Optimization using LINGO for cropping pattern for the canal command area of Jayakwadi Reservoir

Rahul Agrawal[1], D.G. Regulwar[2]

[1]Research Scholar, Department of Civil Engineering, Dr. Babasaheb Ambdekar Marathwada University Aurangabad (M.S.) India- 431001
[2]Professor, Department of Civil Engineering, Dr. Babasaheb Ambdekar Marathwada University Aurangabad (M.S.) India- 431001

ABSTRACT

According to the current study, cropping patterns should be optimised for the Left-canal and Right-canal Command in the Jayakwadi Reservoir. The ideal area under various crop activities was allocated using the linear programming tool LINGO-14. The Penman-Monteith equation, effective rainfall, and 20 years of climatology data were used to predict the periodical gross irrigation demand. The cropping pattern plan made use of the periodical canal discharge, gross irrigation demand, and current net discharge from key irrigation infrastructure. The optimization strategy includes a total of 10 crops. Based on the amount of canal water that was accessible as well as 60%, 80%, and 100% of the groundwater's current net draw through small irrigation structures, three best crop plans were created. Plans-1 with 60%, Plans-2 with 80%, and Plans-3 with 100% of the existing net draught of groundwater, produced annual returns of Rs. 14.812, Rs. 202.952, and Rs. 168.304 lakhs, respectively. The study also found that one might increase profits by 60% by using groundwater pumpage and canal water that are already accessible at the current rate of their optimization.

Keywords: The Cropping Pattern, Water Requirement, LP Model, LINGO

I. INTRODUCTION:

It is commonly well-known that land and water are our society's two fundamental needs, and that the availability of water is declining alarmingly due to increased urbanisation and extensive irrigation systems (Regulwar et al.). Due to the increased need for land for construction of buildings, roads, industries, etc., the area of land under cultivation is also diminishing. With almost 17.5% of the global population, India is second-most populous nation.

In 1993, an amount of land available per person worldwide was 0.28 ha; this amount fell to 0.24 ha by 2007, while the amount of water available per person worldwide in 1993 was 7900 cum/year; this amount has now fallen to 6600 cum/year. Therefore, it is crucial to boost production while also making the most use of the available water and land resources. Food, fibre, and fodder are mostly produced by agriculture. However, because of low production, food, grains, and fuel supply per person has decreased. For our population, we are unable to produce enough food, cereals, and fibre. To avoid these issues, we must improve the agricultural product as a whole. More land must be put under cultivation or the amount produced per unit of available land & water resources must be increased in order to meet the rising demand for food, fibre, and fuel.

Table 1 Condition of Grains

Grains	Rainfall	Soil Type
Rice	**150-300 cm**	Deep clayey and loamy soil
Wheat	**75-100 cm**	Well-drained fertile loamy and clayey loamy
Grams	**40-45 cm**	Loamy Soil

Sugar Cane	**75-150 cm**	Deep rich loamy soil
Cotton	**50-100 cm**	Deccan and Malwa Plateau's black soil.

The factors listed below affect different types of cropping patterns: Cropping patterns play a role in determining the degree of agricultural productivity. This is an illustration of the regional agriculture industry. Cropping patterns are being negatively impacted by changes in agrarian policy, the availability of agricultural inputs, and technological improvements. In order to increase soil fertility through increased crop yields, cropping patterns are crucial. It ensures that the crops will be protected and will have access to nutrients.

Due to urbanization and reluctance to harm natural habitats, expanding agricultural land is challenging. Additionally, during the subsequent 15-20 years, the amount of water allocated for irrigation is likely to decline. Since the current cropping pattern hasn't changed in a long time, it's possible that it doesn't make the best use of resources economically. To achieve optimum productivity, it is crucial to utilize the existing land & water resources to their full potential. Due to the ever-growing population's dependence on these natural resources, it is crucial that they are managed effectively, optimally, and sustainably. A model of optimization was developed to maximize net revenue of farmers by the side of various levels of water availability while keeping in mind the necessity to come across a better alternative solution to challenges faced by farmer.

An optimization model has been created to find the better alternative to maximize the net returns of farmers at various levels of water availability while keeping in the mind the necessity solution. The objective of the study has been to identify best cropping strategy for maximizing net returns on a significant scale. The current study was carried out for the Jayakwadi Canal Command of the Jayakwadi Reservoir with the goals of determining the ideal farming pattern producing the greatest net yield at various water availability levels.

II. MATERIALS AND METHODS

The dam irrigates 237,452 hectares of arable land in the districts of Aurangabad, Jalna, Beed, Ahmednagar, and Parbhani through its network of canals. The right bank canal's length is 132 km, while the left bank canal's length is 208 km, commanding a total area of 183,858 hectares.

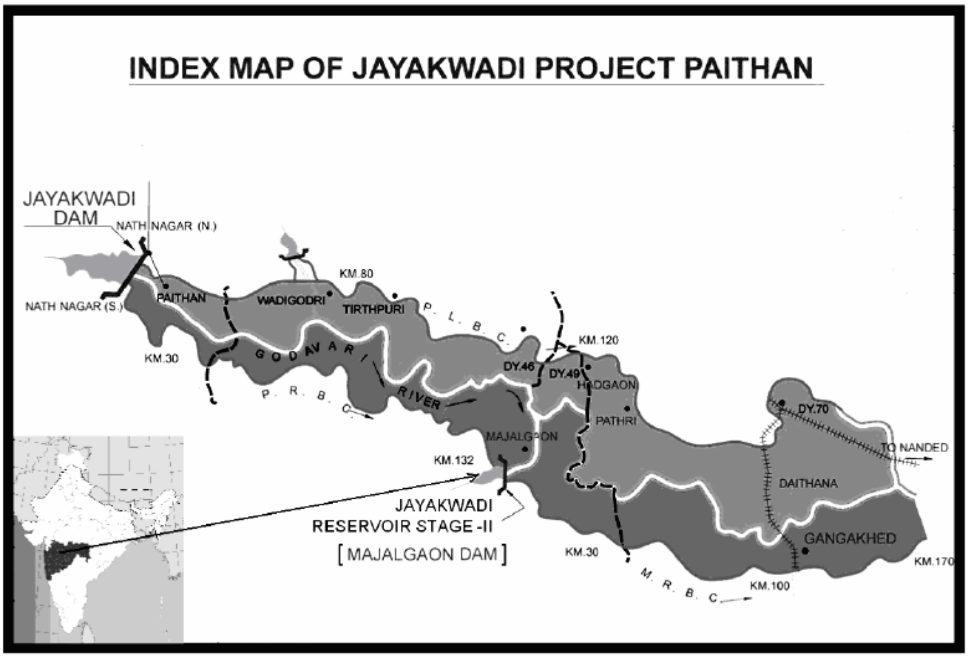

Figure 1 Location of Jayakwadi Command Area

The research region is located in a humid sub-tropical climate zone with a long and hot summer, a moderately nice monsoon season, and pleasant winter months. The district experiences roughly 679 mm of rainfall on average annually, but there is a significant annual variance. The daily maximum and minimum temperature, humidity, number of daylight hours, amount of rainfall, & wind speed has been used to determine evapotranspiration (ETo) values. A crop coefficient was added to reference evapotranspiration (ETo, mm/day) to compute crop evapotranspiration (ETcrop) (Kc).

ECrop = ETo Kc

The field water balance is used to assess the crop's net irrigation needs.

NIWR = ETcrop - (Pe + Ge + Wb)

III. MODEL DEVELOPMENT USING LINEAR PROGRAMMING METHODS

Using a linear programming (LP) technique, the optimization model has been created to maximise the size of cropped areas under typical rainfall conditions. LINGO 14 was used to solve the optimization model. The following is a description of the model's constraints and objective function. The model's goal has been to identify the area that is needed to be irrigated for a range of crops in order to get the most out of the given land and water resources. Consequently, the decision factors will be the area irrigated for various crops.

IV. MODEL CONSTRUCTION

Objectives function (Z) is subjected to linearity and no negativity restriction. Model's aim is to maximize net return from the command area, which is computed as follows:

$Max\ Z = \sum_{i=1}^{n} C_i X_i$

Cultivable land area constraint: $\sum_{i=1}^{n} X_i \leq A_T$

Crop area restriction Constraints: $X_i \leq A_i$

Water requirement constraints: $\sum_{i=1}^{n} W_i X_i \leq CW_t + GW_t$

Annual groundwater draft constraint: $\sum_{i=1}^{n} GW_i \leq AGW_T$

[Where Ci = net return from ith crop (Rs/ha), Wi = total irrigation water used for crop production i (ha-cm) during month k, Xi= area under ith crop (Ha), N = number of crops, A_T = Total cultivable area, AGW = permissible seasonal groundwater extraction (Ha-cm) in command]

To distribute the land area under various crops, a linear programming (LP) model was created using LINGO-14 by means of the goal of maximising net return from the study area. Ten different crops were taken into account for the linear programming model. Therefore, based on the available canal water and 60%, 80%, and 100% of current net groundwater flow through major irrigation infrastructure, optimal crop plans have been created for the study region.

Table 2 Solution for Net Benefits for Crop Areas by LP Model

Variable	Crop and Season	60%	80%	100%
a.	Sorghum (K)	17889.34	14858.08	16996.8
b.	Paddy (K)	14907.79	12381.73	6445.75
c.	Sorghum (R)	0	0	0
d.	Wheat (R)	23832.78	32603.34	35410
e.	Gram (R)	7263.18	6190.86	7082
f.	Sugarcane (P)	1871.8	2166.18	4249.2
g.	Banana (P)	1872.26	1857.26	2124.6
h.	Chilies (TS)	3714.52	4357.91	4249.2
i.	L S Cotton (TS)	30124.8	24725.47	0
j.	Groundnut (HW)	0.01	0.01	0.01
Net Cropped Area (Ha)		99140.83	101476.5	76557.55
Net Benefits (Million)		1481.112	2029.529	1683.04
Crop Production (Tons)		422156	492162.5	472166.5
Irrigation Intensity (%)		52.15	61.15	54.05

CONCLUSION

The optimization strategy includes a total of 10 crops. Based on the amount of canal water that was accessible as well as 60%, 80%, and 100% of the groundwater's current net draw through small irrigation structures, three best crop plans were created. Plans 1 with 60%, Plans 2 with 80%, and Plans 3 with 100% of the existing net draught of groundwater, produced annual returns of Rs. 14.812, Rs. 202.952, and Rs. 168.304 lakhs, respectively. The study also found that one might increase profits by 60% by using groundwater pumpage and canal water that are already accessible at the current rate of their optimization.

REFERENCES

[1] D. G. Regulwar, J. B. Gurav, R. U. Kamodkar, and V. S. Pradhan (2017)"Conjunctive use of Surface Water and Groundwater using Fuzzy Logic" book chapter in a Book Sustainable Holistic Water Resources Management in a Changing Climate, Editors: K. Srinivasa Raju and A. Vasan,M/S Jain Brothers, New Delhi

[2] Regulwar, D.G., and Anand Raj, P. (2008). "Development of 3 – D Optimal Surface for Operation Policies of A Multireservoir in Fuzzy Environment Using Genetic Algorithm for River Basin Development and Management", Water Resources Management, Springer, Vol. 22, 595-610 DOI 10.1007/s11269-007-9180-1

[3] Regulwar D.G. and Gurav J.B. (2010). "Fuzzy Approach Based Management Model for Irrigation Planning", Journal of Water Resources and Protection, Scientific Research, Vol.2, No.6, June 2010, pp. 545-554 DOI: 10.4236/jwarp.2010.26062

[4] Regulwar D.G. and Gurav J.B. (2011) "Irrigation Planning under Uncertainty - A Multi Objective Fuzzy Linear Programming Approach", Journal of Water Resources Management- An International Journal (Springer-Netherlands), Vol. 25, No.5, pp. 1387-1416 (doi 10.1007/ s11269-010-9750-5)

[5] Regulwar D.G. and Pradhan V.S. (2013). "Irrigation Planning with Conjunctive use of Surface and Groundwater Using Fuzzy Resources", Journal of Water Resources and Protection, Scientific Research, Vol.5, No.8, 816-822 DOI: 10.4236/jwarp.2013.58082

[6] Regulwar, D.G., Ghangrekar, M.M., and P, Anand Raj (2002) "Optimal reservoir operation for irrigation using Genetic Algorithms." Advances in civil engineering, ACE 2002, I.I.T., Kharagpur, India, (2002), Vol.1, pp 259-265

[7] D.G.Regulwar and J.B.Gurav (2013), Optimal Irrigation Planning with Minimization of Cost of Cultivation using Fuzzy Logic, Proceedings of International Conference on 35th IAHR World Congress, September 8 to 13, 2013 Chengdu, China, pp 369

[8] S.N Singh, M.A. Alam, D.M Denis, S.K. Srivastava and Vikram Singh (2020) "Optimization of cropping pattern for the Bellan canal command of Urwa block of Allahabad, Uttar Pradesh" Journal of Pharmacognosy and Phytochemistry2020, VOL. 9, ISSUE 2 Pages: 530-536