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Optimising Reservoir Operation A Case Study of the Tulasi River

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Abstract:-**Realistic reservoir operation is an important component in basin hydrological models. However, the operation rules can be complex under various situations and are not well understood yet. The present investigation tries to analyze the most suitable Method A and Method D for the effective operational management of reservoirs in the study area. The results are helpful to understand realistic reservoir operation behaviors. Moreover, the work will contribute to building a reservoir component for hydrological models and provide references for improving reservoir operation decisions in the future. This study collected the historical records of Tulasi reservoir in the Kolhapur district a comparison between the representative operation modules was conducted to show the spatial variability of reservoir operations. The operation rules adopted by reservoirs with different operation functions are also analyzed and compared. With proper level disparities, technique A can boost operational effectiveness in the study area. The comparison of Tulasi Dam ROS using the existing Guide Curve and Method D Guide Curve demonstrates a significant variation. Method D was deemed ineffective with appropriate level disparities. The differences between the existing method and method D could lead to misconceptions while regulating dam water.**

Keywords: ROS, A & D Method, Reservoir, Flood management

I. INTRODUCTION

Due to the tropical monsoon climate and its highly varied flow in time and location, India has a large number of reservoirs that play a key role in the economic growth of the nation. The majority of reservoirs serve many functions, such as flood control, hydropower generation, water supply, navigation, and environmental restoration. However, in many instances, flood control and hydropower generation are viewed as the most significant factors for establishing reservoir control measures. In recent years, numerous specialists have frequently identified the issue of inefficient operation of existing reservoirs utilizing obsolete technology and highly subjective management approaches (e.g.Guariso et al., 1986; Oliveira and Loucks, 1997; Chen, 2003; John, 2004). Problems with reservoir functioning arise when water levels are either too high or too low. Even though many reservoirs in Vietnam are empty during the dry season, dam breaks during the rainy season pose a serious risk to the country's water supply. The rules for operating reservoirs must be carefully adjusted to account for the effects of climate change and the growth of the economy in the river basin. The reservoirs' operating standards vary from one location to the next because of variations in hydro-meteorological circumstances and the varying water needs of each. Therefore, it is important to take these factors into account when operating the reservoir.

The operation of a reservoir is a complicated problem with many decision variables, multiple goals, and a lot of risk and uncertainty (Oliveira and Loucks, 1997). Also, having goals that are at odds with each other makes it hard for operators to make good operational decisions. Traditionally, a reservoir is run based on heuristic procedures, including rule curves and the operator's own subjective decisions. This gives general guidelines for how to operate reservoir releases based on the level of the reservoir, the weather, how much water is needed, and the time of year. Set rule curves, on the other hand, don't let the operations be fine-tuned (and thus optimized) in response to changes in conditions. Because of this, it would be helpful to set up a more analytical and systematic way to run reservoirs, based not only on traditional probabilistic/stochastic analysis but also on information about and predictions of extreme hydrologic events and advanced computational techniques. This would make the reservoir more efficient at meeting the needs of all its users.

Since the 1970s, reservoir operation has been an important area of study in the field of water resources. For each system, the different parts that go into making a reservoir work are different. Yeh (1985) and Labadie (2004) have given reviews of the current state of knowledge about how to run a reservoir most effectively. Simonovic (1992) talked in depth about reservoir systems analysis and explained why theory and practice are so different. He came up with some ways to deal with them. Yazicigil et al. (1983) showed how the four reservoirs in the Green River Basin work in real-time. Flood control was the main reason for the reservoir system. Low-flow augmentation and recreation were also important, but not as important. Kelman et al. (1989) made a plan for the best way to design the flood control volume for a system of eight reservoirs on Brazil's Parana River. The goal was to minimize the costs of flood protection or the total amount of energy lost by the firm. Marien et al. (1994) used controllability conditions to come up with flood control rule curves for the multipurpose multi-reservoir system. When the rule curve was made, both the randomness of future inflows and the fact that decisions about when to release money were taken into account. This also worked for more than one flood control section and for releases that had to happen. In Brazil, a system with eight reservoirs was used to show how this method works. Ahmad and Simonovic made the Decision Support System (DSS) in

2006 to help people make decisions about flood management at different stages. The DSS can help choose the best ways to reduce flood damage, predict floods, model how flood control structures work, and describe the effects of floods in time and space. The DSS is used in Manitoba, Canada, for the Red River Basin. It's not a new idea to use optimization techniques to run a reservoir. Different ways have been tried to make the operation of the reservoir(s) more efficient. In the operation of reservoirs, A&D is well known as the most popular optimization method that has a lot of benefits. It is easy to understand and doesn't need to be solved right away. The irrigation department provides several examples of applying A & D methods to reservoir operations, the government of Maharashtra. The current study attempts to examine the most appropriate way from Method A and Method D for the effective operational management of reservoirs in the study area. The present investigation tries to analyse the most suitable methods, Method A and Method D for the effective operational management of reservoirs in the study area.

II. STUDY AREA

The case study considered, Tulasi single reservoir system is situated the in Panchganga basin. Tulasi River is one of the tributaries of the Panchganga River. The multipurpose Tulasi reservoir is utilized mainly for three purposes, flood control, irrigation, and agriculture production. The entire area of the study region is 165 sq. km. The area has diversified Physiography with complex geological structures. The minimum and maximum elevation of the region are 500 m and 800 m respectively.

Flood control is the first preferred objective. This reservoir is situated 40 km upstream the of confluence the of Panchganga River. As Tulasi reservoir is on the upstream side of the delta area in the basin, it plays an important role in alleviating the flood severity for this area. This is done by regulating release from the reservoir

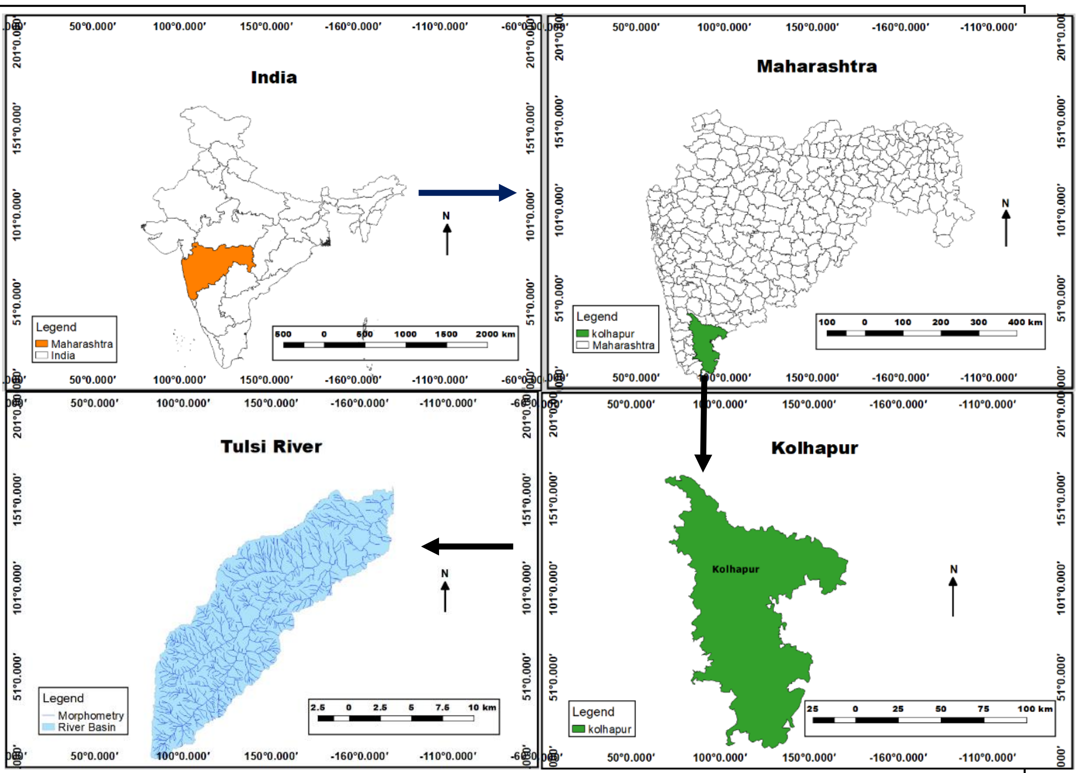

Figure 1: Location Map of the study region

III. RESEARCH METHODOLOGY

Updated reservoir circulation list of Tulasi reservoir if the hydrological information of the last several years is available, a series of cumulative flows should be prepared from the beginning of the monsoon (method A) to the end of the monsoon (method D) for different periods of monsoon. Method A would be useful for dams in highly flood-prone areas and those whose catchment area receives assured rainfall at the end of the monsoon season. Method D would be more suitable for dams where the rainy season ends early and there is a high priority for storage reservoirs.

A. Method

The dam safety manual 1984 gives Step by Step Procedures for the preparation of Guide Curves. The highlights of the same are given below

Preparation of Guide Curves:-
Compile available inflow data (from 11th ^{June} to 15th Oct) at the dam site into Ten-Daily Periods (TDP). Then, for each TDP workout following:

1. A run-off series and 90% & 75% dependable yields

2. Calculation of fortnightly withdrawals or utilization.

3. Surplus or deficit storages at corresponding dependability.

4. The date of attainment of monsoon storage level or FRL by the last TDP and arrive at the TDP which has surplus inflow as worked out above at 90% dependability.

5. If 90% dependable inflows for all 3 TDPs in Oct are less than respective TDPs in Sept, then in such a case adopt the monsoon storage level at the end of respective TDP in Sept i.e. the reservoir must reach FRL at the end of that particular TDP.

6. The guide curves for 75 % & 90% dependability at the end of each preceding TDP by successively deducting the 75% & 90 % dependable surplus yields from the respective lake full contents for each TDP starting from the last surplus TDP at 90% dependability.

B. Method: D

The method of cumulative yields by working backward from 15tst October (method: d) to period interval is similar to the method of working cumulative yields from 1st June (method: A). Method D is less effective and avails slightly more flood absorption capacity than the method of working cumulative yields from 1st June. There is every possibility that the reservoir may attain FRL when inflows are sufficient. This method may be more appropriate for the reservoirs where the monsoon recedes early and conservation has top priority.

Step by Step procedure for Preparation of Guide Curves by Method D:-

1. Available data series of fortnightly inflow of independent period is arranged in chronological order (1978 to 2019).

2. Calculate Cumulative Inflow by working Backwards from the end of monsoon i.e 31 st October to Fortnightly period at Tulashi Dam Site for the year 1978-2019.

3. Calculate cumulative inflow by working backward in descending order with 75 % & 90% dependability yield available for each fortnight.

4. Calculation of Fortnightly Dependable yield / InflowDependable yield/inflow for the fortnightly period is calculated by deducting the cumulative yield for the subsequent period from the cumulative yield for the period arrived in Step No 3.

5. Calculation of fortnightly withdrawals or utilization.
   Utilization should be calculated from the average utilization of the water for the eastward, and eastward sides, and Evaporation. In the case of the Upper section of Tulasi dam water is mostly utilized for Irrigation & Drinking purposes. Hence, this is also considered during the calculations.
6. Calculate fortnightly series of Dependable yield for the fortnightly period to be used as fortnightly inflow for calculation Lake level for each fortnight to calculate lower and Upper Guide curves Method D.
7. Calculation of Upper Guide Curve (90% Dependability) and lower Guide curve (75% Dependability) levels at end of each fortnight during the Monsoon period by considering inflow and utilization during a particular fortnight.

IV. RESULT AND DISCUSSION

As the major objective of the Tulasi reservoir is flood control, reservoir operation is considered only for the monsoon season (floods occur only in this season) in the present study. So for control purposes, the reservoir is made empty at beginning of the monsoon and is made full by the end of the monsoon to utilize the water for conservative purposes during the following non-monsoon period. The monsoon period for reservoir operation is taken from 1st June to 15th October. The reservoir is operated for filling up from the dead storage level of 591.31 m on 1st June to the full reservoir level of 616.91 m by 1st October every year. There is 137 days duration from 1st June to 30th September. Hereafter, 1st June is termed as the 1st day, and 30th September is the 92nd day. The outflow from the reservoir on the 137th day will take one more day to reach Balinga. The outflow from the reservoir of 137thday will collect the downstream section catchment contribution of 138thday to form the flow at Balinga of 138thday.

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Table1: Comparison of Existing Approved ROS and Proposed ROS by Method A

Comparison of Existing Approved ROS and Proposed ROS by Method A (Each Fortnightly period as a dependable period)							
Sr. No	***Period***	***Crest Level***	***Full Reservoir Level***	***Proposed Upper Guide Curve***	***Proposed Lower Guide Curve***	***Existing Approved Upper Guide Curve***	***Existing Approved Lower Guide Curve***
1	Jun 1-15	611.91	616.91	614.980	610.760	615.06	613.89
2	Jun 16-30	611.91	616.91	614.980	611.010	615.06	613.91
3	July 1-15	611.91	616.91	615.100	611.770	615.06	613.91
4	July 16-31	611.91	616.91	616.600	614.200	615.78	614.00
5	Aug 1-15	611.91	616.91	616.910	616.200	616.89	616.70
6	Aug 16-31	611.91	616.91	616.910	616.860	616.91	616.91
7	Sept 1-15	611.91	616.91	616.910	616.910	616.91	616.91
8	Sept 16-30	611.91	616.91	616.910	616.910	616.91	616.91
9	Oct 1-15	611.91	616.91	616.910	616.910	616.91	616.91

Every 15 days are considered for placing one flood in the river. Although there is no chance of flood occurrence in each of the 15 days simultaneously, it is assumed that, to get the rule curve, to tackle the flood individually during any duration. The peak of maximum probable Flood into the Tulasi reservoir is 5 thousand cumecs (WRD Kolhapur). So an operating policy is to be developed for peaks of inflow lying between 0.5 and 5 thousand cusecs.

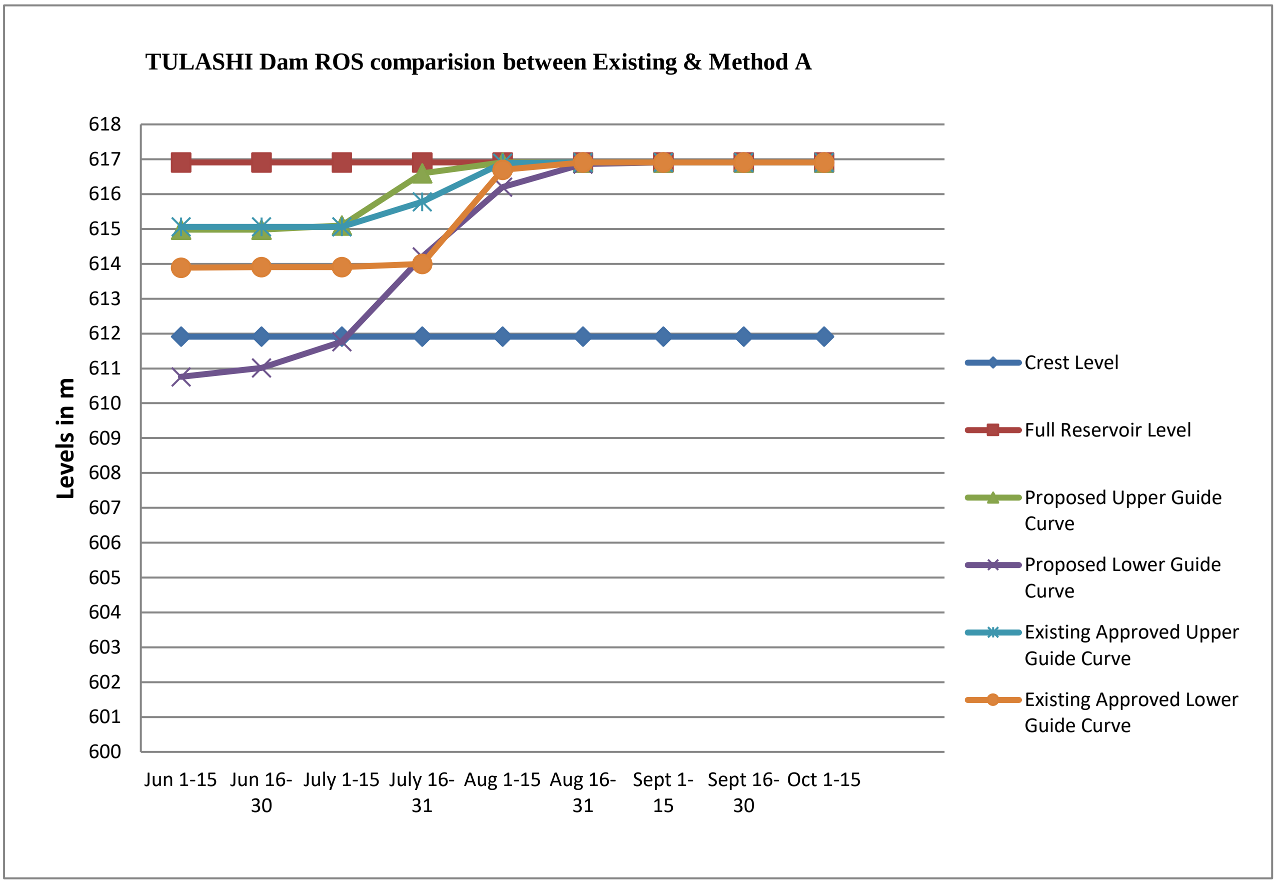

Figure 2*: Tulasi Dam ROS comparison between Exiting and Method A*

The comparison between Tulasi Dam ROS by employing the existing Guide Curve and Method AGuide Curve denotes that there was a slight variation in the existing upper curve guide and Method an upper Guide Curve. The maximum variation in the levels was observed in the case of the Proposed Lower Guide Curve and the Existing Approved Lower Guide Curve. Hence, it was recommended that method A can increase operational effectiveness with appropriate level differences.

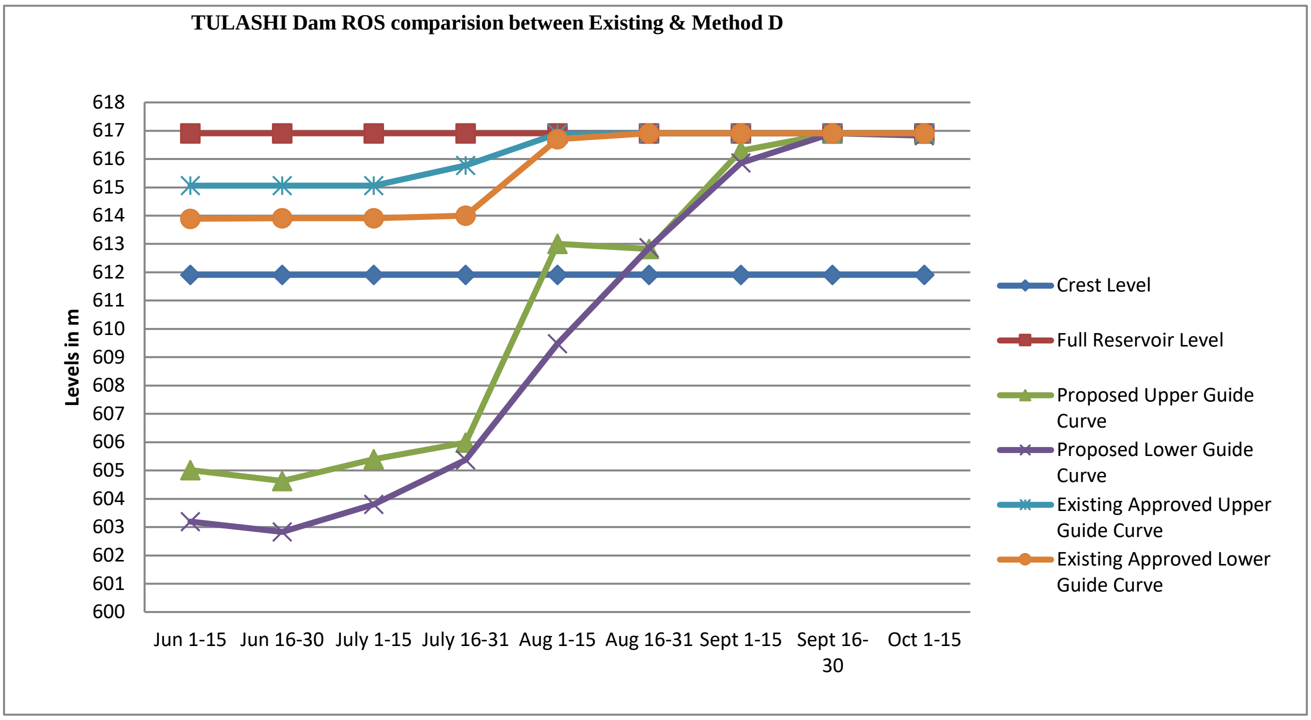

Table1: Comparison of Existing Approved ROS and Proposed ROS by Method D

Comparison of Existing Approved ROS and Proposed ROS by Method D

Sr. No	*Period*	*Crest Level*	*Full Reservoir Level*	*Proposed Upper Guide Curve*	*Proposed Lower Guide Curve*	*Existing Approved Upper Guide Curve*	*Existing Approved Lower Guide Curve*
1	Jun 1-15	611.91	616.91	605.010	603.190	615.06	613.89
2	Jun 16-30	611.91	616.91	604.630	602.830	615.06	613.91
3	July 1-15	611.91	616.91	605.400	603.800	615.06	613.91
4	July 16-31	611.91	616.91	605.980	605.370	615.78	614.00
5	Aug 1-15	611.91	616.91	613.000	609.480	616.89	616.70
6	Aug 16-31	611.91	616.91	612.830	612.870	616.91	616.91
7	Sept 1-15	611.91	616.91	616.300	615.870	616.91	616.91
8	Sept 16-30	611.91	616.91	616.910	616.910	616.91	616.91
9	Oct 1-15	611.91	616.91	616.910	616.830	616.91	616.91

Figure 3: *Tulasi Dam ROS comparison between Exiting and Method D*

The comparison of Tulasi Dam ROS employing the existing Guide Curve and Method D Guide Curve reveals a considerable difference between the current upper guide curve and Method D upper guide curve. Hence, it was recommended that method D is not suitable for operational effectiveness with appropriate level differences. There were large discrepancies between the levels obtained using the existing method and method D, which could lead to misunderstandings throughout the process of managing dam water.

V. CONCLUSION

An innovative technique to increase the Tulasi reservoir's operational effectiveness in terms of flood management during the flood season has been devised by employing methods suggested in the paper. The reservoir has been controlled in line with a regulation that limits the discharge based on the season, the level of water at an upstream and downstream flood control facility, and the reservoir's level at any given time. The comparison between Tulasi Dam ROS using the existing upper Guide Curve and Method A's upper Guide Curve shows a modest difference. The existing Lower Guide Curve and Method A's Lower Guide Curve had the most level variation. With proper level disparities, technique A can boost operational effectiveness in the study area. The comparison of Tulasi Dam ROS using the existing Guide Curve and Method D Guide Curve demonstrates a significant variation. Method D was deemed ineffective with appropriate level disparities. The differences between the existing method and method D could lead to misconceptions while regulating dam water.

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