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Agricultural Land Apportionment through Goal Programming

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ABSTRACT

Predominance of agriculture is the third major problem of Indian economy. The economic contribution of agriculture to India's GDP is gradually on the way out with the country's broad-based economic growth. Lack of agricultural planning, monsoon failure, lack of water supply, lack of quality seeds, lack of fertilizers, lack of proper planning of apportionment of agricultural land and many more are the reasons for decrease of agricultural economic growth in India. This research work is an attempt to reveal the potential of goal programming for Agricultural land apportionment on a drought prone model district Ananthapur, Andhra Pradesh, India. It also intends the agricultural land apportionment for various major crops. The specific priorities used in the current goal programming problem are maximum utilization of agricultural land in the district, utilization of maximum available water sources, duration of the yield and needs of the district. This model of goal programming is solved by framing an objective function defined by the decision-maker and by converting the desired priority goals into linear constraints by introducing underachievement (di-) and overachievement (di+). The purpose of this research paper is to present the application of goal programming for the optimization of agricultural land apportionment and there by overcoming agrarian unsolved problems of drought prone districts of not only India, but also of the globe. This may even lead the drought prone districts to contribute directly or indirectly to the economy.

Keywords: Goal Programming, Agricultural Apportionment, Indian Economy.

I. INTRODUCTION

India is an agrarian country with 70% of its population depends directly or indirectly on agriculture. The farmer's suicide rate in India has ranged between 1.4 and 1.8 per 1,00,000 total populations, over a 10-year period through 2005[7]. Activists and scholars have offered a number of conflicting reasons for farmer suicides, such as monsoon failure, high debt burdens, government policies, public mental health, personal issues, family problems, lack of proper planning of apportionment of agricultural land and many more. The apportionment of the land, availability of water resources, allocation of the crop, availability of water resources, handiness of labor, availability of power supply, availability of machine power, wants of the district etc are the key points in the view of agriculture. The rapid growth of population and vast development of industrialization in India makes us to think of optimization of apportionment of agriculture land. The increase in the yield depends on selecting the methods of irrigation, soil characteristics, climatic conditions, rain water, land water, socio-economic condition and many more factors. With the availability of mathematical models to the decision-makers, they may able to be maintaining a certain rate or level of the development in the agricultural yield.

Various operational techniques were used in agriculture planning in the past few decades. Linear programming is one of the most widely useful tools of operation research. In 1956, H.W.Caldwell gave an application using linear programming to farm planning. Arnold et al. [1975] has used the linear programming for maximization of production of crops. Glen (1987) used LP for allocating the land under cultivation. Qingzhen et al. (1991) developed an optimal production plan for crops and livestock.. Maximiliano Salles Scarpari et al. [2010] contributed with an optimized agricultural planning of sugarcane using linear programming. Aquil Ahmed et al. [2015] used a linear programming approach for decision making in agriculture. Majeke Felix et al. [2013] gave Model in a Small Farm Livelihood System using Linear Programming. Neela Patel et al. [2015] solved

Agricultural Land Allocation to the Major Crops model through Linear Programming.

The linear programming technique can solve the models with single objective, but most of the real time models does not have single objective to get solved by linear programming. Goal programming is a kind of tool which is used to solve the models which have multiple and conflicting objectives (multiple goals) and it attempts to achieve each goal sequentially up to a satisfactory level rather an optimal level. The concept of goal programming is first introduced by Channes and Cooper in 1961. In 1965, Ijiri has developed the concept of pre-emptive priority factors, assigning different priority levels to incommensurable goals and different weights to the goals at the same priority level. Even in agriculture planning, many goals like maximizing the profit, maximum use of the available land, maximum utilization of the available water, to meet the needs of the people, the maximum usage of man power, maximum usage of machine power and many more are involved.

The objective of this research paper is to solve the agricultural land apportionment through goal programming of the model district Ananthapur, Andhra Pradesh, India. In sequentially, certain goals were taken such as maximum usage of the land, maximum usage of available water, maximum utilization of man power, restrictions on the yield of the crop basing on the number of days required for the crop to yield and the quantity of water consumption by the crop. The aim of this research paper is to have a control on the production of the different crop yields, so that the famer can be benefited with maximum profits and also to have a glance on the water resources required.

II. DATA OF THE PROBLEM

The total land available in Ananthapur distrct is 19,13,000[14] hectares and the land under agriculture is 10,00,000[3] hectares. Among the agricultural land available, 9,00,000[3] hectares is under rain fed and 1,00,000[3] is under irrigation. The population of the district is forty one lakhs (2011 scensus). The penakacherla dam located in the model district is the only dam with the capacity of supplying 21.73 tmc[3] of water for irrigation in the district. Rainfall of 328 mm is noted on an average in the karif season in the district through last 10 years. Of the agricultural land available, the portion of the red soil is 8,34,000[3] hectares and the black soil is 1,66,000[3] hectares. According official figures, there are 3,60,000[16] lakh farmers are present in the district. The major crops of the district are ground nut, sunflower, rice, cotton, millets, chilies and sugarcane. The present scenario is considered for the karif season (June-Sep). The detailed agricultural data is collected from the farmers of the district and from the government website www.india.gov.in/topics/agriculture and is given in the following TABLE I & TABLE II

Table 1. Data Of Major Crops, Water Required, Yield Duration And Labour Man- Hours

S.No	Major Crops	Requirement of water (in m^3/hectare) a_i	Yield Duration (in days)	Labour (man-hours/hectare) b_i
1	Ground nut	6000	130	80
2	Sunflower	8000	90	50
3	Rice	13500	120	150
4	Cotton	10000	150	200
5	Millets	6500	120	60
6	Chilies	9000	85	200
7	Sugarcane	25000	435	600

Table 2. Data Of Major Crops, Expenditure, Cost, Income, Profit

S. No	Major Crops	Expenditure/ hectare (in Rs.)	Yield/hectare (in quintals)	Cost / quintal (in Rs.)	Income (in Rs.)	Profit (in Rs.)
1	Ground nut	37,000	16	4,875	78,000	41,000
2	Sunflower	25,000	14	3,700	51,800	26,800
3	Rice	80,000	60	3,200	1,92,000	112,000
4	Cotton	75,000	25	4,300	1,07,500	32,500
5	Millets	55,000	57	1,425	81,225	26,225
6	Chilies	50,000	18	6,500	11,7000	67,000
7	Sugar cane	75,000	800	265	21,2000	137,000

III. GOAL PROGRAMMING MODEL

3.1 Priority Structure for Agricultural Goals

The agriculture department has multiple conflicting goals to achieve from within the district.

Here are the following goals in ordinal ranking of importance:

P_1 = Maximum of the available agricultural land should be utilized

P_2 = Maximum of the available water should be used for rain fed agriculture and irrigation.

P_3 = the area of the land under the cultivation of rice and sugar should be restricted to 1,00,000 hectares.

P_4 = the area of the land under the cultivation of cotton and ground nut should be more than 3,00,000 hectares.

P_5 = maximum land should be cultivated with the crops that take 120 days or less to yield.

P_6 = Maximum utilization of available man-hours

P_7 = Millets should be cultivated in more than 40,000 hectares.

3.2 The Goal Constraints are developed as follows

Let the crops ground nut, sunflower, rice, cotton, millets, chilies and sugarcane are cultivated in X_1, X_2 ……. X_7 number of hectares.

G1: Maximum utilization of the land

The first goal is to maximize the total available 10,00,000 hectares agricultural land in the district.

$$\sum_{i=1}^{7} x_i + d_1^{-} - d_1^{+} = 1000000 \quad \ldots.. \quad (1)$$

Where x_i = number of hectares for the i^{th} crop

d_1^- = under achievement of the land under cultivation

d_1^+ = over achievement of the land under cultivation

G2: Maximum utilization of the water

The total amount of rain water 328 mm (1mm = 0.001m^3 for 1sq m , 1 hectare = 10,000 sq m total land is 10,00,000 hectares) and 21.73 tmc (1 tmc = 2,80,00,000 m^3) of water from the penakacherla dam is 388,84,40,000 m^3 which should be utilized completely.

$$\sum_{i=1}^{7} a_i x_i + d_2^{-} - d_2^{+} = 3888440000 \quad \ldots.. \quad (2)$$

Where a_i = the water requirement per hectare in m^3 for the i^{th} crop

d_2^- = underachievement of the water level

d_2^+ = overachievement of the water level

G3: Restriction on rice & sugar cane

The third goal is to restrict the occupancy of rice and sugar to less than 1,00,000 hectares since they consume more water.

$$x_3 + x_7 + d_3^- - d_3^+ = 1,00,000 \quad \ldots\ldots \quad (3)$$

G4: Restriction on cotton and groundnut

The fourth goal is to restrict the occupancy of cotton and groundnuts to more than 3,00,000 hectares.

$$x_1 + x_4 + d_4^- - d_4^+ = 3,00,000 \quad \ldots\ldots \quad (4)$$

G5: Less duration crops

The fifth goal is to put the maximum land under cultivation with the crops that yield in 120 or lesser days.

$$x_2 + x_3 + x_5 + x_6 + d_5^- - d_5^+ = 6,00,000 \quad \ldots. \quad (5)$$

G6: Maximum utilization of man-hours

The agriculture dept gave the sixth priority to the maximum utilization of available man-hours. The total available agricultural workers are 3,60,000 and their total man-hours(8 hrs per day) are 2880000

$$\sum_{i=1}^{7} b_i x_i + d_6^- - d_6^+ = 28,80,000 \quad \ldots\ldots \quad (6)$$

Where b_i = the man-hour requirement per hectare in hrs for the i^{th} crop

d_6^- = under achievement of the man-hours

d_6^+ = over achievement of the man-hours

G7: Restriction on Millets

The seventh goal is that the millets cultivation should be in more than 40,000 hectares.

$$x_5 + d_7^- - d_7^+ = 40,000 \quad \ldots\ldots \quad (7)$$

3.3 The Objective Function

The objective of the model is to minimize deviations from a set of goals by assigning appropriate priority factors. After reviewing the priority structure of goals and the model constraints formulated above, we can derive the following objective function as:

Min Z = $P_1\, d_1^- + P_2\, d_2^- + P_3\, d_3^- + P_4\, d_4^+ + P_5\, d_5^+ + P_6\, d_6^- + P_7\, d_7^+$

IV. RESULT

This Goal Programming model is solved by Lingo software. The GP is developed with seven decision variables, 14 deviational variables and 7 primitive priority goals. The table 3 shows the solution for the agricultural apportionment.

Table 3

S.No	Priority	Goal Attainment	Decision Variables	Deviation Variables
1	Priority 1 (P_1)	Fully Achieved	X_1 = 300000	d_1^- = 0.0
2	Priority 2 (P_2)	Not Fully Achieved	X_2 = 560000	d_1^+ = 0.0
3	Priority 3 (P_3)	Fully Achieved	X_3 = 0.0	d_2^- = 0.0
4	Priority 4 (P_4)	Fully Achieved	X_4 = 0.0	d_2^+ = 5151560000
5	Priority 5 (P_5)	Fully Achieved	X_5 = 40000	d_3^- = 0.0
6	Priority 6 (P_6)	Not Fully Achieved	X_6 = 0.0	d_3^+ = 0.0
7	Priority 7 (P_7)	Fully Achieved	X_7 = 100000	d_4^- = 0.0
8				d_4 = 0.0
9				d_5^- = 0.0
10				d_5^+ = 0.0
11				d_6^- = 0.0
12				d_6^+ =111520000
13				d_7^- = 0.0
14				d_7^+ =0.0

V. CONCLUSION

It is hereby clear that all the priorities are fully achieved except the priorities P_2 and P_6, because the deviational variable d_2^+ which involved in P_2 and the deviational variable d_6^+ which involved in P_6, are not zeros, violating the achievements of these priorities. With the given priorities and the constraints, the decision variables and the deviational variables took the values as shown in the TABLE III**.** The agricultural land is not distributed for the cultivation of Rice, cotton and chilies since X_3=0.0, X_4 = 0.0 and X_6 = 0.0. The overachievement of water level d_2^+ = 5151560000 m^3 shows the excess water requirement of the district and also supports the statement that "India's biggest drought is no stranger to ananthapur district in Andhra Pradesh". The over achievement of labour d_6^+ =111520000 man-hrs shows, the lack of man power in the district. So, the model presented in this paper will help the government to plan the policies and the subsidies to the farmers of the district to attract more men to choose farming as their profession. The government specifically, may allot more budgets for the policies in the draught prone districts to full fill the Agricultural needs as mentioned in the model. This model's bare policy is to increase the cultivating land, as it obviously results in the increase of the agrarian products, which leads to an increase in the agricultural economy and thereby an increase in the India's GDP.

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