Groundwater Governance and Managed Aquifer Recharge: Experiences and Lessons Learnt from Case Studies in North India

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Abstract: *Groundwater has traditionally been dealt in north Indian states with in a laissez-faire mode without attention to the sustainability of the resource. Groundwater institutions are in an evolutionary phase and no simple blueprints for management success are appropriate. The main objectives of this paper are to examine the institutional arrangements for groundwater governance in the states of north India and to discuss some case studies focusing on managed groundwater recharge (MAR) and to highlight some key policy options regarding the way forward in groundwater governance for the future. What really needs to be addressed is the demand-supply imbalance at the local level, which has already acquired serious proportion in north Indian states, as manifested by declining water tables. The increased use of and access to groundwater is often considered as instrumental behind spread of new agricultural technology in Punjab and Haryana. The pattern of development of groundwater in north Indian states has created a number of sustainability, equity and efficiency concerns. Groundwater overexploitation is a major concern. In Punjab, the level of exploitation is already at the level of around 98 per cent and Haryana follows with 80 per cent. The situation is also precarious in state of Rajasthan where the level of exploitation is about 62 per cent. Several parts of north Indian states have seen a steep decline in water tables. The implications of this trend are serious.*

An important ingredient in groundwater institutional framework is organizational form for groundwater governance. Groundwater is formally managed by government agencies, often at central and sometimes at a lower administrative level. With increasing groundwater scarcity problems, however, aquifer management organizations, which consist of local stakeholders, have started to develop. This tends to coincide with changes in the laws governing groundwater management, but can also happen spontaneously. In view of increasing thrust on development of groundwater resources, several attempts have been made to recharge these depleting resources in active recharge zone through community participation in MAR. The dominant method of MAR is through use of civil structures (such as check dams, recharge shafts, rainwater harvesting structures and ponds etc) that arrest or slow down surface runoff, under suitable hydro-geological and hydrologic conditions. Some states such as Rajasthan, Himachal Pradesh and Jammu and Kashmir have implemented few schemes for construction of these structures at scattered locations.

MAR has augmented groundwater supply and delayed the groundwater crisis. Significant policy efforts by respective state governments have occurred in recent past and have shown significant localized progress in key areas of groundwater governance, however, the major performance challenges and institutional issues continue to persist. Therefore, the correction of institutional and governance bottlenecks in the development of groundwater is very vital. The development of groundwater resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. The detrimental environmental consequences of over-exploitation of groundwater need to be effectively prevented by legislation and its enforcement by local government bodies. Groundwater recharge projects should be developed and implemented with community participation for augmenting the available supplies.

Keywords: *Groundwater, Governance, Managed Aquifer Recharge, Experiences, Lessons Learnt, North India*

1. Introduction:

Groundwater institutions can be defined as rules that define action situations, delineate action sets, provide incentives, and determine outcomes both in individual and collective decision setting in the context of groundwater governance, which can be broadly categorized as legal rules, policy rules, and organizational rules [1]. Groundwater institutions also share same features characterizing all other institutions such as subjective in origin and operation but objective in manifestation and impact [2], path-dependent in the sense that their present status and future direction are dependent on their earlier course and past history [3], stable and durable [4], hierarchic and nested both structurally [3, 5] and spatially [6] and embedded and complementary not only with each other but also with their environment defined by the cultural, social, economic and, political milieu [3]. Institutional arrangements for groundwater governance play an important role in allocating, managing and sustaining scarce groundwater resources, which have long been a vital legal, constitutional, and social issue [7]. Undoubtedly, institutional arrangements for groundwater governance largely influence the welfare outcomes; however, groundwater governance in India is confronted by several institutional challenges and grappling with poor performance, deterioration of infrastructure, high levels of extraction and related economic and environmental problems [8]. At the same time, there is little agreement about appropriate institutional arrangements for groundwater governance and criteria for successful institutional design [5, 9]. Thus, redefining groundwater institutions remains the top priority in the water policy arena.

In India, the spread of green revolution and development of drilling technology allowed the spreading of intensive groundwater abstraction in agriculture since mid 1960s, however, this was not accompanied simultaneously by the evolution of institutional arrangements. Therefore, the groundwater has traditionally been dealt in north Indian states with in a laissez-faire mode. Groundwater has been used to irrigate crops typically without attention to sustainability of resource, which has twofold effects: (a) unregulated groundwater use has permitted spectacular expansion of agricultural growth and lifted millions of people out of poverty, and (b) many aquifers are now under severe stress and groundwater cannot wholly sustain the production. Introducing aquifer management is a time-consuming and politically challenging endeavour in overexploited areas. North Indian states of India have started to proactively manage their groundwater resources; however, it is still in infancy stage and there are as yet few well-established examples of good practices and effective groundwater governance. As compared to surface water management, groundwater institutions in north Indian states are in an evolutionary phase and no simple blueprints for management success are appropriate. With above backdrop, main objectives of this paper are to examine the institutional arrangements for groundwater governance in north Indian states and to discuss some case studies focusing on managed groundwater recharge (MAR) and to highlight some key policy options regarding the way forward in groundwater governance for the future..

2. Methods:

The study has utilized the potentially rich sources of secondary data available through the publications of the national and international institutions, Ministry of Water Resources, the Central Ground Water Board (CGWB), Government of India and Governments of selected North Indian States and the research conducted by individual researchers.

3. Results and discussions:

3.1. Groundwater scenario:

Groundwater is being used in India since the Vedic times, for over 6,000 years. Today, India has 16% of world's population and only 6% of world's water resources and 2.5% of world's land. The annual precipitation in India is estimated to be 4000Bm^3, the southwest monsoon being the major contributor (3000Bm^3). The major and medium river basins contribute over 90% of the total runoff in the country. The Indo-Gangetic planes have enormous amount of water, but the current method of utilization is not appropriate [10]. Of the total water potential of 1869Bm^3, only 1122Bm^3 can be put to beneficial use. Out of this, 690Bm^3 is surface water and 432Bm^3 is replenishable groundwater [11]. Currently, total water use (including ground water) is 634 Bm^3, of which 83% is for irrigation. The demand for water is projected to grow to 813 Bm^3 by 2010, 1093 Bm^3 by 2025 and 1447 Bm^3 by 2050, against utilizable quantum of 1123 Bm^3. Clearly, there will be a considerable gap between the water need and availability in next few decades.

What really needs to be addressed is the demand-supply imbalance at the local level, which has already acquired serious proportion in north Indian states, as manifested by declining water tables. The increased use of and access to groundwater is often considered as instrumental behind spread of new agricultural technology in Punjab and Haryana. The pattern of development of groundwater in north Indian states has created a number of sustainability, equity and efficiency concerns. At national level, groundwater overexploitation may not be considered to be a major problem as India exploits only about 30% of annual utilizable potential. However, groundwater overexploitation is a major concern in north Indian states. For example, in Punjab, level of exploitation is already around 98% and Haryana follows with 80%. The situation is also precarious in states such as Rajasthan where level of exploitation is about 62% [12]. Among selected north Indian states, Punjab and Haryana have more groundwater resources from unconsolidated rocks. Several parts of north Indian states have seen a steep decline in water tables, often implying that water is being 'mined', or extracted at unsustainable rates. The implications of this trend are serious as these states of India are witnessing phenomenon of falling water tables, are also India's agriculturally important states with a heavy dependence on groundwater. The area irrigated by groundwater in states of Punjab and Haryana is over 61% and 48% respectively [13].

Groundwater utilization is very high in states of Punjab, Haryana, and Rajasthan. However, states like Himachal Pradesh and Jammu and Kashmir utilize only a small proportion of their groundwater potentials. If present trend in groundwater utilization in Punjab and Haryana continues, demands for water would need more supplies and such situation will be detrimental to development and can cause social upheaval and disruptions. The degree of groundwater exploitation has varied widely across north Indian states [12]. Some states have a large number of semi critical, critical and overexploited assessment units. Out of 237, 137 and 113 assessment units assessed jointly by State Groundwater Departments and CGWB in Rajasthan, Punjab and Haryana respectively, 32 (14%), 25 (18%), and 42 (37%) are safe, and high proportion of them are over-exploited (59% in Rajasthan, 75% in Punjab, and 49% in Haryana) [12].

In agriculture, water is mainly used for irrigation because of spatio-temporal variability in rainfall. Large tracts of north Indian states are deficient in rainfall and are drought prone. Hence, it is difficult to practice agriculture without assured irrigation during dry seasons. Water need of certain crops also makes irrigation necessary. For instance, water requirement of rice and sugarcane is very high, which can be met only through irrigation. The provision of irrigation makes multiple cropping possible and irrigated lands have higher agricultural productivity than unirrigated land. Further, high yielding varieties (HYVs) of crops need regular moisture supply, which is made possible only by a well developed irrigation systems. In fact, this is why that green revolution has largely been successful in Punjab and Haryana.

In these states of north India, more than 85% of their net sown area is under irrigation, where wheat and rice are grown. Of the total net irrigated area, 76.1% and 51.3% are irrigated through wells and tube wells respectively in Punjab and Haryana [12], which shows that these states have utilized large proportion of their groundwater potential and has resulted in groundwater depletion. Besides, the share of area irrigated through wells and tube wells is also very high in these states.

In most parts of the over-exploited areas, the prime cause of over-exploitation is the rising demand for groundwater from agriculture. Further, in groundwater irrigated areas, decisions on cropping pattern and cropping intensity, which are predominant determinants of agricultural demand for groundwater, are being taken largely independent of ease of groundwater availability. Thus, water intensive crops have tended to be grown even in face of scarcity of groundwater, if these crops are perceived to be relatively remunerative. Such distortions occur partly due to legal/regulatory regime governing groundwater and partly to minimum support price policy and agricultural trade policy currently being followed.

The problem has been compounded by availability of cheap/subsidized or even free power (for example in Punjab), since power is a main component of cost of groundwater. Moreover in other states, electric supply is not metered and a flat tariff is charged depending on horsepower of pump. This makes marginal cost of power zero and provides farmers with little incentive to use power or water more efficiently. Power subsidy has undoubtedly encouraged greater use of groundwater. In most districts of these states, concentration of dark blocks is more due to overexploitation of groundwater resources for agriculture.

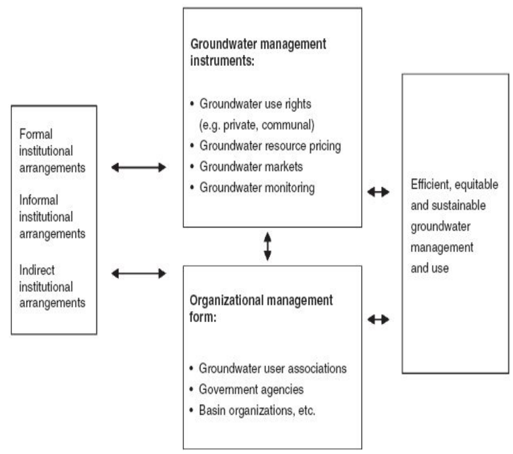
3.2. Groundwater institutions:

An important ingredient in groundwater institutional framework is organizational form for groundwater governance. Groundwater is formally managed by government agencies, often at central and sometimes at a lower administrative level. With increasing groundwater scarcity problems, however, aquifer management organizations, which consist of local stakeholders, have started to develop. This tends to coincide with changes in the laws governing groundwater management, but can also happen spontaneously. Figure 1 illustrates schematically how all of above constitute the institutional framework that conditions groundwater governance, with different institutional arrangements, instruments and organizational forms influencing each other.

Looking at legal framework for management of groundwater in India, there are no *de jure* rights in groundwater; but *de facto*, all landowners having the right to groundwater underlying their land. This is product of a set of colonial legislation, the Easement Act (1882), which allows private usufructuary rights in groundwater by viewing it as an easement inseparably connected to land. The Transfer of Property Act 1882 provides that easements (groundwater) can be given to one only if the dominant heritage (land) is also transferred. Conversely, the Land Acquisition Act asserts that if someone is interested in getting rights over groundwater, he would have to be interested in land. Thus, groundwater is viewed essentially as a chattel attached to land. There exists, at the same time, no limit to how much water a landowner may draw, in contrast to a legal structure that specifies well-defined property rights setting absolute limits to collective and individual withdrawals.

India is a federal republic and its constitution distributes the legislative power over some subject matters to the States, some to Centre and for some to both Centre and States. The constitutional provisions in respect of allocation of responsibilities between the States and the Centre fall into three categories: (i) The Union List (List I in the Seventh Schedule); (ii) The State List (List II in the Seventh Schedule); and (iii) The Concurrent List (List III in the Seventh Schedule). Under the Constitution, "Water" is a matter included in Entry 17 of List II in the Seventh Schedule i.e. in the State List. "Water" as such is a State subject and that States have jurisdiction to regulate and control groundwater, as Entry 17 of the State List, clearly states that water, that is to say, water supplies, where "water supplies" can be argued to include groundwater. The roles that the Government is expected to play in groundwater development and management are outlined in two important policy statements: National Environment Policy and National Water Policy.

Figure 1: Schematic of institutional framework for groundwater governance



Source: [14]

The National Environment Policy has suggested the following action points in relation to groundwater: (a) take explicit account of impacts on groundwater tables of electricity tariffs and pricing of diesel; (b) promote efficient water use techniques, such as sprinkler or drip irrigation among farmers and provide necessary pricing, inputs and extension support to feasible and remunerative alternative crops for efficient water use; (c) support practices of contour bunding and revival of traditional methods for enhancing groundwater recharge; (d) mandate water harvesting in all new constructions in relevant urban areas as well as design techniques for road surfaces and infrastructure to enhance groundwater recharge; and (e) support R&D in most effective techniques suitable for rural water projects for removal of arsenic and mainstream their adoption in rural drinking water schemes in relevant areas.

The Model Ground Water Bills have also been framed to form a template for the States in their own regulations of rainwater harvesting, notification of areas, requirements for applications for permits prior to digging and drilling of new wells, registration of existing wells and all existing water users. The salient features of the Model Bill are: (i) states to establish a Ground Water Authority; (ii) authority to have powers to notify areas for control and regulation of groundwater development; (iii) authority to grant permit for extraction and use of ground water in notified areas; (iv) existing users in notified areas and new users in non-notified areas to register with the Authority; (v) penalties prescribed for offences; (vi) states to implement rainwater harvesting for groundwater recharge. However, once again, provisions seek only to regulate the creation of water extraction mechanisms, rather than quantum of water withdrawn. Besides, there has been opposition to the bills on the grounds that like the past record with the system of licensing, they would tend to breed corruption and inequity. Besides, it is felt that such an approach ignores the possibility of successes through localized, participative approaches and adopts a simplistic, centralized approach that fails to consider wide array of management options suited to diverse sociological as well as hydro-geological contexts. Box 1 summarizes the institutional arrangements and responses for groundwater governance in India.

Box 1: Institutional arrangements and responses for groundwater governance

Institutional arrangements and responses
Cooperative tube well organizations
Emergence of groundwater markets
Groundwater extraction and water trading
Pricing arrangements for groundwater transactions
Check-dams
Common property institutional arrangements
Primarily used for groundwater recharge
Surface irrigation, livestock, and domestic needs
Beneficiary contribute to construction and maintenance

3.3. Groundwater regulation:

Some North Indian State governments have enacted groundwater legislation. An attempt has been made in the following paragraphs to examine the approach to and experience with groundwater regulation in case of Punjab, Himachal Pradesh and Rajasthan. Punjab is a predominantly agrarian state having 85% of its geographical area under cultivation with an average cropping intensity of 188%. The water demand for the kind of agricultural practices followed in the State is very high and a large part of it is for groundwater. Out of 137 blocks in the State, only 25 are safe; 103 are over exploited, 5 critical and 4 semi-critical. Punjab is not in favour of groundwater legislation as it apprehends that such a step will cause hardship to farmers. Instead, to tackle groundwater over exploitation, the State is in favour of the following initiatives: (i) crop diversification by extending minimum support price to other crops to wean away farmers from paddy cultivation, which is water intensive and contract farming for sowing alternative crop of chick-pea has been successfully tried; (ii) large scale artificial recharge through construction of check dams, use of drainage water and roof top rainwater harvesting; (iii) electricity supply to be controlled, regulated and metered supply in critical areas; (iv) micro irrigation for promotion of drip and sprinkler to conserve water; and (v) alteration in crop calendar by encouraging late sowing of paddy after 16th June to decrease evapo-transpiration. Punjab is also contemplating complete ban on new tube wells and restricting horse power to 10 HP so that deeper aquifers are not tapped. Pumps need to be replaced with energy efficient pumps. Conjunctive use of saline and fresh water will also help in bringing down the demand for fresh water.

Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005 stipulates for establishment of "The Himachal Pradesh Ground Water Authority" with power to notify areas to regulate and control the development and management of groundwater, maintain database on groundwater, grant permit to extract and use groundwater, register existing groundwater users and drilling agencies, alter, amend or vary terms of permit or certificate of registration, cancel permit or certificate of registration, and collect royalty in respect of use of groundwater. Every user of groundwater in a notified area shall install water measuring device on ground water abstraction structure. Emphasis should be made on rainwater harvesting for conservation and groundwater recharge. Provisions have also been stipulated for cognizance and trial of offences and penalties.

Box 2: Groundwater institutions in Rajasthan

Institutional aspects of groundwater development
Regulation of exploitation of groundwater resources as not to exceed recharging possibilities and also to ensure social equity Periodical reassessment on a scientific basis of groundwater potentials Amending existing laws/new legislation be enacted Controlling deep drilling through licensing and control on private operators Public awareness for self-control in groundwater exploitation from WUAs Developing a sense of water scarcity and need to conserve Improving data collection Preventing detrimental environmental consequences of over exploitation of groundwater Review and charging rationalistic and realistic water rates Volumetric measurement of water consumption in all sectors

In the context of most driest State of Rajasthan, it has been propagated that groundwater institutions need to be evolved and strengthened for optimal economic development and social well-being, which calls for an integrated and multi-disciplinary approach to planning, evaluation, approval and implementation of irrigation and drainage projects, including river basin management, of surface and groundwater. There is need for optimisation of groundwater resources exploitation and raising the level of reliability of supplies through conjunctive use of surface and groundwater. Besides, judicious and economically sound allocation of water resources to different sectors has also been called for. Institutional aspects and mechanisms for groundwater governance in Rajasthan are presented in box 2.

In sum, ownership of groundwater should be governed by ownership of land to the extent the uses (exploitation) of groundwater is not causing depletion in groundwater levels so similar rights of adjoining land owners and public at large are not encroached upon as this natural resource is meant for public use and it should not be allowed to be exploited beyond replenishable level. Therefore, there is a need of an "Act" at the State level to monitor the groundwater levels through scientific methods by piezometers under the advisory guidance of CGWB.

State Government should also ensure that groundwater levels should not fall below replenishable level and accordingly take necessary measures for regulation/restriction of groundwater uses in area. Enforcement for regulation/reduction/restriction in groundwater usage should be made effective by State Government through users' group/community participation/ involvement of Panchayat. Users group should be responsible for regulating groundwater usage among various sectors i.e. irrigation, drinking and industrial. Such regulations by user group will be made effective on advice of State Ground Water Board (SGWB). CGWB along with SGWB should assist State Government in controlling over exploitation through negative and positive incentives such as restricting institutional loans, limiting electricity supply, strengthening oversight of community specially that by user group. Positive incentives can be supported for rainwater harvesting and watershed development. Also CGWB and SGWB should prepare suitable guidelines for aquifer water management based planning for use of groundwater. Efforts should be made to merge schemes for watershed development, rainwater harvesting etc. along with involvement of panchayat in critical and semi-critical areas.

3.4. Case studies:

3.4.1. Bhakra canal augmentation system:

In 1908, a proposal was made to construct Bhakra dam on river Sutlej and in 1963 construction of dam was completed and irrigation system was made fully operational. Projects on rivers Ravi, Beas and Sutlej are shown in Figure 2 and Bhakra command in Punjab is shown in Figure 3. Proposed irrigation potential was overestimated up to 25% compared with available water and storage and no planning was made for conjunctive use of water in command area due to ample availability of water through Beas-Sutlej-Ravi system. However, groundwater (especially dugwells) is a significant source of irrigation.

With advent of Green Revolution, tubewell irrigated areas had dominated over canal irrigated areas in Punjab. Same is true of Haryana too. Thus, besides Bhakra canal system, groundwater is major source of irrigation, which is responsible for less utilization of irrigation in the Bhakra command. In districts of Punjab (Patiala, Fatehgadh, Jalandhar and Kapurthala), net area irrigated from Bhakra canals ranges from 1.5% to 19%, whereas in districts of Haryana (Hissar, Sirsa and Fatehbad), due to poor quality of groundwater, dependence on canal irrigation is high. High dependence on groundwater for irrigation in Punjab and Haryana is due to use of high yielding varieties (HYV) of seeds requiring assured water supply, which also coincided with droughts of 1965-66 and 1966-67. The cropping pattern in Punjab with Bhakra command irrigation intensity of 62% also compels farmers to use tubewells even in saline groundwater areas. Besides, water of Bhakra canal system has also declined due to deterioration of the structures and siltation of reservoir (Duggal et al, 2002).

Figure 2: Projects on rivers Ravi, Beas and Sutlej

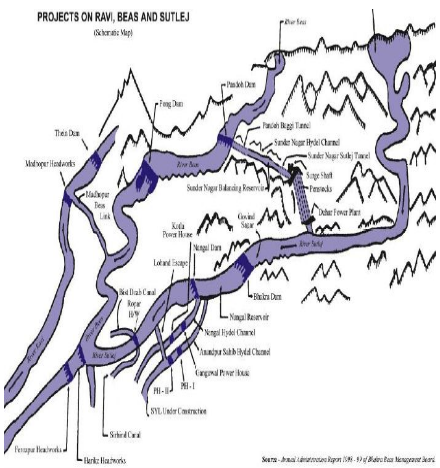
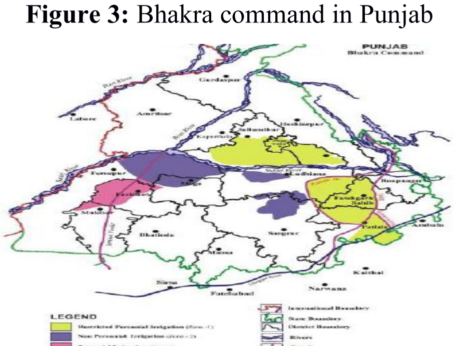


Figure 3: Bhakra command in Punjab



Over the period, over-extraction of groundwater has resulted in classifying several districts as “dark” and “grey”, which has serious repercussions on agricultural sustainability in Punjab and Haryana. Groundwater level in Punjab is going down by 30 cms per annum and a critical water table depth below 10 m has been reached in most parts of districts of Ludhiana, Sangrur, Jalandhar, Patiala. Situation is worse in districts of Haryana. The declining water tables are putting economic costs on users for re-boring, deep drilling, use of submersible pumps, poor water quality, etc. Thus, groundwater crisis are responsible for mounting hardships and economic costs to users, which calls for appropriate actions to address groundwater crisis and may include change in power tariffs, subsidizing diesel and change in cropping pattern and intensity.

3.4.2. Participatory irrigation water management

India has embarked upon participatory irrigation management (PIM), under which management of some of systems is being turned over to water users’ associations (WUAs). WUAs reflect definite institutional arrangements in which rewards and sanctions were clearly defined in order for systems to work. Integrated watershed development project (IWDP), Jammu and Kashmir decision on PIM was a step in this direction. WUAs were expected to serve as channels for feedback and feed-forward information to improve performance and services provided by operation and maintenance (O and M) and to transfer irrigation management to users. WUA is basic foundation of irrigation reform process under IWDP. The election process to form WUAs was highly democratic and fair and was conducted in a participatory manner. Initially, WUAs have been formed in those areas where physical infrastructure for irrigation already existed in the form of water harvesting structures and small canal outlets in upper hill slopes fed by rains, which were in need of repairs and maintenance.

To begin with, entire reform process has been repair and renovation oriented [16]. Majority of works have been done through WUAs along with *panchayats* (village level democratic institutions). WUAs have executed works in a fair and impartial manner, with proper records of all financial transactions maintained, and contracts given in a fair and just procedure. In general, cost of works done by WUAs was 25% lower than those carried out by contractors [17]. Project authorities have given clear instructions that there will be no new structures, or alteration of original designs. So, major emphasis has been on restoring original designs. Repairs and strengthening of structures, adding of missing structures, desilting structures, installation of water regulation structures wherever damaged or not installed earlier, and strengthening distribution channels and bunds were some of major works carried out by WUAs. In process of users identifying and executing works in case of drainage system, a lot of attention has been paid on users' needs like cattle pathways, bathing steps for women, removal of encroachments and clearing shrubs and silt for smooth flow of water till the tail-reach. System of voluntary labour contribution has been introduced for improving water-harvesting structures. In some cases, WUAs has been trapped in difficulties owing to lack of proper manpower and material planning, which resulted in severe losses to them.

The extent of area to be cultivated as well as timing of start of irrigation in a particular season was generally decided by WUAs in light of available water supply and rainfall at beginning of season. As entire service area cannot be irrigated, system was confronted with problem of rationing supplies. Mechanisms have been evolved to ensure equitable sharing of shortfall in supplies among all users. Acreage rationing was one element of water rationing system. In times of shortage, water allocation was regulated even more strictly to ensure that all users share reduction in both area and water supply in more or less the same proportion. A system of rotational use of water was adopted even in a normal year to permit all users to grow paddy. WUAs have established conventions regarding timing of repairs, division of work, and responsibility of members and obligations of users. There was provision of sanction (ranging from fines to loss of water rights) against non-compliance, for which WUA has authority to enforce sanction to ensure compliance. However, not even a single case has been reported of sanction against non-compliance. Potential beneficiaries were mobilized on issue related to fair sharing of benefits and costs. Users' participation has resulted in cost-effectiveness in repairs and maintenance and efficient management. If conflicts occur among users, executive committee of WUA had mediated disputes among its members. Disputes that cannot be resolved at WUA level were referred to village *panchayat*.

There were perceptible economic gains to farmers after initiation of PIM [17]. Land values have increased in range of 10-15%. New acreage has been added to irrigate lands due to better coverage and maintenance. Irrigated area has increased mainly in tail-reaches. With better maintenance of irrigation system, availability of water for various crops has increased. Level of income derived from various crops has increased significantly. Cropping pattern may now conveniently be shifted to some extent to commercial crops like vegetables and pulses. Overall, the cropping intensity has improved. WUAs have addressed the key issues pertaining to irrigation management: institutional structure, incentives, accountability, transparency, and sustainability. Ultimately, WUAs will need to be financially self-sustainable, which essentially depends on their capacity to operate and manage the system on their own, after the withdrawal of IWDP. There is need to transfer all operation and maintenance function to WUAs in near future. There is also need to ensure replicability of the successes achieved.

3.4.3. Managed groundwater recharge: Some evidences

In view of increasing thrust on development of groundwater resources, several attempts have been made to recharge these depleting resources in active recharge zone through managed aquifer recharge (MAR). The dominant method of MAR is through use of civil structures (such as check dams, recharge shafts etc) that arrest or slow down surface runoff, under suitable hydro-geological and hydrologic conditions. Some States such as Rajasthan, Himachal Pradesh and Jammu and Kashmir have implemented few schemes for construction of these structures at scattered locations.

Water Harvesting through Check dam

MAR through rainwater harvesting is being practised in different parts of Himachal Pradesh and Jammu and Kashmir. MAR yields encouraging results in terms of arrest of rate of decline in groundwater levels, reduction of run off, increased availability of groundwater especially in summer months (when demand is more), increase in irrigation, and revival of springs, improvement of the environment through increase in soil moisture and improvement in groundwater quality. The efficacy of MAR scheme is not uniform and depends largely on source of water availability, capability of groundwater reservoir to accommodate it, site selection and design of artificial recharge structure. Check dams, recharge shafts and sub-surface barriers are effective structures in hard rock areas of Jammu and Kashmir and Himachal Pradesh.

Rainwater Harvesting

Runoff Farming Water Harvesting

Besides, collected runoff water is being diverted directly into cropped area during rainfall event known as runoff-farming water harvesting. Generally, quantity of runoff exceeds infiltration capacity of soil. Therefore, ridges, borders or dikes are placed around cropped area to retain water on soil surface. Surface storage based irrigation water harvesting system is practiced when crop water requirements cannot be met due to inter-seasonal rainfall distribution. Surface storage structures range from an underground storage on-farm pond or tank to a small dam constructed across the flow.

Water Harvesting through Farm Pond

However, even with full development of MAR, groundwater availability would remain limited. It is, therefore, critical to find ways to limit use of groundwater to keep it sustainable. Cooperative management by users to facilitate groundwater use in an equitable manner seems inescapable. While groundwater recharge schemes may not be the final answer, they do call for community efforts and create spirit of cooperation needed to subsequently manage sustainably groundwater as a community resource.

4. Conclusion:

The rate of extraction of groundwater is increasing in north Indian States and in many blocks exceeds the rate of recharge leading to lowered water tables and higher proportion of blocks are now semi-critical, critical or over exploited. Number of dark or over exploited critical is increasing rapidly. Artificial recharge has augmented groundwater supply and delayed the crisis. Experience of north Indian States with groundwater governance shows that by itself it is not very effective and requires community cooperation. Groundwater institutions in India remains legally weak, functionally disjoint, sectorally biased, and regionally uncoordinated. While physical stress and financial crisis have exposed the legal, policy, and administrative weakness of water sector, myopic political issues and administrative resistance have impeded institutional change. Similar is the situation of selected north Indian States. Significant policy efforts by respective State governments have occurred in recent past and have shown significant localized progress in key areas of groundwater governance, however, major performance challenges and institutional issues continue to persist. Therefore, correction of institutional and governance bottlenecks in development of groundwater is very vital.

Since there is a declining availability of fresh water and increasing demand, need has arisen to conserve and effectively manage this precious life giving resource for sustainable development. There is urgent need to take quick steps and make effective policies and laws and adopt effective measures for groundwater conservation. Besides developing water saving technologies and methods, concerted attempts need to be made to prevent groundwater pollution. There is also need to encourage MAR through watershed development, rainwater harvesting, water recycling and reuse, and conjunctive use of water for sustaining groundwater supply in long run.

Use of groundwater resources should be so regulated as not to exceed recharging possibilities, as also to ensure social equity. Detrimental environmental consequences of over-exploitation of groundwater need to be effectively prevented by legislation and its enforcement by local government bodies. To give teeth to their actions the Central and State governments should enact suitable legislation and notify permissible water depths to which groundwater depletion will be permitted for each region/block/watershed after identifying special problems of each area. MAR projects should be developed and implemented with community participation for augmenting available supplies.

Government should transfer authority for regulating groundwater use to lowest level, village panchayat. Government should have responsibility of laying down rules and regulations and then monitoring implementation. Effective groundwater governance requires (a) awareness of status of groundwater, both its quality and the quantity available and monitoring is a prerequisite in order to identify whether problems are occurring or are likely to occur; (b) understanding of aquifer sufficient to be able to identify options (and targets) to remedy a problem situation; (c) water laws and rights in place, widely accepted and clear, or in their absence a practicable system of incentives/disincentives; (d) surveillance, to monitor adherence to regulatory measures or response to incentives/disincentives; and (e) awareness in governmental planning and society at large of the importance of groundwater. Unfortunately these requirements are very rarely met in full. In particular, water rights and laws applied to groundwater can be ambiguous or uncertain in their interpretation. Realistically, changing the situation will take time, but long term goals need to include (a) increasing public and government awareness so that legislation on water issues (like ownership and rights) can be passed and enforcement accepted by society at large; (b) resourcing agencies to actively manage groundwater; (c) encouragement of community management; and (d) incentives (or disincentives) to reduce pollution load.

5. References:

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