OPTIMAL OPERATION OF MULTI-PURPOSE MULTI-RESERVOIR WATER RESOURCES SYSTEM

By

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DEDICATED TO:

MY WIFE MAHA, DAUGHTERS,
MARWA, SAFA, ASALA AND
SON ABDULRAHMAN

CERTIFICATE

This is to certify that the thesis entitled " ***OPTIMAL OPERATION OF MULTI-PURPOSE MULTI-RESERVOIR WATER RESOURCES SYSTEM*** " being submitted by Mr. **KAMEL ALI ABD AL-MOHSEEN** to the Indian Institute of Technology, Delhi, for the award of the degree of 'Doctor of philosophy' in the Civil Engineering Department, is a record of bonafide research work carried out by him.

Mr. AL-MOHSEEN has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard.

The results contained in this work have not been submitted in part or full, to any other University or Institute for the award of any degree.

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ABSTRACT

A study of six-reservoir system (Hemavathy, Harangi, KRS, Kabini, Mettur and Bhavani) reservoirs within Cauvery River Basin in South Peninsular India has been carried out with the aim of exploring the capability of Genetic Algorithms to derive an optimal operating strategy of the system.

The study have been done in the following two phases:

Phase I: In the belief that a comprehensive study of a single reservoir system may also provide insights for operation of more complex reservoirs systems, Hemavathy and Kabini reservoirs were selected for a detailed individual study.

Phase II: Findings obtained from Phase I were then expanded to include all the six reservoirs as an integrated system.

Phase I

(1) Hemavathy reservoir

Genetic Algorithms (GAs) based optimization techniques have been used to derive a deterministic operating policy for Hemavathy reservoir, which is used mainly for irrigation purposes. Both, binary coded as well as real coded chromosomes are tried in the development of the algorithm. Results show a satisfactory performance of GAs in finding optimal operating rules for the given reservoir. Between real coding and binary coding, the study revealed that the former yields a better performance.

Four different criteria functions including (i) maximizing withdrawals, (ii) achieving a full reservoir at the end of the monsoon season and (iii) minimizing the spill over the monsoon season were tried in order to derive the optimal

operating policies all seeking to achieve a dominant goal of maximizing the level of irrigation. A fourth criterion, in which the three models criterion were lumped together as a single scalar criterion, was also tried.

Optimal operating policies for five different inflow states (categories) are derived and studied.

Relationships were derived and studied between expected monsoon season inflows and the level of irrigation possible in that season and end of monsoon season state of the reservoir and the extent of irrigation possible in the following post-monsoon season.

To test the family of policy alternatives for time reliability, as obtained from optimization models, a simulation model was designed using Simulink in MATLAB environment.

The time reliability values were computed based on the observed historical series of inflows as well as a 100 year synthetic sequence and were found be consistent.

Rule based Single Criteria Multiple Option Operating Policies (SCMOP) have been designed and used to select the appropriate operating policy based on the expected state of inflows during the monsoon season. This approach is seen to increase the irrigation areas without compromising on the achieved reliabilities. For example, SCMOP based on model criteria no. 1 was able to irrigate 5508.7 THa with time reliability of 0.845.

As an improvements, Multiple Criteria Multiple Options Operating Policies based approach, (MCMOP), has been proposed. It achieved 5520.8 THa of irrigated area with the same level of time reliability as that obtained by SCMOP.

(2) Kabini reservoir

The Kabini Reservoir System, with two distinct planning objectives of irrigation and hydropower generation was studied. Additionally, Goal Attainment method was used to identify non-inferior solutions.

Phase II

Methodologists studied in *phase I* were implemented to derive optimal operating strategy for the expanded six-reservoir system.

The MCMOP based approach was seen to yield better results in terms of area irrigated and the time reliability than SCMOP based approach.

Finally, system performance has been evaluated in relation to the Cauvery Waters Dispute Tribunal (CWDT) Interim Award of 5809.14 Mcm of water annually, to Tamil Nadu using both optimization and simulation procedures. It is found that imposing a constraint on inflows into Mettur Reservoir, based on a full Interim Award irrespective of inflows actually realized, is not practical. Any allocation in a given year, should be based on the inflows that are expected into the reservoir systems during the monsoon season of that year.

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