Institutional Framework of Managing Ground Water in a Water Stressed Region

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Abstract: Groundwater utilization has medium and long-term impacts, which affect the future availability and access to the resource. To address the multidimensional requirement of ground water, institutional organizations have an important role to play. As the present world is becoming more concerned with sustainable and environmentally sound water management, the issue of groundwater quality and other environmental consequences due to groundwater overdraft, a conceptual model of the institution that would be needed to incorporate the participatory approach involving decision-makers, planners, implementing bodies and direct beneficiaries in groundwater management has been suggested in the present paper.

INTRODUCTION

Warnings of a groundwater crisis (with depleted groundwater tables and polluted aquifers) have compelled to call for urgent management responses. Ground water continues to serve as a reliable source of water for a variety of purposes—domestic, industrial and irrigation (this dwarfs all other uses). Invent and popularization of mechanical pumping technologies in the mid twentieth century have induced widespread draw down externalities, including the depletion of the all-important shallow aquifers. The disposal of human and industrial waste and percolation of pesticides and herbicides have degraded many aquifers beyond economic remediation.

The area under present investigation is no exception. In view to those, the purpose of this paper is to

- illustrate the water stressed condition of a region arising due to draining of wetlands to recover land areas for habitation;
- estimate water budget of the region under study;
- management issues of ground and surfacewater; and
- suggest institutional framework for managing groundwater resources.

BACKGROUND

Unorganised and unscientific planning of water quite often causes disruptions of hydrologic and environmental regimes at micro and/or regional level which are common to our experiences; such activities eventually lead to breakdown of economic fabrics and social setup. Unfavourable changes both in the environment as well as in the socio-economic fronts resulting from encroachment and draining of perennial swamps or wetlands could be noticed in different parts of the world. We, in the country, are no exception to this.

There exist several definitions of wetland. In the present context, a wetland is defined as an area of water body which are capable of supporting water related vegetation and other aquatic lives (Shaw and Fredine, 1972). Wetland may be perennial and usually identified as flood retention basin, prime wild life habitats, source of mosquitoes and other harmful insects, etc. and may also cause occasional water logging and floods. Wetlands, in general, are interface between land mass and water and maintain a balance between the hydrologic and aquatic regimes of a region.

Quite often we fail to appreciate the long chain of activities and the direct or indirect economic gains associated with wetlands and swamps. In spite of several contributory aspects, the wetlands are abused by the civilization. A study in the early seventies reveal that more than one-third wetland acreage was destroyed in the United States alone (Shaw and Fredine, 1972). The trend, however, is going on practically unabated.

Coming back to our own condition in the country considerable areas of swamps and water bodies in and around urban peripheries have steadily been disappearing every year for the rising economic pressures on them. Wetlands and swamps are being encroached upon to meet the increasing demand for more land for building houses, urban expansions, roadways, real estate, industries and also agriculture. The official agencies as well as private individuals, real estate brokers are engaged in this game disregarding and often ignoring the warnings from environmentalists and rational thinkers at times even legal dictums.

The state of West Bengal is no exception in this direction and the conditions are continuously getting worse due to high pressure on land and increasing population concentration; unfortunately both are rising steadily. The present study is concerned with natural perennial freshwater wetlands, which were drained to recover land areas mainly for habitation and agriculture. The wetlands covered a region called Sonarpur-Arapanch and situated between 15 km and 30 km south of the city of Kolkata (Fig. 1).

Average depth of water in the swamps varied between 1.2 m and 1.0 m during the dry monsoon (Goswami and Bose, 1992). During monsoon, depth of water in some places increased by a metre or so. Drainage congestion, a regular feature during the monsoon, used to cause floods around the swamps. Prior to the alteration agriculture was practiced in some places, and some marginal area in and around the swamps was inhabited. Flood damages were also a regular feature in the region. Prior to the transformation the said perennial wetlands were used to be natural fisheries, sanctuaries for migrating birds and game reserves. The region is close to saline tracts of coastal region with gentle slope towards sea. Standing water round the year maintained quality of the sub-surface water and prevented intrusion of saline water into the sub-surface aquifers. In view of public pressure against frequent floods and consequent damages and to meet up the demand for more additional lands, the Government of West Bengal had eventually decided to drain the wetlands and reclaimed about 134

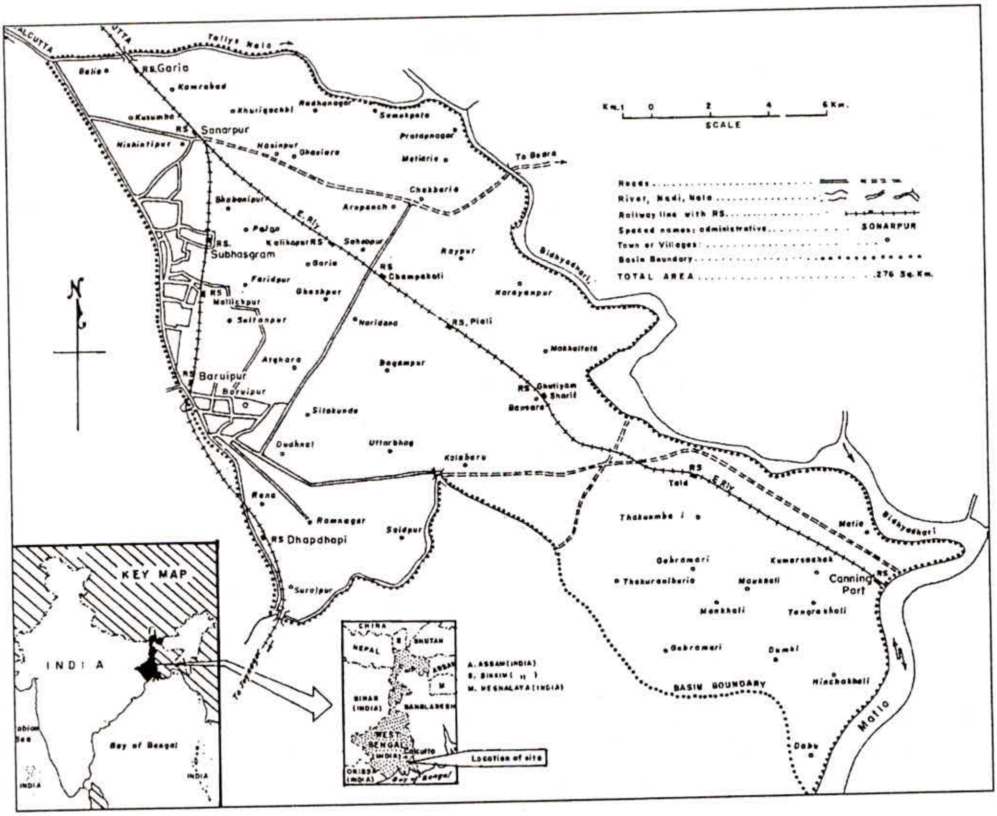

Fig. 1. Location map of the study area.

sq. km (or 13,400 ha) of lands during the mid–1950s (Bose et al., 1987). To facilitate proper flow of rainwater, a number of drainage channels were cut criss-crossing the region. A pumping station was also installed along the course of the main canal to pump out the accumulated runoff from the regions. The pumped water eventually flows into the Bay of Bengal through the Matla, a tidal river.

LOCATION AND EXTENT OF THE STUDY AREA

The area under the present investigation, popularly known as the Sonarpur-Matla Basin, is located in the district of 24 Parganas (South), 10 to 15 km south of the city of Kolkata. It covers an area of 276 sq. km (or 27,600 ha) stretches from Garia to Canning Town (Fig. 1) and bounded approximately by north latitude 21° 30′ and 22° 38′ and east longitudes 88° 02′ and 88° 45′. The entire region presents a monotonously alluvial tract, criss-crossed by a number of drainage channels and with gentle slope from north to south (Bose and Bose, 1998). The important rivers that encompass the region are the Bidyadhari and Matla. The Bidyadhari river flows easterly to join the river Matla near Canning and the combined stream finally flows into the Bay of Bengal. The course of the Bidyadhari river is now disrupted and the flow in stretches is also irregular.

WATER RELATED PROBLEMS

That total draining of the wetlands might upset the hydrologic balance of the Basin, and its surroundings seemed to be totally overlooked or ignored. Neither any scheme had been drawn up nor any follow up action contemplated to encounter the undesirable impacts, if any, that might crop up later. The impacts of hydrologic disruptions in a region in micro and macro-level, in general, manifest slow modifications or alterations or transformation of a hydrologic system. About a decade or so after draining of the Basin, during the mid-1950s, water level in most of the tanks and ponds within the Basin declines drastically and the relatively shallower ones dry out, if not, completely by the month of March or early April. Drainage channels also dry up during prolonged dry spells. Further, retention capacity of most of these channels have declined significantly due to siltation over the years and also due to inadequate or lack of conservatory works. As a matter of fact, the people in the Basin suffer from water shortage conditions during the long non-monsoon spell from November to the onset of the monsoon. Water stress conditions prevail for about 150 days and of which critical condition continues for nearly 90/92 days particularly during March till the onset of the monsoon. Water shortage during the period affects even the household activities of large section of villagers in the region. Shortage of water is also one of the main reasons for the dwindling of cattle population in the region. Before draining of the wetlands a reasonable number of households in the Basin could afford to maintain cattle and ducks. Such a feature was common in significant parts of the region. Vast stretches of agricultural lands remain uncultivated during the non-monsoon months even though the average annual rainfall in the region is quite high (almost 1740 mm/annum) (Bose and Bose, 1995). Rainfall distribution is highly skewed and about 80 to 85% of the rainfall occurs during the monsoon periods (i.e., mid-June till the end of September or at times early October). The sub-surface water at relatively shallow depths (4.38 m to 4.8 m) has become unsuitable for irrigation due to the problem of salinity.

The region being close to coastal tracts, increased level of salinity of water available in subsurface aquifers highly suggests that there is intrusion of saline water into the unconfined aquifers. Good quality freshwater is available at depth below 240 m or so. Use of water from deep layers for irrigation is not advisable for two counts. Firstly, withdrawal of water from deep layers is quite costly and hardly cost-effective. Secondly, this is the main source of drinking water (both safe and reliable till date) in the coastal tracts. It is also a fact that demand for freshwater is also increasing in the region due to growing pressure of population. The important issue here is whether it would be pragmatic to use water from deep layers indiscriminately for irrigation. To-day substantial portion in the Basin remains waterlogged for considerable period of the year (nearly 12% of the Basin area). This is due to the deterioration of the drainage which could be noticed since 1960's or so. Waterlogging and drainage congestion are apparently due to poor maintenance and mainly inadequate soil conservational measures of the channels in the Basin. Waterlogging has made sizeable areas of the Basin during the monsoon periods unsuitable even for Kharif cultivation i.e; cultivation during monsoon. In addition to that water scarcity during the dry periods has already become chronic and, in fact, has been affecting all the activities of the population namely cultivation, farming, breeding of livestock and general household activities as mentioned above besides hardships of thousands of people. Some farmers grow cash crops by withdrawing water from shallow aquifers or by lift irrigation method and that too in a very scattered manner, as sub-surface water of most of the regions is saline and unsuitable for agriculture. As a whole most of the population remain almost without any employment or job during the dry periods, as agriculture is the main occupation of the people. The cumulative impacts of all these have been causing deterioration of the regional ecology and continual erosion of the economic base of the predominantly rural and backward region in the district or for that matter in the state.

WATER BUDGET

Available water potential in the Basin can be determined from the analysis of water budget in the area (Bose and Bose, 1998) (illustrated schematically in Fig. 2). The available water Q_p in the Basin may be obtained from

$$Q_p = (P + Q_{in}) - AE$$

where, P = precipitation, Q_{in} = imported canal water and AE = actual evaporation.

It may be noted that annually about 30% or about 143.79 MCM (million cubic metre) of the hydrologic input (i.e., precipitation and imported canal water) 490 MCM goes back to the atmosphere as actual evaporation (AE). Remaining 346.21 MCM may be considered as the available water potential (Q_p) in the Basin (Fig. 2).

It has been observed that many of the drainage channels in the Basin have changed their courses and some had even ceased to exist at stretches. The Basin receives little amount of upland runoff even during the peak monsoon. There is, however, some inflow (Q_{in}) through the Suryapur Canal, an irrigation canal gets its supply from the river Hoogly and is available usually from February to April. The share of water for the Basin located at the extreme end of the canal amounts to about 10 MCM (i.e. Q_{in}) annually. This is mainly withdrawn for irrigation during the non-monsoon period. Again a

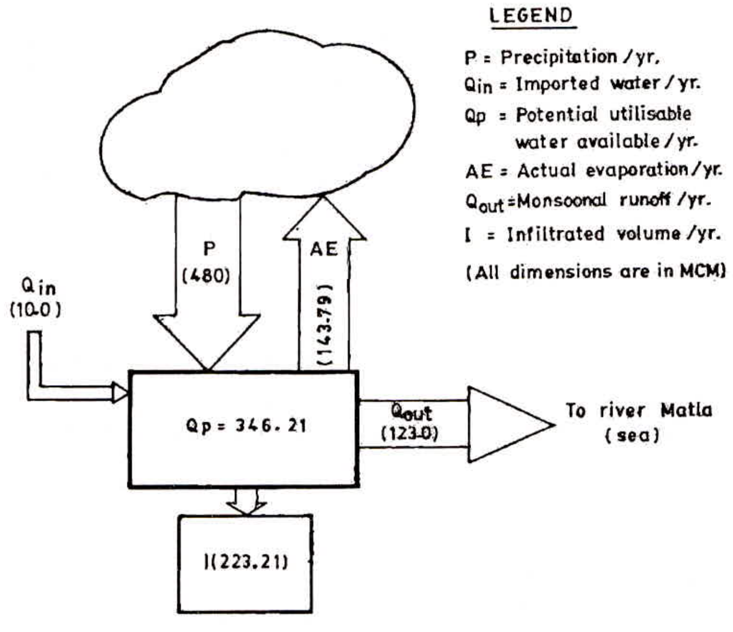

Fig. 2. Water budget of the study area.

large quantum of potential water available (i.e. 35% of Q_p) drains off as excess monsoon runoff from the Basin [i.e. Q_{out} about 123.0 MCM annually. Remaining 65% of Q_p (223.21 MCM) i.e. 'I' may be considered as storage volume in the existing water bodies as well as infiltrated quantum through the soil of the Basin (Fig. 2).

HARVESTING OF RAINWATER – ONLY SOLUTION TO OVERCOME THE PROBLEM

It has been found that about 123.0 MCM of rainwater drains off as runoff during the monsoon period from the region (Bose and Bose, 1995). It strongly suggests that additional water resources could be generated by harvesting drained off volume, which might be stored in dug out ponds/tanks. This appears to be the only solution to counter the water-stress conditions since there are no streams/rivers with upland supply, no natural surfacewater bodies and no ground water (good quality) is available at economical exploitable depths.

It would now be necessary to ascertain the volume of the excess runoff (123 MCM) that could be harvested considering the constraints and likely benefits. From field survey, it has been observed that more than 50% conservation of the excess runoff (which comes around 62 .0 MCM) would not be practically feasible.

MANAGEMENT ISSUES

Rural users generally abstract ground water themselves through wells that they own and control. They anticipate access in the form of direct abstraction from local aquifers without caring for their legal or customary status. Drawdown externalities are evident in many systems as shallow wells dry up. Further irrigated agriculture looking for high volume of raw water being indifferent about quality unless the ground water is saline. In most situations ground water is a common property resource. In some cases, ground water is or has been linked to land ownership. There is often unclear distinction between the private nature of groundwater rights and the public ownership of the resource itself .The locally exploitable groundwater resource is often depleted or drained by the end of dry season. In addition domestic use is not limited to potable water and personal hygiene but also to stock watering and small-scale irrigation.

In formulating effective management strategies of ground water of a region the understanding of the following aspects are to be required:

- Who is actually affected by emerging groundwater problem?
- What individual communities and local governments are doing to address such problems.
- The short- or long-term coping strategies individuals follow when faced with water scarcity.
- The patterns of social and economic change that affect groundwater use and management options.

Traditionally groundwater management was generally controlled by economic efficiency considerations in water-use and capital. Presently the effect of non-measurable or intangible quantities/ factors in decision-making cannot be ignored.

The main constraint in groundwater management arises out from the belief that ground water is considered to be an inexhaustible resources. As a result, over estimation takes place. It has been predicted that the demand-oriented measure will play a vital role in future groundwater resource planning. Water quality management of ground water depends on six factors. Among them—soil, geology, climate and hydrology—available in nature, are beyond the control of mankind; at the most, they can be modified. The other two factors —land-use and growth pattern—are very much under the control of mankind and responsible for groundwater contamination.

Appropriate goals /objectives are to be set in managing this scarce resource. The goals should be (Dasgupta, 1996):

(i) To define the extent, degree and critical of groundwater protection and assign their implementation to all levels of relevant government authorities (national, regional, local).
(ii) To establish the legal and institutional bases, regulatory statutes and standards for groundwater protection.
(iii) To establish a system of inspection and an effluent—control system, including fines on the polluters of ground water.
(iv) To provide methodological and technical guidelines for activities related to groundwater protection and rehabilitation.
(v) To support and co-ordinate research programmes for the development of methods of groundwater protection and technologies for detecting and eliminating pollution in the underground.
(vi) To educate the general public about the utilities of groundwater protection schemes.

PROPOSED INSTITUTIONAL FRAMEWORK IN MANAGING GROUNDWATER RESOURCES

Programmes intending to exploration, distribution and management of ground water resource in a country like ours are generally controlled by Government agencies. An organizational structure is necessary to protect the available groundwater resources in the study area. In developing a conceptual model in managing this scarce resource, proper stress should be given on:

- Public participation
- Development of law
- R & D activities

Water being a finite and shared resources, at the same time, it has strong regional feature, the development and management of water resources should not be, therefore, taken or considered in isolation and separated from the concerned community and the surrounding physical environment. Help from local administrative body i.e. Panchayat system of administration may be utilized to mobilize the local population in reducing the over-exploitation of groundwater resources.

In protecting the scarce resource, the government of West Bengal has adopted the Ground Water Management, Control and Regulation Act, 2005 (www.ielrc.org/content /eo502.pdf) which indicates that the implementation of the act should be entrusted on state level authority. The state level authority in turn would authorize the district level authorities to control and regulate the use of groundwater resource in effective manner.

There is a lack of understanding of many important physical processes and system's dynamics in groundwater environments. Among them important areas where research and development activities are urgently needed may be identified as

- Development of interdisciplinary technologies to solve groundwater contamination problems.

- Understanding of the physical and chemical processes taking place in different subsurface environment and in developing mathematical representations of these processes.
- Collection of database for changing of social context due to overdraft.

In view of the above, a conceptual integrated model for management of groundwater in the study area has been suggested (Fig. 3).

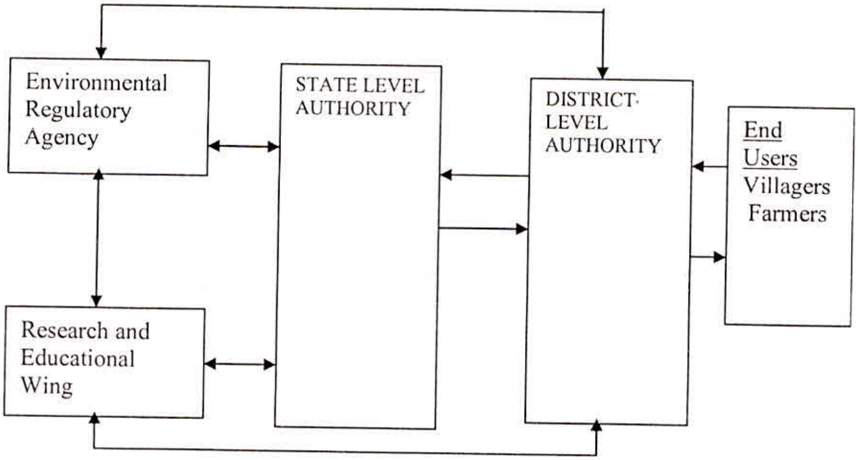

Fig. 3. Proposed institutional framework for management of ground water.

The functionaries and their functions for the management of groundwater could be as under

Functions	*Functionaries*	*Mode of operation*
Formation of Laws and Implementation	State Level Authority District Level Authority Environmental Regulatory Agency End Users	Through discussion
Public Participation and Awareness	District Level Authority Research and Educational Wing End Users	Through discussion and conducting awareness programmes among the end users
Research & Development • Formulation of modelling to combat contamination • Collection of data base • Changing of social context due to overdraft	State Level Authority District Level Authority Research and Educational Wing	Through R & D work

CONCLUDING REMARKS

Feasible management approach depends heavily on the presence of basic data and on institutional capacities for regulation and scientific research. Such capacities and data often require decades to develop; alternate approaches are essential in order to address the types of problems now emerging in many regions. Furthermore, research should suggest the strategies built on existing trends within society or help populations to manage groundwater resource base directly.

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