ABSTRACT

Hydrological modeling is an indispensable tool for obtaining a better understanding of hydrological processes, their interactions, and prediction. Hydrologic models are simplified, conceptual representations of real-world system, commonly through mathematical equations, developed with the aim to understand hydrological processes, predict their future behavior, and to manage water resources, both in terms of quantity and quality of water. Hydrologic models help faster and logical decision making.

A large number of hydrologic models ranging from simple to highly complex have been developed world over and are available for solving wide ranges of domain problems. Each model has its own merits, limitations, data requirement and complexities in use. Water professionals are interested in estimation of response of water systems to hydro-meteorological inputs and intervention to plan, construct, and operate water resources development projects. Some models are comprehensive and derived based on the physics of underlying hydrological processes. Keeping in view the hydro-climatic regions, topographic variability in India, and data availability, a group of models need to be identified for wider use. Selection of an appropriate model for an application requires consideration of the suitability of the model to the catchment conditions, data requirements and availability, model assumptions, complexity, and its accuracy and validity. Therefore, a model user must fully understand these aspects before using a model. If necessary and possible, suitable modification may be incorporated in a model to make them more useful for Indian river basins. Reliable data at a range of spatial and temporal scales are critical to calibrate and validate the hydrological models.

An important area of surface water modeling is contribution of snow and glacier melt in snowfed catchments. In mid and high latitude mountain ranges, for example, seasonal snow cover exerts a strong influence on runoff variability whereas glaciers are the dominant source of water during the dry season at low latitudes. Improved understanding of snow and glacier melt runoff studies will help better management of water resources in rivers fed by these two.

Groundwater, one of the India's most important natural resource, is under constant threat of exploitation with increasing population and economic development. Proper understanding and modeling of subsurface water movement has been an enduring challenge for hydrologists and practitioners. Current modeling efforts are plagued by the complex heterogeneity within the subsurface, reconciliation with spatial and temporal scales, and lack of supporting data.

Water quality management including soil erosion and transport is a critical component of overall integrated water resources management. Water quality modelling can give answers to a large number of management questions related to prospective social, economic, environmental, technical and political issues of future scenarios based on past and present conditions. Decisive use of water quality modelling as a tool for policy evaluation & decision, water quality management, risk assessment, and water quality conservation is yet to pick up momentum in India.

Data challenges continue to plague modeling efforts, particularly in India. Complex models

have too many parameters that need to be estimated accurately and independently for the models to be used at their full and correct potential. Most efforts rely on calibration and corroboration exercises that are fraught with uncertainty. Field-scale experiments are time-consuming and costly. State-of-art data acquisition techniques need to be applied for reliable modeling and impact studies. There is a need to devise low-cost and rapid ways to accurately determine hydrogeologic parameters. Geographical information systems (GISs) are increasingly being included in planning and management models. Most of the current models have been linked with GIS database.

Assessing the potential impacts of climate change on surface and ground water regime is yet another long-term challenge that confounds both researchers and managers. Developing new models that account for uncertainties and provide more realistic assessment of predictive capabilities is needed for devising effective management practices. Uncertainties in modeling and in defining climate change scenarios make it difficult to assess the state of future groundwater resources. Methods for quantifying and reducing these uncertainties need to be derived using advanced mathematical techniques, and modeling strategies.

This document reviews the hydrologic and water resources modeling and management challenges in India covering surface and sub-surface water, snow and glacier melt water, water resources systems, water quality aspects, and sediment transport, and also reviews the most promising models developed to solve wide ranges of problems covering all those hydrological domains. A critical appraisal of the most widely used domain models including their characteristics has been elaborated in this document to help readers choose which models have what capability, limitations, data requirements and complexities.

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