SUSTAINABLE WATER MANAGEMENT IN AGRICULTURAL DEVELOPMENT - A REVIEW

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Abstract

Sustainable water management (SWM) requires allocating between competing water sector demands, and balancing the financial and social resources required to support necessary water systems. The objective of this review is to assess SWM in three sectors: urban, agricultural, and natural systems. This review explores the following questions: (1) How is SWM defined and evaluated? (2) What are the challenges associated with sustainable development in each sector? (3) What are the areas of greatest potential improvement in urban and agricultural water management systems? And (4) what role does country development status have in SWM practices? The methods for evaluating water management practices range from relatively simple indicator methods to integration of multiple models, depending on the complexity of the problem and resources of the investigators. The two key findings and recommendations for meeting SWM objectives are: (1) all forms of water must be considered usable, and reusable, water resources; and (2) increasing agricultural crop water production represents the largest opportunity for reducing total water consumption, and will be required to meet global food security needs. The level of regional development should not dictate sustainability objectives; however local infrastructure conditions and financial capabilities should inform the details of water system design and evaluation.

Keywords: Water management, urban water systems, Irrigation, Water requirements.

INTRODUCTION

Water resources have been historically regarded as essential for a good agricultural output and adequate food supply for the people. All ancient civilizations that have prospered developed successful water resources management schemes. Water resources for agriculture and food production are classified as either surface or underground water. In humid climates surface water is the main source for irrigation systems. Under sub-humid and arid conditions, underground water is the major water resource for agriculture and food production.

Water in the form of rain and snow is made available by nature in the yearly hydrological cycle. Precipitation is even intercepted by the vegetation, infiltrated into the ground or runs off as runoff. From infiltrated amounts, a sizeable part goes to evapotranspiration for biomass generation. Another part percolates into the water table feeding natural aquifers. Surface runoff concentrates in channels that drain into larger channels making up a watershed drainage network that discharge into the sea or is stored in lakes or dams. Water is recycled continuously through transpiration, evaporation from land, river systems and oceans. A watershed or river basin is a natural entity that should be used as an integrating unit for water resources planning.

Precipitation, withdrawals and availability of water vary widely around the world. Per capital availability is highest in Latin America and lowest in North Africa and the Near East while withdrawals are highest in North America and lowest in Africa. Per capital water availability in Europe and North America is not expected to change greatly by 2000 while Asians, Africans and Latin Americans will face less per capital water availability as their populations continue to grow. The present global water use for agriculture and food production is about 70% of the total. As demands rise in all the sectors, availability problems will enlarge. The potential water resource available in various regions and countries to meet the requirement of 2025 is extremely varied.

GROUND WATER RESOURCES AVAILABILITY

Rainfall is the major source of ground water recharge in India, which is supplemented by other sources such as recharge from canals, irrigated fields and surface water bodies. A major part of the ground water withdrawal takes place from the upper unconfined aquifers, which are also the active recharge zones and holds the replenishable ground water resource. The replenishable ground water resource in the active recharge zone in the country has been assessed by Central Ground Water Board jointly with the concerned State Government authorities. The assessment was carried out with Block/Mandal/Taluka/Watershed as the unit and as per norms recommended by the Ground Water Estimation Committee (GEC)-1997. As per the latest assessment, the annual replenishable ground water resource in this zone has been estimated as 432 billion cubic meter (bcm), out of which 399 bcm is considered to be available for development for various uses after keeping 34 bcm for natural discharge during non-monsoon period for maintaining flows in springs, rivers and streams (Central Ground Water Board, 2006).

Ground water extraction for various uses and evapotranspiration from shallow water table areas constitute the major components of ground water draft. In general, the irrigation sector remains the main consumer of ground water. The ground water draft for the country as a whole has been estimated as 231 bcm (Central Ground Water Board, 2006), about 92 percent of which is utilized for irrigation and the remaining 8 percent for domestic and industrial uses. Hence, the stage of ground water development, computed as the ratio of ground water draft to total replenishable resource, works out as about 58 percent for the country as a whole. However, the development of ground water in the country is highly uneven and shows considerable variations from place to place.

MANAGEMENT OF GROUND WATER RESOURCES

Management of ground water resources in the Indian context is an extremely complex proposition as it deals with the interactions between the human society and the physical environment. The highly uneven distribution of ground water availability and its utilization indicates that no single management strategy can be adopted for the country as a whole. On the other hand, each situation demands a solution which takes into account the geomorphic set-up, climatic, hydrologic and hydrogeologic settings, ground water availability, water utilization pattern for various sectors and the socio-economic set-up of the region.

Any strategy for scientific management of ground water resources involves a combination of A) Supply side measures aimed at increasing extraction of ground water depending on its availability and B) Demand side measures aimed at controlling, protecting and conserving available resources. Various options falling under these categories are described in detail in the following sections.

SUPPLY SIDE MEASURES

As already mentioned, these measures are aimed at increasing the ground water availability, taking the environmental, social and economic factors into consideration. These are also known as 'structural measures', which involves scientific development and augmentation of ground water resource. Development of additional ground water resources through suitable means and augmentation of the ground water resources through artificial recharge and rainwater harvesting fall under this category. For an effective supply-side management, it is imperative to have full knowledge of the hydrologic and hydrogeologic controls that govern the yields of aquifers and behavior of ground water levels under abstraction stress. Interaction of surface and ground water and changes in flow and recharge rates are also important considerations in this regard.

1. Scientific Development of Ground Water Resources

a. Ground Water Development in Alluvial Plains

b. Ground Water Development in Coastal Areas

c. Ground Water Development in Hard Rock Area

d. Ground Water Development in Water-logged Areas

e. Development of Flood Plain Aquifers

2. Rainwater Harvesting and Artificial Recharge

DEMAND SIDE MEASURES

Apart from scientific development of available resources, proper ground water resources management requires to focus attention on the judicious utilization of the resources for ensuring their long-term sustainability. Ownership of ground water, need-based allocation pricing of resources, involvement of stake holders in various aspects of planning, execution and monitoring of projects and effective implementation of regulatory measures wherever necessary are the important considerations with regard to demand side ground water management.

GROUNDWATER DEVELOPMENT PROSPECTS IN INDIA

The analysis of available data indicates that contribution made by ground water to the agricultural economy of India has grown steadily since early 1970's. In just last two decades, the ground water irrigated lands in India has increased by nearly 105%, this change was most striking in northern India, the heart of the Green Revolution.

A close examination of the ground water resource availability in different geomorphological terrains of the country and its utilization as presented in Table 1, indicates that out of the total of 433 BCM of annual replenishable ground water resources available in the country .

The share of alluvial areas covering Eastern Plain states of Bihar, Orissa (part) , Eastern Uttar Pradesh and West Bengal; and North Western plain states of Delhi, Haryana, Punjab, Western Uttar Pradesh, Chandigarh; is about 192 BCM which is works out to be 44% of the total available resource. The enigma is in the eastern plain states the overall stage of ground water development is about 43%, whereas the overall stage of ground water development in North Western Plain states covering Punjab, Delhi and Haryana is 98%. Except Western part of Uttar Pradesh, a major part of the area is overexploited.

A perusal of statistics of the increase in the number of mechanized wells and tube wells also illustrates how quickly ground water irrigation has spread. Number of wells rocketed in the last 40 years from less than one million to more than 19 million in the year 2000 itself as per the last census record. Further, the ground water irrigation has greater impact in poverty alleviation, as in relation to the amount of land they cultivate, poor farmers are better represented than richer farmers in their use of ground water. Small and marginal farmers (less than 2 Hectares land) make up only 20% of the total agricultural area. Yet these small farmers account for 38% of the net area irrigated by wells and 35% of the tube wells fitted with electrical pump sets.

Probably, the time has come to focus our attention on analyzing the imbalances on the use of ground water. There is no doubt that overuse of ground water is occurring in isolated areas, and it can have devastating effects on communities. This leads to two burning questions about ground water overexploitation, why are some areas affected and not others? How can be it is pre determined or predicted? The answer becomes clear when one key point is understood: ground water use is dependent on Demand, not Supply. The fact that ground water is tapped only where there are large aquifers, or a lot of rainfall or surface irrigation systems exists – which results in more recharge to ground water may not be true in strict sense. This can be very well visualized from the fact that in spite of abundance of ground water resources, the utilization in the Eastern Plain states of Bihar, West Bengal is much less as compared to Punjab and Haryana. This proves the fact that ground water use is purely Demand driven. There might have been several reasons for less demand of water in the eastern states, but the fact remains that, there is ample scope of ground water development in these areas so as to balance the ground water use of country.

Hence, there is an urgent need to have a comprehensive accelerated ground water development plan for the areas having low stage of development and further scope for ground water development which should go parallel with the measures for ground water augmentation. The ground water governance must include the supply side management.

COASTAL AREAS

Many parts of the coastal areas of India have thick deposits of sediments ranging in age from Pleistocene to recent, which have given rise to multi-aquifer systems of good potential. There is considerable scope for development of ground water from such aquifer systems. However, development of ground water from such aquifers needs to be done with caution and care should be taken to ensure that over-exploitation of resources does not lead to saline water intrusion. Large diameter dug wells, filter point wells and shallow tube wells are ground water abstraction structures best suited for such aquifers. Radial wells and infiltration galleries can also be constructed in areas where the requirement of water is large. As the multi-aquifer systems in coastal areas are likely to have all possible dispositions of fresh and saline waters, it is necessary to take-up detailed studies to establish the saline fresh water interface and establish the replenishable discharge of ground water to sea. This will ensure the implementation of ground water development plans. Further, sanctuary wells need to be constructed in hydrogeologically suitable areas to meet the unforeseen situations during cyclonic disasters as well as Tsunamis.

WATER-LOGGED AREAS

Water-logging and soil salinity problems, resulting from gradual rise of ground water levels, are observed in many canal command areas due to the implementation of surface water irrigation schemes without due regard to environmental considerations. As per the assessment made by the Working Group on Problem Identification with Suggested Remedial Measures (1991), about 2.46 million hectare of land under surface water irrigation projects in the country is either water-logged or under threat of it. Such areas offer good scope for further ground water development as the shallow water table in such areas can be lowered down to six meters or more without any undesirable environmental consequences. The problems related to inferior quality of water in such areas can be solved by mixing them with the canal waters available.

Judicious development through integrated use of surface and ground water resources can greatly reduce the menace of water-logging and salinity in canal irrigated areas.

Such efforts will also be in line with the directives of National Water Policy which states that surface and ground water should be viewed as an integrated resource and should be developed conjunctively in coordinated manner and their use should be envisaged right from the project planning stage.

FLOOD PLAIN AQUIFERS

Flood plains of rivers are normally good repositories of ground water and offers excellent scope for development of ground water. Ground water levels in these tracts are mostly shallow, leaving little room for accommodating the monsoon recharge, a major portion of which flows down to the river as surface (flood) and sub-surface runoff. A planned management of water resource in these tracts can capture the surplus monsoon runoff, which otherwise goes waste. The strategy involves controlled withdrawal of ground water from the flood plains during non-monsoon season to create additional space in the unsaturated zone for subsequent recharge/infiltration during rainy season.

There are two distinct conditions as regards to induced recharge from the river/stream to ground water aquifer. The first condition involves setting up a hydraulic connection between the aquifer and the river as recharge boundary due to heavy exploitation of ground water and expansion of cone of depression. This condition is common in case of perennial rivers and leads to changes in river flow conditions in the downstream. The hydraulic connection between the river and the aquifer ceases as soon as pumping is stopped.

The second scenario is more common in case of rivers having intermittent flows; the loose sediments in the flood plains are more or less saturated resulting into shallower ground water level. The heavy withdrawal of such flood plain aquifers during the non-monsoon creates ample space in the ground water reservoir which gets recharged by the river during the flood season. In absence of such created space the river water would overflow. This condition is more prevalent in Indian scenario and provides opportunity for augmentation of ground water reservoir through induced recharge.

RAINWATER HARVESTING AND ARTIFICIAL RECHARGE

Rainwater harvesting and artificial recharge have now been accepted worldwide as cost-effective methods for augmenting ground water resources and for arresting/reversing the declining trends of ground water levels. Artificial recharge techniques are highly site-specific. Need suitability of area in terms of availability of sub-surface storage space and availability of surplus monsoon run-off is important considerations for successful implementation of artificial recharge schemes.

Rainwater harvesting and artificial recharge schemes implemented by various organizations in the country including Central Ground Water Board have shown encouraging results in terms of augmentation of ground water recharge, check in rate of decline of ground water levels and reduction of surplus run off. Increased sustainability of existing abstraction structures, increase in irrigation potential, revival of springs, soil conservation through increase in soil moisture and improvement in ground water quality are among other benefits of the schemes. In the coastal tracts, tidal regulators, constructed to impound the fresh water upstream and enhance the natural recharge are effective in controlling salinity ingress.

Experience gained from pilot artificial recharge schemes implemented by Central Ground Water Board in different hydrogeologically settings in the country has indicated that optimal benefits can be achieved when various recharge structures are constructed at suitable locations in complete hydrological units such as watersheds, sub-basins etc.

REGULATION OF GROUND WATER DEVELOPMENT

Regulation of over-exploitation of ground water through legal means can be effective under extreme situations if implemented with caution. Ground water regulatory measures in India are implemented both at Central and State level. The central Ground Water Authority, constituted under Environment (Protection) Act of 1986 is playing a key role in regulation and control of ground water development in the country. Central Ground Water Authority initially notifies over-exploited areas in a phased manner for registration of ground water abstraction structures. Based on data thus generated, vulnerable areas are notified for the purpose of ground water regulation. In these areas, construction of new ground water abstraction structures is regulated.

As water is a State subject, the management of ground water resources is a prerogative of the concerned State Government. Ministry of Water resources has prepared and circulated Model Bills to all States and Union Territories during 2005.

The main thrust of these bills is to ensure that all the States and Union Territories form their own State Ground Water Authorities for proper control and regulation of ground water resources. As water is a basic need and thereby an important social issue, the regulatory mechanism needs to be transparent and people-friendly.

Continuous monitoring of ground water regime is required in notified areas. Micro-level studies needs to be taken up in such areas on a regular basis to assess the impacts of the regulatory measures on the ground water regime. Real-time dissemination of information on the ground water situation in the affected areas is to be provided to the stakeholders. Involving local people in the administrative process as social volunteers may also help.

International experiences in ground water regulation and management are varied. United States ground water management practices are more in the form of financial incentives. In Spain and Mexico, water laws are formulated making ground water a national property. However, implementation of various clauses of ground water legislation could not be effectively achieved on a large scale in these countries (Planning Commission, 2007). National and international experiences indicate that enforcement of legislative measures for ground water regulation and management would be meaningful only when stakeholders are motivated through local self governing bodies and directly involved in the decision-making and enforcement process.

CONCLUSIONS

The highly diversified hydrogeologic settings and variations in the availability of ground water resources from one part of the country to other call for a holistic approach in evolving suitable management strategies. The emphasis on management needs does not imply that ground water resources in India are fully developed. Effective management of available ground water resources requires an integrated approach, combining both supply side and demand side measures.

There is a vast area in the Indo Gangetic alluvial plain where the ground water development is sub optimal and there is sufficient scope for future development. Similarly, urgent action is required to augment the ground water in the water stressed areas. However, focus on development activities must now be balanced by management mechanisms to achieve a sustainable utilization of ground water resources. Ground water constitutes the most important source of irrigation water in the Gangetic plains including the three states i.e. Bihar, Punjab and West Bengal. The productivity in terms of agricultural output is relatively low in Bihar and West Bengal as compared Punjab. Though, groundwater development for irrigation is feasible in these areas based on hydrogeological and environmental considerations, there is often a great economic barrier for the predominantly small and marginal farmers. A multitude of mechanisms have been developed or have emerged in these areas to enable farmers to benefit from ground water. Assured power supply is one of the key factors, the tariff, access and availability of which to a large extent determines the ground water use. Since the ground water development is mostly demand driven, it can be geared up through proper agricultural, credits, subsidy and energy support policies along with creation of suitable markets. In addition, the flood plains along the major river courses of the country offer good scope for groundwater development. Similarly, there are areas in the country with artesian condition, which can be mapped and suitable development plans formulated. In the alluvial areas, where multi-aquifer systems exist, there is a need to concretize methodologies for assessment of development potential of deeper aquifers. There is urgent an need for coordinated efforts from various Central and State Government agencies, non-Governmental and social service organizations, academic institutions and the stakeholders for evolving and implementing suitable ground water management strategies in the country.

REFERENCES

1. National Ground Water Congress, New Delhi

2. Central Ground Water Board (2002), Master Plan for Artificial Recharge to Groundwater in India. New Delhi.

3. Central Ground Water Board (2006), Dynamic Ground Water Resources of India . New Delhi.

4. Das, S. (2006), Groundwater overexploitation and importance of water management in India – Vision 2025. Tenth IGC foundation lecture. The Indian Geological Congress, Roorkee.

5. Llamas, M. Ramon, Mukherjee, Aditi and Shah, Tushaar (2006), Guest editors' preface on the theme issue "Social and economic aspects of groundwater governance. Hydrogeology Journal, vol. 14(3), pp. 269-274.

6. Ministry of Water Resources (2002), National Water Policy. New Delhi.

7. National Institute of Hydrology, Roorkee and Central Ground Water Board (2006), An operational model for groundwater pumping at Palla Well Fields, NCT Delhi – Project Report.

8. Planning Commission (under publication), Ground water ownership in the country. Draft report of the Expert Group.

9. Romani, Saleem (2006), Groundwater Management – Emerging challenges. Groundwater Governance – Ownership of Groundwater and its Pricing. Proceedings of the 12th National Symposium on Hydrology. November 14-15, 2006. New Delhi.

10. Shah, Tushaar and Shilp Verma (2007), Real-time Co-management of Electricity and Groundwater: An assessment of Gujarat's Pioneering Jyotigram Scheme - Discussion paper. International Water Management Institute (IWMI).

11. Ground water governance in the Indo-Gangetic and yellow River Basins - Realities and Challenges. Edited Vol. Aditi Mukherjee et.al, IAH selected papers.