A STUDY OF SOME ASPECTS OF SUSTAINABLE DEVELOPMENT OF INDIA'S WATERS

by

QUAMRUL HASSAN

Department of Civil Engineering

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Dedicated to

My father (late) and my role model
who couldn't see the day,

My youngest and the dearest sister,
whom Almighty has taken back from
us so early and suddenly, still difficult
for me to accept the fate,

My loving mother.

CERTIFICATE

This is to certify that the thesis titled, "**A Study of Some Aspects of Sustainable Development of India's Waters**", being submitted by **Mr Quamrul Hassan** 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 requirements 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.

(Prof. N. K. Garg)
Department of Civil Engineering
Indian Institute of Technology
New Delhi 110 016, INDIA

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(Quamrul Hassan)

ABSTRACT

Humanity is facing a worsening series of local and regional water quantity and quality problems, largely as a result of poor water allocation, wasteful use of the resources, sectoral approach towards water resources, and lack of adequate management actions. There is no one to one relationship between population and water requirement but it is evident that with improvement in standard of living the water demands per capita increases. In India the pressure on water resources is becoming alarmingly high in view of the large population and its continued growth along with economy. From the literature review, it is evident that no comprehensive policy regarding water resources development is available in India and the decisions are taken on adhoc basis. The sectoral approach of water resources development causes other associated problems and therefore it is not sustainable. The vision of a more sustainable water future, a policy framework tool, and practical steps towards sustainable development of water resources are needed. From the studies, it is evident that the complexity and interdependence are the salient features of water resources development. The study of sustainable development of the water resources requires an integrated approach towards water resources management and the understandings of long-term interactions among the human development, resource base of water and environment in a comprehensive way. Therefore, it is most desirable to explore the various policy options with the help of an interactive model in the search of a sustainable policy for water resources development. In the present study, an effort is made in this direction and a comprehensive framework model based on system dynamics concepts is developed and is named as INDIAWATER.

INDIAWATER can be understood as a set of interlinked sub-systems and has been schematized into four sub-systems: pressure, state, impact, and response. Accordingly INDIAWATER integrates the four interacting sub-models. The human development exerts pressure on the water system and as a consequence, the state of water system changes. These changes have impacts on water supply. These impacts in turn will evoke policy responses, in the form of actions that feedback upon the pressure, or directly upon the state or impacts. Indicators are used to represent the status and performance of various sub-systems that help in updating the policy.

The application of model requires an operating policy and data framework. The operating policy and data framework for simulation of INDIAWATER in the Indian context has been worked out. For such a large scale of study requires huge data which has been collected from various government organisations and international agencies and published reports. The collected data are presented comprehensively and uniformly. Sometimes required data are also derived from the developed database in the present study. The simulation period is from the year 1990 to 2050.

The model is validated before its application for different combination of population and economic development for evolving a sustainable policy for water resources development. The simulation results for the given data framework are presented and analysed. Five combinations of population and economic development are considered namely – Population and Economic Development – Low scenario, (PEDL); Population and Economic Development – Medium scenario (PEDM); Population and Economic Development - High scenario (PEDH); High projection of Population & Low projection of Economic Development, (PEDHL), and Low projection of Population & High projection of Economic Development (PEDLH). For each

combination of population and economic development, three cases are considered for the simulation depending upon the level of water supply system efficiency, pricing policies, technological improvement, recycling, and type of water resources development. The model is run for all these scenarios and results are presented and analysed. Water supply efficiency, pricing policy, recycling of wastewater, technological improvement, and type of water resources development are considered as key variables to explore a sustainable policy to meet a particular target for the desired population and economic development. In some cases, the contribution of foodgrains from irrigated areas, (fgirr) and lower fertilizer consumption are also considered to explore a sustainable policy, to reduce the pollution level, if required.

Based on the present study it is found that that water resources developments are sustainable under population and economic development – low scenario (PEDL) and medium scenario, PEDM. But it is considered unsustainable under PEDH because of high water demand and pollution level. Under PEDHL i.e. high population and low economic development scenario it may not be sustainable because of expenditures of high order of GNP. Under low population and high economic development (PEDLH), the water resources development are sustainable only if high level of water supply efficiency, high pricing policy, high technological improvement, recycling of industrial wastewaters, and low fertiliser consumption are considered.

Although it will also be necessary to back up the policy with appropriate institutional modernization as technology and social institutions are the two essentials for water resources management but the present study is limited to evolve a long-term sustainable policy for water resources development.

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