CONJUNCTIVE USE OF SURFACE AND GROUNDWATER TO IMPROVE FOOD PRODUCTIVITY IN A RESTRICTED AREA

Degree of Doctor of Philosophy

By

Saravanamuttu. Subramaniam. Sivakumar.

University of Moratuwa Sri Lanka

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Thesis submitted for the award of the Degree of Doctor of Philosophy

Submitted by

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Abstract

This thesis presents alternate policy decisions based on technical strategies to operate minor and medium irrigation schemes with integrated conjunctive use of surface and groundwater to improve groundwater systems in a restricted area for the economic pumping for agricultural and domestic water use, by optimizing the use of groundwater and surface water.

A groundwater simulation model was formulated using integrated finite difference method to carryout this research. Unlike finite difference method the integrated finite difference method can be formulated to any shape of catchment by connecting perpendicular bisectors of the observation points through out the catchment. An electronic spread sheet model was developed for groundwater system in integrated finite difference method and was applied to a selected restricted catchment area of about 185.23 km^2 in Vavuniya, for testing its validity after calibration.

Forty one domestic dug wells were identified as observation wells among the available domestic/agro wells within the study area of 185.23 km^2, to represent the aquifer. This study area was divided into forty one Thiessen polygons by connecting the perpendicular bisectors of adjoining observation wells. A groundwater simulation model was formulated for this polygonal net work using integrated finite difference method in spreadsheet. The model was calibrated for the period 1997 to 2001 having eight seasons. The recharging period of eight months was taken as from 1st October to 31st May of the following year and discharging period of four months was taken as from 1st June to 30th September. By this calibration the hydro geological stress parameters such as Transmissibility, Storage coefficient, Recharge coefficients for irrigation tank, irrigation field, rainfall and the Withdrawal factor for agro and domestic pumping were found using an optimization technique.

A complete water balance study for each polygon for each season was carried out. Forty one error models have been prepared for the water balance, for each polygon for all the seasons. To avoid the negative and positive errors getting cancelled, the squares of all seasonal errors were added and minimized with suitable constraint. Practicable ranges for Transmissibility, Storage coefficient, Recharge coefficients and Withdrawal factor were given during minimization as constraint. MATCAD2000 was used for this optimization. This model in spreadsheet, calibrated by error optimization technique, validated and recalibrated was used to predict the system behavior for various operational policies of the selected restricted groundwater catchment.

Water levels were predicted for changes in operational policy of minor and medium irrigation schemes by forgoing certain percentage of cultivation, boundary treatment to reduce the transmissibility in steps, and combination of both. The economic feasibility was analyzed by taking the energy saved in pumping of raised groundwater as a benefit and boundary treatment cost and income loss due to change in operational policy of minor and medium irrigation schemes by forgoing certain percentage of cultivation as cost. The present worth of benefit and cost for various interest rate and project life period were calculated and compared.

Change in operational policy of minor and medium irrigation schemes by forgoing one third of the cultivation under them or keeping one fourth of the storage of minor and medium irrigation schemes at any time together with 40% - 50% reduction in boundary permeability will recover an average of 60% to 70% of the loss of water table in any consecutive season in almost 95% of the area under consideration.

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The Director General, Irrigation Department Colombo, Director, Irrigation Department North East Province Trincomalee and Director, Irrigation Department Northern Province Trincomalee kindly gave me permission to use departmental facilities for this research work. I thank all of them and their staff for giving direct and indirect encouragement and moral support in this research work and for providing the necessary facilities.

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Dedication

To my 86 year old dear mother Mrs.Rasamani Subramaniam of Point Pedro for her dedicated determination to turn her third son also to complete his PhD by exerting continuous encouragement and moral support to complete this research.

and also

To my wife Logeswari Sivakumar, daughter Jananie Sivakumar and son Sivakumar Janen for their utmost support in completing this research project.

Declaration

I hereby declare that the research reported here, is an authentic record of my own work carried out during the period from October 2001 to May 2008, for the PhD degree under the guidance of Prof.D.C.H.Senarath, Senior Professor, Department of Civil Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka.

The matters embodied in this research thesis have not been submitted for award of any other degree to any other institution.

Date:

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Certification

I certify that, this thesis is the bonafide work of Eng.S.S.Sivakumar, who carried out this research under my supervision.

I certify further that to the best of my knowledge, the work reported herein does not form part of any other thesis on the basis of which a degree or award was conferred on an earlier occasion on this or to any other candidates.

Date:

Professor D.C.H.Senareth

Research supervisor

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Abbreviations

ac	Acres
ac.ft	Acre-Foot
APC	Agrarian Production Centre
ASC	Agrarian Service Centre
CEB	Ceylon Electricity Board
DAC	District Agriculture Committee
DOA	Department of Agriculture
DP	Dynamic Programming
DS	Divisional Secretary
ET	Evopotranspiration
FDM	Finite Difference Method
FSL	Full Supply Level
GDP	Gross Domestic Product
GN	Grama Nilathari
GNP	Gross National Product
IFDM	Integrated Finite Difference Method
k	Permeability
K	Hydraulic Conductivity
MSL	Mean Sea Level
NGO	Non Governmental Organization
NEPC	North East Provincial Council
NWSDB	National Water Supply and Drainage Board
OFC	Other Food Crop
RE	Recharge
RF	Rain Fall
S	Storage Coefficient/ Storability of the Aquifer
SLAAS	Sri Lanka Association for Advancement of Science
SMD	Soil Moisture Deficit
sq.mls	Square Miles
S_s	Specific Storage Coefficient
T	Transmissibility
WRB	Water Resources Board

List of Annexure