UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION OF OPERATIONAL POLICIES FOR THE MINAB RESERVOIR, SOUTHERN IRAN

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DOCTOR OF PHILOSOPHY

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2012

OPTIMIZATION OF OPERATIONAL POLICIES FOR THE MINAB RESERVOIR, SOUTHERN IRAN

By

MOHAMMAD GHOLAMPOOR

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

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Dedication

In the name of God the Beneficent the Merciful

To the majority of people in Iran who are suffering from the shortage of water through Droughts, especially people of Hormozgan province

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Abstract of Thesis Presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

OPTIMIZATION OF OPERATIONAL POLICIES FOR THE MINAB RESERVOIR, SOUTHERN IRAN

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MOHAMMAD GHOLAMPOOR

September 2012

Chairman: Associate Professor Abdul Halim Bin Ghazali, PhD

Faculty: Engineering

Water resources management in an arid region with severe drought, such as the Minab area, in Iran, is very critical. Periods of drought have resulted in severe stress on the amount of current inflow to the reservoir. These severe stresses could not be addressed by the reservoir management through the standard operation policy method. The operation policy should be changed to consider the drought period conditions. There is a need for a reservoir management system to optimize water allocation policies during the inadequate water supply periods. Forecasting and accurate estimation of the future water inflow to the reservoir are the most important challenges in the management of water resources for the system. In the past, the management of the reservoir was widely concentrated on developing the operating rules in managing water resources. This research focuses on the optimization policies

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combined with a forecasting model for reservoir operation during drought conditions.

The main objective of this research is to develop and optimize the operational policy for managing the Minab reservoir operation to maximize the benefit of water release from the reservoir for different demand scenarios. The Soil and Water Assessment Tools (SWAT) model and the Focused Time Delay Recurrent Neural Network (F.T.D.N.N) method were used to simulate and forecast future inflow to the reservoir by considering stream flow factors and their constraints. The FTDNN was found to produce a higher accuracy and thus was selected as the forecasting model.

The current operation model uses the standard operation policy (SOP) rules to simulate the water demand and to recognize the shortage of agricultural water demand as the main demand sector. The SOP estimated the shortage of water for agricultural allocation in a monthly, three- month, six- month or yearly periods. To solve the shortage of water during drought, the Limiting Hedging Rules model and Genetic Algorithm (GA) were developed to determine the optimal allocation for agricultural demand. Through the hedging rule optimization an algorithm was developed to determine the benefit of water release and the water conserved in the reservoir. Also, three triggers were estimated for use as guidelines for managing the reservoir during drought occurrence. To mitigate the drought condition the probable scenarios, policies and management were applied. Rule curve for five possible scenarios were optimized by using Genetic Algorithms. The agricultural management optimization was applied to optimize the parameters like area, relative yield water requirements and irrigation efficiency. These parameters were optimized to reduce the water requirement based on the cost and benefit by using the Lingo model.

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As a result, when severe drought occurs, using optimized operational policies combined with the forecasting model could have a significant effect on reducing drought severity in an arid region. This research shows that a combination of forecasting and optimized operational policies models can be applied to manage drought conditions in water resource management. An algorithm was also developed for reservoir storage to determine the benefits of water conservation and reservoir water release to optimize reservoir operations in drought periods.

Comparing the performance of the different optimized operational policy models showed that the Hedging Rule, SOP, and Genetic Algorithms (GA) can respectively allocate 2404, 1991, 1811 million cubic meters (MCM) of water for agriculture during the shortage period while the benefit values of following these models were estimated to be 10,915, 7,395 and 6,075 thousand US dollars respectively.

Keyword: Reservoir Operation Models, Hedging Rule, Standard Operation Policy.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGOPTIMUMAN POLISI OPERASI BAGI TAKUNGAN MINAB DI SELATAN IRAN

Oleh

MOHAMMAD GHOLAMPOOR

September2012

Pengerusi: Prof Madya Abdul Halim Bin Ghazali, PhD

Fakulti: Kejuruteraan

Pengurusan sumber air di kawasan kering seperti Minab, Iran dengan keadaan kemarau teruk, adalah sangat kritikal. Tempoh kemarau yang panjang menjadi penyebab bagi kekurangan yang paling teruk terhadap kadar aliran masuk ke kawasan takungan.Keturangan teruk ini tidak boleh dlatasi dengan kaedah polisi operasi piawai (SOP). Oleh karena itu, polisi operasi takungan harus diubah untuk mempertimbangkan keadaan semasa kemarau. Justeru, ia amat memerlukan kepada sistem pengurusan takungan bagi pengoptimuman polisi pengagihan semasa pembekalan air tidak mencukupi. Ramalan dan anggaran yang tepat bagi aliran masuk air pada masa depan ke takungan adalah cabaran yang paling penting dalam pengurusan sistem system. Pada masa dahulu, pengoperasian takungan menumpukan

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secara meluas kepada pembangunan peraturan operasi dalam pengurusan sistem air, sedangkan penyelidikan ini menumpu kepada polisi pengoptimuman bersama model ramalan bagi pengoperasian takungan sepanjang keadaan kemarau. Tujuan utama bagi penyelidikan ini adalah untuk membangunkan pengoptimuman bagi polisi pengoperasian untuk mengurus pengoperasian takungan Minab bagi memaksimumkan keuntungan daripada air yang dikeluarkan untuk sinario keperluan yang berbagai di kawasan hilir takungan. Sistem pengurusan pengoperasian takungan secara jangka masa yang panjang dan sederhana telah dibangunkan bagi takungun ini. Model SWAT dan kaedah FTDNN telah digunakan bagi simulasi dan ramalan aliran masuk pada masa depan kepada takungan dengan mengambil kira faktor aliran sungai dan kekangan. Ramalan SWAT bagi bulan seterusnya telah dijalankan dengan mengguna beberapa kitaran ramalan dan akhirnya 50 kitaran telah dipilih. FTDNN didapati menghasilkan ketepatan yang tinggi dan ia telah dipilih sebagai model ramalan. Model pengoperasian telah menggunakan standard polisi peraturan pengoperasian untuk simulasi keperluan air dan mengenalpasti kekurangan air bagi keperluan pertanian sebagai sector utama.

SOP menganggarkan kekurangan air bagi peruntukan pertanian dalam tempoh bulanan, tiga bulan, enam bulan atau tahunan. Untuk menyelesai masalah kekurangan air sepanjang musim kemarau, model Limiting Hedging Rule dan Algoritma Genetik telah dibangunkan untuk menentukan peruntukan yang optima bagi keperluan pertanian semasa kemarau Melalui pengoptimum hedging rule dan algoritma yang telah dibangunkan untuk menentukan manfaat pengeluaran air dan simpanan air dalam takungan Begitu juga dengan tiga pencetusan telah dianggarkan untuk diguna sebagai garis panduan untuk mengurus takungan sepanjang kemarau berlaku. Untuk mengurangkan keadaan kemarau, sinario yang berkemunkinan, polisi

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dan pengurusan telah digunakan *Rule curve* untuk lima sinario yang berkemunkinan telah dioptimakan dengan mengguna Algoritma Genetik Pengoptimum pengurusan pertanian telah digunakan untuk mengoptimakan. parameter seperti kawasan, hubugan keperluan air dan hasil dan kecekapan pengairan Parameter ini telah dioptimakan untuk mengurangkan keperluan air berasaskan kos dan manfaat dengan menggunakan model *Lingo.* Hasilnya, apabila kemarau teruk berlaku, penggunaan polisi pengoperasian yang optima bersama dengan model ramalan boleh memberi kesan yang ketara dalam mengurangkan kemarau yang teruk di kawasan kering. Kajian ini menunjukkan bahawa pertimbangan, kombinasi ramalan dan model polisi pengoperasi yang optima boleh digunakan sebagai indeks kemarau yang baru untuk pengurusan keadaan kemarau dalam pengurusan sumbur air untuk digunakan bagi pengoperasian takungan di kawasan kering. Satu algoritma telah dibangunkan untuk simpanan takungun bagi penentuan manfaat penyimpanan air dan pengeluaran air takungan untuk pengoptimum pengoperasian takungan dalam tempoh kemarau. Pelbagai model polisi pengoptimum pengoperasian telah dibandingkan sesama sendiri dan akhirnya bersama data cerapan sejarah bagi aliran masuk dan aliran keluar. Keputusan menunjukan bahawa *Hedging Rule*, SOP dan Algoritma Genetik masing-masing mampu memperuntukkan air untuk pertanian semasa kemarau dengan nilai 2404, 1991, 1811 juta meter padu (MCM). Sedangkan nilai manfaat dari model-model ini telah dianggarkan masing-masing sebanyak 10,915, 7,395 dan 6,075 ribu USD.

Kata Kunci: Model Operasi Takungan, *Hedging Rule*, *Standard Operation Policy.*

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I certify that a Thesis Examination Committee has met on **September2012** to conduct the final examination of Mohammad Gholampoor on his thesis entitled "**OPTIMIZATION OF OPERATIONAL POLICIES FOR THE MINAB RESERVOIR, SOUTHERN IRAN"** in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998.The Committee recommends that the student be awarded the (DOCTOR OF PHILOSOPHY).

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of University Putra Malaysia and has been accepted as fulfillment of the requirement for the **Degree of Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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Date of Viva ……..

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