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Multi-Objective Programming (MOP) Model for Aquaculture Production Systems in the Northern India

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Abstract*: India is the second largest producer of fish in the world. India is also a major producer of fish through aquaculture and ranks second in the world after China. Fisheries sector occupies a very important place in the socio-economic development of the country. This study was conducted in Maharajganj district of Eastern Uttar Pradesh the highest fish producing district was selected purposively Total of 200, fishers of four blocks were selected for the study. A multi objective programming was used which is a mathematical technique where by two maximizes or one minimizes linear function subjects to various constraints or side conditions, stated in the form of linear in equalities. Optimization of resources may increase the income and employment by 29.83 percent and by 22.35 percent, respectively in MOP solution over existing plan first in which three species viz. Rohu, Katla and Mangur were considered for production systems. Optimization of resources may increase the income and employment by 18.35 percent and by 21.67 percent, respectively in MOP solution over existing plan second in which three species viz. Rohu, Katla, Mangur and Common Carp were considered for production systems. Optimization of resources may increase the income and employment by 18.35 percent and by 41.49 percent, respectively in MOP solution over existing plan third in which three species viz. Rohu, Katla, Silver Crap, Grass Carp, Common Carp and Mangur were considered for production systems.

***Keywords*: sustainability, Aquaculture, linear programming, Optimization of resources**

1. Introduction

The country also occupies second position in the world after china. Aquaculture accounts for about half of the total fish production and provides food and nutritional security to millions of people at affordable price as well as contributes to the livelihood support to a large number of rural populations in the country. The fisheries sector is an important player in the overall socio-economic development of India. Fish production was purely traditional activity in the early fifties, but now fisheries and aquaculture have now transformed into a significant commercial enterprise. The sector's contribution to employment generation, food and nutritional security and foreign exchange earnings is now well recognized. The number of people employed in direct production in the sector cannot be taken as the only indicator of the magnitude of fisheries contribution to the national economy. The contribution of people engaged in other ancillary activities, such as processing, net and gear making, ice production and supply, boat construction and maintenance, packaging, marketing and distribution is also substantial and adds to the overall contribution from the sector. Besides, those engaged in research, development and administration linked with the fisheries sector are also important contributors to the sustainable growth of the sector. The contribution of this sector to the gross domestic product is about 1.07 percent in 2016-17. Similarly, the share of fisheries to agricultural GDP (Gross Domestic Product) has increased from 2.17 percent in 1980-81 to 5.15 percent in 2016-17. Fisheries development in Uttar Pradesh it is an inland state having vast water potential in the shape of rivers and their tributaries. Uttar Pradesh is also well endowed with natural resource in the fisheries sub sector having large area covered by rivers and canals 720000 ha. Large and medium size man made reservoirs, natural and oxbow lakes and small rural ponds. Apart from following water, the total confined water which offers tremendous scope for fish culture and capture operations, is 4.32 lakhs ha (Reservoirs: 1.38 lakhs ha, Flood plain lakes/derelict waters: 1.33 lakhs ha and Ponds/tanks: 1.61 lakhs ha) of which 53 percent has been covered under aquaculture so far, and the remaining water area is also needed to be covered under fisheries program me with a view to double the level of fish production. The total fish production from all sources in the state is registering an increasing trend and the existing level of fish production is of order of 6.17 lakhs MT, till the year 2016-2017.

A simplex based solution procedure for the multiple objective linear fractional programming problems. By (1) departing slightly from the traditional notion of efficiency and (2) augmenting the feasible region as in goal programming, the solution procedure solves for all weakly efficient vertices of the augmented feasible region (Jonathan, S. H. Kornbluth, and Ralph, E. S. 1981). The integrated rural development plan is formulated for a block in hills of Uttar Pradesh for increasing the income, employment and decreasing the soil erosion. A multiple objective programming approach was used in this study (Sen, C. 1982). He asserted that the "trade-offs" between conflicting objective were note made. Rural development plans consisting several conflicting objectives like maximization of soil erosion, minimization of disparity etc. (Sen,C.1983), developed optimum cropping plans for a Punjab with multiple objectives using compromised programming (CP).these were of opinion that according to them, the limitations of traditional linear programming (TLP) techniques are too obvious as a decision maker on a farm firm is seldom confronted with a single objective .in reality ,while multiple objectives are a rule in farm planning , single objective is only an exception thus decision maker always seeks the optimization of several of his objectives which are invariability in conflict with each other. With the help of multiple objectives programming (MOP) approach, the objective functions were maximization of income and the maximization of employment with two objectives considered in this planning process (Sankhyan et al. 1988). Multi-objective programming approach was developed multi-level rural development plan for Jounpur district. The maximization of income and employment were considered and found significant different regarding income and employment at each level in the existing and the optimum plans (Dubey 1990). A multiple objective linear programming model developed to consider a wide range of farming situations, which allowed optimization of profit or environmental outcomes or both in question. The objective was to identify the best cropping and machinery options which were both profitable and resulted in improvements to the environment, depending upon the farm situation of market prices, potential crop yields, and soil and weather characteristics. In particular, the model used a flexible approach in choosing the machinery, timing of operations, crop rotations and levels of inputs (Annetts and Audsley 2002). Multiple objective programming supports overviewed basic concepts, formulations, and principles of solving multiple objective programming problems (Korhonen 2010). Therefore, this study was conducted with the objective to know The multi-objective programming model (MOP) model for Aquaculture production systems in the Northern India.

2. Material and methods

Uttar Pradesh is divided in to four economic region viz. Eastern, Western, Central and Bundelkhand. The study was confined in eastern Uttar Pradesh which comprises five divisions Viz. Varanasi, Gorakhpur, Azamgarh, Mirzapur and Basti. Maharajganj district of Gorakhpur division being the highest fish producing district in eastern Uttar Pradesh was selected purposively. A list of all 12 blocks was prepared on the basis of fish production. Two blocks having highest fish production viz. Partawal and Mithaura, two blocks with lowest fish production viz. Bridzemanganj and Pharenda, were selected purposively. Fishers were categorized in to three categories': viz. Private fish ponds, community fish ponds and leased fish ponds. Thus a total of 10 Private fish ponds, 148 community fish ponds 42 leased fish ponds selected from four blocks. Thus, a total of 200, fishers of four blocks were selected for the study. The mathematical formulation of the model of three objective functions was given below.

1. The maximization of total income of fisher

Maximize

$$Z_1 = \sum_{j=1}^{n} I_j X_j \quad (j = 1, \quad 2, \quad 3, \dots\dots\dots n)$$

Subject to

$$\sum_{j=1}^{n} (a_{ij} X_j \leq \text{bi} \; (i = 1, \quad 2, \quad 3, \dots\dots\dots m))$$

Such that

$X_1 \geq 0$; $X_2 \geq 0$ ....$X_n \geq o$

Where,

Z_1 = Total income of the fisher

X_j = Level of j[th] activity on the pond

I_j = Total income of the fisher per unit of j[th] activity

a_{ij} = Amount of i[th] resources' used per unit of j[th] activity

2. The maximization of employment of fisher

Maximize

$$Z(2) = \sum_{j=1}^{n} E_j X_j \quad (j = 1, \quad 2, \quad 3, \dots\dots\dots n)$$

Subject to

$$\sum_{j=1}^{n} (a_{ij} X_j \leq \text{bi} \; (i = 1, \quad 2, \quad 3, \dots\dots\dots m))$$

Such that

$X_1 \geq 0$; $X_2 \geq 0$ ....$X_n \geq o$

Where,

Z_2 = Total employment in days in different species

X_j = Level of j[th] activity on the pond

E_j = Total employment of the fisher per unit of j[th] activity

a_{ij} = Amount of i[th] resources' used per unit of j[th] activity

3. The minimization of fertilizer used

Minimize

$$Z_3 = \sum_{j=1}^{n} P_j X_j \quad (j = 1, \quad 2, \quad 3, \dots\dots\dots n)$$

Subject to,

$$\sum_{j=1}^{n} (a_{ij} X_j \leq \text{bi} \; (j = 1, \quad 2, \quad 3, \dots\dots\dots m))$$

Such that

$X_1 \geq 0$; $X_2 \geq 0$..................$X_n \geq 0$

Where,

Z_3 = Total fertilizer of pond

X_j = Level of j[th] activity on the pond

P_j = Total fertilizer of the fisher per unit of j[th] activity

a_{ij} = Amount of i[th] resources used per unit of j[th] activity

4. The multi-objective programming model of fisher

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

Subject to

$$\sum_{j=1}^{n} (a_{ij} X_j \leq b_i (i = 1,2, \ldots \ldots \ldots .m))$$

Such that

$X_1 \geq 0; X_2 \geq 0 \ldots X_n \geq 0$

Where,

W_1 = Maximum Income

W_2 = Maximum Employment

W_3 = Minimum Fertilizer

And all the variables are such as stated above.

3. Results and discussion

Plan-first: The plan-I is based on a production system which include three species of fish viz., Katla: Rohu: Mangur.

It is evident from the above table 1, that when income is maximized the income increased by 31.56 percent, employment by 5.88 percent and fertilizers by 43.10 percent over existing plan. The maximization of the employment, income increased by 15.41 percent, employment by 29.41 percent and fertilizers by 25.79 percent over existing plan. It showed that maximization of income and maximization of employment did not increase in same proportion. In case of minimization of fertilizers, loss in the income was found by 29.30 percent, loss in employment was found to the tune of 17.64 percent and the expenditure on fertilizers was decreased by 52.63 percent over existing plan. While the increase in income, employment and decrease in fertilizers was observed to be the tune of 29.83 percent, 22.35 percent and -49.54 percent, respectively in MOP solution over existing plan. The above analysis indicated that MOP solution is the only way to overcome the conflicts between the three objectives and sustainability of the fish production. Therefore, the solution obtained through MOP was selected as the best compromising optimum solution.

Plan-Second: This plan is based on a production system which include four species viz., Katla:Rohu: Mangur: common Carp.

It is evident from the above table 2, that when income was maximized the income increased by 23.39 percent, employment by 3.11 percent and fertilizers by 79.89 percent over existing plan. In the process of maximization of the employment, income was increased by 12.56 percent, employment increased by 34.04 percent and reduction in the fertilizers use was by 16.01 percent over existing plan. I, it showed that maximization income and maximization of employment did not increase in same proportion. In case of minimization of fertilizers use, the income was reduced to be 21.76 percent, the employment was reduced by 9.27 percent and fertilizers use was declined by 36.82 Percent over existing plan. While the increase in income,

Table 1
Optimum level of income, employment and fertilizers under Plan first

Sl. No.	Existing plan	Alternative plan			MOP Solution
		Maximization of Income	Maximization of Employment	Minimization of Fertilizers	
Income (Rupees)	74761.61	99791.12 (31.56)	86289.32 (15.41)	52850.20 (-29.30)	97068.92 (29.83)
Employment (Man-days)	22.10	23.40 (5.88)	28.60 (29.41)	18.20 (-17.65)	27.04 (22.35)
Fertilizers (Rupees)	570.87	816.92 (43.10)	718.12 (25.79)	270.4 (-52.63)	288.08 (-49.54)

Note: figure in parentheses show percentage change over the existing plan

Table 2
Optimum level of income, employment and fertilizers under Plan second

Sl. No.	Existing plan	Alternative plan			MOP Solution
		Maximization of Income	Maximization of Employment	Minimization of Fertilizers	
Income (Rupees)	76632.34	94558.12 (23.39)	67011.61 (-12.56)	59979.40 (-21.73)	90695.39 (18.35)
Employment (Man-days)	28.61	29.50 (3.11)	38.38 (34.04)	25.96 (-9.27)	34.81 (21.67)
Fertilizers (Rupees)	396.86	713.90 (79.89)	333.35 (-16.01)	250.74 (-36.82)	310.63 (-21.66)

Table 3
Optimum level of income, employment and fertilizers under Pan third

Sl. No.	Existing plan	Alternative plan			
		Maximization of Income	Maximization of Employment	Minimization of Fertilizers	MOP Solution
Income (Rupees)	116992.30	139002.20 (18.81)	124827.30 (6.69)	87492.60 (-25.27)	138638.00 (18.50)
Employment (Man-days)	43.00	56.16 (30.61)	68.64 (59.62)	36.66 (-14.75)	60.84 (41.49)
Fertilizers (Rupees)	743.69	1143.48 (53.75)	511.68 (-31.20)	470.34 (-36.76)	497.64 (-33.09)

Note: figure in parentheses show percentage change over the existing plan.

employment and decrease in fertilizers was observed to be 18.35 percent, 21.67 percent and decline in fertilizers was found 21.66 percent, respectively in MOP solution over existing plan. The above analysis indicated that MOP solution is the only way to overcome the conflicts between the three objectives. Therefore, the solution obtained through MOP was selected as the best compromising optimum solution.

Plan-Third: This plan is based on a production system which include six species viz, Katla: Rohu: Mangur: Silver Carp: Grass Carp: Common Carp.

It is evident from the above table 3, that when income is maximized the income increased by 18.81 percent, employment by 30.61 percent and fertilizers by 53.75 percent over existing plan. The maximization of the employment, income increased by 6.69 percent, employment by 59.62 percent and decline in fertilizers was found to be 31.20 percent over existing plan. It shows that maximization income and maximization of employment did not increase in same proportion. In case of minimization of fertilizers use in income was declined to be 25.27 percent, employment by 14.75 percent and fertilizers by 36.76 percent over existing plan. While the increase in income, employment and decline in fertilizers decline was found to be 18.50 percent, 41.49 percent and 33.09 percent, respectively in MOP solution over existing plan. The above analysis indicates that MOP solution is the only way to overcome the conflicts between the three objectives. Therefore, the solution obtained through MOP was selected as the best compromising optimum solution.

It was found that the increase in income, employment and decrease in fertilizers was observed to be the tune of 29.83 percent, 22.35 percent and -49.54 percent, respectively in MOP solution over existing plan first, in which three species viz. Rohu, Katla and Mangur were considered for production systems. The increase in income, employment and decrease in fertilizers was observed to be 18.35 percent, 21.67 percent and decline fertilizers was found -21.66 percent, respectively in MOP solution over existing plan second, in which three species viz. Rohu, Katla, Mangur and Common Carp were considered for production systems and increase in income, employment and declined in fertilizers was observed to be 18.50 percent, 41.49 percent and -33.09 percent, respectively in MOP solution over existing plan third, in which three species viz. Rohu, Katla, Silver Crap, Grass Carp, Common Carp and Mangur were considered for production systems. The above analysis indicated that MOP solution is the only way to overcome the conflicts between the three objectives and sustainability of the fish production. Therefore, the solution obtained through MOP was selected as the best compromising optimum solution.

4. Conclusion

Optimization of resources may increase the income and employment by 29.83 percent and by 22.35 percent, respectively in MOP solution over existing plan first in which three species viz. Rohu, Katla and Mangur were considered for production systems. Optimization of resources may increase the income and employment by 18.35 percent and by 21.67 percent, respectively in MOP solution over existing plan second in which three species viz. Rohu, Katla, Mangur and Common Carp were considered for production systems. Optimization of resources may increase the income and employment by 18.35 percent and by 41.49 percent, respectively in MOP solution over existing plan third in which three species viz. Rohu, Katla, Silver Crap, Grass Carp, Common Carp and Mangur were considered for production systems.

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