INTERNATIONAL POLICY BRIEF SERIES
Education and Science Journal of Policy Review and Curriculum Development
Volume 5 Number 2, May 2015.

RESOURCE ALLOCATION FOR OPTIMAL PRODUCTIVITY IN AGROFORESTY FARMING IN NOTHERN ADAMAWA, NIGERIA

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Abstract
This paper deals with the issue of optimal farm planning in agroforestry farming. It determined the optimum crop mix, the limiting factors in production and the level of support required by agroforestry practitioners to include the activities necessary for the sustenance of livelihood that were excluded in the optimal farm plan. Descriptive statistics, gross margin analysis and the linear programming model were the analytical tools adopted. The agroforestry practitioners were mostly without formal education and of the age of 50 years and above constituting 57.5%. These indicate low capacity to adopt new technology of production and rural-urban migration of the younger generation that is supposed to be in farm production. Three enterprises Silvopastoral, Agrisilvicultural and Agrosilvopastoral were selected from the study area. The optimum farm sizes for the respective enterprises were 1.25 ha., 1.50 ha and1.75 ha. as against the pre-plan sizes of 1.58 ha. 2.90 ha. and 4. 00 ha respectively. Agrosilvopastoral has the highest gross margin with a value of N26, 367.00 as against the N17, 790.00 realized in Silvopastoral farming. The land area, hired labour and operating capital were the limiting resources. It is only the land area that can be further increased to enhance the value of the farm plan. The family labour was not a binding constraint in production. For sustenance of livelihoods, Agricultural crops with the opportunity cost of N891.80 and Pastorals with the reduced cost of N9, 769.97 needs to be incorporated into the Silvopastoral and Agrisilvicultural farm plan respectively. These monetary estimates indicate the level of government support; the farmers need to operate optimally within the context of agroforestry practices. There is the need for the government to mobilize and empower the extension services to work closely with the agroforestry practitioners to ensure self-sufficiency in wood, livestock and food production on the national level and enhanced production for export.

Keywords: *Agroforestry, Sustenance of livelihood, Optimum crop mix, Optimal farm plan.*

Background to the Study

Agroforestry is a set of approaches to land management practiced by more than 1.2 billion people worldwide involving the integration of trees with annual crop cultivation, livestock production and other farm activities. Agroforestry system range from open parkland assemblages to dense imitations of tropical rainforests such as home gardens, to planted mixtures of only a few species. Theses systems can increase farm productivity when their various components occupy complementary niches and the associations between them are managed effectively (Steffan-Dewenter *et al.*, 2007; FAO, 2008).

Trees in agroforestry systems provide important ecosystem services, including soil, spring, stream and watershed protection, animal and plant biodiversity conservation, and carbon sequestration and storage, all of which ultimately improve food and nutritional security (Garrity, 2004). Individual farmers can be encouraged to preserve and reinforce these functions, which extend beyond their farms by payments for ecosystem services (Roshetko, Lasco and Delos Angeles, 2007; Place *et al.*, 2012).

Appropriate combinations of crops, animals and trees in agroforestry systems cannot only increase farm yields; they can promote ecological and social resilience to change because the various components of such systems, and the interactions between them, will respond in differing ways to disturbances (Steffan-Dewenter *et al.*, 2007). A diversity of species and functions within integrated production systems is therefore a risk-reduction strategy, and agroforestry can make important contributions to both adaptation to, and the mitigation of, climate change (Thorlakson and Neufeldt, 2012). Agroforestry system is therefore so important and it need to be properly managed through effective farm plan to enable it perform its enormous task of sustained food production.

Resource productivity is definable in terms of individual resource-input. It is an index of the ratio of the value of the total farm output to the value of the total input used in farming production (Olayide, 1982; Zira and Ghide, 2013). Maximum resource productivity implies obtaining the maximum possible output from the minimum possible set of inputs. In this context, optimal productivity of resources demands an efficient utilization of resources in the production process. Allocation of resources has been found to be the basis of agricultural productivity and these factors of production have been classified as land, labour, capital and management. They possess high economic value owing to their relative scarcity because if efficiently allocated, it guide against the problem of underutilization or over utilization of their resource as is being especially experienced by the agroforestry farmers.

The basics for this paper are that resources are poorly allocated and agroforestry practitioners do not know when to allocate more, when the need arises to make more profit or less when the market situation is less conducive. In addition, is that enterprise combination among these agroforestry practitioners in most cases is faulty as they are not such that can bring in maximum profits. Management decisions or manipulation of resources that are limiting need to be effected appropriately for positive business enhancement.

Objectives of the Study

It is in this light, the study sought to investigate the following objectives:

i. Determine the optimum crop enterprise mix, given the resource constraints and the optimum profits maximizing output levels.
ii. Identify the most limiting factors of production affecting the agroforestry practitioners and determine managerial manipulations for increased productivity and resource use efficiency.
iii. Determine level of support in terms of subsidy to the agroforestry practitioners to include enterprises excluded from optimal farm plan that are necessary to ensure sustenance of livelihood.

Methodology

The study was carried out in the Northern part of Adamawa State, which is also the zone one of the Adamawa State Agricultural Development Programme (ADADP). The region comprises of five local government areas which include Maiha, Madagali, Michika, Mubi North and Mubi South. The area lies between latitude 9°30' and 11° 45' North of the equator and longitude 13° 45' East of the Greenwich Meridian. The region is bounded by Hong and Song Local Government Areas in the West, Borno State in the North and in the South and East by Cameroon Republic. It has a land mass of 4,728km^2 with population of 589,320(Adebayo, 2004; NPC, 2007). The mean annual rainfall ranges from 900mm to 1050mm with distinct dry season, which begins in October and ends in April while wet season begins in May and ends in September or sometimes October. The region is also located within the Sudan Savannah belt of the Nigeria's vegetation zones (Adebayo, 2004).

Sampling Techniques

A multi-stage sampling technique was employed in the selection of the respondents. In the first stage was selection of agroforestry practitioners in ADP Zone 1, which is located in the Northern part of the state. Adamawa State has been divided into four ADP Zones namely, Mubi, Gombi, Guyuk and Mayo-Belwa. The selection of Zone 1 was purposive because of its prominence in agroforestry farming in the state. In the second stage was the random selection of the three local government areas (Maiha, Mubi North and Michika Local Government Areas) out of the five local government areas. The third stage was purposive selection of the cells or communities practicing agroforestry farming. In the final stage was random selection of the respondents from list of agroforestry practitioners obtained from their various leaders and ADP Zonal Office. One hundred and twenty- five farmers were selected and administered structure questionnaires out of which 120 were valid and data regard farming activities and socio-economic characteristics of the agroforestry practitioners were obtained from the study.

Analytical Techniques

The analytical techniques used in this study were descriptive statistics, gross margin analysis and linear programming (LP) approach. The descriptive statistics involved the use of frequency table with percentage distribution for the analysis of socio-demographic characteristics. Gross margin analysis was used to determine operating farm income from each enterprise or activity. For each activity, gross margin (GM) was calculated as follows:

$$GM = TVP \quad TVC \qquad (1)$$

Where:
TVP = Total Value Product
TVC = Total Variable Cost

Linear programming technique was used to maximize the operating income subject to available resources. These were used to analyze the input-output data collected on the principal food crops cultivated by the farmers in the study area.

Specification of the Model

The mathematical structure of the linear programming model is given as:

$$\text{Maximize } Z = c_g x_g \qquad (2)$$

Subject to:

$$a_{fg}x_g = b_f \quad (3)$$

$$X_g = 0 \quad (4)$$

Where:

Z = the objective function to be maximized which in this case is the total gross margin
C_g = gross margin per unit of the g^{th} activity (Objective coefficient)
x_g = the level at which g^{th} is produced
a_{fg} = the amount of f^{th} resources required per unit of g^{th} activity
b_f = amount of resource *f* available (Constraint level)
Land, labour and operating capital are the main limiting factors. The inequality sign (=) in the equation is converted into (=) by the addition of a slack variables (Surplus capacities) which take care of unused resources. This is expressed as follows:

$$a_{fg}x_g + s_{fg} = b_f \quad (5)$$

Where:
s_{fg} = surplus capacity of resource *f* in the production of activity *g* or all of the f^{th} resource.

This model was used to determine the optimum farm plan, which emphasized the most profitable combination of crop enterprises to produce, the farm sizes of each to cultivate, the realizable optimum profit, the limiting resources and the manipulation for enhanced profit maximization. The model also gave the opportunity cost (reduced cost) that helped to determine the level of financial support needed by the farmer to incorporate crops that could not make up the optimal mix for strategic reasons.

In this line, the linear programming matrix of the agroforestry farmers based on the gross margin, land area of the cultivation, operating capital, family, hired labour for each of the three enterprises was designed, and analyzed with the aim of working out the optimal farm plan. The non-included enterprises in the optimum-enterprise mix were investigated for those strategic for the sustenance of livelihoods. The opportunity cost (reduced cost) of these non-included enterprise-mix were used to assess the level of financial grant (or subsidy) required for farmers to include them in their profit maximizing activities and so ensure sustenance of livelihoods.

Result and Discussion

The socio-economic characteristics of the agroforestry practitioners involved age, sex, martial status, family size, and level of education attained. Majority of the practitioners (92.5 %) were male with only (7.5%) female (Table 1). The agroforestry practitioners of the age group between 40 -59 years constituted (57.5 %) of the age distribution, followed by those on the age group of 20 -39 years with (24.2 %) while those of 60 years and above occupied (18.3 %). This implies that agroforestry farmers of 40 years and above constituted (75.8 %) and the implication is rural-urban migration for the young and able bodies' peoples that were supposed to be productive in the farm. The agroforestry practitioners were mostly married (87.5 %) with the single and younger agroforestry practitioners occupying the rest of the percentage distribution. The family size of 3-5 person occupied the highest percentage distribution of (49.2 %) while that of 6-8 persons was (35 %). There was therefore the high probability of the practitioners depending more on family labour in contrast to hired labour for most of their farming activities. The agroforestry practitioners were mostly without formal education (47.5 %) while those with primary, secondary and tertiary levels of education were 27.5 %, 17 % and 7.5 % respectively. The low level of education affects the low adoption of improved technology and so resulted in loaf ram productivity and outputs.

The gross margin of agroforestry enterprises are revealed in Table 2. Three enterprises constituting Silvopastoral (X_1), Agrisilvicultural (X_2), and Agrosilvopastoral (X_3). Agrosilvopastoral (X_3), agrisilvicultural (X_2) and silvopastoral (X_1) had N26, 367.00, N23, 475.00 and N17, 790.00 respectively.

The different enterprises with their resources availability with respect to land area, operating cost, hired labour and family labour and resource constraint levels are indicated in the linear programming matrix of the agroforestry farmers in Table 3. The gross margin for each of the enterprises is equally represented in Table 3. The objective and constraint equations were derived from matrix. The objective was to maximize the total gross margin from the enterprises operations. Three enterprises were selected based on the knowledge of agroforestry in the study area. Enterprises budgets were constructed for each of the agroforestry enterprises and their gross margin were N26, 367.00, N23, 475.00 and N17, 790.00 respectively.(Table 2). Three main types of resources were identified as constraints on the production Land, Labour, and operating capital. Labour was further divided into family and hired labour.

Analysis of the farm plan as constructed for the agroforestry practitioners in the study area shows that out of the three enterprises agrosilvopastoral maximized the total gross margin with a value of N26, 367.00, (Table 3) as against N17, 790.00. realized by Silvopastoral. The farm size for the three enterprises stipulated in the optimal farm plan were 1.58 ha(X_1), 2.90ha (X_2) and 4.00ha (X_3) as against the pre-plan size of 1.25 ha(X_1), 1.50ha (X_2) and 1.75ha (X_3) respectively. Opportunity costs for the enterprises were zero meaning the enterprises had positive values in the optimal solution model.

The optimal level of resources utilized shows that land area, hired labour and operating capital were the binding constraints. This is justified with the slack or surplus columns against these resource constraints indicating zero. The implication is that these resources were completely utilized in the course of production and their increased use would enhance the value of the optimal farm plan. If therefore an extra unit of these individual limiting resources can be mobilized for production, the shadow price against each resource in Table 4 indicate by what value the gross margin will increase. This help in managerial decisions as the shadow price is compare against the cost of hiring an extra unit of limiting resource to see the rational of taking such a decision. Family labour is the only non-binding or non-limiting resource in the optimal farm plan. It had 227.76 man-days as surplus or slack which means available capacity was never exhausted in the production process. An extra unit increase in land area would lead to N12, 735.00 returns in terms of gross margin and for hired labour and operating capital, such unit will increase in N14.86 and N0.18 return respectively. It therefore means the room for managerial manipulation for enhanced value of optimal farm plan only exists for land area, as this is the only resource that the return for an extra unit application of the resources surpasses the cost of the rent of an extra unit of land area.

The sensitivity analysis carried out shows to what extend the resource constraints can be adjusted without affecting the optimal worked out farm plan. Land area with the current value of 8.48ha could be varied within the range of 1.58 4.00ha without affecting the optimal farm plan (Table 5). For hired labour, the range can be varied from the current value of 580 man days within 570.78 -768.96 man days and for the operating capital with current value of N18, 855.00 it can be varied within N15, 978.00 and N19, 167.18. The family labour through non-binding or limiting can be varied from its current value of 453 man-day to not less than 225.26 man-days. These managerial manipulations are very necessary to enhance the optimal farm plan for profit maximization.

Conclusion and Recommendation

The practitioners were mainly of male gender (92.5 %) and with age of 40 years and above constituting above 75.8 %. This portrays much of the youths are no longer in the farm mainly due to rural urban migration with only the aged left behind. The family size have averagely five and this indicates surplus family labour to be relied upon for cultivation. The practitioners were mostly with no formal education (47.5%) with every few with having higher education. This affected the adaptation of technology and so farm output and resource productivity. The maximized gross margin in the optimal farm plan was in Agrosilvopastoral with the value of N26, 367.00, (Table 3) as against N17, 790.00. realized by Silvopastoral. The optimal farm plan land areas were 1.25ha as against the earlier farm size of 1.28ha for Silvopastoral (X_1). It was 1.50ha as against 2.90ha for Agrisilvicultural (X_2) and 1.75ha as against 4.00ha for Agrosilvopastoral (X_3). These indicate more productive resources use for maximization of profit.

The binding constraints were land area, hired labour and operating capital. The family labour was not binding, as it was not exhausted in the production process. Managerial decisions through unit increases in limiting resources use to enhance profits realizable in the optimal farm plan was only favourable in land size as the return surpassed the rent of acquiring extra unit of this resource. With hired labour and operating capital, the returns were quite outweighed in silvopastoral and agrisilvicultural by putting extra units of these resources into production. In order to incorporate agriculture to satisfy silvopastoral and pastoral to satisfy agrisilvicultural, the optimal farm plan shows the farmers need to be supported to the tune of opportunity cost, which is N891.80 for agriculture and N9, 769.97 for pastoral.

The urgent need arises therefore to properly mobilize the extension services to disseminate relevant research result to agroforestry practitioners with respect to worked out optimal farm plan for the study area. This should be with respect to what should be produced, the land area (sizes) to be mobilized and the levels of hired labour and operating capital to be used conforming with what is worked out in this study. This will go a long way to improving the productivity in resource use of agroforestry practitioners, increase their farm output and maximize their profits. Enhanced sustenance of livelihoods will result with respect to improved market earnings and household food consumption. This will go a long way in helping to keep the young and able men in the farms rather than their engaging in rural-urban migration in search of the non-available jobs in the cities.

Land size was binding in the production and the monetary value of the farm plan could enhanced by putting much of it into production. There is the need to subsidize the practitioners' operations the assistance of government to increase the farm holdings and improve the infrastructural facilities that will facilitate quite access to the areas. This can be effected through the Adamawa State Agricultural Development Program. The provision of improved planting materials, soft loan as at when due is equally a very important operating capital need that can be effected by the government, the agroforestry practitioners will be better put in a position to further render in an enhanced form their invaluable services for national and global food security.

References

Adebayo, A. A.. (2004), 'Adamawa State in Maps". Pp 112. Second Edition Paracelate , Yola Nigeria.

dFAO. (2008), "The State of Food & Agriculture". Biofuels: Prospect, Risk & Opportunities". Rome.

FAO. (2010), "Global Forest Resources Assessment 2010". FAO Forestry Paper No. 163. Rome

Garritty, D.P. (2004), "Agroforestry & the Achievement of the Millennium Development Goals". Agroforestry System, 61: 5-17.

National Population Census (2007), http://le.n.wikepedia.org/w.k1/list of Nigerian States by Population pdf. Retrieved 6/5/14

Olayide, S.O (1982), "Characteristics, Problems & Significance of Small farmers in Nigeria-Problems & Prospects In: S.O Olayide, J.A. Eweka, V.E. Bello-Osagie (Eds): Nigerian Small Farmers". Ibandan: CARD Publishers, pp. 96-113.

Place, F., Ajayi, O.C., Torquebiau, E., Detlefsen, G., Gauthier, M. & Buttoud, G.(2012), Improved Policies for Facilitating the Adoption of Agroforestry". In M. Kaonga, ed. Agroforestry for Biodiversity & Ecosystem Services: Science & Practice, pp 113-128. Rijeka, Croatia, inTech.

Roshetko, J.M., Lasco, R.D. & Delos Angeles, M.S. (2007): Smallholder Agroforestry Systems for Carbon Storage. Mitigation and Adaptation Strategies for Globaal Change, 12:219-242.

Steffan-D., Kessler, M., Barkmannn, J., Bos, M.M., Buchori, D., Erasmi, S., Faust, H., Gerold, G. & Tscharntke, T. (2007), "Tradeoffs between income, Biodiversity, & Ecosystem functioning during Tropical Rainforest conversion & Agroforestry intensification". Proceedings of the National Academy of Science of the USA, 104: 4973-4978.

Thorlakson, T. & Neufeldt, H. (2012), "Reducing Subsistence Farmers Vulnerability to Climate Change: Evaluating the Potential Contributions of Agroforestry in Western Kenya". Agriculture & Food Security, 1:15 www.agricultureand foodsecurity.com/content/ Retrieved 1/1/15.

Zira, B.D., & Ghide, A.A. (2013), "Illustrative Optimal Portfolio Selection for Agroforestry Crops: A Linear Programming Approach". International Journal of Management & Social Sciences Research 2 (8): 139 141

Appendix

Table 1: Socio-Economic Characteristics of Agroforestry Practitioners

Variables	Frequency	Percentage
SEX		
Male	111	92.5
Female	9	7.5
Total	120	100
AGE		
20-39	29	24.2
40-59	69	57.5
60 and Above	22	18.3
Total	120	100
MARITAL STATUS		
Married	105	87.5
Single	9	7.5
Widowed	6	5
Total	120	100
FAMILY SIZE		
? 2	3	2.5
3-5	59	49.2
6-8	42	35
? 8	16	13.3
Total	120	100
EDUCATIONAL LEVEL		
No. Formal education	57	47.5
Primary	33	27.5
Secondary	21	17.5
Tertiary	9	7.5
Total	120	100

Source: Field Survey, 2014.

Table 2: Linear Programming Matrix of Agro forestry Practitioners in the Study Area.

Enterprises	Silvopastoral (X_1)	Agrisilvicultural (X_2)	Agrosilvopastoral (X_3)
Land area (ha)	2.0	2.0	2.0
Operating Capital ₦	9,030.00	14,250.00	23,925.00
Hired labour ₦	270.00	612.00	733.00
Family labour ₦	138.00	390.00	555.00
Gross margin ₦	17,790.00	23/ 475.00	26, 367.00

Source: Field Survey, 2014.

Resource Constraints limit:

Total land available (b_i) = 2.90 ha

Total family labour (b_i) = 453 man days

Total hired labour (b_i) = 580 man days

Total operating capital (b_i) = N18,855.00

Table 3: Final Optimal Solution to the Model

Enterprises	Silvopastoral (X_1)	Agrisilvicultural (X_2)	Agrosilvopastoral (X_3)
Land area (ha)	1.25	1.50	1.75
Opportunity cost ₦	0	0	0
Objective coefficient ₦	17,790.00	23,475.00	26,397.00
Minimum coefficient ₦	17,748.36	21,597.71	25,494.68
Maximum coefficient	21,898.48	24,140.79	30,640.00

Source: Field Survey, 2014.

Table 4: Resource Capacity used in Maximizing Gross Margin

Resource constraints	Status	Total capacity available	Shadow price	Slack / Surplus
Land Area (ha)	Tight	2.90	12,735	0
Family labour(man days)	Loose	453	0	227.76
Hired labour (man days)	Tight	580	22.29	0
Operating capital N	Tight	18,855	0.18	0

Source: Field Survey, 2014.

Table 5: Sensitivity Analysis for Resource Constraints level

Resource constraints	Lower value	Current value	Upper value
Land Area (ha)	1.58	2.90	4.0
Family labour(man days)	225.26	453	Infinity
Hired labour (man days)	570.78	580	768.96
Operating capital ₦	15,978.00	18,855.00	19,167.18

Source: Field Survey, 2014.