Scarcity and Challenges of Water Resource Related Management and Planning in India: A Geographical Study

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Abstract :

Water scarcity become a huge problems not only in india but also in the world. I deeply analyse the water problems, emerging issues and management challenges in India in this research paper. The authors argue that the demand for water will grow by leaps and bounds during the next few decades due to population growth, especially in urban areas, concentration of urban population in a few urban cities, rising income levels, and rapid industrial growth. While water resources would continue to deplete due to groundwater degradation, surface water pollution, and depletion of existing surface reservoirs, water scarcity problems would grow in terms of both intensity and extent. Along with scarcity, the conflicts are likely to grow not only between sectors, but also within sectors. Challenges to evolving sustainable, equitable and efficient management of India's water resources are several. First, the non-availability of adequate scientific data on quantity and quality of water, demand for water in different sectors, nature and extent and causes of water problems become major hindrances to developing sustainable water management strategies. Technology poses another set of challenges. Advancements in water technology aimed at evolving technically feasible, economically viable, environmentally and ecologically sound and socially acceptable solutions in water management are not occurring. Secondly, existing institutions in the water sector are technically oriented, sectoral, and centralised, having the mandate of managing supplies.

Keywords:- Population Growth, Groundwater Degradation, water pollution, sustainable development , Economically viable.

INTRODUCTION

Water is a key natural resource for human survival. Water plays a vital role in sanitation for our rural and urban communities. Water is also an important economic resource. It is necessary for all forms of agriculture and most of the industrial production processes (Merrett 1997; Kay *et al.* 1997). Water also provides a wide range of ecosystem and environmental services (Frederick 1993; Seckler *et al.* 1998). It is essential for assimilation of pollution caused by industrial effluents and domestic sewage. Pressure on freshwater resources is increasing across the globe (WRI 1995; Brown *et al.* 1998). During the first 8 decades of this century, consumption of water increased fivefold, 75 percent of which was during the second half of the century (Frederick 1993). From a macro perspective, the overall fresh water availability across the globe remains more or less constant. But, from a micro-perspective, the freshwater supplies in many regions and localities are dwindling due to alterations in hydrologic balances, over-exploitation and increasing pollution of freshwater reserves. Many third world countries are already facing serious water shortages (Brown *et al.* 1998; Seckler *et al.* 1998). Increasing freshwater scarcity is becoming a major constraint in producing food for growing world population, ecosystem protection, and maintaining health, social and food security and peace among nations (Postel 1996).India is not an exception to this impending crisis. The growing population, which is about to touch the billion mark, the preference for water intensive agriculture and rapid urban industrialisation are putting enormous pressure on the fragile freshwater resources (Kumar 1997; World Bank 1998). Growing water scarcity problems pose serious threat to ecosystem management, social sustainability and economic growth. The undivided India had 28.2 million hectares (mha) of net irrigated land, including 15.2 mha of canal irrigated land. In the partition, the country lost a part of the irrigation sources to Pakistan (Bharadwaj 1990). The foodgrain production in the country during 1949-50 was nearly 62 million tons (Sarma and Roy 1979). In order to boost agriculture production and achieve self-sufficiency in food, irrigation development was given a major investment priority during the subsequent five-year plans (Bharadwaj 1990; Vohra 1995). Several major, medium, and minor irrigation schemes were built. As a result, the net irrigated area increased from 21 m. ha to 46.2 m. ha from 1951 to 1991 (Vohra 1995), enabling an annual growth of2.42 percent in food production to reach 180 million tons by 1995. During 1964-65 to 1970- 71 food-grain production grew at a record rate of 3.3 percent, mostly due to expansion in irrigated area (Sarma and Roy 1979).The last few decades have seen a dramatic rise in the demand for water in India, triggered by the rise in population, especially in urban areas, causing increased demand for food production and domestic water supplies; and industrial growth resulting in increased demand for production purposes and assimilating pollution. Supplies have also grown manifold, to keep pace with the demand through exploitation of surface and groundwater. As a result, groundwater resources are over-exploited in many arid and semiarid regions, leading to large drops in water levels, deteriorating groundwater quality and sharp reductions in the availability of good quality groundwater. Surface water resources are over-appropriated in many basins. Freshwater supplies are increasingly coming under threat of pollution from industrial effluents and municipal waste. The situation has developed steadily and dramatically. At the time of independence, the per capita freshwater availability in the country was 6008 M^3 per year. In 1997, it stood at approximately 2200 M^3 per annum (Engelman and Roy 1993). The situation is already critical in 6 out of the 20 major river basins, with the per capita freshwater availability going below 1000 M^3 per annum (World Bank 1998; Mehta 1999). Water related issues are becoming far more complex than ever before.

WATER RELATED PROBLEMS IN INDIA

At the time of Independence, India was faced with the dual challenge of enhancing food- grain production and providing safe drinking water supplies. Irrigation development was a major investment priority in the five-year plans. Since 1951, India had made remarkable achievements in irrigation development (Bharadwaj 1990; Varghese 1990; Vohra, 1995). The net irrigated area had almost doubled during the period of 1951 to 1991 from 21 m. ha to 45.6 m. ha in 1991 (Vohra 1995). The annual foodgrain production increased from a meagre 50.8 million tons to 198 million tons in 1996-97. Substantial achievements had also been made in water supplies through the development of surface and groundwater resources. While at the time of independence, only 6.15 percent of the country's population had safe drinking water supplies (source: Five Year Plans as quoted in TERI 1998), by the year 1997, about 81 percent of the total population had access to safe drinking water supplies (CSE1997). However, the development had also brought to the fore several physical, social and management problems. In this section, we attempt to analyse the major water related problems that pose challenge to meeting the future water supply needs.

Water Resources under Stress: Declining Potential of Surface Water

1. Reducing Scope for Augmenting the Existing Supplies

Though the overall level of utilisation of natural runoff is very low, the scope for further utilisation is greatly limited due to several reasons. First, almost all the viable sites are already exploited (Kumar 1992) and the utilisation is quite intensive. Construction of any new water storage facility is more likely to provide a means of re-allocating the available supplies among different uses than adding to the aggregate supplies (Frederick 1993). The social and environmental costs of future exploitation are very high (World Bank 1991; Kumar 1992; Frederick 1993). Construction of big dams, while creating large submergence, had resulted in large-scale displacement and uprooting of human communities, depriving them of their traditional livelihood sources and opportunities Second, large water projects in India are increasingly coming under the scrutiny of environmentalists and social justice activists (Paranjape and Joy 1995). The threats to environment and ecosystems posed by large dams are well understood. The conventional wisdom suggests that large dams, involving large-scale submergence have serious negative environmental consequences, while the positive environmental and ecological impacts of irrigation were ignored (Kay *et al.* 1997). Third, availability of funds for large water projects is also open to question. Greater awareness among the world community about the social and environmental consequences of large dam projects is putting international aid agencies under increasing public scrutiny.

2. Reducing Potential of Existing Supply Schemes

There are numerous problems facing the large reservoir projects in India that have implications for the potential of existing supply schemes. Accelerated soil erosion in the catchments and subsequent faster silting up of reservoirs, a serious concern for hydrologists, is one among them. Most often, the actual rates of soil erosion and siltation were found to be much higher than the estimates arrived through hydrologists' calculations. For example: the estimated rate of siltation for Dharoi reservoir built on Sabarmati River was nearly 1.6 MCM per year at the time of planning. But, twenty years down the line, catchment surveys conducted in 1994 showed that siltation in the catchment was occurring at a rate of nearly 10 MCM per year (GOG 1994). The net result is the depleting storage and reduced life of reservoirs. Large impoundment often cause reduced in-stream flows in the downstream portions of the river with a resultant negative impact on recharge of underlying aquifers. All these factors have a negative impact on the future supplies. First, introduction of canal water is causing widespread problems of waterlogging and salinity in many canal command areas in India due to excessive seepage from canals and poor drainage of irrigated fields[2]. Waterlogging and salinity, in the long run, causes sharp decline in productivity of agricultural land and convert them into wasteland. Today, some of the canal irrigated areas in Punjab and Haryana, which are already affected by waterlogging and salinity, are showing declining productivity. The country is loosing out large tracts of fertile irrigated croplands to water logging and salinity. Artificial drainage of land waterlogged due to excessive irrigation is found to be far more expensive than bringing the same amount of land under irrigation.

Secondly, large dam projects are increasingly becoming un-viable in economic terms. A close look at the performance figures of canal irrigation projects brings out this issue. First of all, the efficiency of canal irrigation is very poor[3]. It is only 50 percent as efficient as compared to groundwater irrigation. Considering the efficiency factor, the net area served by surface irrigation (as on 1990) is only 11.35 M ha instead of 22.7 M ha. Hence, the growth achieved is only 7.2 M ha of Net Ground Water Equivalent Irrigation (Vohra 1995). Thus, the level of investment required to bring one hectare of land under irrigation is nearly 47,000 rupees.

Dwindling Supplies of Natural Freshwater

Today, water pollution is one of the most serious environmental problems facing developing countries like India due to its direct effect on human welfare and economic growth (WRI 1995). In India, this has come up as the larger environmental, social and economic consequences of industrialisation pursued through liberal economic policies. Presence of industries had a manifold impact on the effective availability of water supplies. Industries create demand for labour and therefore along with them concentrated migrant populations, leading to development of new urban centres and slums. Industries generate waste in the form of effluents. Concentrated populations also generate huge amount of waste in the form of domestic sewage. Most often, industries dispose off their treated, untreated or partially treated waste in the natural streams and rivers causing severe pollution, which drastically reduces the effective availability of freshwater. Domestic and municipal waste also finds its way into the flowing streams.Pollution of rivers is quite extensive in India. According to a study conducted by the Central Board for Prevention and Control of Water Pollution, as early as 1979, large stretches of all the 14 major rivers had become contaminated due to indiscriminate disposal of industrial effluents and urban domestic waste.

Groundwater Over-Development Problems

Depletion

Groundwater resources are showing increasing signs of over-development in India. But, the national level statistics of groundwater development provides a rosy picture of the overall scenario. According to official statistics, only 30 percent of the rechargeable annual groundwater potential is so far utilised (Kittu 1995). However, these figures are highly influenced by the groundwater surplus areas of Eastern and the NorthEastern parts of India (World Bank 1998). Long viewed as unlimited renewable natural resource, threats to groundwater supplies are increasingly becoming evident (Moench 1991). The resource is already over-exploited in many areas. Alarming drops in water levels in the alluvial areas of North Gujarat, and intrusion of seawater in the coastal areas of Kutch and Saurashtra are well-documented (Bhatia 1992; Moench 1995:

Kumar 1995b). Problems of dropping water groundwater levels are observed in many parts of Rajasthan, Punjab, Tamil Nadu and Karnataka (quoted from Moench 1995).There are several factors contributing to the over-development of groundwater resources. They are lack of well-defined property rights, presence of subsidised energy for groundwater extraction, easy access to institutional financing for well development and rural electrification (Singh 1995; Moench 1995). *De jure* rights in groundwater are not clear. But, *de facto* rights to groundwater are attached to land ownership rights (Singh 1995). A landowner has total right to the groundwater underlying his/her piece of land to use it in away he deems fit. There is no restriction on the amount of water he/she can pump out. Another important reason being the subsidised electricity for groundwater pumping. In many states, electricity is nearly 100 percent subsidised. In some states, a flat rate system of electricity pricing, based on pump horsepower, is followed. Due to this, the marginal cost of extraction is zero and the implicit cost of extraction of unit volume of water reduces with increase in hours of pumping. This creates incentive for farmers to over-use groundwater. Thus, groundwater resources tend to be over-exploited. According to official estimates, as on January 1992, 10 percent of the blocks in the entire country fall in the overdeveloped or critically developed category (Raju 1995).The social, economic and environmental consequences of dropping groundwater levels and depletion of economically accessible resource are often great. As water table drops, shallow wells dry up and poor farmers abandon their wells. Then, the access is limited to only those who can afford to deepen their wells or buy water from neighbouring well owners at prohibitive prices. From an economic perspective, dropping water levels increases the energy required to pump out unit volume of water and therefore the cost of extraction, reducing the economic viability of irrigated agriculture. From an environmental perspective, groundwater is a drought buffer. During years of low and no rainfall, the buffer storage of groundwater is used for protecting the crops, drought proofing and meeting a variety of social and environmental needs.

Groundwater Quality Deterioration

Groundwater quality is showing declining trends throughout many parts of India. This causes sharp reductions in the availability of groundwater for various uses. On the basis of causes, the problems of poor groundwater quality can be classified into three categories as follows. *First*: There is an inherent problem of water quality due to natural contamination caused by the presence of minerals in the formation bearing water. Several parts of the country have saline groundwater[6]. Fluoride concentrations above the permissible limits of 1.5 ppm is prevalent in 8700 villages and has affected the drinking water supplies of 25 million people. As the concentration of fluorides in groundwater is controlled by the rainfall and evaporation, and the residence time of water in the soil and phreatic zone, higher levels of fluoride are generally occurring in the arid and semiarid tracts of Rajasthan, Gujarat, UP, Haryana, Karnataka and Andhra Pradesh (Kittu 1995). Arsenic contamination of groundwater in deep aquifers, which is by far the biggest mass poisoning case in the world, has affected 6 districts in West Bengal (*Down to Earth*, October 15, 1996).*Second*: Increased human activities directly contaminate the groundwater. Pollution of groundwater due to indiscriminate disposal of industrial effluents and municipal waste in water bodies is a major concern in many cities and industrial clusters in India (Kittu 1995). Groundwater in the whole of Vapi-Ankleshwar-Surat-Baroda belt, known as the golden corridor of India, is severely polluted by effluent from chemical industries. Groundwater is highly vulnerable to pollution of surface water bodies in areas where the river and aquifer are hydraulically linked. Intensive use of chemical fertilisers in farms and indiscriminate disposal of human and animal waste on land result in leaching of the residual nitrate and potassium causing high nitrate concentrations in groundwater. High concentrations of nitrates in groundwater are reported from many parts of India (Moench and Metzger 1992; WRI 1995). *Third*: Induced pollution. Excessive withdrawal of groundwater from coastal aquifers has led to intrusion of seawater in the coastal aquifers rendering many thousands of drinking water and irrigation wells useless. Examples are coastal areas of Kutch and Saurashtra in Gujarat and Chennai coast (Bhatia 1992; Kittu 1995; Kumar 1995b and 1996).

Growing Water Scarcity

Growing Demand

A wide variety of demographic and socio-economic trends such as population growth, urbanisation, industrialisation, changes in agricultural practices and cultural changes, in combination, have triggered off this explosion in demand for water. The country's population has more than doubled since Independence from a mere 400 million to around a billion now (nearly 250 percent increase). The relation between population and demand for water is non- linear. Population growth impacts positively on the demand for water in many ways. First of all, the demand for water for drinking and cooking and sanitation increases proportionally, provided the economic conditions and poverty rates remain constant. Rather more important than the population rise is where the population rise really takes place, i.e., whether it is in the urban areas or rural areas, and how it grows. The per capita demand for the basic needs and a variety of environmental services are likely to be high for urban areas. Faster growth rate will impact demand rates positively. The rise in demand for water for a given rise in urban population will be much higher than what will occur if the rural population grows by the same magnitude. This is due to the implications urban population growth has on waste disposal. Urban population constituted more than $1/4^{th}$ the country's total population in 1994, while only $1/6^{th}$ of the total population lived in urban areas at the time of Independence. Urban population is growing at a rapid rate, much faster than the rural population. According to the projections of the UN populations division, India's urban population will touch 600 million-mark by the year 2025, making it nearly 45 percent of the country's total population (WRI 1995). Along with the rapid growth in aggregate urban population, there has been simultaneous concentration of the population in a few cities, adding to urban population growth rates and per capita demand for water. Economic condition and poverty are two important parameters that can potentially impact on the way natural resources are being consumed (WRI 1995). This can significantly impact water use practices and use patterns, causing overall increase in the demand for water in the domestic sector. Economic growth increases the demand for a wide variety of environmental services related to water. One of the competitive demands which has been growing exponentially over the last one or two decades is industry. The water requirement for water consuming industries such as agro- based industries, petrochemicals, fertilisers, refineries, and industrial chemicals industries increased 40 times from just 100 million litres a day in 1947-50 to 4000 million litres a day in 1997 (TERI 1998). Though industrial water demand constitutes a small fraction of the total water demand in India today, it is likely to dominate other important sectors like urban and rural, domestic/ drinking water in the coming decades following the rapid sectoral growth.

Dwindling Water Supplies

Groundwater Scarcity

Indiscriminate exploitation of groundwater for irrigation and other uses has resulted in resource depletion. This was manifested by alarming drops in water levels in alluvial areas, drying up of open wells, yield reductions in deep tube wells, and depletion of economically accessible groundwater resources[8]. In hard rock areas, excessive withdrawal is causing sharp seasonal drops in groundwater levels and drying up of wells in summer causing acute seasonal scarcity of groundwater for all purposes. The case of Coimbatore district of Tamil Nadu illustrates this phenomenon with enough clarity. The district, characterised by a record density of irrigation wells, had recorded a steep decline in groundwater levels over the last few decades, with water levels falling up to 200 feet in some parts. The number of wells in the district doubled during the period from 1960 to 1990, while the net irrigated area by groundwater almost stagnated. This means that the net area irrigated by a single well had almost reduced by half, unless we expect significant changes in the cropping pattern during this time period, sufficient to make substantial increases in the depth of irrigation watering.

Surface Water

Pollution is posing a major threat to natural freshwater supplies from surface water bodies. A Central Pollution Control Board report cites 20 critically polluted areas along the stretches of some of the most important rivers in the country, where the level of pollution is far above what the flows could assimilate (Biswas and Sharma 1995). Eventually, they are close to the vicinity of some of the booming industrial clusters and major cities in the country. The enforcement of pollution control norms by the concerned agencies is precariously poor. Large industries often flout pollution control norms. But, the agencies lack the administrative and institutional capabilities and legal powers to penalise the free riders. Often, identifying the source of pollution is also an issue. Notices issued by Ministries and agencies for closure of erring industries are often met with stay orders resulting in shifting of decisions to judiciary, causing long delays. The storage capacity and life of many large and small reservoirs in the country, is reducing much faster than estimated. This can greatly reduce the ability of many large cities and towns in the country, which heavily depend on these reservoirs, to maintain future water supplies to the current levels. The problem arising out of the reduced availability of water gets compounded by rapid population growth occurring in the urban areas, with the result that the per capita supply levels further dip, widening the gap between the per capita supply requirements and the supply levels. According to a UN projection, total water demand in India by the year 2025 will be at par with the total exploitable freshwater supplies.

Increasing Competition and Growing Conflicts

One of the major challenges India is facing in the water management sector today is the growing competition between demand sectors (World Bank 1998; Kumar *et al.* 1999; Ballabh and Singh 1997). Heavy concentration of populations in urban areas creates quantum jumps in municipal water supply requirements. This is not only of good quality, but also of high priority. As urban areas are increasingly finding it difficult to manage their required supplies from within, they often start laying claim on the resources in rural areas, thereby running into conflict with other competitive demand in the rural areas. Dispersal of industries in rural areas leads to a situation where the overall demand for water in those areas increases rapidly with the result that industries directly compete with irrigation and drinking for the limited freshwater supplies. to meet the ever increasing demands (Kumar 1997; Kumar *et al.* 1999). Such allocations have always been at the cost of reduction in supplies for irrigation, leading to conflicts. Many river basins in India are characterised by growing competition between sectors such as irrigation vs. municipal uses, irrigation vs. drinking, industrial use vs. irrigation, etc., (World Bank 1998; Ballabh and Singh 1997).

WATER MANAGEMENT CHALLENGES IN INDIA

India is faced with dual problems in water resources. First is of scarcity of freshwater due to the declining natural supplies and the increasing demand for enhancing foodgrain production, providing water supplies for drinking and industries, and ecosystem management (Ballabh *et al.* 1999). The second is of increasing conflicts over sharing of water. The core water management needs are maintaining the balance between demand and supplies to address growing scarcity; and equitable allocation of water across sectors to resolve the conflicts. This is a dual challenge. To begin with, evolving water management strategies to meet this challenge needs scientific database on water supplies in relation to a range of social, economic and environmental objectives.

Water Quality

Quality is another important variable that determines the suitability of water for a particular purpose and hence quantity and quality issues are inter-linked (Moench and Metzger 1992; Kumar 1995a; Biswas 1996). There are numerous biological, physical and chemical parameters that determine the quality of water. There are four important issues associated with water quality monitoring. i) There are a few observation stations in the country that cover all the essential parameters for water quality and hence the data obtained are not decisive on the water quality status (Biswas and Sharma 1995). ii) Water quality measurements involve expensive, sophisticated and that are difficult to operate and maintain; and require substantial expertise in collecting, analysing and managing the data (Biswas 1996). Therefore, in a country like India, where water technology is still not advanced, it is very likely that the available data on water quality is less reliable.

iii) The existing methodology for water quality management is inadequate to identify the various sources of pollution and contamination of water (Moench and Metzger 1992). iv) Available water quality data are hardly integrated with data on water availability of water supplies. But, such integration is very important not only from a purely physical science perspective, but also from the point of view of assessing water availability for meeting various social, economic and environmental objectives (Moench 1995).

Water Demands and Use Rates

Demand estimation in different sectors of water use is often based on agency norms. These norms fail to capture the variations in physical, socio-economic, cultural and institutional factors that greatly influence the demand of water in various sectors. As a result, the demand figures estimated through norms are unrealistic. Water use rates are important for analysing demand management interventions. But, no data are compiled by official agencies on the actual use of water in different sectors such as per capita water use in municipal areas, water use by livestock, crop water use, and industrial water use.

Objectives of Data Collection

The process of collection and interpretation of data on water availability and condition in India has a strong technological bias. Hydrological objectives override the larger social, economic and environmental objectives. As a result, the hydrological data are often interpreted in a way it does not indicate the availability of and access to the resources for meeting various social, economic and environmental needs. First, it is important to assess the status of development of water resources in relation to economic efficiency objectives. It is also essential to know whether the current levels of exploitation of water in a river basin are economically efficient or not. From an economic perspective, surface water in a river basin is over-exploited if the cost of unit volume of additional water harnessed is high. So is the case with groundwater. In a river basin, if new water projects only help in reallocating the available water within the basin, then it can be called an over-exploited basin, as the cost of unit volume of water would be enormously high. In the case of groundwater, over-development occurs if the extraction is economically inefficient. Similarly, it is important to assess development of water in relation to social objectives. Ensuring adequate quantities of water for human survival is a social goal. Therefore, from a social perspective, over-development of water resources occur, when the water resource in a basin cannot meet the basic drinking water needs in a basin on a long-term. In many hard rock areas like Saurashtra region in Gujarat, dug wells dry out before the onset of summer due to sharp declines in groundwater levels and drinking water becomes scarce. However, current assessment methodologies classify such areas as “under-exploited”.

Criteria and Variables for Assessment of Resource Condition

As the objectives of collection and interpretation of data change, the criteria for assessment of water availability or water scarcity situation is bound to change. Currently, water balance is the only criteria used for assessment of over-development of water and scarcity. However, water balance does not provide enough indicators of the actual social, ecological, environmental and economic impacts. From a social perspective, it is important to know how far whether the available water in the basin would be sufficient to meet the basic survival needs, especially drinking. In the economic sense, one important criterion for assessment of scarcity could be the investment communities have to make in accessing water supplies for various uses, or whether water is within economically accessible limits or not. Dropping groundwater levels can increase the investment for well digging and energy cost for groundwater extraction. Therefore, it is important to include pumping depths and yield levels as important parameters to be measured.

Institutional Challenges

The institutional challenge is analysed on the basis of the following five core water management needs: effectiveness in responding to local water scarcity problems; competence to evolve comprehensive water management approaches to address regional problems; ability to design water management systems to alter social systems affecting water use; capability to ensure equitable and sustainable resource use; and, ability to implement water allocation plans effectively and resolve conflicts.

Centralised and Segmented Approach

All state and national level institutions that are directly dealing with water are centralised institutions. They use "centralised" and "top-down" approaches for data collection, compilation and management, water development planning, implementation and finally water management (World Bank 1998).First, centralised planning processes do not involve local communities at any stage of data collection, issue identification and water development planning. Official agencies identify the issues on the basis of macro-level data they gather. Such processes are grossly inadequate to capture the local resource availability, conditions and problems. The involvement of local communities in data collection is essential in view of the fact that they are aware of the condition of the resources in their locality. On the other hand, involvement of local user groups in planning could lead to development of plans that are implementable as they are aware of the range of factors that determine the type of interventions that are physically and socially viable (Kumar *et al.* 1994). "Centralised" and "top-down" planning processes create doubts and fear in the minds of local people and often leads to conflicts and opposition to the project implementation. Secondly, by and large, the centralised systems do not encourage effective participation of the user groups in water management, due to the reason that they are often too large for the local communities to handle. Water management being a social activity, the involvement of user groups is critical to achieve the desired water management objectives.

Regulatory Approach to Management

Several states in the country had passed legislations to control and regulate the over- development of groundwater resources in accordance with the Model Bill[16]. They were, by and large, command and control approach to affect changes in the resource use. Over and above, they are blanket legislation and do not capture the potential variations in the overall physical, social, economic, cultural and institutional settings across different localities and regions, which would determine the needs of any locality. As a result, they are often not hydrologically less meaningful and socially and politically non-viable (Moench 1995; Kumar 1995b).The Central and State Pollution Control Boards, set up under the provisions of the Water Pollution (Control and Prevention) Act 1974, have evolved norms and standards with regard to quality of trade effluents and sewage discharged in natural streams and wells (including biological, chemical and physical) and also water quality of the natural streams. These norms, however, have largely been ineffective in controlling water pollution due problems in implementation. The roots of the problems lie in the following. First, the institutional and administrative capabilities to monitor water quality are increasingly becoming inadequate in the wake of the increasing number of industries, rapid increase in the chemical effluents. Secondly, the traditional water treatment plants are incapable of treating the new, toxic chemicals industries produce. Fourth, the Municipal authorities, and small industries, which are major sources of pollution, do not have financial resources to invest in treatment plants that are prohibitively expensive. Thirdly, the pollution control agencies are not been given powers by the provisions of the Act to penalise the violators, and hence are to be prosecuted in the normal course in Judicial Courts (Bhatt 1986).

Sectoral and Segmented Approaches

The approach to water sector in India is sectoral (World Bank 1998). Institutions were created to cater to the needs of different sectors such as rural drinking, urban water supplies, irrigation, recreation, fisheries etc. Often, the dynamics of interaction between various socio- economic systems influencing water use in different sectors is poorly understood. New water projects often alter the allocation among existing uses. For example, adverse impact of structural interventions in the natural flows on in stream uses has always been ignored.

Supply Focus

The scientific and technological advancements made during the 20th century, led to major breakthroughs in understanding the natural systems underlying water supplies and the capacity to control and exploit it. The advancements made in earth moving, dam construction, deep drilling and pumping technology etc., greatly encouraged resource exploitation (Frederick 1993), often beyond the threshold of sustainable carrying capacities. Till recently, water management was viewed as an engineering activity involving building of large dams and diversion head works, creation of storage reservoirs and conveyance systems to take care of the spatial and temporal variations in annual rainfalls. The institutions that were created were largely technically oriented, with the skills and competence for water resource investigation, and identification, planning and execution of water development projects. The supply focus in the water sector, to a great extent, helped these institutions remain as technically oriented for a significant period of time. With the resources increasingly becoming scarce, new water development projects hardly add to the aggregate supplies, and only allocates the available supplies among alternative uses. Thus, the priorities of these institutions are changing from managing supplies to conservation and demand and allocation management (Frederick 1993).

Institutional Frameworks and Market Instruments

Human interactions with the environment and their impacts depend heavily on the property rights systems or the institutional regimes that are embedded in the social, cultural, economic and political setting. In developing countries, including India, there is very little understanding of the role of institutional regimes in determining the way in which natural resources are used (Hanna and Munasinghe 1995). Given the institutional vacuum, in which communities exercise control and access water resources, the property rights issues in water are self-evident. The lack of a well-defined property right system creates uncertainty about the impact of the resource use on environment and therefore creates incentives for overuse (Pearce and Warford 1993). But, the governments increasingly tend to use "command and control" approach to restrict the use of water. Water has always been at the centre of political agenda in independent India. They use it as a tool for creating vote banks. Therefore, policies, laws, regulations and legislation and institutions that would restrict or redefine the rights of communities in accessing water is bound to become a politically sensitive issue. As a result, institutional changes are not likely to be forthcoming in the water sector in India.

Technological Challenges

In India, water problems have grown much faster than the advancements made in water conservation and management technologies. First of all, there is very limited understanding of the physical problems. The use of management information systems that can help understand the problems and evolve management decisions is extremely limited in India. The problems associated with this are absence of systematic and scientific data collection, compilation, processing and retrieval systems, highly segregated nature of information, and poor degree of access to the existing information.

Technological options being advocated for water management is limited to structural interventions for increasing the supplies. During scarcity, the usual discourses focus on creation of new sources (Bhatia 1992; Kumar 1995a; Prabhakar *et al.* 1997). Supply side approaches to water management have several limitations (Kumar 1995b). The concept of end-use conservation, recycling and reuse are recent in India's water management sector. The customary approach for water quality management is wastewater treatment, which is at best, end of the pipe treatment. The role for environmental management systems in minimising waste is not widely debated.

CONCLUSION

India had a long water management tradition. However, these began to decline with the arrival of the British who introduced large-scale irrigation systems and systematically destroyed the traditional village institutions and collective action by the communities to store, use and manage the water in their locality. Since Independence, India has made remarkable achievements in water sector, which is evident from the large growth in irrigated agriculture, increase in agricultural production, and advancements in drinking water supplies in rural and urban areas. In doing so, development of water resources has crossed the thresholds of physical sustainability in many areas, manifested by groundwater depletion, groundwater quality deterioration, dwindling supplies and increasing pollution of surface water. As demand for water grows by leaps and bounds in all sectors due to demographic and socio-economic changes, the magnitude and extent of scarcity problems increases. The water management challenges India is facing today are really great. First of all, wide gaps exist in our understanding of the physical problems and management solutions. Management solutions that are technically and economically feasible and socially and politically viable are not forthcoming. Over and above, the government policies and programmes are largely tuned to develop water resources rather than manage it. The non- availability of adequate scientific information regarding availability and quality of water, demand for water in different sectors, nature and extent and causes of water problems become major hindrances to developing sustainable water management strategies. The root of the problem also lies in the lack of co-ordination among agencies for data collection, processing and retrieval, and the lack of integration of social, economic and environmental factors in assessment of resource condition. Technology is another major challenge. Technologies available for water conservation and management are limited and less popular. Advancements in water technology aimed at evolving technically feasible, economically viable, environmentally and ecologically sound and socially acceptable solutions in water management are not occurring.

References

Agarwal, A. and Sunita Narain (eds.) (1997) Dying Wisdom: Rise, Fall and Potential of Traditional Water Harvesting Systems in India, 4th Citizen's Report. New Delhi: Centre for Science and Environment.

Ballabh, V. and Katar Singh (1997) "Competing Demands of Water in Sabarmati Basin: Potential and Future Conflicts," Paper presented at the ICIPD conference on water, Amsterdam, Netherlands, October 11-17.

Ballabh, V., M. Dinesh Kumar and Jayesh Talati (1999) "Food Security and Water Management: Institutional Challenges for Early 21st Century," Paper presented at the National Symposium on Building and Managing Organisations for Rural Development in the New Millennium, Institute of Rural Management Anand, December 13-14.

Centre for Science and Environment (1997) "Statistics: Water and Sanitation," Down to Earth, September 15, page 60.

Chaudhari, S. (1996) "To Sell a Resource," Down to Earth, February 15.

Engelman, R. and P. Roy (1993) Sustaining Water: Population and Future of Renewable Water Supplies. Washington, DC: Population and Environment Programme, Population Action International 56.

Government of Gujarat (1992) Report of the High Level Committee on Estimation of Groundwater Resources and Irrigation Potential in Gujarat State. Narmada and Water Resources Department, Government of Gujarat, Gandhinagar, September, pp.66-85.

Government of Gujarat (1994) Integrated Plan of Sabarmati River Basin. Draft Report, Gujarat State Water Resources Planning Group, Gandhinagar, Gujarat, India.

Mehta, M. C. (1999) "The Role of Judiciary and Citizens in Environmental Protection and Sustainable Development," Journal of the Indian Water Resource Society, 19 (5), No.2.

Merrett, Stephen (1997) Introduction to the Economics of Water Resources: An International Perspective. London: UCL Press, page 211.

Paranjape, S. and K.J. Joy (1995) Sustainable Technology Making Sardar Sarovar Project Viable: A Comprehensive Proposal to Modify the Project for Greater Equity and Ecological Sustainability. Ahmedabad: Environment and Development Series, Centre for Environment Education.

Pearce, D. W. and J. Warford (1993) World Without End: Economics, Environment, and Sustainable Development. New York: Oxford University Press.

Raju, T. S. (1995) Emerging Problems, Options and Strategies in the Development and Management of Ground Water Resources," in M. Moench (ed.) Groundwater Availability and Pollution, The Growing Debate over Resource Condition in India. Monograph. VIKSAT-Natural Heritage Institute, VIKSAT, Ahmedabad.

Sangvai, S. (1994) "Peoples Initiative to Solve Water Crisis in Saurashtra," Economic and Political Weekly, XXIX (34).

Sarma, J. S. and Shyamal Roy (1979) "Behaviour of Foodgrain Production and Consumption in India, 1960-77," Staff Working Paper 339, Washington DC: World Bank.

TERI (1998) Looking Back to Think Ahead Growth with Resource Enhancement of Environment and Nature. New Delhi: Tata Energy Research Institute.

Vani, Vina, V. Ballabh and Tushaar Shah (1995) "Drinking Water Supply of Rural Gujarat: Institutions, Technology and Public Policy," Paper presented at the International Conference on the Political Economy of Water in South Asia: Rural and Urban Action and Interactions, Madras, January 5-8.

Varghese, B.G. (1990) Water of Hope: Himalaya-Ganga Development and Co-operation for a Billion People. New Delhi: Oxford and IBH Publishing Company Pvt. Ltd.

Wijdemans, R.T. J. (1993) "Sustainability of Ground Water for Water Supply; The Competition between the Needs of Agriculture and Drinking Water," Paper presented at the workshop on Water Management: India's Groundwater Challenge', VIKSAT, Ahmedabad, December 14-16.

World Bank (1991) "Irrigation Sector Review," World Bank-Government of India, India Water Resources Management Sector Review, Volume I- Main Report, New Delhi.

World Resources Institute (1995) World Resources 1994-95: People and the Environment, Report prepared by World Resource Institute in collaboration with United Nations Environment Programme and United Nations Development Programme. Bombay: Oxford University Press.