

Comparative Analysis of Farmers' Livelihood Strategies by Optimizing Resource Use in Farming Areas of Adamawa State, Nigeria and Eastern Uttar Pradesh, India: An Application of Sen's Multi-Objective Programming Approach

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ABSTRACT---- *This paper explores the likelihoods of optimal allocation of resources as livelihood strategies for the farmers in Eastern Uttar Pradesh, India and Adamawa State, Nigeria. The study compared and determined the best production plan and resource allocation among food crop farmers in the two location of the study area Eastern Uttar Pradesh and Adamawa State, Nigeria. The objective of the study was to examine the socio-economic characteristics of food crop famers and to formulate alternative farm plans for improving farm economy. A multistage random sampling technique was used to select a total of 300 food crop farmers, the data for the study were randomly collected from 150 farmers from the eight district of Varanasi District of Eastern Uttar Pradesh and 150 from eight villages of the 21 local government area of Adamawa state. Structured questionnaire survey was used to obtained data from the respondents in the study area. Descriptive statistics and Sen's Multi-Objective Programming (MOP) Model was used to analyze the data obtained from the field survey. The study shows that in Eastern Uttar Pradesh and Adamawa State, majority 96% and 68.7% were full time farmers with average mean of 46.5 and 31 years of age respectively. They had average agricultural farming experience of 27 years for farmers in Uttar Pradesh and 30.96 years of farming experience for farmers in Adamawa State Nigeria. Majority (94%) Eastern Uttar Pradesh and (85.3%) Adamawa State were male farmers and only 18.7% in Uttar Pradesh and 15.3% of the respondent had no formal education with average land holding of 0.73 (Uttar Pradesh) and 3.1 (Adamawa State) hectares. The result of the multiple objective programming reveals that the existing average income of ₹58168 (Uttar Pradesh) and ₹69348.97 (Adamawa State) was realized while the optimal income obtained from the multi-objective programming was ₹61251.40 Uttar Pradesh and ₹71979.95 Adamawa State which is 5.30 and 3.79 per cent higher over present income respectively. Consequently, for employment, the existing plan was 80.92 man days for Uttar Pradesh and 156.5 man days for Adamawa State while the optimal plan for the maximization of employment recommends 81.32 man days which represent 0.49 per cent increase for Uttar Pradesh and 162 man days which represent 3.51 per cent increase for Adamawa State. Lastly for the minimization of fertilizer the existing plan allocated 218.97 kg for farmers in Uttar Pradesh and 282.15 kg for farmers in Adamawa State of fertilizer while the optimal plan for minimization of fertilizer use recommends 204 kg Uttar Pradesh and 218.03 kg Adamawa State which represents a decrease of 6.83 per cent and 22.73 per cent respectively. It is recommended among others that the food crop farmers be educated on allocation of resources for optimum utilization to raise their level of production and income for a better livelihood.*

Keywords--- Farmers' Livelihood Strategies, Optimising resource use, Sen's Multiobjective Programming

1. INTRODUCTION

Livelihood strategies reflect range and combinations of activities and alternatives that people make to achieve goals and livelihoods. Livelihood strategies evolve according to implicit and / or explicit decision-making foundation on the internal and external verity of livelihood. Subsistence strategies are diverse and are in a constant process of change and adaptation. An efficient agricultural system aims to develop optimal combinations in enterprises for greater integration of agricultural activities. In order to make better use of the agricultural lands, in order to support farmers' families and produce crops in a sustainable way, agricultural planning must be carefully organized at farm level. Most farmers build a diversified portfolio of social support activities and survival skills to raise living standard. They grow more crops in a season to meet the needs

of family consumption along with generating sufficient income for other household expenses. Therefore, improving farmers' income is an important consideration for the formulation of alternative business plans. Farmers use high-dose chemical fertilizers with less use of organic fertilizers in crops that are not suitable for soil health (Kushwaha, 1998a). The reduction in the use of chemical fertilizers becomes the second goal for agricultural planning. It is also desirable to offer more job opportunities for rural workers. The third objective of agricultural planning is to increase the use of labor in crop cultivation. Therefore, this study attempt to formulate alternative farm plans to increase income and employment by reducing the use of fertilizers in farms of Varanasi Uttar Pradesh, India using Sen's MOP method (Sen, 1983). This paper aims to examine the socioeconomic characteristics of food crop framers and formulate alternative farm plans for improving farm economy that will consequently have positive impact on their livelihood strategies. This method has been used successfully by many researchers (Sen and Painuli 1984, Kushwaha 1992 b, Memariani, 1993, Sen and Dubey 1994, Gangwar 1994, Singh 2002, Kumar 2012, Gautam 2015, Kumari et al. 2017) to formulate the right farming plan to achieve multiple goals at the same time.

2. METHODOLOGY

Sampling procedure and Data Collection

The study was conducted in Varanasi district of Uttar Pradesh which comprises of 8 blocks. Multi-stage random sampling technique was employed in the selection of respondents in this State. In the first stage one block was selected purposively. In the second stage one village was selected randomly in each of the selected block to give a total of 8 sampled villages. The third stage sampling involved the random selection of 150 farmers in the 8 villages.

Primary data was used for the study, which was obtained through the administration of questionnaire to farmers in the sampled villages with the assistance of trained personnel. The data collected was for 2016 and 2017 farming seasons.

Methods of Data Analysis

Inferential statistic was used to analyse the data. Sen's (1983) Multi-objective programming was used to achieve the optimum utilization and resource allocation of farmers' in the study area. Linear Programming model is described as:

$$\begin{aligned} \text{Maximize } Z1 &= \sum_{j=1}^n I_j X_j \\ \text{Maximize } Z2 &= \sum_{j=1}^n E_j X_j, \text{ and} \\ \text{Minimize } Z3 &= \sum_{j=1}^n F_j X_j \end{aligned}$$

Subject to the constraints,

$$\sum_{j=1}^n a_{ij} x_j \geq \leq b_i$$

$$x_j \geq 0 \quad j=1,2,\dots,n \quad i=1,2,\dots,m$$

Where,

Z_1 = Total net returns from all the crops in rupees

Z_2 = Total employment on the farm in man days and

Z_3 = Total fertilizer use on the farm in Kg.

I_j = Net return from j^{th} crop in rupees/ha.

E_j = Employment of j^{th} crop in man-days/ha

F_j = Fertilizer use in j^{th} crop in kg/ha

X_j = Area under j^{th} crop in ha.

a_{ij} = Quantity/Number of i^{th} input required per hectare by j^{th} crop.

b_i = Quantity/Number available of the i^{th} resource/ Input

The individual optimization of income, employment and fertilizer use have generated three different cropping patterns with high degree of conflicts in achievement of the objectives. To overcome this problem and generating an appropriate farming system that achieves all the three objectives simultaneously, Sen's MOP method (Sen 1983) was used. Sen's MOP method is described as below:

$$\text{Maximize } Z^* = \frac{\sum_{j=1}^n I_j X_j}{W_1} + \frac{\sum_{j=1}^n E_j X_j}{W_2} - \frac{\sum_{j=1}^n F_j X_j}{W_3}$$

Subject to the constraints,

$$\sum_{j=1}^n a_{ij}x_j \geq \leq b_i$$

$x_j \geq 0, i=1,2,\dots,m, j=1,2,\dots,n$

Where, Z^* = Multi Objective Function, W_1 = Maximum Income, W_2 = Maximum Employment and W_3 = Minimum Fertilizer use.

3. RESULTS AND DISCUSSION

Formulation of Optimal Farm plans:

The alternative farm plans have been formulated increasing the income of the farmers with more employment opportunities with lesser use of fertilizer. The optimization model is described as below;

Max $Z_1 = X_1 + X_2 + \dots + X_8$

The decision variables are:

X_1 = area allocated for paddy crop, X_2 = area allocated for maize crop, X_3 = area allocated for red gram crop, X_4 = area allocated for black gram crop, X_5 = area allocated for wheat crop, X_6 = area allocated for pea crop, X_7 = area allocated for gram crop, X_8 = labour hiring, X_9 = capital borrowing

Subject to:

Resource constraints

- Kharif land (0.73 ha),
- Rabi land (0.73 ha)
- Kharif labour (120 man-days)
- Rabi labour (130 man-days)
- Wage rate (Rs.300 man-days)
- Rate of interest on borrowings (4% p.a)
- Kharif own capital (Rs.31500)
- Rabi own capital (Rs.31500)

Temporally-Ordered Routing Algorithm (TORA) computer based software was used to obtain the optimum land allocation area for food crop farmers.

The optimal farm plan generated for maximizing income, employment and minimizing fertilizer use is presented in Table 1 and this is based on the assumption that maximization of income, employment maximization and minimization of fertilizer use is the underlying behavioral principle guiding the farmers in their resource use and allocation decision. The Table shows that the existing average income of ₹58168.5 was realized while the optimal income obtained from the multi-objective programming output is ₹61251.40 which represent 5.30 per cent enhancement in income. This results reveals that the farmers in the study area were already working close to the efficiency level as there is only a marginal variation between the existing and the alternative suggested plan. Consequently, for employment, the existing plan was 80.92 man days while the optimal plan for the maximization of employment recommends 81.32 man days which represent 0.49 per cent increase. Lastly for the minimization of fertilizer the existing plan allocated 218.97 kg of fertilizer while the optimal plan for minimization of fertilizer use recommends 204 kg which represent a marginal decrease of 6.83 per cent.

Table 1: Results of Existing and Alternative Plans of Income, Employment and Fertilizer use of farmers in Uttar Pradesh farms

Particulars	Existing plan	Individual Optimization			Sen's M.O.P.
		Max. Income	Max. Employment	Min. Fertilizer	
Income (₹)	58168.5	62306.37 (+7.11)	57472.05 (-1.19)	41009.94 (-29.49)	61251.40 (+5.30)
Employment (Man-days)	80.92	77.52 (-4.20)	83.82 (+3.58)	52.36 (-35.29)	81.32 (0.49)
Fertilizer use (Kg)	218.97	204.84 (-6.45)	228.48 (4.34)	202.45 (-7.54)	204 (-6.83)

Source: Field Survey 2017

Note: Figures in parentheses shows the percentage increase/decrease over the existing levels.

Table 2 reveals the optimal farm plan generated for maximizing income, employment and minimizing fertilizer use and this is based on the assumption that maximization of income, employment maximization and minimization of fertilizer use is the underlying behavioral principle guiding the farmers in their resource use and allocation decision. The table shows that the existing average income of ₹69348.97 was realized while the optimal income obtained from the multi-objective programming output is ₹71979.95 which represent 3.79 per cent enhancement in income. This results reveals that the

farmers in the study area were already working close to the efficiency level as there is only a marginal variation between the existing and the alternative suggested plan. Consequently, for employment, the existing plan was 156.5 man days while the optimal plan for the maximization of employment recommends 162 man days which represent 3.51 per cent increase. Lastly for the minimization of fertilizer the existing plan allocated 282.15kg of fertilizer while the optimal plan for minimization of fertilizer use recommends 218.3 kg which represent a marginal decrease of 22.73 per cent.

Table 2: Results of Existing and Alternative Plans of Income, Employment and Fertilizer use of farmers in Nigeria farms

Particulars	Existing plan	Individual Optimization			Sen's M.O.P.
		Max. Income	Max. Employment	Min. Fertilizer	
Income (Rs.)	69348.97	74281.09 (+7.11)	60772.05 (-12.37)	51147.65 (-26.25)	71979.95 (+3.79)
Employment (Man-days)	156.5	129.25 (-17.41)	167.75 (+7.19)	148 (-5.43)	162 (+3.51)
Fertilizer use (kg.)	282.15	263.80 (-6.50)	287.30 (+1.83)	209.30 (-25.82)	218.03 (-22.73)

Source: Field Survey 2017

Note: Figures in parentheses shows the percentage increase/decrease over the existing levels.

The percentage allocation of existing cropping pattern along with the MOP percentage efficient recommended cropping pattern if the farmers in the study area are to enhance their income by reallocating the existing plan to adopt the MOP recommended efficient best technology and management practice. In Table 3 the result reveals that the efficient cropping pattern that enhances the income of the farmers is by reducing the area under paddy from 0.52 ha which represents 71.23% of the total land earlier allocated to 0.42 ha i.e. 57.53%. Similarly for maize from 0.10 ha (13.7%) to 0.02 ha (2.74%) and increase the area under Redgram from 0.06 ha (8.22%) and Black gram 0.05 ha (i.e. 6.85%) to 0.10 ha (13.70%) and 0.19 ha (26%) respectively. Consequently, the existing plan during the rabbi session allocated 0.62 ha (84.93%) while MOP recommended a reduction to 0.56 ha (i.e. 76.71%), for pea the existing plan allocated 0.07 (9.59%) ha while the MOP recommended that the allocation be increase to 0.10 (13.70%) ha and for gram from 0.04 (5.48%) ha should be increase to 0.70 ha which represents 9.59%.

Table 3: Percentage Change of Existing and Optimal Plan on food crop farms in Uttar Pradesh

Crops	Existing plan		Optimal plan	
	Area (ha)	Percentage	Area (ha)	Percentage
Kharif season				
Paddy	0.52	71.23	0.42	57.53
Maize	0.10	13.70	0.02	2.74
Redgram	0.06	8.22	0.10	13.70
Blackgram	0.05	6.85	0.19	26.03
Total	0.73	100	0.73	100
Rabi season				
Wheat	0.62	84.93	0.56	76.71
Pea	0.07	9.59	0.10	13.70
Gram	0.04	5.48	0.07	9.59
Total	0.73	100	0.73	100

Source: Field Survey 2017

Table 4 presents the percentage allocation of existing cropping pattern along with the MOP percentage efficient recommended cropping pattern if the farmers in the study area are to enhance their income by reallocating the existing plan to adopt the MOP recommended efficient best technology and management practice. The table reveals that the efficient cropping pattern that enhances the income of the farmers is by reducing the area under maize from 1.13 ha which represents 36.33% of the total land earlier allocated to 0.56 ha i.e. 18.01%. Similarly decrease area for paddy from 0.47 ha (15.11%) to 0.41 ha (13.18%) and the area under sorghum from 0.36 ha (11.58%) to 0.41 ha (13.18%) and 0.23 ha (7.40%) respectively. Consequently, the existing plan for groundnut allocated 0.35 ha (11.25%) while MOP recommended the same plan, for cowpea the existing plan allocated 0.80 (25.72%) ha while the MOP recommended that the allocation be increase to 1.56 (50.16%) ha. This agrees with Kushwaha (1996) in their study of estimation of hectareage response of irrigated tomato to some selected economic factors in Bauchi State, Nigeria.

Table 4: Percentage Change of Existing and Optimal Plan on food crop farms in Nigeria

Crops	Existing plan		Optimal plan	
	Area (ha)	Percentage	Area (ha)	Percentage
Maize x1	1.13	36.33	0.56	18.01
Paddy x2	0.47	15.11	0.41	13.18
Sorghum x3	0.36	11.58	0.23	7.40
Groundnut x4	0.35	11.25	0.35	11.25
Cowpea x5	0.80	25.72	1.56	50.16
Total	3.11	100	3.11	100

Source: Field Survey 2017

4. CONCLUSION AND RECOMMENDATIONS

This study revealed that male dominated the farming activities in the study area and majority of them were small and marginal farmers within the middle age group. The study also revealed that most of the respondents are married with small family size and majority of them were **educated with years of farming experience**. It was revealed also from the result that most of them were farmers. The findings from the results also reveals that majority of the farmers had no extension visit and their land acquisition is based on inheritance. Both family and hired labor is the major source of labor in the study area.

The result of the multiple objective programming reveals that the farmers in the study area were already working close to the efficiency level as there is only a marginal variation between the existing and the alternative suggested plan. Based on this findings, the following recommendation are made:

1. The need to support the farmers with the extension service for better subsistence strategies cannot be underestimated. Therefore, it is recommended that extension services be modernized and strengthened through appropriate governmental and non-governmental funding. This will help and encourage extension workers to educate farmers about the allocation of critical resources and managerial skills that will enable farmers to plan and evaluate commercial activities on farms for better standard of living.
2. There is need to educate the farmers on how to utilize their limited resources for optimal allocation and use to enable them harness the best productivity and income.

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