the mandate of genetic improvement of natural rubber and other latex producing plants of economic importance (Uraih et al., 2006). Germplasm collection for the purpose of genetic improvement started in 1960s with the importation of primary and improved hybrid clones from Malaysia and Sri - Lanka. Among the collections are the RRIM series, RRIC series, PB series, GT1 and so on. Some clones of Indonesian origin such as PR and Tjir series and IAN series of Brazil were part of the collection from Malaysia and Sri-Lanka. To date, twenty-four high latex yielding clones have been developed in Nigeria. These clones have latex yield of 2000 3500 kg / ha / yr (Omokhafe and Nasiru, 2004).

It is important to emphasize that despite the potential benefits of the natural rubber, it's overall productivity remains low due lack of tapping and is most clearly evidenced by much lower standards of living in the rural areas compared to urban areas, thus the largest concentration of absolute poverty, illiteracy and infant mortality in the rural areas (Abolagba et al., 2003). Adebayo and Olayemi (2005) reported two widely used algorithms for solving goal programming problems; lexicographic pre-emptive goal programming (LGP) and weighted goal programming (WGP) methods. Despite the advantages, their application in natural rubber production (tapping) in particular is scanty. Going through the review of relevant literatures, a lot of researches were conducted on other crops using various tools of analyses. Several studies conducted on natural rubber like the works of Omokhafe and Nasiru, (2004);

Umar et al (2008) and Mesike et al.(2010) extensively dealt on crop improvement and other production innovations in Nigeria but many of the studies have not examined the allocation problems of small-scale rubber farmers in the former Bendel State(Edo and Delta States). A study on the tapping of rubber is necessary to give direction in resources use and allocation in order to increase output from natural rubber. ective was to determine optimal tappable trees / task satisficing a set of multiple objectives of plantation owners.

Objectives of the study

The main objective of this study is on optimal farm plan in rubber latex tapping in Southern Nigeria. The specific objectives were to examine resource allocation plan and to determine an optimal tappable trees / task satisficing a set of multiple objectives of plantation owners.

Brief Review of Literature on Linear programming in agriculture

Linear programming techniques have been widely used in farm planning as mainly a procedure for providing answers to problems which are so formulated. The techniques involve the optimization of a linear function subject to linear inequalities. Linear programming constitutes the major tool a broad field of empirical method known as activity analysis (Adebayo, 2006). It generally refers to the computational method used in prescribing production patterns which maximize profit of firms, minimize costs of producing a specific commodity or related type of aggregate analysis.

The linear programming paradigm used in farm planning is stated as:
Maximize Z = f(x) = CX ………………………………………………………………(1)
Subject to AX = b
and
X = 0

Where: Z is the criterion function, it is a scalar of C and X. X is a vector of decision variables such as acres of wheat, tapping tasks and C is the vector giving corresponding constituents of these variables to the criterion factors. The vector b represents the physical, institutional and personal in which choices are made and A defines the technical relationship between variables and the restraints (Okoruwa, 1994).

Goal programming is one of the satisficing multiple- criteria decision making models which help the decision maker to minimize deviation from his / her set of goal targets (Aromolaran, 1992). It was developed by Charnes and Coopers in 1961 and has been widely used in management sciences. Goal programming tries to optimize several simultaneous goals and this is accomplished by minimizing the deviations between goal target or aspiration levels and the actual levels through addition of positive and negative deviational variables operating either underutilization or over achievement of each goal.

In order to incorporate the goals into the model, each goal is expressed in the form of a goal constraint and generally takes the form:
f(x) = t or f(x) =t……………………..............…………..(2)

Where t is a parameter representing the aspiration level or target values with goals, the right hand is a target aspired to be achieved by the decision maker which may or may not be achieved. This can be considered as soft constraints, which could be violated without producing infeasible solutions. The amount of violation is measured by introducing positive and negative deviational variables into the model. For example if n and p are negative and positive deviational variables, a goal can be represented mathematically as f(x) +n- p = t. A goal cannot be both under and over achieved, hence at least one of the deviational variables for each goal would be zero. When a goal (Gi) matches its aspirational level exactly, then both ni and pi are zero. In lexicographic pre-emptive goal programming, the minimization process is carried out by attaching pre emptive or absolute weights to the sets of goals situated in different priorities i. e fulfilment of a set of goals situated in a certain priority is immeasurably preferable to the achievement of any other situated in a lower priority (Piech and Rehman, 1993). A higher priority is not degraded by lower priority goal. What is derived from this is referred to as the achievement function, which replaces the objective function of the traditional paradigm. Weighted goal programming considers all goals simultaneously in a composite objective function which minimizes the sum of all the deviations between the goals and their aspiration levels. The deviations are however weighted according to the relative importance of each goal to the decision maker. The deviations from the targets are always expressed as percentage in objective function to overcome the problem of differing units used to measure various goals. Goal programming has a lot of advantages over and above the traditional linear programming techniques (Adebayo, 2006).Whereas the linear programming is characterized by optimization of a single objective function or decision criterion and all constraints are rigid and flexible, the weighted goal programming model on the other hand is more practical in model building as well as in its application to real life situations. Goal programming involves multiple and possibly conflicting objectives. It automatically adjusts the level of certain resources to satisfy the goal of the decision maker. It also accommodates objective function with non-homogeneous units of measurements. Moreover, it is possible to obtain feasible solution even with conflicting objectives.

It can be expressed as:

Minimice $Z = a_1n_1x100 / K_1 + a_2n_2 x100 / K_2 + a_3n_3x100/ K_3$ etc……….. (3)

Where: a_1 - a_3 are the weights that reflect the decision makers' preferences regarding the relative importance of each goal, $K_{1 \ldots\ldots\ldots\ldots} K_n$ are goal targets of the respondents.

Amir et al. (1986) evaluated the potential of integrating sheep and smallholder rubber producers in Sumatra and by subjecting their analysis to goal programming and found that there is economic viability in the combination to enhance the income of rubber farmers.

San (1995) studied the dynamic decision making in agricultural households by integrating sheep and crops with smallholder rubber producers in Indonesia by subjecting the data to linear programming. Analysis revealed that integrating sheep production activity into rubber plantations increases net present value of future income by 20%, and integrating both sheep and soybeans into a rubber plantation can provide a 38% increase in net present income. San and Deaton (1999) conducted a study on the feasibility of integrating sheep and crops with smallholder rubber production systems in Indonesia using linear programming model. Result of the study indicated that for a given level of resources, technology, and credit repayment policy, the optimal number of trees for a smallholder producer is 593.

Methodology

The Study Area

The study was conducted in Edo and Delta States of Nigeria. Edo State lies between Latitudes 5° 44´ and 7° 34´ N of the equator and between Longitudes 5° 04´ and 6° 43´ E of the Greenwich Meridian. It shares boundary to the south by Delta State, in the West by Ondo State and in the East by Kogi and Anambra States (Emokaro and Erhabor, 2006). The State covers a land area of about 17,902 km^2 with a population of 3,218,332. Edo State is divided into 18 Local Government Areas (NPC, 2006). The State is characterized by a tropical climate which ranges from humid to sub humid at different time of the year. Three distinct vegetation were identified in the State are mangrove forest, fresh swamp and Savannah vegetation's. The mean annual rainfall in the northern part is 1270 mm to 1520 mm while the southern part of the State receives about 2520 mm to 2540 mm rainfall respectively. Mean temperature in the State ranges from a minimum of 24 ^{0}C to a maximum of 33^{0}C. The people of the State are mostly farmers growing a variety of crops such as cassava, rice, yam, plantain, pineapple and tree crops such as rubber, oil palm and cocoa. Other occupations of the State include small and medium scale businesses and jobs done by artisans and civil servants who engage in farming on part time basis (Emokaro and Erhabor, 2006).

Table 1: Proportionality of Rubber Farmers Selected in each State

State	LGA/ Locality	No of rubber farmers	No. of rubber farmers selected
Edo	A. Ovia south West		
	1. Iguoriakhi farm settlement	94	70
,,	2.Igueladidi	29	21
,,	3. Iguelaiho	15	11
,,	B. Ikpoba - Okha LGA		
,,	1. Imasabor	12	9
,,	2. ObagieNevbuosa	9	7
,,	3. Obayantor	6	4
,,	C. Uhunmwode LGA		
,,	1. Eguaholor	15	11
,,	2. Iguezomo	10	7
,,	3. Evbueneki	17	13
,,	Total	207	153
Delta	A. Ika North East LGA		
,,	1. Mbiri Farm settlement	115	85
,,	2.Emuhu	3	2
,,	3. Akumazi Umuocha	5	4
,,	B. Ndokwa East LGA		
,,	1. Utagba - Uno	25	18
,,	2. Umutu	10	7
,,	C. Ndokwa west LGA		
,,	1. Kwale	23	17
,,	2. Abraka	19	14
Total		200	147

Source: Field survey 2010

Delta State lies between latitude 5^0 00´and 6^0 30´ N of the equator and longitude 5^0 00´ and 6^0 45´E of the Greenwich meridian. The State has a land area of 17,440 km^2; about one third of this is swampy and waterlogged (Delta State Diary, 2003). The State is bounded in the North by Edo State, in the East by Anambra and Rivers State and in the South by Bayelsa State. The Atlantic Ocean forms the Western boundary while the North West boundary is Ondo State. There are 25 Local Government Areas in the State with a population of 4,098,391 people (NPC, 2006) .The State has a tropical climate marked by dry and rainy seasons. The rainy season starts in April and ends in October. The dry season starts in November and ends in March. The rainfall ranges from 1905mm to 2660 mm monthly. The temperature ranges from 24 ^{0}C to 34^0 C with an average of 30^0C (Delta State Ministry of Agriculture, 2000; Ike, 2010).

Source of Data and Sampling procedure

Data for this study were obtained mainly from primary source. The data were mainly collected on the 2009 and 2010 production activities of the farmers using structured interview schedule in a multi-stage sampling technique. The first stage involved the purposive selection of Ikpoba - Okha Local Government Area, Iguoriakhi Farm settlement, Odia Rubber Estates (Ovia South West and Uhunmwode Local Government Areas in Edo State) and Utagba Uno, Mbiri Farm settlements and Mars Plantation in Ndokwa East, Ika North East and Ndokwa West Local

Government Areas of Delta State respectively. The second stage of the sampling was obtaining the list of 407 rubber farmers from the selected locations from Tree Crop Units and Ministry of Agriculture and Natural Resources in Edo and Delta States. Out of this number 300 rubber farmers were selected proportionate to their population in each location and used for the study (Table 1).

Goal programming Model

Goal programming was used to address the resource allocation problem associated with rubber latex production in the study area. Weighted goal programming method was used and the model is specified as:

Minimize Z = $(a_i n_i + a_i p_i)$……….............…………......(4)

Subject to:

? $G_{ij} X_j$ $P_i + n_i = g_i$ for all i_s

? $ak_j X_j$ = bk for all k_s

$X_i, P_i n_i$ = 0 for all i and j

Where: G_{ij} = coefficient of goal achievement, P_i = the amount of deviation or overachievement of goal g_i; n_i = the amount of negative deviation or underachievement of goal gi; a_{kj} = technical coefficients of xj subject to resource endowment of b_{ks} and X_j = matrix of $X_{ij.}$(Adebayo,2006).

The activities consisted of tapping all tasks allocated and rubber latex production. Resource and subjective constraints were included in the model. The most important constraints are hired labour, cash income while the subjective are minimum tree density/ha or task, minimum gross margin. The costs incurred include variable and fixed cost of tapping inputs. Data was collected from hired labour and wage rate in the study area. Conversion rate for the aggregation of man, woman, child days suggested by Norman in 1973 and adopted for study by Adebayo (2006) was used. The Goal Programming analysis was done using Quantitative Systems for Business plus Version 2(QSBPlus).

Results and Discussion

The linear goal programming model consisted of five activities and two constraints. The activities are indicated in Table 2. The data were first subjected to the conventional Linear programming analysis to generate an optimum gross margin which was built into the goal programming model. The model produced an optimum gross margin of N3, 018,358.96.

The achievement function for the farm was expressed as:

Minimize : $a_1 n_1$x100 / 27787.98 + $a_2 n_2$ x100/ 282+ $a_3 n_3$x100/ 3018358.96 + $a_4 n_4$ x 100 /24090.70 + $a_5 n_5$x100/30760.50.

The equivalent form of the objective function was obtained as follows:

$1.439a_1n_1+354.609a_2n_2+0.019a_3n_3+0.830a_4n_4+0.325a_5n_{5.}$

The result produced by LP model is presented in Tables 3 and 4. The optimal plan (Table 2) is that the average rubber farmer allocates his resources to tap 282 trees, produced 37, 345.98 litres of rubber latex, 25,523.23 kg of dry rubber and N3, 018,358.94.

Moreover, the included resources in the programme and their status of usage as indicated in Table 5 revealed that the fully utilized resource is land with a shadow price or marginal value of N550. If land is forced into the programme, the cost of latex production would increase by N550. Shadow prices are marginal returns to increments of available resources. In a maximization problem, shadow prices are income penalties. They indicate the amount by which farm income would be reduced if any of the excluded activities is forced into the programme. In a minimization problem, shadow prices are cost penalties. They indicate the amount by which the value of the programme will increase while keeping other parameters constant.

Labour according to this study was not fully utilized by the respondents and is consistent with earlier studies conducted by Tanko et al. (2011) and Igwe et al. (2011) who reported labour resource misallocation among farmers in Nigeria.

The result in Table 5 shows that the average rubber farmer cannot fully achieve his production goals from the available resources at his disposal. The plan is able to achieve or satisfy completely two goals out of the five as both deviational variables were zero. These are tappable rubber trees and latex production in litres. The goals of rubber production in kilogramme dry rubber and income were underachieved by 2, 264.75 kg and N13, 797.70 respectively while production cost was overachieved by N274, 921.40, because it overshoot the desired level. The gross margin, dry rubber and cost of production goals did not reach their desired levels. The average rubber farmer cannot fully satisfy his multiple production goals.

Table 2: Tabular representation of the objective function of goal programming model for the average farm household

Goals of production	Achievement of Objective	Function Statement: to Minimize	Deviation variable in Objective Function	Priority Level	Pre emptive weights
Increased Tappable Trees	Minimum tappable trees	Under achievement	N	2	10
Increased rubber production (k g)	Minimum production(kg dry) of rubber	Under achievement	N	1	4
Increased Income	Minimum gross margin	Under achievement	N	3	6
Increased Latex production in Litres	Minimum Latex	Under achievement	N	5	1
Reduced Cost of operation	Maximum cost of operation	Over achievement	P	4	2

Source: Field survey 2010. N= Negative deviational variable, P= Positive deviational variable.

Table 3: Optimum production plan for LP model

Activities	Existing or production Level	Optimal Level
Gross margin	2,729,697.968	3,018,358.936
Tapped Trees	282.16	283.34
Latex production (litres)	30,760.5	37, 345.98
Rubber production(kg dry)	27787.98	25523.23

Source: Computer printout of LP model

Table 4 : LP result for average farm resource

Resource	Status of Use	Slack	Shadow Price
Land (ha)	Fully Utilized	-	550
Labour	Not fully utilized	14	-

Source: Computer prints out of LP model.

The optimal tappable tree of 282 obtained in the study is low as compared to the optimum tappable trees of 593 reported in Malaysian smallholder farms (San and Deato 1999). Several factors have been reported to affect the population of tappable rubber trees in many rubber producing countries of the world. In Nigeria for instance, the damaging effects of the wind (stem and branch snapping, total uprooting), incidences of pest and diseases, fire outbreak and management practices are factors that can determine rubber tree population. These factors might have been responsible for the low optimum tappable trees found in the study.

Conclusion and Recommendation

It can be concluded that the average rubber farmer cannot fully achieve his production goals from the available resources at his disposal as the plan was able to achieve or satisfy completely two goals out of the five. These are tappable rubber trees and latex production in litres. The goals of rubber production in kilogramme dry rubber and income were underachieved by 2,264.75 kg and N13,797.70 respectively while production cost was overachieved by N274, 921.40, because it overshoot the desired level. The gross margin, kilogramme of dry rubber and cost of production goals did not reach their desired levels.

Based on the findings of the study, .farmers are advised to form cooperative societies and associations to enable them access production credit from commercial and Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB).This will enable the farmers to employ labour and pay for wages commensurate to output. End users of research results on rubber, NGOs and the three tiers of government in the rubber producing belt should be encouraged to fund farmers' capacity building activities like famers field days, OFAR trials for increased production.

Table 5: The LGP production and goal attainment results

Goals	Existing targets	Programme Value	Under achieved	Over achieved	Degree of attainment
Tappable Trees	282	282	0	0	Achieved
Rubber production Kg	27787.98	25523.23	2264 .75	0	Not Achieved
Income	3018358.96	3004561.26	13797.70	0	Not Achieved
Latex production	30,760.5	30,760.5	0	0	Achieved
Cost	₦24090.7	₦299012.1	0	274921.4	Not Achieved

Source: Computer print Out of goal programming

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