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Research and Development in Hydrology
General Summary

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RESEARCH AND DEVELOPMENT IN HYDROLOGY

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GENERAL SUMMARY

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The water is one of the important natural resource available to mankind. With the increasing pressure of rising population, there is a growing need for finding, developing and maintaining suitable water supply and for proper management of this natural resource. Water as a resource is available as surface water and ground water. Surface flow in streams is made up of flow due to direct response of the basin to precipitation input and the flow from snow melt and base flow contributions representing delayed smoothed out response. The surface runoff data is thus subjected to seasonal and yearly variations and the information content of surface flow observation is very small. Moreover, surface flow is susceptible to changes in the basin brought about by nature or man's various activities. It is also subject to quality deterioration due to discharge of industrial effluents, sewage, etc. The surface water projects involve decisions regarding major investments generally with insufficient or non-existent flow information. In contrast to this, the ground water data information content is considerably greater than that of comparable surface flow data. Moreover, the initial investment in ground water development project is relatively less. However, for an integrated planning of water resources both surface water and ground water have to be developed conjunctively. Both these represent two phases of occurrence of the total water potential of the basin and any intervention in one phase affects the other. The development of water resources has to be undertaken through integrated river basin development programmes.

Watershed or river basin implies a drainage area containing a few thousand or a few hundred thousand hectare from which water drains towards a single channel. It is a natural, social and economic unit for community development and conservation or water, soil, forests and related resources. The concept of the small watershed approach to land and water resource development at meso level and river basins at mega level is necessary for integrated planning of resources. This will also involve the application of principles of scientific hydrology for data collection and analysis for planning, design, construction, and operation of water resources development projects.

In recent years, considerable interest has been generated regarding optimum and efficient utilization of the country's water resources for the benefit of entire nation, over-riding narrow regional considerations. A large number of rivers in the country are interstate in character and as such a national view is as necessary in planning, development and management of river basins. By adopting improved methodology of basin-wise development, by creation of additional storage reservoirs, conjunctive use of

surface and ground water and by inter basin transfer of surplus water to needy areas, it is possible to create an additional irrigation potential of 35 to 37 million hectares. As there is hardly any scope to increase the cultivated areas, as such conservation and efficient utilization for various purposes through storage reservoirs, conjunctive use and water transfer system have assumed importance.

Realising the crucial importance of water for development and planning as the country is preparing itself to enter the 21st Century, a National Water Policy has been formulated, so that this precious resource is planned, developed and conserved as a national resource in an integrated and environmentally sound basis, keeping in view the needs of the States concerned. The water resource planning will have to be done for a hydrological unit, i.e. basin or sub-basin, and suitable data base and information system along with necessary infrastructure will have to be established for management of river basin as a unit. For effective and economical management of our water resources, the frontiers of knowledge will have to be pushed forward in several directions by intensifying research efforts in various areas. These include hydrometeorology, assessment of water resources, snow and lake hydrology, ground water hydrology, and recharge prevention of salinity ingress, water harvesting, evaporation and seepage losses, sedimentation of reservoirs, recycling and reuse, use of sea water resources and water management practices (Ministry of Water Resources, 1987).

Klemes (1988), while discussing various aspects of a hydrological perspective has quoted the following definitions:

Science: The body of organised knowledge. The mission of science is to understand things.

Technology: The ways in which society provides itself with the material objects of its civilization. There is an implication that technology based on science is superior to one which is not. The mission of technology is to do things.

Research: Extension of knowledge by discovery of new facts, relations, laws, i.e. advancement of science.

Development: Creation of technology with an emphasis on applying science, i.e. making the existing knowledge useful.

The author mentions about: (1) the growth of the scale of human interference with nature, (2) the advances in observational and data handling technologies, and (3) the growing collaboration and interdependence between bio-geographical sciences as they tackle problems on continental and global scales, for providing extraordinary opportunity of development of hydrology as a geosciences.

Chander (1993) has recently discussed the scale and shape aspects of rainfall runoff problem and highlighted the shift in emphasis in hydrological research from tools to principles or from

'how' to 'why' in finding solutions to the problems. It is stated that assessment of the impact of large scale interference by man on various components of water balance equation at basin, regional and continental scales, will form one of the focal points of further studies.

The optimal and judicious use of a natural resource like water, particularly when it is finite, can be ensured only when its exploration, exploitation and management are backed by a strong research and development component. This becomes all the more important and critical when the resource is linked with multi-objective options like dwindling potential, conflicting interest, and biased environmental concerns. It is, therefore, necessary to look at the status of research in hydrology in India vis-a-vis the current global status. In this paper an attempt has been made to overview various areas of hydrology requiring special thrust, so that water resources development in the country can contribute to accelerated pace of economic growth and social welfare of our population.

Keeping in view the needs and status of research and development in hydrology, it would be desirable that specific areas of activities are taken up, on priority basis as 'Hydrology Missions'. These could include:

a) Software development
b) Regionalisation and hydrological mapping
c) Physically based mathematical modelling
d) Water resources assessment
e) Hydrological information system
f) Technology transfer
g) Hydrological forecasting
h) Hydrologic instrumentation development
i) Remote sensing applications

The details of research and development in hydrology covering following aspects are being presented by National Institute of Hydrology in four papers and thrust areas have been recommended, as follows:

1. Surface Water Hydrology

(A) Priority 1

(i) Preparation of software, user manuals, guidelines, manuals and standards for hydrologic analysis, design and operation of water resources projects

(ii) Methodology for hydrologic design for water resources projects for ungauged/limited data situations and gauged catchments (including design storm estimation and design flood estimation and risk based design)

(iii) Water balance and water availability studies for river basins and water bodies (lakes and reservoirs)

(iv) Regionalization of hydrological parameters for water yield and floods, and preparation of hydrological maps including geomorphological characteristics of river basins

(v) Snow hydrology - (a) Effect of elevation on temperature and

precipitation in Himalayan region, (b) Relationship between snow covered area and snow melt runoff

(vi) Urban hydrology - (a) Effect of urbanization on surface runoff and water balance for major urban centers in the country

(vii) Flood studies - (a) Dam break flood studies for major dams, (b) Flood risk mapping and zoning for flood prone areas, (c) real time flood forecasting models for catchments of major dams

(viii) Physically based hydrologic modelling for important river basins undergoing or likely to have significant land use changes for use in integrated planning, flow forecasting, and operation of projects

(ix) Climate variability - Case studies for selected river basins for studying effect of climate variability on hydrologic processes at various time and space scales

(x) Policies for optimal operation of water resources projects (Hydrological aspects)

(B) Priority 2

(i) Development of integrated models for atmospheric and land surface processes interlinked with general circulation model for atmosphere for studying expected changes in runoff and other water balance components of large regions and water bodies due to climatic changes (greenhouse effect), or man's activities (inter basin transfer of water on a large scale, irrigation, fertilizer use, industrialisation, etc.)

(ii) Development of regionalization methods considering non-stationarity in hydrologic time series

(iii) Development of snow melt runoff models for Himalayan catchments

(iv) Development of hydrological models for river basins incorporating use of remotely sensed information on a real time basis

2. Groundwater Hydrology

(i) Evaluation of components of ground water balance for assessment of ground water resources

(hi) Ground water flow modelling for multi-aquifer system and stream aquifer interaction studies

(iii) Unsaturated flow modelling

(iv) Spring flow modelling

(v) Salt water intrusion in coastal aquifer

(vi) Artificial recharge

(vii) Modelling of ground water quality

(viii) Water logging, salinisation and drainage in canal command areas

(ix) Conjunctive use of surface and ground water

(x) Water conservation measures in drought prone areas

(xi) Drought indices

3. Hydrological Investigations and High Tech Applications

I. Hydrological Investigations

(i) Hydrological soil classification

(ii) Infiltration studies
(iii) Evaporation and interception

II. Isotope Applications
(i) Soil moisture measurements
(ii) Low flow measurements
(iii) Water balance and sedimentation of natural lakes
(iv) Surface water and ground water pollution
(v) Water equivalent of snow (Snow depth and density)

III. Remote Sensing Applications
(i) Snow cover mapping
(ii) Flood plain and inundation mapping
(iii) Erosion, sedimentation, land slide and drought area mapping
(iv) Surface water potential mapping

IV. Hydrologic Instrumentation,
(i) Development and automation of laboratory and field instrumentation
(ii) Telemetry for networking applications
(iii) Standardisation of various instruments and data formating
(iv) Automatic data acquisition system

V. Data Base Management System
(i) Data storage and retrieval techniques
(ii) Geographical Information System

4. Environmental Hydrology

(A) Priority 1
(i) Identification of sources of pollution and monitoring of hazardous substances, biological degradation in water bodies
(ii) Impact of insecticides, pesticides and fertilizers on water quality
(iii) Water quality modelling
(iv) Influence of afforestation and deforestation on hydrological parameters
(v) Representative basin studies
(vi) Environmental impact assessment of existing major water resources projects
(vii) Impact of urbanisation on hydrological characteristics of a basin
(viii) Hydrological processes in the humid tropics environment

(B) Priority 2
(i) Measurement and prediction of bio-monitoring indicators
(ii) Water quality standards for various uses and uniformity in water quality standard for each use
(iii) Reuse and recycling of waste water
(iv) Determination of infiltration capacities of different soils by different types and densities of forest covers
(v) Development of generalised, computer based, quantitative methodologies for EIA studies preferably with different scenario and data availability
(vi) Land use, erosion and sedimentation - their consequences and control

(vii) Preservation and restoration of rivers and wetlands
(viii) Resolution of water conflicts

SOME SUGGESTIONS

The main goal of R & D activities in hydrology and water resources is to balance demand and supply of water through environmentally sound water development and management practices following the concept of sustainable development and considering the river basin as a unit. It would be desirable that short term and long term country plans for R & D activities in hydrology are formulated covering basic as well as applied research, and technology transfer needs and priorities. These country plans should be widely publicised for ensuring participation on a large scale. The involvement of various government organisations at Central and State level as well as academic organisations could be specified including the objectives and outputs envisaged for various activities (basic research, applied research, operational procedures, guidelines, manuals, software, standards, training courses, seminars, symposia, workshops, etc.). The tendency for unnecessary duplication is to be avoided and the progress of implementation/ studies by various agencies should be coordinated/monitored by a high level committee. The Government funding shall be provided for sound result oriented projects under the country plan and such projects should have provision of monitoring and evaluation by experts. Some of the projects could involve participation of more than one agency/organisation. Suitable mechanism has to be evolved for pooling together of expertise and infrastructure available in the country in an optimal manner for achieving the objectives of country plans. There should also be suitable mechanism for supply/availability of field data for R & D activities under the country plan. Besides specific projects and studies, the activities of technology transfer and creation of public awareness should also be carried out in a well planned and coordinated manner.

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