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River Basin Planning Concept – Decision Support System

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ABSTRACT

This paper summarizes the water resources availability in India, development of surface and groundwater resources and the need for integrated planning of river basins, especially in Indian context. Future demand projections for increasing population and various issues for integrated water resources management are highlighted. The paper also details the advancements made in the field of integrated river basin planning and the efforts being pursued in the Central Water Commission for improvements in the related software.

INTRODUCTION

Water is one of the most important natural resource and a key element in the socio - economic development of a country. India is one of the rich countries in the world in water resources. A large number of river valley projects have been constructed to boost power production; to enhance agriculture production and to achieve flood protection of flood prone areas in the country. These projects have been contributing overall socio-economic development of the country. India has so far utilised a part of the valuable water resources that needs to be further developed to meet the requirements of ever growing population.

Freshwater resources are facing problems both on the demand as well as on the supply-side. There are many, and often competing and conflicting water demands for various sectors. Traditional large use such as irrigation is now competing with rapidly rising demands for domestic, industry, hydropower, recreational, fisheries, in stream water uses, environment, etc. Sometimes, non-consumptive uses such as hydropower generation can contribute to scarcity as the timing of the releases for hydropower may conflict with other water demands in the downstream. As the population of India is 18% of world's population against annual water flow availability of 4%, the pressure for conservation and efficient utilisation is far more

in our case than elsewhere. Further, the ever-increasing population and demand of water in various sectors for economic and non-economic purposes emphasizes need for efficient water management to derive maximum benefits from use of limited water resources for general socio-economic welfare of the people.

The planning and management for such an increased scope requires the need for water management in an integrated manner involving traditional supply management to locate, develop and exploit existing and new sources, as well as, demand management which is concerned with the way water is used to promote desirable levels and patterns of use. For management of water we have to understand that water in all its forms – rain, snow, rivers, ponds, glaciers, soil moisture, humidity, ground water in the aquifers constitutes a unity. There is a finite quantity of water on the globe that cannot be added nor destroyed. Thus, water available to us today is the same quantity that was available centuries ago. This finite quantity of water has to be managed against increasing demands of development and growing population.

In the initial years of development the water resource planning concept was to plan water storages by construction of dams and planning of other infrastructures like powerhouse and canals etc. for utilization of the stored water. These projects constructed in the past have contributed to the overall development like increased food production, creation of power capacity and provision of water for municipal and industrial use besides helping in flood mitigation. However several drawbacks have been noticed in this approach. Major drawback noticed is that these projects have been designed as individual projects. These are not conceived as a part of integrated development of the whole river basin. There is also criticism about negligence of environmental and social aspects of the projects. Environmental problems include depletion of river flows beyond minimum required, water quality degradation from agro chemicals, domestic and industrial effluent polluting the water bodies, water logging, ground water depletion, degradation of wet lands, reservoir silting etc. Environmental issues have become critically important to social welfare and long-term sustainability of the water resources. Social concern relates to dis-satisfaction for rehabilitation and resettlement of Project Affected People, and supply side approach to management of irrigation supply with participation of users and NGO.

The other problems that dogged the water resources projects are thin and sub-optimal spreading of resources on a large number of projects, poor institution coordination between different government agencies like Irrigation, CAD and Water Shed etc, dominance of irrigation sector at the expanse of other uses like water supply, industrial demand, navigation, fisheries, ecological, flood control, recreation etc.

The past management of the country's water resources has been unable to cope effectively with these issues. Water resources have been developed but not managed. There is need for comprehensive management multi-sectorally for the entire basin considering surface water

management, ground water management, water shed management, water harvesting, land management and ecological preservation. This requires linking of various important issues having wide impacts directly or indirectly on water resources management in a coordinated manner such as environment, ecosystem, economics etc. River basin planning aims at such integrated water management.

The need for integrated management was recognized in the initial years of planning. For the planned development of river basins, the River Boards Act was passed by the Parliament in 1956 for preparation of water resources development schemes and for advising the States on the regulation and other aspects. The Irrigation Commission 1972, recommended that the river basin plans must be prepared, if the water resources of the country are to be developed to the best advantage and this could be done only by an organisation vested with statutory authority. The commission also recommended for setting up of a National Water Resources Council and River Basin Commission to ensure the planned development of water resources.

The National Water Policy adopted in 1987, also recommends that resources planning in the case of water has to be done for a hydrological unit such as a drainage basin as a whole or for a sub-basin. All individual developmental projects and proposals should be formulated by the States and considered within the framework of such an overall plan for a basin or sub-basin so that the best possible combination or options can be developed.

However, in India water resources development and management continues to be fragmented across a variety of agencies with overlapping jurisdictions at the national, state and local levels. There are problems of coordination and dissemination of information for decision-making in national perspective. The general lack of strong institutions at river basin level have also led to the lack of comprehensive analysis in general and particularly in the case of river basins shared across one or more states having vast resource potential.

WATER RESOURCES OF INDIA

India is blessed with a large network of rivers comprising 12 major basins having combined catchment area of about 253 million hectares (m.ha.). Besides, there are 46 medium basins of sizes varying 2,000 to 20,000 sq. km. covering a total area of about 25 m.ha. Other water bodies including tanks and ponds cover an area of about 7 m.ha.

The average annual precipitation including snowfall, has estimated to be of the order of 4,000 billion cubic meter (BCM) of which the monsoon rainfall during June to September is around 3000 BCM. The estimated average natural runoff is 1869 BCM out of which 690 BCM can be utilised, if appropriate storages created. Moreover, the spatial and temporal distribution of the water resources in the country is highly uneven.

The total replenishable ground water potential in the country is estimated as about 432

BCM. Analysis of the basin-wise potential indicates that the Ganga basin has the highest potential which is 171 BCM followed by Godavari (41 BCM) and Brahmaputra (27 BCM). Statewide, Uttar Pradesh has the maximum potential (about 84 BCM) followed by Madhya Pradesh (51 BCM) and Maharashtra (38 BCM).

Developments in Surface Water Resources and Ground Water Resources

The average water availability in the country remains more or less fixed according to the natural hydrologic cycle, though the per capita water availability is reducing progressively owing to increasing population. In 1955, per capita availability was 5,300 cubic meters, which has now come down to 2,200 cubic meters and by 2025, with the projected population growth, the estimated availability worked out is 1500 cu.m. as national average, while it will be much less in some of the regions/ basins.

India is among the foremost countries in the world in exploiting its river water resources. Remarkable achievement has been made in conserving the water resources for irrigation, domestic water supply, hydropower etc. during the five decades of planned development of independent India. From less than 300 large dams existing at the beginning of planned development, the number of dams constructed (including about 700 dams under construction) has gone upto about 4,300.

As a result of this, the total live storage capacity of dams and reservoirs completed in the country has since gone upto about 177 BCM in 1995. Besides, dams to create an additional live storage capacity of 75 BCM are under various stages of construction. In addition, dams under formulation/ consideration will provide an additional live storage of 132 BCM.

Developments in Ground Water Resources

Ground water is an important source of irrigation and caters to about 45 per cent of the total irrigation in the country. The contribution of ground water irrigation to achieve sufficiency in food grain production in the past three decades is phenomenal. In the coming years the ground water utilisation is likely to increase manifold for expansion of irrigated agriculture and to achieve national targets of food production. Although the ground water is annually replenishable resource, its availability is non-uniform in space and time. Hence, precise estimation of ground water resource and irrigation potential is a prerequisite for planning its development.

In India, ground water development is generally restricted to shallow zone within 50 m depth and is mostly financed through institutional sources and private efforts. The shallow ground water structures include dug well, dug-cum-bore well, shallow tube well, filter points etc. The deeper structures include heavy-duty tube wells and bore wells. The ground water

development has been intensive in the alluvial areas of Indus-Ganga-Yamuna, plains of Punjab, Haryana, Uttar Pradesh and in parts of hard rock terrain in Southern States.

There is a large scope for exploitation of ground water. Though a large portion of the available ground water resources remains untapped, over exploitation of the resource in some areas has created serious problems. The hydro-geological surveys carried out during 1976-86 in twelve major states namely Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal cover 627 blocks, 351 have been declared as dark blocks with over exploitation and reduced ground water, whereas 276 blocks have been identified as gray blocks where similar problems are developing.

Future Projections on Water Requirement

The projections of population and food requirement of the country indicate that the population of India may stabilise at 1.5 to 1.8 billion by 2050 AD and would require about 450 million tones (mt) of food grain annually at the present level of consumption. The present productivity of irrigated land is about 2.5 t/ha and less than 0.5 t/ha for rain fed lands. Assuming that these levels can go up to 3.5 and 1.0 t/ha respectively, it is imperative that we create an irrigation potential of at least 130 m.ha for food crop and 160 m.ha for all crops to meet the food and fiber demand by 2025 AD.

It is projected that nearly 45% of the population will be living in urban areas by end of first quarter of twenty first century. So the water supply for drinking, domestic use and various civic amenities have to be met with accordingly. Livestock population will also go up considerably requiring adequate provision for water. Industries are also to grow over the years for catering the demand for the rising population. Though, there is no comprehensive estimate of water demand by various industries available, it is anticipated that water requirement for industries will rise substantially in view of the emphasis being put on industrial development. Tentative studies have indicated that total annual requirement of fresh water from various sectors will be about 1050 BCM by 2025 AD.

Thus, fresh water requirement by 2025 AD will be almost at par with exploitable water resources including both surface and ground water. Thereafter, additional supply will be necessary else; we have to bear with the stress. Therefore, the present water resource development programme has to continue for harnessing the available resources and exploration of additional resources besides best management of existing developments using modern integrated planning and management technology.

RIVER BASIN MANAGEMENT IN INDIA

Several river basin organisations such as Sone River Commission, Ganga Flood Control Board and Ganga Flood Control Commission and Brahmaputra Board, Narmada Control Authority, Bhakra-Beas Management Board, Upper Yamuna River Board etc. were established for the planning and development of their respective basins for specific purposes. None of these deal with all the aspects of water resources development and management in integrated manner.

Even though river basin organisations were proposed for the integrated planning and development of river basins, the Basin State has to play their own role. They should formulate plans for the portion of a river basin lying within their territory, taking into account their projected demand for diverse uses and share of water. These state-wise plans for a basin can then be coordinated to evolve an integrated plan of development and management. This will enable the state Governments to put forward their views on the basin development and also bring out existing or likely to be encountered problems in the basin. In order to formulate such plans, the State Governments should constitute basin-planning units consisting a multidisciplinary team of experts. This unit will have, apart from water resources engineers, experts in hydrology (both surface and ground water), agronomy, economics, systems analysis, environmental analysis and water quality etc. Some state governments have also created multi-disciplinary units in their water resources departments.

INTEGRATED WATER RESOURCE MANAGEMENT ISSUES

Integration of water resources has to take into account:

(i) Different sectoral demands – agriculture
(ii) Conjunctive use
(iii) Water use and land use including forests
(iv) Local water harvesting measures to all big projects within the basins.
(v) Environment, ecological, social/human concerns.
(vi) Water quality issues
(vii) All relevant discipline (hydrology, agriculture, sociology, environment, legal etc)
(viii) Claims of all the stakeholders – different states and different sectoral users, NGOs, farmers.
(ix) Finance and economics.

River basin development and management involves issues of multi-disciplinary nature. There are several intervening agencies in the field with varied functions. Therefore, the entire

basin has to be integrated in the management functions including the whole of watershed, the banks, the valley and the basin being inter-dependent upon each other. The issue has been under active consideration for a number of years to define the form and the role of the basin level organisations. The Parliamentary Consultative Committee of Ministry of Water Resources came out with a report on river basin organisation (RBO) in 1988, which contained recommendations on the functions and powers, organisational setup and other details of RBOs.

The National Water Board (NWB) was set up to operationalise the National Water Policy recommendations and to discuss the issues related to the development of water resources of the country and the progress achieved in implementing the NWP recommendations.

A Sub Committee set up by NWB in 1992 came out with a policy paper giving recommendations on the functions and powers of RBOs such as administrative, technical legal issues and regulations, financial and user's participation.

PRESENT DAY NEEDS

Remarkable changes have taken place world wide in the recent past with the advancement of computing technology, computer hardware and software. For systematic water resources planning and management at river basin level, various facilities such as graphics, user interfaces, Geographical Information Systems (GIS) and Decision Support Systems (DSS) under WINDOWS environment are available.

Good data and information base of river basin resources at basin/ sub-basin scale can be easily archived and handled using modern information system tools. The information/ database can also have links with river basin simulation models leading to decision support systems. It would then be helpful in studying the various alternative possibilities/ prioritisation with respect to a set of objectives taking into account the physical and managerial opportunities, constraints and limitations.

Therefore, there is a need to develop/acquire decision support systems integrating the facilities such as hydro meteorological and other water related data base management system, Geographical Information Systems, river basin simulation models and WINDOWS environment facilities for the cost effective river basin management in India. These tools may prove to be essential in near future for effective water resources management.

Multi-year simulation of climate and runoff permits close evaluation of demands and water availability. On basin scale, projections of future human activities and demands of agricultural and urban water usage need to be examined besides ecology, environment and other socio-economic issues in a basin. To meet multipurpose objectives of such complexity requires application of decision support systems to

* Depict clearly all the sectoral and inter-sectoral aspects in the basin.
* Look into technical engineering, economic, social and environmental aspects in an integrated way.
* Represent the water resources planning, allocation and management issues.
* Provide Inter-active and user-friendly environment to make a fruitful exercise and decision-making.
* Depict the inter-regional as well as inter-state issues,
* Bring engineers, planners, administrators, policy makers and stakeholders on a common platform in terms of incorporating their inputs and ascertaining their views on the outputs. In other words, a participatory approach.
* Prepare river basin master plans.

Thus, comprehensive and flexible river basin simulation packages are reliable and cost effective instruments for river basin modeling, analysing impacts of mutually conflicting interests, data management and water allocation options. The information systems can take advantage of recent advances in Geographic Information Systems (GIS). The models/ software need to be customised to individual basins depending upon the purpose. These systems/ models could be ideally suited as public information systems and in the new paradigm of interactive stakeholder participation in decision making and in serving as focal points for information on a river basin.

It would be easier to coordinate programs and information flow across departments, agencies and organisations, and to take advantage of the increasing openness in data sharing and access to promote more information based decision-making and public participation.

All above aspects bring to light the necessity of having some implementing and decision making mechanism for river basin development in the country which inter-alia may consider various options and eventually adopt a model most suitable to Indian situations in view of varied geographical and hydrological realities or large basins in India.

ADVANCEMENTS IN INTEGRATED RIVER BASIN PLANNING TECHNOLOGY

With the rapid advances in computer hardware, software, Geographic information systems, and modeling methodologies, comprehensive analysis of water resources planning and management can be advantageously applied for reliable, efficient and cost effective planning and management of river basin as one unit. The planners and policy makers can include a number of options, for comprehensive view and conjunctive use of surface and groundwater supplies to meet spatially, temporally and sectorally varying demands.

River Basin Models, could establish the basis for reliable assessment of the available water

resources and for analysing multi-disciplinary impacts of mutually conflicting interests and different management and water allocation options with insight into various sectors such as agriculture, water supply, hydropower supply, forestry, sustainable socio-economic development etc.

The river basin models thus developed provide an adequate scientific description of water systems for the comparison of different strategies and measures and to:

* Integrate research efforts in different scientific disciplines and translate the results to the management level;
* Increase the understanding at the management level of the relations between users of a water system and the system itself
* Provide different authorities with a common framework for the analysis and comparison of management decisions
* Facilitate the comparison of many different management options and measures;
* Enrichment / evaluation of the decision making process with generation/ availability of additional information.

INTEGRATED RIVER BASIN PLANNING IN CWC

It is now increasingly being realised that technological planning involving the development of appropriate policies and programmes has to be carried out with an increasing sense of creativity and through careful analysis in assessing complex techno-economic, environmental and social implications otherwise environmental and ecological degradation and its effects on changing human values would lead to far reaching implications and would make the problems much more pervasive.

Although country have adopted computer technology in different sectors, the use of appropriate information technology by water resources agencies is not common neither for providing reliable assessments for long term planning and management activities nor as part of the daily work.

An approach, known as the systems engineering approach has been well adapted to the field of water resources for defining a concept, methodology and technique for technological planning and decision-making. Lately, the concept has changed to the comprehensive development of the river basin for general welfare of the people, aiming at development of total water resources along with development of land, minerals, industry and trade. Concern is also being expressed for environmental quality and social betterment. The objective of planning has become the resolution of conflicting and ever increasing/ changing demands for varied inter-sectoral uses of water. Therefore, full attention must be paid for efficient management of water resources with the use of high technology in planning and management

procedures such as use of river basin simulation software compatible computers, scientific information system for information management etc.

Efforts are being made in CWC to use the modern river basin management software along with databases and Geographical Information System, leading to decision support system, for reproducing the essential features of a river basin under present and future water demands scenarios under a wide range of possible engineering developments and operation strategies as a pilot case of Sabarmati basin. With this technological development, it would be possible to extensively manipulate input and output data at river basin scale in an efficient manner, and in presentable formats allowing a quick evaluation of the effects of alternative water resources development.

CONCLUSIONS AND RECOMMENDATIONS

Decision-making in Water resources sector is an evolving process, technically and institutionally. One group makes rarely such decisions at one time and one place for one purpose. There is a need to have flexible and interactive systems in place to adapt to evolving needs, information, options, and decision-making structures.

In India, where water resources management is fragmented across a variety of agencies with overlapping jurisdictions at the national, state and local levels, there are many problems in the collection, use and dissemination of information for coordinated, information based decision making. The general lack of strong institutions at river basin level have also led to the lack of comprehensive analysis of options at the river basin level, especially in the case of river basins shared across one or more states. Well designed decision support systems help in adoption to evolving institutional mechanisms and structures while trying to make the best use of current knowledge, determining and prioritizing data gaps and enhancing the development of creative solutions from a larger stakeholder community.

A judicious combination of the information systems and river basin simulation models is necessary for development of good decision support systems to get a quick overview of the current knowledge of a basin, its issues, problems and options. These systems can be developed in stages at increasing levels of sophistication. An initial effort in any river basin can be extremely useful to focus attention on issues of relevance, narrow down options and identity trade-off, sensitivities and data gaps.

These systems, if properly designed and implemented also have the capability to adapt to changing data, modeling techniques, and decision-making frameworks. They are ideally suited as public information systems and in the new paradigm of interactive stakeholder participation in decision-making. This would essentially coordinate programs and information flow across departments, agencies and organisations, to take advantage of the increasing openness in data

sharing and access to promote more information based decision-making and public participation.

Basin modeling is an essential part of water resources planning and management. Water resources agencies in many countries have adopted appropriate models as part of the daily work to provide reliable assessments of resources and short, medium and long term planning and management activities keeping with various political, legal, constitutional constraints.

In other words, a water resources plan, consistent with the overall economic, social and environmental policies of the country, is an important element to ensure that water resources contribute to the country's development objectives in the best possible manner.

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