

R&D Initiatives of NRDMS Division in Water Resources Management

PREAMBLE

The Natural Resource Data Management Systems (NRDMS) Division of the Department of Science & Technology, Govt. of India, in support of the 73rd & 74th Constitutional Amendment Acts (1992 & 1993), has been engaging in R&D initiatives in the development of appropriate tools and technologies on Geographical Information System (GIS) to facilitate the local bodies of governance (Panchayat Raj institutions) in the preparation of integrated area development plans. The vision of the programme is to **"Enable people, communities and institutions of self-governance to use Spatial Data Technologies for informed participation in the decision-making for integrated development of the local areas"**.

LOCAL AREA DEVELOPMENT - SIGNIFICANCE OF WATER RESOURCES

Land and water system analysis is an important area under the NRDMS programme as they form the two crucial and complementary resources that influence the local area development. Water, its abundance, or scarcity, directly affects the quality of human life. Water is a renewable resource and the per capita water availability in India is reasonably good. Owing to its inequitable distribution in time and space and indiscriminate exploitation and wastage, there has come to be its acute shortage in many regions of India. The increasing demand for clean water, on the one hand, and the decrease in the availability and deteriorating quality, on the other, has become matters of serious concern.

Recognising this particular concern, the NRDMS attached prime importance to the understanding and evaluation of spatial distribution, extent, mobility and quality of water resources so that appropriate strategies for its optimal use, development, and conservation could be devised. Technologies, employing both traditional and contemporary knowledge aimed at sustainable resource use, are encouraged and conscious efforts are made to empower the end user community with this knowledge base to promote their participation in the conservation and development processes.

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LATEST TRENDS IN DEVELOPED COUNTRIES

At the international level, the primary concern is to protect human health and to safeguard the natural environment, viz., air, water and land, upon which life depends. Three decades of R&D efforts at finding solution to social, economic and environmental problems of the people of developing countries by International Development Research Centre (IDRC) - a public corporation of the Canadian Government - has shown that:

- Sustainable development in any realm is a multi-dimensional enterprise and starts with a collection of facts on the ground.
- Community economics of water- supply and scarcity need to be addressed.
- Water resources management is the domain of demand management. Water policy must, therefore, lay emphasis at all levels - national, regional or local - to turn from supply to demand.
- Energetic participation of local people in water management issues is a necessity, if the research results are to be reliable and influential and have much lasting effect.
- Monitoring is important to determine the nature and the extent of change to observe whether technical results match expectations.
- Research must be translated speedily into common language, which the policymakers and the local people could easily comprehend and be diffused through extension programmes.
- Experience establishes the axiom: **"Social and economic factors, not technical problems, ultimately present the worst obstacles - and the best instruments - in implementation"**.
- It is always worthwhile to examine carefully what is socially and culturally acceptable to the local community, and then design and test remedies consistent with the local traditions to avoid rejection risk.

NATIONAL PRIORITIES OF R&D ACTIVITIES

The **National Water Policy** (NWP) recognises the importance of S&T initiatives in devising effective and economical management of the water resources and advocates that the R&D efforts in water resources sector should primarily aim at bringing about improvements in the technologies to plan, investigate, develop and manage the resource efficiently in an optimal, integrated, and environmentally harmonious manner to meet the ever-growing demand in a sustainable manner and ensure equitable distribution. Further, the NWP underscores the need for an accurate and a reliable information system with a network of databanks and databases, integrating the existing Central and State level agencies for reliable projections for future demands and supply of water to support realistic planning.

The **Water Information Bill** (WIB) drafted by National Water Board of Ministry of Water Resources, Govt. of India, too emphasises the freedom of access to information and data, concerning water.

The **National Commission for Integrated Water Resources Development Plan** (September, 1999) constituted by the Ministry of Water Resources, Govt. of India, prioritises initiatives and models aimed at: -

- Regeneration of organic fertility & enlargement of operational soil depth for primary production systems as well as for hydrologic manipulation, and
- Micro-level network of water harvesting systems & in-situ moisture conservation methods with minimum loss of area and maximum distributed benefits to all

Initiatives of NRDMS

The NRDMS programme of DST, within its framework of programme objectives and in line with the global perspective and National R&D requirement, has been supporting several academic and R&D institutions of national repute to carry out research related to geo-informatics, aimed at evolving spatial decision-support tools for making objective decisions for possible solutions to local specific problems related to Natural Resources Management. The philosophy is explained in Fig. 1.

For a couple of decades, the Division has been supporting research projects covering a wide spectrum of water resource management issues, viz., watershed management technologies, flood zone management, ground water assessment/ conservation, water pollution, etc., spreading over different agro-climatic zones of the country, using different techniques and approaches ultimately to evolve a comprehensive water management strategy (Fig.2). In April 1997, a **National Meet On S&T Inputs for Water Resources Management** was organised by the - NRDMS Division (DST) at IIT-Delhi to focus efforts on evolving a more "holistic and sustainable water management approach at the local level". It was in this Meet that a decision was taken to focus the research activities through specific smaller but coordinated programmes. Accordingly, programmes on hydrology of small watershed and ground water modeling were initiated under NRDMS programme.

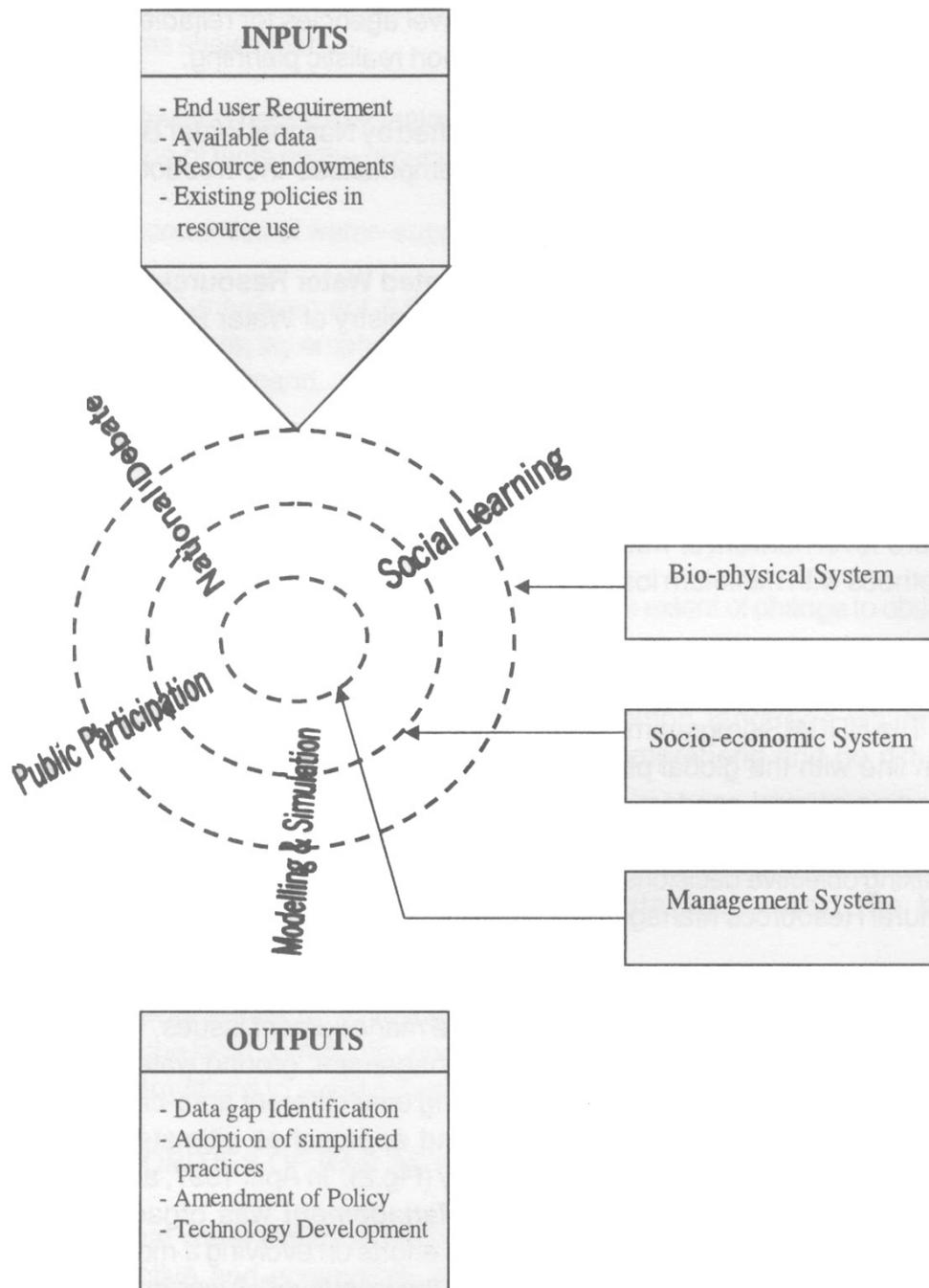


Fig. 1. Research approach for resource optimisation & local area development.

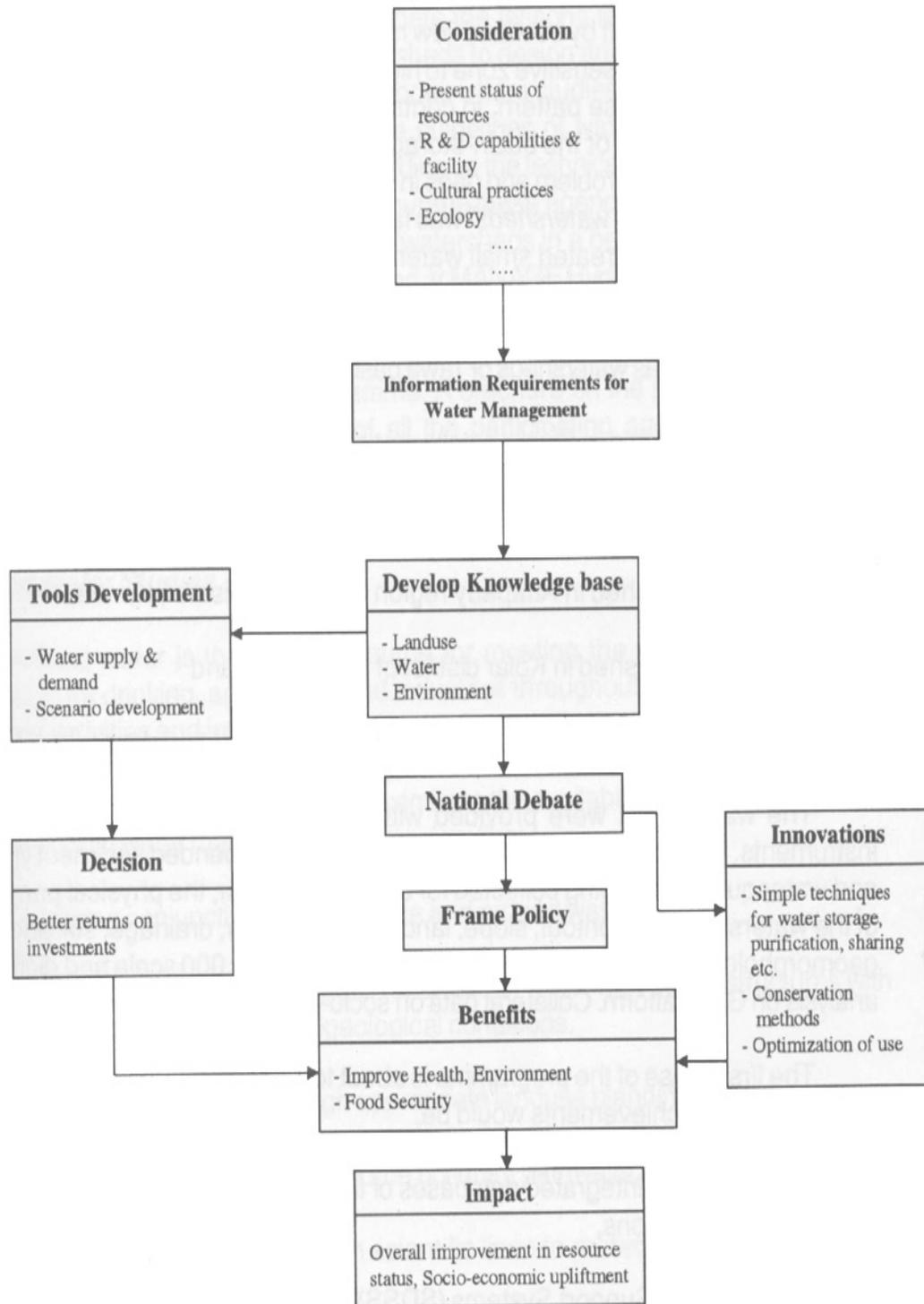


Fig.2. Water management strategy.

Hydrology of Small Watersheds

International Committee on Runoff defines a small watershed as the region affecting the peak runoff by over land flow rather than the channel flow. Consequently, a small watershed is a sensitive zone to high intensity rainfall of short duration and to the changes in land use pattern, in contrast to the larger watershed, wherein the effect of channel-flow, or the basin-storage, becomes very pronounced. Realising the importance of the problem and gaps in understanding, a coordinated programme on "**Hydrology of small watersheds**" was launched in 1997. Under this programme a pair of treated and untreated small watersheds (about 10 sq km) were selected in the areas listed below: -

- (a) DLjdhi and Bewas watersheds of Tawa basin in Raisen district of Madhya Pradesh,
- (b) Pundlu & Madpuria in Siyara catchment of Jodhpur district, Rajasthan,
- (c) Chandrabhaga Garh and Danda watersheds in Garhwal district of Uttaranchal,
- (d) Paykkara watershed in Attapady region of Palghat district, Kerala,
- (e) Rampatna watershed in Kolar district of Karnataka, and
- (f) Waikhulok and Awang Khujialo 1 Watersheds in the Loktak lake basin of Manipur.

The watersheds were provided with hydro-meteorological data collection instruments. Data pertaining to rainfall, stream-flow, suspended sediment yield, and water quality are being collected for analysis. Further, the physical parameters of the watershed, like contour, slope, land use/land cover, drainage, soil and geomorphologic information have been mapped on 1:50,000 scale and digitized for analysis on GIS platform. Collateral data on socio-economy have also been collected.

The first phase of the programme is about to be completed in July 2003. Some of its significant achievements would be:

- The availability of integrated databases of the selected watersheds over agro-climatic regions,
- Spatial Decision Support Systems (SDSS) for watershed management,
- Development of scientific indices for impact assessment of management programmes,
- Technology transfer. To fulfill this objective two training programmes had been conducted in 2001 and 2002. In addition, User Manuals are getting prepared.

Efforts are being made to disseminate the lessons learnt with regard to the hydrological behaviour of the small watersheds to design and modify land and water management plans in the agro-climatic zones where studies have been carried out. Initiatives are on to make it a part of the guidelines of watershed planning of the implementing ministries. With a view to building up the technical capability of the Project implementation Agencies (PIA) and encourage these agencies to extend support to the watershed societies to manage their watersheds in a better and efficient way, a one-day explorative meeting was organised at MANAGE Hyderabad in October 2002.

Recently in Trivandrum, a demonstration workshop was organised showcasing the results and findings of the programme. A brochure on the programme is being prepared through the involvement of all the participating agencies at CWRDM, Kozhikode. A website and possibly a data-clearing house for trading and transferring the data generated in this programme is on the anvil with interested research community.

Ground Water Studies

Ground water is the major resource for meeting the water demand of the population for drinking, agriculture, and industries through out the year. The spurt of industrial activities and intensive agricultural practices in the last two decades have led to severe deterioration in the quantity and quality of water. The solution to this lies in involving appropriate methods for maximising the availability of hazard-free water through holistic water management strategies, like:

- Encouraging conjunctive use of surface and ground water,
- Resource augmentation through placement of water-harvesting structures with due consideration to the hydro-geological conditions,
- Analysis of point and non-point source pollutant pathways,
- Implementation of regulations on scientific lines to protect the water resources from contamination.

All that calls for a good understanding of the system as a whole and its responses to the external forces. Considering that modeling helps in understanding the behaviour of the natural system in a controlled physical and numerical manner, a sub-programme on "**Ground Water Modeling**" had been initiated in 1998.

As an initial step to the study of ground water modeling, the Division had organised and co-sponsored the following **National Meets and Brainstorming Sessions**: -

- Brainstorming Session on - "Ground Water Modeling", at GAZRI, Jodhpur (Rajasthan) in October 1999,
- Sustainable development and Management of Ground Water Resources in semi- arid region with special reference to hard rocks, by NGRI at Dindugal, TamilNadu,
- National Seminar on "Water Quality", held in JNU, New Delhi, in February 2001,
- Two workshops in Upper Barakar Basin in Bihar, aimed at sharing the project highlights with the users for gaining their needs and perceptions.

Officers of NRDMS Division also participated in the Workshop on Past Achievements and Future Strategies organised by the Central Ground Water Authority at New Delhi in 2000, and UNESCO sponsored workshop on "Modeling in Hydrogeology" at Anna University, Chennai, held in December, 2001.

Recommendations and views that evolved at these events were given consideration for initiating research projects through national institutions all over the country.

With UNDP assistance, the following two programmes were organised. These were directed towards capacity building:-

- Training programme on ground water data collection & Organisation – GWW (Ground Water for Windows), GWIS (Ground Water Information System) & Visual Modflow – November 1999 at JNU, New Delhi, conducted by jasminko Karanjack of Atlanta, USA,
- Eight-week advanced training on "Groundwater modeling" in Perth, Western Australia during October-December, 2000.

In these programmes, trainees were encouraged to make use of the generated data in their research projects. Modeling exercise has indicated that: i) Type of unconfined aquifer system of hard rock areas in the Indian conditions is possible to be simulated to near real field condition, ii) Model accuracy is dependent on aquifer geometry, iii) Model can be improved with more spatial data on input parameters, and iv) Model can provide solution for estimating the available ground water resource, optimising the pumping rate and identifying suitable locations/areas, where there will be less adverse effects on the aquifer system by long duration pumping. -

To facilitate the adoption of modeling technology in solution finding with regard to problems related to water management and promote research, software packages (Visual Modflow) were procured and given to the researchers who came up with proposals in the area of modeling.

Support to Research Projects

Coastal Hydrology

Evaluation of the ground water resource and its seasonal variation with regard to water quality, quantity as well as the fluctuation of salt /fresh water interface have been studied in and around the Ramanathapuram coast in Tamil Nadu to devise ground water developmental plan, where an interaction of seawater with the coastal aquifer exists. Aquifer parameters, like transmissivity, optimum yield, and recovery time have been evaluated and modeling studies are in progress to assess the aquifer behaviour under various stress conditions.

Ground Water Modeling

In the Upper Barakar basin in Bihar, studies have been carried out for understanding the hydrological behaviour of the basin under different developmental stages to compute the sustainable yield and design most suitable solution for the area. The study has indicated that: (i) Well success is related to the thickness of the overburden, (ii) No effect on the aquifer system in the watershed by the "Tiliya Dam", located at the down reaches (iii) Optimal pumping rate at 100 m³/day in most parts of the basin, (iv) Dug wells augment the ground water, and (v) Decrease in seepage loss with increase in pumping. The modeling exercise has thus increased the understanding of the conditions in the area for devising methods of artificial recharge, optimize pumping and finally develop a sustainable management plan for water.

GIS Based Decision Support System

The Division has supported the development and field validation of two decision support models on land use planning (ECOLAND) and integrated watershed management (GRAM-SWAT).

ECOLAND: This model was developed & later validated in Chagalkuta Watershed of Chhatna block, Bankura District. The model uses information on geology, geomorphology and the associated non-spatial data on precipitation, potential evapo-transpiration and actual evapo-transpiration, soil moisture, pond water volume, ground water dynamic storage, ground water draft and runoff to generate the pre-monsoon and post-monsoon depths to water level maps and water-table contour maps and to determine recharge/discharge zones. The demonstrative water harvesting structure implemented with the help of Ministry of Rural Development on one of the six identified sites is yielding good results.

GRAM-SWAT- The SWAT (Soil Water Analysis Tool) model developed by A&M University, Texas, was adopted and integrated with GRAM (Geo Referenced Area Management) to accept spatial data inputs and provide spatial rendering. Development capability of the model is a significant step in providing the users/ decision-makers to visualize the impact of certain water management structures through simulation. The model was validated with real data sets of six watersheds spread over different agro-climatic zones of the country.

Application of Isotope Study

Tritium tagging technique has been used in the investigation of ground water recharge in semi-arid region of Kolar. The Piston Flow model adopted for isotope investigations to determine the quantum and rates of recharge. The study indicated that the ground water is augmented to the extent of 5 per cent only through annual precipitation. Interaction between shallow and deep aquifers could be perceived. The most important finding of this study is that at the existing rate of withdrawal the area may fall into dark category in not too long a time.

Recently, support has been extended to Nuclear Hydrology Lab of IARI, New Delhi to investigate the hydrological characteristics and behavior of aquifers of Delhi region through application of radio-isotopes. The study aims to trace the flow-path, rate of transportation, recharge rate, aquifer characteristics, surface-ground relationship, etc.

Hydrochemistry

Research, leading to the study of pollutant transport in porous media, as well as, assessment of pollutant pathways for adoption of suitable remedial techniques is being taken up under a collaborative research project of IIT-Delhi and JNU for the environs in the vicinity of the Yamuna river.

Upcoming R&D Priorities

Considering the recent trends in technological development, the emerging changes in the system of planning, policies, and the overall transformation in the concept of information sharing, R&D thrusts under NRDMS programme have been realigned. Under the land and water theme, the following priority research areas have been identified: -

Information Infrastructure

It comprises: (i) Data need assessment at the watershed level for different agro-climatic regions, for planning and management, (ii) Standardisation of data collection methods - frequency, density, etc., (iii) Standard national codification of natural resources, (iv) Representation in object-oriented database design, and (v) Knowledge base development as per local requirements/preferences.

Technology Development

It includes: (i) Development and improvement of decision support systems and models for local area planning integrating hydrological, ecological, economic, social, institutional and legal aspects of land & water issues, (ii) Environmental impact assessment studies, (iii) Risk assessment relating to extreme events, (iv) Performance Evaluation of Interventions, (v) Improved Water management practices -Salinity ingress prevention, pollution abatement, recycling and re-use of water, geo- thermal water, irrigation methods, wetland management, water harvesting, ground water recharge, etc., (vi) Improved land management practices including land related Studies, (vii) Assessment of water quality and development of remediation techniques, (viii) Ecological modeling - Dynamics of biodiversity, and (ix) Coastal area management and resource conservation strategies

Technology Transfer and Capacity Building

It would embrace programmes related to: (i) Training on technologies relevant for Land & water management, (ii) Development of web-based tools and technologies, (iii) Educational curricula on locally relevant sustainable water management programmes, (iv) Training of trainers in communication skills and gender sensitisation, and (v) Awareness programmes at village community level on water resources identification, quality assessment, and pollution control and adoption of suitable water harvesting techniques.

CONCLUSION

Initiatives as well as the research priorities of NRDMS, outlined in the foregoing pages, are expected to provide information to the researchers on DST'S scheme and help them in formulating suitable research proposals for advancement in the existing knowledge in natural resource management, including water. In this context NRDMS solicit scientific cooperation from research personnel, NGOs, and entrepreneurs.
