DEVELOPMENT OF MULTI OBJECTIVE PLAN USING FUZZY TECHNIQUE FOR OPTIMAL CROPPING PATTERN IN COMMAND AREA OF AUNDHA MINOR IRRIGATION PROJECT OF MAHARASHTRA STATE (INDIA)

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Abstract: In order to consider the importance of efficient and judicious use of available resources, a case study was undertaken to allocate the land under selected crops in command area of Aundha Minor irrigation project, of Maharashtra State, India so as to maximize the net benefit and production. A linear programming allocation model was formulated by considering the four objectives viz. (i) the maximization of net benefit, (ii) the maximization of total production, (iii) the maximization and minimization of labour employment and (iv) the minimization of investment subject to the constraints dealing with the crops, soil, land, individual crop area, food and nutrient requirement, fertilizer and labour availability, irrigation water release policy, area restriction on individual crops were considered. Irrigation efficiencies of 50, 60 and 70 % were considered, while fertilizer availability was considered at 1.5, 2.0 and 2.5 times of present level along with unlimited availability. Single objective allocation model was developed by using Gam 205 package. Single objective alternate plan was worked out with the constraints of 1.5 times the present fertilizer availability and 60 % irrigation efficiency. The programme was verified by using Lindo package. Multi-objective allocation model was worked out using fuzzy technique to obtain a compromise alternate plan. As a whole compromised solution obtained under multi-objectives plan using fuzzy technique equally helps both the farming community and nation as a whole. In fact, the single objective net benefit optimization gave a benefit to the tune of Rs. 9665 ha-1 y-1, whereas the compromise solution by fuzzy technique gave better return to the tune of Rs. 10278 ha-1 y-1 as against existing benefit of Rs. 4310 ha-1 y-1. Farmers are advised to advocate the optimal cropping pattern obtained by multi-objective allocation model for better return.

Keywords: linear programming, irrigation efficiencies, fuzzy technique, optimization

1. INTRODUCTION

India has made considerable progress as far as irrigation potential created is concerned. The irrigation potential has increased from 22.5 million hectares in 1951 to 92 million hectares in 1996 against an ultimate potential of 113 million hectares. Out of this irrigation potential, the contribution of minor irrigation project alone constitutes about 38.6 million hacters. The number of minor irrigation projects is increasing. These projects mainly utilize surface water and each consists of small reservoir with a canal system for distribution of water. Unlike command area planning of major irrigation projects, no proper importance has been given to these tank irrigation projects for effective utilization of the resources. Thus, there is a need to develop an approach for efficient water management practices in tank irrigation projects.

In view of the massive investment in minor irrigation scheme, it is necessary that the scarce and expensive water resources be utilized judiciously to achieve higher economic efficiency. Therefore, effective and efficient utilization of existing tanks is necessary and the only way perhaps to achieve this is to adopt an integrated water management planning.

Integrated water management planning is a very complex phenomenon, which involves consideration of large number of possible alternate plans (Bhole, 1992). Integrated water management planning aims at increasing net benefit to the farmers with efficient crop production from available water resources, considering constraints of soil, crop management, farmer's limitation and socio-economic conditions. To handle complex water resources system of command area planning along with reservoir scheduling, the conjunctive use of linear programming (LP) and fuzzy technique is an appropriate approach to get a realistic solution. Considering the above factors, an attempt was made to undertake a systematic study of Wagarwadi catchment at Aundha minor irrigation, tank located in the Aundha Taluka of district Hingoli in the state of Maharasthra, India with the specific objectives of optional allocation of command area under different corps by Linear Programming and Fuzzy Technique and to workout the economics of alternate plans to compare them with the existing situations.

Determination of cropping pattern for command area of minor irrigation project finds an important place in crop planning for obtaining maximum net benefit. It involves selecting a group of crops, which can be grown on an area out of number of feasible crop combinations. Crop selection is influenced by factors viz. water requirements, net returns, climatic conditions availability of resources, social needs, technological innovations and agronomic practices. In crop planning, efforts are made to project an optimal cropping pattern satisfying the objective for obtaining better returns. Optimal cropping pattern makes the best use of land and water resources.

2. MATERIALS AND METHODS

The Aundha minor irrigation project is located in Aundha Taluka of Hingoli District of Maharashtra State of India. It is constructed in an existing nala, which is originating from Dargegaon village and flows through the eastern side of Aundha Taluka and finally joins Purna river, which is a tributary of Godavari river. It is located at the intersection of 77O 2', E longitude and 19O 32', N latitude in Hingoli district, Maharashtra , India. The watershed area of the Project is 1190 ha. This has been taken as an average type of watershed for runoff calculation. The project envisages the construction of an earthen dam 400 m along and 15.5 high to impound about 190 ha-m volume of water. The command area is spreaded over four villages namely Aundha, Wagarwadi, Kondsi and Asola. The gross command area of the project is 398.00 ha. Out of which 397.5 ha is cultivated command area.

Mathematical programme was formulated for Aundha minor irrigation project command area, considering various constraints like available land, crop affinity, fertilizer and water availability etc. Single and multiple objective mathematical programming models have been developed to find the best-allocation of resources to (i) various crops suitable for the agro-climatic conditions of the area (ii) animal husbandry and (iii) fodder, Cultivation. The models with single objective like minimization of net benefit to the farmers or minimization of investments have been developed to explore the impact of relaxing the various constraints. Single objective plans viz. maximization of net benefit, maximization of production, minimization of investment, maximization and minimization of labour were considered using the combination of different levels of fertilizer and irrigation efficiencies. Also multi-objective allocation model was worked using fuzzy techniques to obtain a compromise alternate plan (Paudyal and Dasgupta, 1990; Sahoo, 1990; Sinha et al., 1989; Tanka and Asai, 1984; Varshney, 1987). The multiple objective model developed serves two important purposes. Firstly, it gives a more realistic formulation and secondly, a more acceptable solution to the problems as it can incorporate the conflicting objectives of a development-planning problem.

The fertilizer dosages recommended for different crops were taken as per the requirement. The fertilizer availability in command area headquarter was estimated by conducting survey in the area. The present fertilizer availability was found to be 330, 200 and 130 quintals of nitrogen, phosphorous and potash, respectively. In order to establish the optimal irrigation efficiency under given conditions, alternative plans have been introduced considering overall irrigation efficiencies of 50 per cent, 60 per cent and 70 per cent. The optimal irrigation efficiency will be utilized while working out other alternative plans.

3. RESULTS AND DISCUSSION

Detailed area utilization under kharif, rabi and summer with crop intensity and benefit for each of the 15 plans is presented in Table 1. The constraints of the cropping intensity (175 percent) forced all the plans to have the total area to be cultivated under kharif, rabi and summer to be 695.8 ha. However, the crop allocation influenced the fertilizer and irrigation efficiency to a certain extent. From the net benefit (Table 1), it is seen that there is need to go for 60 per cent irrigation efficiency and 1.5 times present level of fertilizer availability. The policy will enhance net benefit by more than 8 per cent compared to that of existing available fertilizer uses, while higher level of fertilizer availability can be best increase net benefit by 0.12 per cent only. An improved irrigation efficiency (70 percent) can also increase the net benefit by 0.3 per cent. Thus, It was finally decided to work out single objective alternative plans with the constraint of 1.5 times the present fertilizer availability (i.e. 495, 300 and 195 quintals of N, P, K, respectively) and 60 percent irrigation efficiency.

3.1 Single objective planning

These results were obtained considering 60 per cent irrigation efficiency and 1.5 times of the existing fertilizer utilization (Table 2). The details of the area allocation under rainfed, critical and fully irrigated conditions for kharif, rabi and summer season for each of the plans are explained. Table 2. also presents the allocation of cows, buffaloes and poultry birds. It is clear that the cropping intensity of 1.75 became a limiting factor in case of benefit maximization, investment minimization and for both labour maximization and minimization. Plans gave the crop intensity of 200 per cent critical irrigation appears to be useful for kharif and rabi crops to the tune of 262.45

ha and 176.18 ha, respectively for benefit maximization without considering the poultry industry. On the other hand, considerable area has been allocated under rainfed condition for both kharif and rabi seasons. In case of all other plans maximum irrigated area is allocated under production maximization. Interestingly, poultry industry is encouraged under benefit maximization and labour maximization plans.

The profit, production, investment and labour utilization under each of the single objective alternate plans are presented in Table 3. Both the benefit and labour maximization gave a net profit of about Rs. 31 million while all other plans provided less than half the amount. Production maximization provided a maximum production of around 22.43 thousand quintals. All other plans gave even less than half the production as compared to the production under production maximization. Investment minimization required Rs. 11.3 million to be invested while benefit and labour maximization require more than 2 times that amount. It is interesting to note that the benefit to cost ratio worked out between 1.1 and 1.2 for all the plans. Labour minimization used just half the labour needed under labour maximization plan. Infact the labour and benefit maximization require more or less the same number of labours. Incorporation of poultry drastically reduces the crop production from a possible maximum of 22.43 to a minimum of 12.40 thousand quintals (Production maximization). In other words, the nation is deprived of food, which is the primary concern of the state. The results drive to the need of a compromised solution, where the interest of both the farmers and the nation are equally taken care of. That is possible only by adopting the multi-objective planning.

3.2 Multi objective planning - optimization techniques

Fuzzy technique was chosen to find the compromise solution. Considering each of the single objective plans viz., benefit production, labour maximization and minimization of investment and labour. The pay off values is presented in Table 4. From the table the difference between the highest value (Uk) and lowest (Lk) were obtained and are presented in the same table utilizing this information all the single objective function were converted as constraints given below.

The new objective function for fuzzy optimization model will be to minimize F subject to all the constraints plus the above five constraints. The programme was run using again Gams package to obtain area allocation under different crops.

The net benefit, production, investment and labour under multi-objective, multi-objective planning for each of the crop allocation is presented in Table 5.

It is clear from the table that there was a decrease in the net benefit by 28 per cent, production by 34 per cent and labour by 24 per cent while investment increased by 60 per cent from respective optimal values. However, the cropping intensity of the compromised solution is 199 per cent which is much higher than the cropping intensities obtainable from net benefit maximization, investment minimization, labour maximization and minimization and is roughly equal to the one provided by the production maximization. Hence multi-objective allocation model has been used to find out the optimal cropping pattern. In case of optimal cropping pattern all the available resources are utilized very effectively.

In fact the single objective net benefit optimization gives a benefit to the tune of Rs. 8386 ha-1 y-1 considering only crop husbandry, while compromise solution by Fuzzy technique indeed helps better returns to the tune of Rs. 10278 ha-1 y-1.

4. CONCLUSION

The compromised solution obtained under multi-objective plan using Fuzzy technique has been found as promising procedure for achieving an optimal cropping pattern in the study area. This procedure can very well be adopted in other locations and immense benefits can be obtained for the farming community.

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