ACTIVITY OPTIMIZATION AND IMPLICATION TO RESOURCE MANAGEMENT AND RURAL DEVELOPMENT IN THE KAINJI LAKE FISHING COMMUNITIES, NIGERIA

[*1]TAFIDA, A. A., [2]A. A. ADEBAYO, [2]M. GALTIMA, [2]B. MODU & [1]A. RAJI
1. National Institute for Freshwater Fisheries Research, New Bussa, Niger State.
2. Federal University of Technology, Yola, Adamawa State.
*Corresponding Author: tafjam2003@yahoo.com +2348054504182

ABSTRACT
The complexities in resources management of Kainji Lake, which reflect on the economy, environment, cultural and social life of the people remain a central concern to many authorities, organizations, institutions, agencies and NGOs, lead to the development of several approaches to address the problem. In this paper, a more convincing approach using empirical evidences from the field is reported. A model was developed and used to practically test data on livelihood activities collected from 30 fishing communities in Kainji Lake basin selected using stratification technique. The result revealed that rearing of free range chicken and livestock are the optimum and best rewarding activities of the available resources in the rural communities. It is hoped that the result will deter the fishers from intensifying fishing efforts and elicit them to the realization and engagement in most rewarding activities hence sustaining the fisheries resources for future generation and improving the fisher's wellbeing.
Keywords: rural livelihoods, fishers, livelihood diversity

INTRODUCTION

Resource management is a problem of major importance in many countries. In fisheries sub-sector of the Nigerian economy lack of management and law enforcement among other factors have over the years subjected the resources to threat of depletion making the actors more vulnerable. Over the years, resource management has remained a main concern in fisheries development in Nigeria. This is particularly applicable to the inland (artisanal) fisheries, which is an open access. At National, Regional and Global levels, there is an increasing pressure on fisheries managers, regulators, practitioners and academicians to develop a sustainable approach to fisheries resource management and to integrate strategies aiming at producing the best practicable and sustainable options, particularly without much government intervention. Most of the approaches designed and implemented by government, donor agencies and NGOs were not successful, primarily due to poor implementation and lack of enforcement, viz lacked the credence of sustainability. Such reasons have led several authors to look into alternative approaches, among which the concept of sustainable livelihood, particularly livelihood diversification is most commonly featured in recent times (Bene *et al*., 2003; Tafida *et al.*, 2009). Several studies have considered this approach as good in poverty reduction, addressing vulnerability of the poor to food insecurity and livelihood collapse and improve the quality and sustainability of natural resources that constitute key assets in rural livelihood (Carter, 1997; Ellis, 1999; Bene *et al.*, 2003; Ellis and Allison, 2004; Homewood *et al*., 2004). Literature equally reveals that the diversification trends are found differently across different socio-economic strata, and they are characterized by different livelihood strategies and economic portfolios (Ashley and Carney, 1999; Ellis, 1999; Toulmin *et al*., 2000). In this paper, advancement is made on the concept of livelihood diversity approach by developing a model (Linear Programming) to test empirical field data in order to concretize reasoning with practical evidences on the optimum activity, considering the local resources at the fishermen's disposal. It is hypothesized that fishing (in spite of the vast Kainji area fishery resources) is not the best rewarding activity. The paper is therefore aimed at evaluating and encouraging exploitation of other available capital assets in the villages for more livelihood options than fishing effort, thereby sustaining the

resources and improving the general well-being of the people and rural development.

STUDY AREA

Kainji Lake is located between longitude 4° 21' and 4° 45' East and latitude 9° 5' and 10° 55' North. It cut-across Niger and Kebbi States, with the greater part located in Niger State. The Lake is the second largest lake and the largest manmade lake in Nigeria (Ayeni and Mdaihli, 1996). It was created in 1968 following the impoundment of River Niger by the construction of the Kainji Dam at New Bussa, in Borgu local Government area of Niger State. The Dam was created basically for hydroelectric power generation to boost industrial growth and general economic development in the country. However, the reservoir created secondary economic opportunities, in particular fisheries, which attracted fishermen from near and far areas around the state and neighbouring countries of Benin and Niger republics (Ayanda and Alamu, 1991). Frame survey on the Lake conducted in 2004 indicated the existence of two hundred and ninety seven (297) permanent fishing villages and camps and one (1) temporary fishing camp around the Lake basin and the Islands (Abiodun and Niworu, 2004). Some studies on the Lake basin revealed the socio-economic characteristics of the people to comprise of the following; majority of the fishermen are *Sarkawa* sub tribe of the Kebbi Hausa, with other tribes like *Laru, Gungawa, Lopawa, Nupes.* Majority of them are illiterates (Ayanda and Alamu, 1991). Traditional occupations of the people apart from fishing include: farming, livestock and local enterprises such as pottery, mat weaving, gear/craft making and servicing (Alamu and Mdaihli 1995). Local fish and general markets abound in the larger villages.

MATERIALS AND METHODS

Data Collection and Analysis

The data collection for the study was in January/February and August/September, 2008 during the two flood regimes on the lake (high flood and draw down), which determine fish catch volume and the two seasons (rainy and dry). The study covered the eight sub-strata of the lake where 30 villages (10%) were randomly selected using random number generator from 297 (total number of fishing villages on the Lake basin) and 259 respondents were drawn using stratification technique. Out of the 259 questionnaires administered, 248 were returned valid for the analysis after sorting. Simple descriptive statistics and Linear Programming (LP) were used for the analysis.

Model Formulation

LP is a quantitative device for planning of diversified activities, in order to decide the optimum combination of factors for producing a given output; or the optimum combination of products. The general form of LP model is given as:

Optimize (Maximization):

$$Z = CX$$

Subject to: $\mathbf{AX}\ (\leq, =, \geq)\ \mathbf{b}$

$$X \geq \mathbf{0} \qquad \textbf{(1)}$$

(Hillier and Lieberman, 1967; Sharma, 2009)

Where: $\mathbf{C} = (c_1, c_2, \ldots c_n)$,
$\mathbf{X} = (x_1, x_2, \ldots x_n)^T$,
$\mathbf{A} = \lfloor a_{ij} \rfloor_{mn}$,
$\mathbf{b} = (b_1, b_2, b_m)^T$
n = number of activities (commodities)
m = number of resources available
x_j = Number of unit of activity j (commodity) considered to be produced, j = 1,2, … n
c_j =Per unit profit contribution of activity j, j =1,2, …

b_i = Amount of resources i available, i = 1,2, … m
a_{ij} = Amount of resources i used per unit of activity j

Model Formulation for optimum activity combination

The activities used for the optimization in this study are categorized into three; in the first category (livestock) three activities, which comprise of large ruminant (cow), small ruminant (sheep, goat) and poultry (local chicken) were considered. In the second category (crop production) six activities, which comprise of corn, maize, rice, millet, beans, and groundnut (common crops cultivated in the study area) were considered. In the third category (fishery), two activities, which comprise of fishing and fish processing, were considered.

The Decision Variables of the Problem

The decision variables of the problem are as follows:

$x_1 =$ *Number of cow produced or reared per annum*

$x_2 =$ *Number of medium ruminant produced or reared per annum*

$x_3 =$ *Number of chicken produced per annum*

$x_4 =$ *Bags of corn produced per annum*

$x_5 =$ *Bags of maize produced per annum*

$x_6 =$ *Bags of rice produced per annum*

$x_7 =$ *Bags of millet produced per annum*

$x_8 =$ *Bags of beans produced per annum*

$x_9 =$ *Bags of groundnut produced per annum*

$x_{10} =$ *"Daro" baskets of fish processed per annum*

$x_{11} =$ *"Daro" baskets of fish produced per annum*

Constraints of the Problem

There were three major constraints. First, is the limited financial resource at disposal of the fishers, relative to the various activities engaged in by the fishing household every year. Second, is the limited availability of man labour hours in fishing households, The third constraint is fishing among other activities cannot be compromised because it is the dominant occupation of the people. These three constraints can be presented mathematically as follows, for the various activities above while evaluating the profits accruing to the participants.

$$\sum_{j=1}^{10} a_{ij} x_i \le b_i, \quad i = 1, 2 \qquad (2)$$

$$x_{11} \ge b_{i+1}, \quad i = 2 \qquad (3)$$

$$x_i \ge 0, \quad j = 1, 2, \ldots 10, \qquad (4)$$

It follows that:

Maximize :

$$Z = \sum_{j=1}^{3} c_j x_j + \sum_{j=4}^{9} c_j x_j + \sum_{j=10}^{11} c_j x_j \qquad (5)$$

this can also be writen as :

$$Maximize : z = \sum_{j=1}^{11} c_j x_j \qquad (6)$$

The LP model of the problem is:

$$Maximize : Z = \sum_{j=1}^{11} c_j x_j$$

Subject to : **(7)**

$$\sum_{j=1}^{10} a_{ij} x_j \le b_i \quad i = 1, 2$$

$$x_{11} \ge b_{i+1}, \quad i = 2$$

$$x_j \ge 0, \quad j = 1, 2, 3, \ldots 11$$

RESULTS

Profit Contribution of Livelihood Activities

Differentiation of economic activities in the fishing villages were identified in various ways. This study revealed three major categories of activities: Livestock; (cow, goat, chicken), Crop production; (Corn, Maize Rice, Millet, Beans, and Groundnut), and Fishery; (Fishing and Fish processing). These prominent activities cut across almost every household in the communities. The result of resource utilization and profit contribution of activities, based on input cost and man hour, item wise showed that cow contribute most profit (₦19,741.67) per unit head of cow, followed by fishing (₦1,460.218) per *Daro (Daro =12 kg)*, and beans (₦1,506.447) per bag of 50 kg (Table 1).

Determination of Optimum Activity

The optimal solution from the model analysis as shown in Table 2, revealed that attaining the objective function of ₦119, 572.8 can best be done by producing 176 of chickens as activity product. Therefore, variable x_3 (local chicken) is the potential optimal product.

Table 1: Resource Utilization and Profit Contribution per Unit of Activity

Activity	No. of household Engaged	Profit Contribution (₦)	Average Cost/Unit	Man Hour/Unit
Cow	116	19741.67	9918.391	418.2716
Goat	164	1300.75	725.8506	103.3513
Chicken	156	263.1129	91.4685	1.598701
Corn	159	558.0153	1234.144	42.12463
Maize	167	328.5023	1435.57	54.0293
Rice	143	1141.904	1134.786	36.8894
Millet	29	460.3628	1125.844	61.60814
Beans	59	1506.447	1321.801	67.18138
Groundnut	45	996.0396	957.2937	45.99264
Fishing	245	1460.218	676.2646	36.63044
Fish Processing	142	474.2363	2171.774	24.38275

Source: Field Survey, 2008

Table 2: Optimization of Activity; optimal solution with objective function value = 119572.809251

Variable	Value	Reduced Cost
X_I	0.000000	8788.9894
X_2	0.000000	787.189086
X_3	176.965513	0.000000
X_4	0.000000	2992.050645
X_5	0.000000	3800.973813
X_6	0.000000	2122.354574
X_7	0.000000	2778.173743
X_8	0.000000	2295.767908
X_9	0.000000	1757.655077
X_{10}	0.000000	5772.96088
X_{11}	50.000000	0.000000

Source: Field Survey, 2008

DISCUSSION

The concern about fisheries resource management in Nigeria following failures of other approaches informed this study. Linear programming was used to develop the optimization model. LP is simply the optimization of an outcome based on some set of constraints using a linear mathematical model. The model was used to test the empirical data from series of categorized activities engaged by fishing households in Kainji Lake Basin (KLB). The underlining idea was to provide a concrete evidence of the optimal activity based on the fishers' constraints. This is essentially to convince the fishing households on adoption and combination of other livelihood portfolios, thereby reducing fishing efforts and attaining efficient resource management and sustainability. On the profit contribution of the various income activities, of interest, fishing households usually combined assets available to them with fishing in strategizing their livelihood activities in order to attain certain outcomes; the choice of additional activity varies from one fisher to another. These outcomes could be to maximize income and produce enough food for the family. This findings conform to the submissions of Bene *et al*., 2003; FAO, 2005. However, the actual cost and benefits of each of these activities are often envisaged. The choice and engagement in the activity are often controlled by some factors, which include environment, resource availability, technical knowledge, capital and interest.

Linear Programming Model is used to identify the optimal activity by subjecting three parameters, average cost per unit of each product, Man-hour per unit of the product and profit contribution per unit of the product. Three constraints were used for the linear programming; these include finance in terms of monetary cost, Labour in terms of Man-hour and

fishing, which in combination with other activities cannot be compromised. Rearing of local poultry appeared as the optimum activity. Reasons for that could be adduced from the perspective of low input involvement in free-range (local) poultry production. Therefore, rearing local chicken is most beneficial in terms of cost. Nevertheless, that does not mean the study is advocating rearing local chicken only, rather is calling for multiple combinations of activities.

CONCLUSION

The result of resource utilization and profit contribution of activities, based on input cost and man hour, item wise showed that cow contribute most profit per unit head of cow, followed by fishing per *Daro (Daro =12 kg)*, and beans per bag (50 kg). This gave us an insight that fishing does not provide the highest profit among the activities engaged in by the fishermen. Similarly, the optimal solution test suggests production of 176 units of chicken as the best objective function (gain) of ₦119, 572.8 from the perspective of low input involvement for the production of chicken. The paper therefore suggests, based on empirical evidences from the field, that fishermen should look into other profitable and optimum activities such as local poultry production and livestock for best utilization of their resources and for profit maximization.

RECOMMENDATIONS

- Policies geared towards fisheries development in Nigeria should have broader insights to look at the rural livelihood in a holistic manner rather than sectoral approach.
- Assets accessibility particularly the Human, Physical, Financial, and Natural should be enhanced and avenue for social participation should be provided.
- Micro-credit facilities should be provided with easy procedure, this would help remarkably in diversifying of livelihood portfolios and subsequent improvement of well-being of the fishing families.
- More emphasis should be laid in qualitative education and skills acquisition; this will improve the capabilities of the fishers in diversifying into more meaningful activities that would eventually enhance their livelihood.

ACKNOWLEDGEMENTS

We wish to sincerely thank the National Institute for Freshwater Fisheries Research, New Bussa for Sponsoring the research work, in particular the Executive Director, Dr. Aminu Raji for his kind support in providing facilities for the work. Also, we appreciate the roles played by our field officers in facilitating collection of data in the 30 fishing villages.

REFERENCES

Abiodun, J. A. and Niworu A. M. (2004). Fisheries statistics bulletin, Kainji Lake fisheries management and conservation unit, *Technical Report Series*. 23 (10):1-22.

Alamu, S. O. and Mdaihli, M. (1995). Evaluation of formal and informal loan schemes existing in Kainji Lake National Institute for Freshwater Fisheries Research Annual Report, pp 188-193.

Ashley, C. and Carney, D. (1999). Sustainable livelihoods lessons from early experience. London: Department for International Development. Pp196-206.

Ayanda, J. O. and Alamu, S. O. (1991). Preliminary investigation into the development and impact of fishermen's organization in the Kainji Lake basin. National Institute for Freshwater Fisheries Research annual report pp 195-204.

Ayeni, J. S. O. and Mdaihli, M. (1996). Identification of non-fishing income opportunities around Kainji. Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project 68pp.

Bene, C., Minjimba, K., Belal, E., Jolley, T. and Neiland, A. (2003). Inland fisheries tenure system and livelihood diversification in Africa: the case of the Yaere floodplains in the Lake Chad Basin *Journal of African Studies 622 (12):187-212.*

Carter, M. R. (1997). Environment, technology and social articulation of risk in West African

agricultural. *Economic Development and Cultural Change* (45):557-591.

Ellis, F. (1999). Rural livelihood diversity in developing countries: evidence and policy implications. *Odi* natural resource perspectives number 40, April 1999, 4p.

Ellis, F. and Allison, E. (2004). Livelihood diversification and natural resources access. Food and Agricultural Organization (FAO) LSP working paper Rome Italy, 50p.

FAO (2005). Increasing the contribution of small scale-fisheries to poverty alleviation and food security. *FAO Technical Guidelines for Responsible Fisheries* No.10 Rome, 2005. pp1-18.

Homewood, K. E., Coast, S., Kiruswa, S., Serneels, M. and Thompson, P. T. (2004). Massai pastoralist, diversification and poverty essay 16p.

Hillier, F. S. And Lieberman G. J. (1967). Introduction to operation research. Six edition, McGraw Hill inc. pp 32-39.

Sharma, J. K. (2009). Operations research, theory and applications, Forth edition, Macmillan publishers India, pp28-32.

Tafida, A.A., Adebayo, A.A., Ayanda J.O, Wara A. and Adedeji, R B. (2009). Rural Infrastructure and poverty alleviation in fishing communities around Kainji Lake Basin Nigeria. *Nigerian Journal of Fisheries Technology* 1(1):35-142.

Toulmin, C., Leonard, R., Brock, K., Coulibaly, N., Carswell, G. and Dea', D. (2000). Diversification of livelihoods: Evidence from Mali and Ethiopia. Research Report No. 47 Brighton University of Sussex Institute of development studies. 136p.