SUSTAINABLE WATER RESOURCES MANAGEMENT FOR A RIVER BASIN

by

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Dedicated to my wife Sunita
and sons - Sonu & Monu

CERTIFICATE

This is to certify that the thesis entitled, "SUSTAINABLE WATER RESOURCES MANAGEMENT FOR A RIVER BASIN" being submitted by Mr. Mahesh Kothari to the Indian Institute of Technology, Delhi, INDIA, for the award of the degree of DOCTOR OF PHILOSOPHY, is a record of bonafide research work carried out by him under my supervision and guidance. The thesis work, in my opinion, has reached the standard fulfilling the requirement for DOCTOR OF PHILOSOPHY degree. The research report and the result presented in this thesis have not been submitted, in part or in full, to any other University or Institute, for the award of any degree or diploma.

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ABSTRACT

Although considerable advances have been made in water resources system planning and management as brought out in the pioneering or state of art works, but emphasis has been on component problems rather than on integrated river basin planning. Secondly, orientation has been towards supply side and on some issues of quality management in context of advanced countries. A few river basin or regional studies are made. But, all these studies are either more towards regional studies or have not considered the resource scarcity and sustainability aspects.

The present study has been performed in three sets - first, sustainable management of water resources for a river basin - a conceptual development; second, development of computer oriented decision support models and third, application to Chambal river basin a real life case study.

Two decision support models, a system dynamics model and a multi-objective optimization model, have been developed to derive long-term sustainable water resources management policies in the river basin. The system dynamics model developed consists of five sectors - population, industrial and capital, agriculture, water resources and pollution & natural resources. The model considers inter-relationship among different vectors of system, dynamic in nature and is used to simulate long-term system's response to depict the water supply - demand scenario in the river basin and behavior of other model parameters.

The multi-objective optimization model is developed to obtain the optimal cropping pattern and monthly water releases to various sectors of economy at sub basin level. The model considers fuzzy theoretic approach for multi-objective analysis and satisfaction level of

decision-maker is maximized for fuzzy transformed problem *to* arrive at efficient compromise between all conflicting objectives.

The Chambal river basin has been selected as a real-life case study. The river basin has been considered divided into five-sub basins - Banas, Upper Chambal, Lower Chambal, Parawati and Kalisindh. The water balance analysis and long-term perspective in the river basin in terms of supply and demand of water resources, was first carried out to visualize need and urgency of sustainable development policies.

The system dynamics model is simulated for Chambal river basin to obtain the water supply - demand scenario in the river basin and behavior of the other model parameters up to year 2100. In addition to standard run, six more simulation runs have been analyzed to study sensitivity of industrial capital - out put ratio (industrial growth rate), birth rate normal and resources use rate normal on overall behavior of model. The sustainable policy considers demand management in industry, agriculture and city living. The model is simulated for sustainable development policy to illustrate its impact and state of river basin in future.

The application of multi-objective optimization model is done in three parts. In the first part, a detailed study on the Banas sub basin is done and optimal cropping pattern and monthly water release to agriculture, industry and domestic sectors is determined from surface and ground water. The model is experimented for various policies such as change in monthly ground water draft, change in ground water pumping cost, mandatory d/s releases, deficit irrigation, demand management in agriculture and industry sector. The model is then applied for different point of time in planning horizon to analyze changing scenario in the basin. The future projections for population, surface and ground water exploitation is obtained through earlier applied system dynamics model.

In the second part of application, the model is applied to the other basins - Upper Chambal, Lower Chambal, Parawati and Kalisindh for existing situations only. The optimal cropping pattern and water releases to each sector of economy are obtained for each sub basin.

In the third part, the water transfer option to deficit Upper Chambal sub basin from Kalisindh has been studied. The optimal cropping pattern and water release to agriculture, industry and domestic sector in changed situation is obtained.

The results of system dynamics model shows that the basin is to face acute water shortage in long run and major sufferer will be the industry sector, if present policies continued in future. But, through sustainable policy run, it is shown that implementing sustainable development policy can circumvent this situation. The industrial growth and economic development in the basin will be maintained. Similar conclusions have been derived from multi-objective optimization model for detailed analysis on Banas sub basin. The results also indicated considerable increase in net benefits and agriculture development in long run with sustainable management policies.

The decision support models developed are quite general and can be applied to any other real-life case study.

m	meter
M	Million
mm	Millimeter
mcm	Million cubic meter
mmhos	milli mhos
MW	Mega Watt
nos.	Numbers
qtls	Quintals
Rs.	Rupee
R.L.	Reduced level
sq km	Square kilometer
UI	Un-irrigated
u/s	Up stream
temp	Temperature
UNEP	United Nation Environmental Program
WCED	World Commission on Environment and development

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