Proceedings WARMICE-2012
Sudhir Kumar, et al. (eds)
I.A.H., 2012

II-6

Integrated Water Resource Management: A Hydrogeological Perspective

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Abstract : Water is a prime need of developing society. More than two billion people in the 40 countries live in water stress. Water withdrawal globally increased seven fold with three times increased in population during 20th century. According to ground water estimation only 30 water blocks out of 237 in the Rajasthan state are left in safe category, while 164 are under over- exploited category and 34 are in critical state. With all affords in last decade, fragmented approach with limited coordination in the lined departments, the ground water resource is on rapidly depleting trend. Towards achieving Village Water Security in light of recently declared State Water Policy, the integrated water resource planning is a better and effective management tool for both surface and ground water resource management. The state government of Rajasthan is now focusing on people participation based water management solutions instead of predominantly engineering-based ones, under the umbrella process of Integrated Water Resources Management. To begin with both district and Garm Panchayat level planning is being exercise in coordination with NGO's and all water related departments. Different water utilization practices in the village for various domestic, industrial and agricultural needs have also been computed for the demand side practices in the village. The paper underlines various tools for data analysis towards water security and better management of both the water resource surface and ground water for each village.

INTRODUCTION

With increase in population and water demand for various purposes, the State is heading towards absolute water scarcity. The per capita annual water availability in the State is about 780 cubic meters (Cum) against minimum requirement of 1000 Cum. It is feared that the availability would fall below 450 cum by the year 2050.

Rajasthan is the largest State of the country. It covers more than 10% of the country's geographical area, supporting more than 5% of the human population & around 19% of the livestock has only around 1% of the total surface water available in the country. The status of water in the State is most critical. Out of the total 142 desert blocks in the country, 85 blocks are in the State of Rajasthan. The State has witnessed frequent drought and famine conditions in the past fifty years.

Rajasthan has always been a water deficit area. The rainfall in the state is erratic and there is a large variation in the rainfall pattern in the State. The average annual rainfall ranges from 100 mm (in Jaisalmer) to 800 mm (in Jhalawar). For the 22 eastern districts, it is 688 mm whereas for the remaining western districts, the rainfall is only 318 mm. Average annual rainfall of the State is 531 mm.

As per the international accepted norms, availability of water below 500 cum is considered as absolute water scarcity. There is a sharp increase in drinking water demand with increase in population and greater consciousness about sanitary facilities. Correspondingly, non-agricultural water demand, which was 3.28 BCM in 1995, is expected to reach 8.07 BCM in 2045.

With vast variation in rainfall pattern and ground water availability, some difference in access to water is inevitable. Therefore stress is being laid on water management to remove inequalities in access to water amongst various water user sectors (drinking, agriculture, industry etc); head and tail reaches; urban and rural population and between rich and poor sections of the society.

Total surface water available in the State is 21.71 BCM, out of which 16.05 BCM is economically utilizable. State has so far harnessed 11.55 BCM which is 72% of economically utilizable portion rest of it is required to maintain minimum environmental flow in the drainage system and to be used in flushing of material from the course of the drainage system. In addition to it 17.89 BCM is allocated through Inter-State agreements.

The available water is not enough to cater to the needs of the drinking, agriculture and non-agriculture demands. The westernmost and south-eastern portion of the state has availability of surface water otherwise whole the state is dependent upon the ground water resources.

In the last two decades ground water condition has deteriorated very fast. The stage of ground water exploitation, which was just 35 % in the year 1984, has reached a level of 125 % as per the published report (GWD, 2004). Out of 237 blocks in the state, only 32 blocks are in safe category. This calls for immediate remedial measures to address the critical water resources situation the State. Ground water is not available in many parts even for drinking purpose. Sometimes water is being transported by trains, trucks, tankers and other means.

INTEGRATED WATER RESOURCE MANAGEMENTAPPROACH

Thus an Integrated Water Resources Management (IWRM) approach is being adopted to have a sustainable in water resources of the State. The Technical Committee of the Global Water Partnership (GWP) has defined IWRM as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP. 1990). IWRM is declared as integral part of State Water Policy. Rajasthan is probably the only state having IWRM tool included in the state water policy for water sustainability (State Water Policy, 2005). An IWRM approach is an open and flexible process that brings together decision-makers across the various sectors, having impact on water resources and bringing all stakeholders to the table to set policy and make sound, balanced decisions in response to specific water challenges which they had faced. In applying knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement efficient, equitable and environmentally sustainable solutions to water related problems are considered in IWRM perspectives. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of ecosystems for future generations. The framework for the IWRM Plan can grouped as under-

A. Selection of local non-government Organization (NGO)
B. Formation of Village level water user groups (WUG)
C. Capacity building of NGO's persons and officials of lined department
D. Data base creation : Collection and Dissemination
E. Planning and Development of IWRM plan

A. Selection of Non-Government Organizations

The NGO having experience to work in the same locality and also having qualified women in their working team are some of the criteria to work with IWRM plan. The non-government organizations had selected and they have to play a constructive role in the formation of village water user group. The NGO will undertake comprehensive community awareness programs related exclusively to water conservation and water-related issues, with particular emphasis upon improved water management and the reduction of

groundwater extraction in over-exploited and critical areas. In addition to this, IWRM-based strategic planning, water resources modeling and direction for water management will be undertaken at river basin, sub-basin and aquifer-levels, depending upon the task's objective.

The State Water Resource Planning Department (SWRPD) is acting as the primary source of water-related information, and will take the lead in planning and enablement of water-user groups through non-government organizations. High priority will be given to provide multi-disciplinary technical support for community water management under the umbrella of IWRM by all the related departments, as and when it is required.

B. Formation of Water User Groups

The construction and strengthening of Water User groups (WUGs) is the main features of the policy adopted by the state, which includes other points like-

- Executive members of WUGs will be chosen by democratic means, with fair representation by large and small-scale stakeholders, including women.
- Community level assistance will be provided by PRIs to Water User groups (WUGs) to initiate, plan and execute water-related solutions within an IWRM framework.
- PRIs will be adequately strengthened for IWRM purpose. Guidance and necessary support will be provided to assist WUGs to undertake responsibility for the management of large water infrastructure.
- As far as efficient operation allows, the framework for 'Integrated Water Resources Management' will develop and utilize intermediate level facilitation between the State Government and water-user associations.
- Water-user groups will be responsible for giving high priority to developing efficient water usage and related WUG activities

To begin with eleven districts of western Rajasthan have been selected for the formation and planning for IWRM plan. These districts have no surface flow and all the water demand is met through ground water and harvested water. Hydrogeologists of the concern districts are helping the NGO and Village water user groups to make them aware of hydrogeological peculiarities of their region and ways to artificially recharge the aquifers.

C. Capacity building of NGO's and lined departments

Technical, logistic and material support will be provided for organizing and training water-user groups in effective water conservation, water resource management, water quality protection. NGOs would be fully involved in water management related activities such as awareness building in communities, capacity building of Water Users Association/ Groups, design, construction of water harvesting structures and preparing IWRM Plan. The line-departments will supply water-related technical data, guidelines, information, etc., to water-user groups and other water-sector stakeholders. This will be maintained with efficient data distribution, continuity of data collection, and continuing data quality control. Capacity building at Government level will be directed towards

a) Broadening their skills-base

b) Reorienting their concept towards the provision of more responsive technical services,

c) A new focus upon data processing, strategic planning and basin-level water resources assessment or aquifer based water resource assessment, as these districts are totally dependent upon ground water resources, and

d) Greater autonomy of action

In putting the IWRM principle into practice, an approach where regulatory decision such as water allocation and water supply is implemented at the scale of the river basin or catchment. For surface water availability and its management, these basins play an important role, whereas in ground water management, these basin boundaries play an important role in water recharging and infiltration. Beside basin wise information, an aquifer based management system will also needed towards better management of their ground water resources. For efficient use of aquifer based management system, restructuring of existing ground water department is under consideration, in the State.

To maintain water supply for various uses in the state departments like Water Resource (Surface water Management) , Ground Water (for ground water management), Public Health and Engineering deptt (for water supply, sanitation and water related health issues) and agriculture deptt. (for crop variety and soil characters) besides soil and water conservation department has to work together for the IWRM planning.

D. Data base Creation : Collection and Dissemination

A user friendly but secured data base is design and housed within the SWRPD. This data base will be in public domain with the arrangement of prompt supply of data on demand. SWRPD will take the lead in data checking and entry, compilation of data, record backup, database security and management, transparency of database operation, and the provision of prompt output on demand. The database will include hydro-meteorological, hydrologic, ground-water, water-quality, water-user, demographic and social data.

Hydrologic instrumentation and data collection throughout the state will be reviewed for reliability, observer resourcing (payment, training and mobility), instrumental efficacy and maintenance, continuity, maintenance of record, and other related factors, recommendations will be prepared for upgrades or replacements as necessary.

To develop a waste data base on water resource availability and various water supply departments in the state all the lined departments are looked to provide details of water demand and supply according to their various sources. These can be grouped as given in Figure -1. The demand for various purpose and existing status of supply data base, gives better data base for management tools. As then ground water demand may be regulate according to the priorities listed in the State Water Policy.

An inter-departmental 'Water Resource Information System' (WARIS) is being developed to have centralized database for the management of surface water, ground water and water security planning for the domestic water demand and supply status. The PHED data are also planned to include in the data base to have a comprehensive picture of water supply system could be ready for the planning purpose. It is observed that under different projects water supply wells are being drilled without looking to the actual need of the village. This is a mere wastage of government money and is also responsible for the rapid depletion of ground water resources.

Prior to development of data base on WARIS, provisional mapping of groundwater, flood zones and environmental zones will have to be modified. In this context, hydrogeological maps and potential zone maps of ground water area being modified according to their present situation. A hydrogeological server is also planned to setup for the data collection dissemination and management of the ground water resource.

E. Planning and Development of IWRM plan

A district level IWRM data base has already prepared with all the lined departments. This database will further be developed on gram

RESOURCE AVAIABILITY ANALYSIS	RESOURCE UTILISATION (DEMAND)
(A)SURFACE WATER-WATER RESOURCE	• P.H.E.D. • UIT • NAGAR NIGAM • AGRICULTURE DEPTT. • FOREST DEPTT. • P.R.I.'s • RICCO INDUSTRIAL ESTATE • SMALL SCLAE INDUSTRIES • CATTLE DEMAND
(B) GROUND WATER-GROUND WATER	
(C) CANAL AREA DEVELOPMENT	
(D) P.R.I.- POND, TALAO/ANICUTS	

Fig. 1. Water Related departments and water demand consuming agencies

panchayat level and then to the village level. The main function of Capacity building will provide sound and timely technical advice besides material assistance to water-user groups and other community based stakeholders in the water sector.

The problem of limited water availability is further aggravated by low operational efficiency. Two major users of water namely, drinking and irrigation both show avoidable losses. Effective communication system will be developed for providing technical information between Government agencies and WUGs on such a sensitive matter. The availability of water in the State does not commensurate with the requirement of water. The deficit between demand and supply is 8 BCM at present and likely to increase to 9 BCM by 2015. Thus the availability of water in Rajasthan is about 780 cubic meter per person per year as against the internationally accepted standards of 1000 cubic meter per person per year and is likely to reduce to 450 cubic meter per person per year by 2045. Efficient crop-water application and utilization practices shall be encouraged by adopting modern water conservation techniques. The economic and technical potential for the re-use of treated wastewater will be assessed in all basins.

WORKS IN PROGRESS : RAIN WATER HARVESTING

The optimizing water availability aims to harness every drop of available water in the state. To this end a comprehensive inventory of potential and actual water resources, perennial and ephemeral will be fully identified and quantified. The SWRPD is developing capabilities to model these resources as a part of its strategic planning obligations. Funds will be provided, on priority basis, to implement program of optimum water utilization. Preservation of traditional water harvesting structures and sources will be encouraged. Roof top rain water harvesting, storm-water harvesting, recycling and reuse of waste waters will be promoted,

Exploitation of groundwater for agriculture and purposes other than drinking will be so managed as not to exceed the average long-term recharge potential. All the water demand has to be maintained as after assessing the demand

computed from various departments covering the information on the tabulated fields (Table-1) to be collected for the data base.

Measures have been undertaken to restrict unplanned extraction of ground water resource to extent of non-availability of domestic water needs of in and around habitations. All the District Collectors have been empowered to allow groundwater data extraction looking to the needs and the ground water recommendation/ observations from the ground water department.

All drilling rigs in the State are being registered and drilling data will be collection become compulsory to have a water sector's database.

Promotion of IWRM in eleven districts having over-exploitation stage of ground water development, on first phase, areas will give prominence to the evaluate groundwater status on planning for different measures to restrict decline, towards its conservation and sustainability. Depletion in water level will be analyzed and reported annually.

Table 1.

- EXISTING SURFACE WATER BODIES
- EXISTING WATER FLOWS IN THE STREAMLETS FROM OUT SIDE AREA
- EXISTING ANICUTS AND ITS STORAGE
- EXISTING TUBE WELLS FOR DIFFERENT USE
- EXISTING DUG WELLS FOR DIFFERENT USE
- EXISTING HANDPUMPS IN USE
- ABONDANT TUBEWELL/DUGWELL/HP

Evaluation of the groundwater recharge potential will be undertaken, with particular emphasis on water-critical and over-exploited areas in each hydrogeological units of the district, to have actual and accurate situation of aquifer recharge relationship. The hypothetical or average values from other areas may not be closer to the local hydrogeological setup of the area and thus all the efforts of ground water management will fail to fulfill the goal of sustainability. Special initiatives have been taken for ground water recharge and it will be obligatory upon bulk water consumers to adopt ground water recharge measures, principally to compensate the water extracted by them. Water harvesting is mandatory for all upcoming industries in the state.

Groundwater will be better utilized by encouraging and facilitating pressure irrigation methods such as drip and sprinkler irrigation technique. Quantitative estimates of future water demands will be estimated by stakeholders with technical assistance of line-departments. The delegated organizations, will undertake comprehensive community awareness programs related exclusively to water conservation and water-related issues, with particular emphasis upon improved water management and the reduction of groundwater extraction in over-exploited and critical areas. As far as efficient operation allows, the framework for 'Integrated Water Resources Management' will develop and utilize intermediate level facilitation between the State Government and water-user associations.

Rooftop Rainwater Harvesting

Roof top rain water harvesting will be promoted both in rural and urban area. The rule for constructing rooftop rain water harvesting on buildings having more 300sq feet rooftop area is already implemented. Now all existing Government building are attached with the rainwater harvesting structures. These structures have been modified according to the nature of hydrogeological setup of the area. These may be grouped into two types

(a) Alluvial area
(b) Hard rock area

Alluvium with sandy nature has tendency to accept water more quickly than the weathered rocks. Similarly weathered rocks have greater tendency to adopt water than the non-weathered and fresh rocks. Thus, looking to the area, specific condition of aquifer and its weathering status besides facies variation in a single aquifer are to be analyzed by hydrogeologists.

The Ground Water Department had done specific studies on ground water pollution from colour and dying industrial clusters in Rajasthan. The department is also planning to have a waste database on water quality variations in the Rajasthan.

A rolling program of water auditing will be undertaken for all large and small industries, to compile a water usage register of industry. This audit will include the quantified water usage, the potential for water recycling and conservation, and actual and potential pollution associated with each site. All water intensive industries extracting ground water will be required to install water meters and undertake ground water recharge activities.

The State will encourage and support training across all disciplines within the water sector, including IWRM, water supply, social infrastructure, public health, chemical and microbiological water quality, environmental management, dryland and brackish agriculture.

Technical capacity building will be directed towards such areas as improved human and instrumental data collection, GIS-database-website development, GIS-applications, computer modeling (of groundwater, surface water and basin hydrology), new and improved ground-water recharge, water resource assessment and modification, and achieving improved irrigation efficiency. The capacity of various Government authorities to collect appropriate, accurate and continuous hydro-meteorological, hydrological, ground water, water-usage, and water quality data will be reviewed.

Recycle and Reuse of Industrial Water and Urban wastewater utilization

Water intensive industries will be required to recycle their water. The re-use of treated effluent will be promoted, with appropriate levels of treatment applying to municipal usage, industrial usage, other horticultural usage, beneficial surface discharge, and recharge to groundwater.

The Department of Mines and Geology, in cooperation with the Pollution Control Board and SWRPD will ensure that groundwater extracted in mining operations will be put to beneficial use, with remediation of chemical pollution where appropriate.

A program to design and construct sewage treatment plants will be implemented for all urban and high-priority rural areas in collaboration with local bodies. Treated effluent disposal will conform to established health standards. The standard of treatment will be determined by the beneficial re-use requirements of the wastewater.

Rural and Agricultural Water Conservation

A rolling program to reduce irrigation water losses will be implemented through village water user group. The villagers have to be educated on pressure irrigation systems and will be promoted as an alternative to flood irrigation. The State Water

Policy provides an opportunity to install each substantive water user will be required to install water meter on ground water extractions for irrigation. The extraction of ground water will be suitably regulated through appropriate legal framework for any use. Re-use of irrigation drainage water will be encouraged. Watershed management will be carried out in the organized manner for each basin.

WORKS TO BE UNDERTAKEN

- **Monitoring mechanism** is highly needed for each and every task of the IWRM plan to avoid failure of the scheme. Monitoring is made for both planning and compliance purposes.
- **Paradigm shift from surface water to ground water management practices**, as 90 percent of drinking water and 70percent of agriculture and almost 95 percent of industrial water requirements are being fulfilled from ground water resources.
- **Hydrogeological basin**, sub-basin, aquifer and ground water resources development along with environmental plans will be prepared with stakeholder participation and lined officials.
- **Aquifer Based Ground Water Management** - For efficient use of ground water aquifer based management system will be developed and for its sustainability surface river basin will be considered. Thus a comprehensive basin wise picture of water cycle has to be developed on priority basis. The physiographic picture of Rajasthan shows that in almost half of the land is showing sandy soil with "no flow" condition. In most of the basins water flow condition exposes to only couple of days, except the Chambal River basin. The Chambal River basin received controlled discharge from the dams of upper reaches, located in other state, and as a result of delayed discharge from the weathered Vindhayan formations. To have information basin wise data bank is required.
- For all water supplies a three or four-stepped water tariffs will be charged, with the highest rate for excessive use of water. This stepped water tariff will be set to ensure magnitude difference in water rates between the lowest and highest rates. For the first stepped rate of relatively cheap water, the set rate will be common to all water users. Differing stepped water rates may be charged for agricultural, industrial, commercial, and municipal purposes. In all cases, the highest rate will be a strong disincentive for profligate water usage.

ACKNOWLEDGEMENT

The author is highly thankful to the Senior and the Chief Engineer, Rajasthan Ground Water Department for the permission to express views on hydrogeological perspective of IWRM planning.

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