



OPTIMAL RESERVOIR OPERATION USING GENETIC ALGORITHM- CASE STUDY

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ABSTRACT

Application of optimization techniques for determining the optimal operating policy of reservoirs is a major issue in water resources planning and management. In this paper we study the Gangapur Dam reservoir water by Genetic Algorithm (GA) is consider at various level related to optimal reservoir operation and com-pare this result according to sudden condition. The main aim of the present study is to develop a policy for optimizing the release of water for the purpose of irrigation. The months considered are from January to December for fifteen years from year 2015to 2016. The decision variables are monthly releases for irrigation from the reservoir and initial storages in reservoir at beginning of the month. The constraints considered for this optimization are the bounds for the releases and reservoir capacity.

Keywords: Gangapur Dam, Genetic Algorithm, Lingo, Optimization, Reservoir Operation, Single Objective

I. INTRODUCTION

Water is the most important requires for all living creatures after oxygen. Life and health of all beings containing human, plants and animals, depends on water. Therefore, nowadays, water is known as human treasure. Although 75 percent of planet earth is composed of water, but only one percent of the fresh water is usable. In spite of the fact that the amount of usable water (drinking water) on earth is limited, but this insignificant amount is not spread on the earth uniformly. This limitation is one of the most important and essential challenges in countries with arid and semi-arid regions.

On one hand, limited access to water resources and on the other hand, human need for water, necessitates the proper management strategies. Taking into aims like providing water, controlling floods, hydro power production, tourism, etc. dams are designed and constructed in order to resolve such problems. Providing water for municipal, agricultural and industrial consumption is one of the main purposes for reservoir operation and planning. In most countries, agricultural purposes have the highest water level consumption. So, optimal operation and management of water resources, among giving proper response to the needs of this part, leads to



reduced waste water and increasing the level of yield of production and gaining sustaining development in agriculture.

Use of Genetic Algorithm (GA) in determining the optimal reservoir operation policies, is receiving significant Attention from water resources engineers. A large number of works has been reported on the application of GA for various complex reservoir problems Sonaliya and Suryanarayana [1] developed a GA model. This policy has been developed for release of water from the Ukai reservoir project for the purpose of irrigation. Nagesh kumar and Shrinivasa [2] presented a genetic algorithm (GA) model for obtaining an optimal operating policy and optimal crop water allocations from an irrigation reservoir. Sharif and Wardlaw [3] presented genetic algorithm approach for optimization of multi reservoir systems for a case study in Indonesia and its results were compared with those of discrete differential dynamic programming. Wardlaw and Sharif [4] evaluated several formulations of a genetic algorithm for four reservoir, deterministic, finite-horizon problem. Chang and Chen [5] applied two types of genetic algorithms, namely, real-coded and binary coded and applied to the optimization of a flood control reservoir model Savic and Walters [6] developed a computer model GANET that involves the application of an area of Evolutionary Computing, better known as Genetic Algorithms, to the problem of least-cost design of water distribution networks

In the present study, a GA model has been used for optimum reservoir operation. The objective of this study is to minimize the squared deviation of monthly irrigation demand deficit along with squared deviation of mass balance equation. The decision variables used are the release for irrigation demand from the reservoir and initial storage in each month. The constraints used for this optimization are bounds for the releases and reservoir capacity.

II. STUDY AREA

The area selected for the present study is the catchment area of the Gangapur dam, this dam is near village in Godawadi and is 10 km from nashik city. This is earthen type dam constructed in between 1954-1963. The total catchment area of the dam is 357.4 sq. The total dam length is 3810m and max. Height of dam 36.57m. the total gross storage of the dam 215.88MCM. (7624MCFT). and total live storage is 203.76MCM (7200MCFT) the length of the water weir is 102m. There are total 9 radial gate of size (9.15*6.10m) having discharge capacity of 2294 Cumec (81013Cusec). The dam has two canal, the left bank canal is 64km long and right bank canal is 30km. the total irrigable area of these dam is 15960ha.

III. METHODOLOGY

In this project report, all with these different optimization techniques we selected Genetic Algorithm technique for analyzing the Gangapur dam releases in this phase-1.

Model Development

In the present study, the fitness function of the GA model is minimizing the squared deviation of monthly irrigation demand and squared deviation in mass balance equation. The objective function is given by equation (1)



$$\sum_{t=1}^{12} (R_t - D_t)^2 + \sum_{t=1}^{12} (S_t - S_{(t+1)} + I_t - R_t - E_t)^2 \quad \dots (1)$$

Where,

R_t = Monthly irrigation release for the month 't'.

D_t = Monthly downstream irrigation demand for the month 't'.

S_t = Initial storage in the beginning of month 't'.

S_{t+1} = Final storage at the end of month 't'.

I_t = Monthly inflow during the period 't', and

E_t = Monthly evaporation loss from the reservoir during the month 't'.

The above fitness function of GA model is subjected to the following constraints and bounds,

A. Release constraint.

The irrigation release during any month should be less than or equal to the irrigation demand in that month and this constraint is given by

$$R_t \leq D_t, t = 1, 2, 3, 4 \quad \dots (2)$$

B. Storage constraint.

The reservoir storage in any month should not be more than the capacity of the reservoir, and should not be less than the dead storage. Mathematically this constraint expressed as:

$$S_{min} \leq S_t$$

and

$$S_t \leq S_{max}, t = 1, 2, 3, 4 \quad \dots (3)$$

Where,

S_{min} = Dead Storage of the reservoir in MCM and

S_{max} = Maximum capacity of the reservoir in MCM.

IV. RESULTS AND DISCUSSION

To apply Genetic algorithm (GA) to the given formulated model, the data of inflow, demand, actual releases by all the outlets, evaporation loss from reservoir used in MCM. The important input variables in present Genetic Algorithm formulation model study are the monthly inflows into the reservoir system and monthly irrigation demands for all the month of hydraulic year 2015 to 2016. The main objective of the study is to compute the quantity of water that should be released to meet the monthly irrigation demand. Since, the fitness function is based on the monthly irrigation demands (D_t) and monthly inflow in the reservoir (I_t), so releases from the reservoir for irrigation purpose (R_t), and initial storage (S_t) in the reservoir for monthly time period are chosen as decision variable. Thus eight decision variables are considered for a year 2015-2016. After applying GA to the above formulated model the following results are generated which gives the releases by GA and that we consider as optimum releases for year 2015 to 2016.

Table 1: Shows that the values of actual releases, demand and releases by GA for year 2015-16

Month	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Actual Releases, MCM	6.183	8.9	8.47	28.59	89.29	76.25	70.30	76.8	28.41	23.35	24.15	6.98
Releases By GA, MCM	5.283	7.0	6.33	26.43	87.30	74.22	69.8	74.30	25.30	22.11	23.15	5.98
Demand, MCM	5.25	6.9	5.89	25.44	86.90	73.12	68.8	73.29	24.85	21.89	22.15	4.98

Table 1. Shows the value of the actual releases from reservoir, demand for downstream and releases calculated by Genetic Algorithm for all the months for the hydraulic year 2015-16. From the values of releases by using Genetic Algorithm technique, it can be shows that for all the months of hydraulic year 2015-16, the demands are completely satisfied.

Table is represented graphically in figure.1

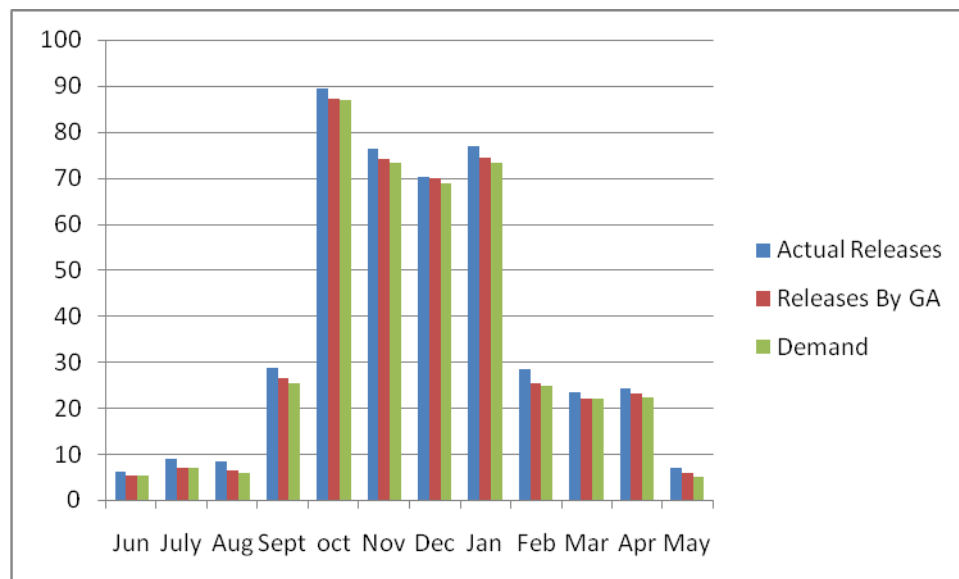


Fig 1 Actual Releases by GA And Demand For Year 2015-16

Fig1. shows the value of the actual releases from reservoir, demand for downstream and releases calculated by Genetic Algorithm for all the months for the hydraulic year 2015-16. From fig 1 it shows that the releases for all months calculated by GA is less than actual releases from reservoir and to satisfy the demands. So, the calculated releases for all the months of hydraulic year 2015-16 are the optimal releases. The amount of percentage of water saved is shown in table 2.



Table 2: Amount of water saved in MCM and in percentage for the year 2015-16

Months	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Amount of water saved in MCM	0.9	1.9	2.14	2.16	1.99	2.03	0.5	2.5	3.11	1.24	1	1
Percentage of water saved(%)	14.15	21.34	25.26	7.5	2.22	2.66	0.71	3.25	10.94	5.31	4.14	14.32

Table 2 shows that the amount of saved water in MCM and in percentage for all the months respectively for the hydraulic year 2015-16. In month of July and August 1.9 and 2.14 MCM of water is saved respectively, Which shows that the maximum water saved in percentage in the months of July and August i.e., 21.34% of water is saved from the actual release in July and similarly almost 25.26% of water is saved from the actual release in August to fulfil the demand.

V. CONCLUSION

An optimization process has been developed for release of water from the Gangapur dam project for the purpose of irrigation. The releases developed by Genetic algorithm satisfied completely the irrigation demands for all the months of hydraulic year 2015-16 i.e. the maximum amount of water saved in the month of August is 2.14 MCM and the minimum amount of water saved in the month of December is 0.5 MCM for year 2015-16 respectively. The maximum and minimum amount of water saved in Percentage in the months of August and December for year 2015-2016 is 25.26% and 0.71% respectively. Thus, an optimal releases obtained by Genetic Algorithm, are less than actual releases for almost all the twelve months, which leads to saving considerable amount of water.

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