Paper No. 717

GROUNDWATER MANAGEMENT IN PAKISTAN: THE QUESTION OF BALANCE

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By

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Abstract

In Pakistan, on-demand availability of groundwater has transformed the concept of low and uncertain crop yields into more assured crop production. Increased crop yields have resulted in food security and improved rural livelihoods. However, this growth has also led to problems of overdraft, falling watertables and degradation of groundwater quality, therefore yields generally remain well below potential levels. Over the last three decades, Pakistan has tried several direct and indirect management strategies for groundwater management. However the success has been limited. This paper argues that techno-institutional approaches such as introducing water rights, direct or indirect pricing and permit systems are fraught with difficulties in Pakistan due to its high population density and multitude of tiny users. Therefore there is a need to develop frameworks and management tools that are best suited to Pakistani needs. Pakistan should follow both supply and demand management approaches. For demand management, adoption of water conservation technologies, revision of existing cropping patterns and exploration of alternate water resources should be encouraged. For supply management, implementation of the groundwater regulatory frameworks developed by Provincial Irrigation and Drainage Authorities (PIDAs) and introduction of institutional reforms to enhance effective coordination between different organizations responsible for the management of groundwater resources should be given priority.

Keywords: groundwater management, Pakistan, institutional reforms, groundwater development, regulatory framework

1. INTRODUCTION

1.1 Groundwater development in Pakistan-historical perspective

The Indus Basin is underlain by an extensive unconfined aquifer covering about 16 million ha of surface area, of which 6 million ha are fresh and remaining 10 million ha are saline (Haider et al., 1999). The aquifer receives its direct recharge from natural precipitation, river flow, and the continued seepage from the unlined canals, distributaries and watercourses and application losses from the irrigated fields. The safe groundwater yield is estimated to be about 68 BCM, whereas the extraction for agriculture, domestic and industrial sectors is already approaching to about 56 BCM. This virtually means that this resource is available for future in very limited quantity. Furthermore, the remaining potential is located in areas where groundwater quality is poor or in areas where it is economically not feasible to extract it for normal crop use such as hard rock areas of Balochistan.

Large-scale extraction and use of groundwater for irrigated agriculture in the Indus basin started during the 1960s with the launching of Salinity Control and Reclamation Projects (SCARPs). Under this public sector program, 16,700 wells (supplying an area of 2.6 million ha) with an average capacity of 80 l s^{-1}were installed to control groundwater and salinity problems (Bhutta

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and Smedema, 2007). The pumped groundwater was discharged into the canal system to increase irrigation supplies (Qureshi et al., 2008).

Following SCARP and the provision of subsidized electricity and introduction of locally made diesel engines provided an impetus for a dramatic increase in the number of private tubewells. Currently, about 1.2 million small capacity private tubewells are working in Pakistan (Qureshi et al., 2008). Out of these, 800,000 are only located in Punjab (Figure 1). According to recent estimates, 13% of these tubewells are run by electricity whereas the rest 87% are run by diesel engines of various capacities (Qureshi and Akhtar, 2003; World Bank, 2007). Diesel engines are preferred by farmers because of their low installation and operational costs as compared to electric tubewells. Diesel tubewells are also more feasible for small and fragmented land holders.

Investments on the installation of private tubewells are of the order of US$ 400 million whereas the annual benefits in the form of agricultural production are to the tune of US$ 2.5 billion (Shah et al., 2003). The estimated number of users is over 2.5 million farmers, who exploit groundwater directly or hire the services of tubewells from their neighbors. Their behavioral patterns are highly variable and they understand little about any adverse interaction, which is likely to result due to unsystematic and erratic nature of groundwater exploitation. Their major interest is to pump even more water to meet the crop water requirements. On average, every fourth farming family has a tubewell and a large proportion of non-owners purchase groundwater through local, fragmented groundwater markets (Qureshi and Akhtar, 2003). The groundwater is currently providing more than 50% of the total crop water requirements with the flexibility of its availability on as and when needed basis (Shah, 2007).

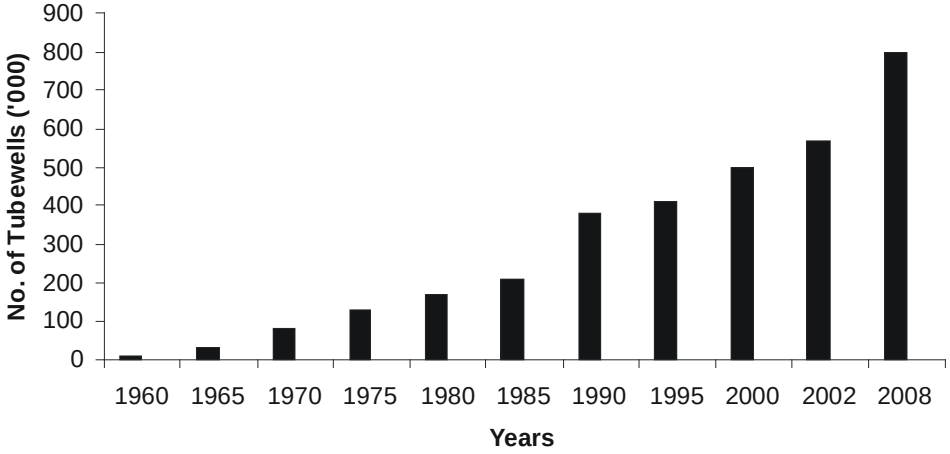


Figure 1: Historical development of private tubewells in the Punjab Province.

1.2 Patterns and Benefits of groundwater use

More than 70% of the private tubewells are being used to irrigate lands in conjunction with the canal water whereas the rest provides irrigation based on groundwater alone. The area irrigated by groundwater alone has increased from 2.7 million ha (Mha) to 3.4 Mha whereas the area irrigated by canal water alone has decreased from 7.9 Mha to 6.9 Mha (Qureshi et al., 2004). The production of major crops such as wheat, cotton, rice and sugarcane is only sustainable because of the supplemental use of groundwater for irrigation. The average cost of irrigating with groundwater is 30 times higher than that of surface irrigation (World Bank, 2007). The cost of canal water per year per hectare is US$ 5.5, whereas the groundwater is marketed as 167 US$ per ha per year.

In the water short environment of the Indus basin, accessibility to groundwater is a dividing line between poverty and welfare. The uncontrolled and relatively cheap access to groundwater proved significant not only for the livelihoods and food security of the poor, but also as a driving force for rural economies. In many water short areas of Pakistan, it transformed the concept of low and uncertain crop yields to a more secure and predictable crop production. Groundwater exploitation enabled farmers to attain 50-100% higher crop yields as compared to those fully dependent on canal water.

The flexibility provided by groundwater has strategically supported employment generation, rural development and poverty alleviation. The role groundwater irrigation has attained in maintaining agricultural boom is very unique and vital and will further expand in future due to mounting pressure to grow more food and increasing incidences of drought in the region. Qureshiand Akhtar (2003) have shown that more than 70% of the farmers in the Punjab depend directly or indirectly on groundwater to meet their crop demands. This clearly indicates that without groundwater availability not only Punjab but the whole country would face food shortages as Punjab produces more than 90% of the total grains.

2. PROBLEMS OF GROUNDWATER DEVELOPMENT

2.1 Groundwater overdraft

The unregulated and uncontrolled use of groundwater diminished the relative accessibility. The trend of continuous decline of the groundwater table has been observed in many areas of the Indus basin, which illustrates the serious imbalance between abstraction and recharge (Figure 2). Many wells have gone out of production, yet the water tables continue to decline and the quality deteriorates. Depletion of groundwater is more pronounced in non-canal command areas of Punjab and where surface water supplies are low and agriculture is heavily dependent on groundwater (Qureshi et al., 2008).

Excessive mining of aquifers in fresh groundwater areas has resulted in falling water tables and groundwater has become inaccessible in 5% and 15% of the irrigated areas of Punjab and Balochistan provinces, respectively. Although no recent estimates exist, it was estimated that under the *business as-usual* scenario, this area is expected to increase to 15% in Punjab and 20% in Balochistan by 2020 (PPSGDP, 2000).

With the increasing groundwater table depths (> 15 m), farmers were left with no choice than to drill deeper wells. This transformation led to increased installation and operational costs due to high energy use. The construction cost of a deep electric tubewell (>20 m) is US$ 5000 as compared to US$ 1000 for a shallow tubewell (< 6 m). The average cost of installation of such a pump is about US $ 10,000 in Balochistan and maintenance of these deep tubewells is generally beyond the capacity of poor farmers. The electricity for pumping groundwater is heavily subsidized in Balochistan. The negative side of this subsidy is that only rich farmers having deep tubewells are the real beneficiaries and the poor are not getting any benefit of this state facility. This policy is not only creating unrest in the society but also exacerbating the problems of groundwater over-draft in Balochistan.

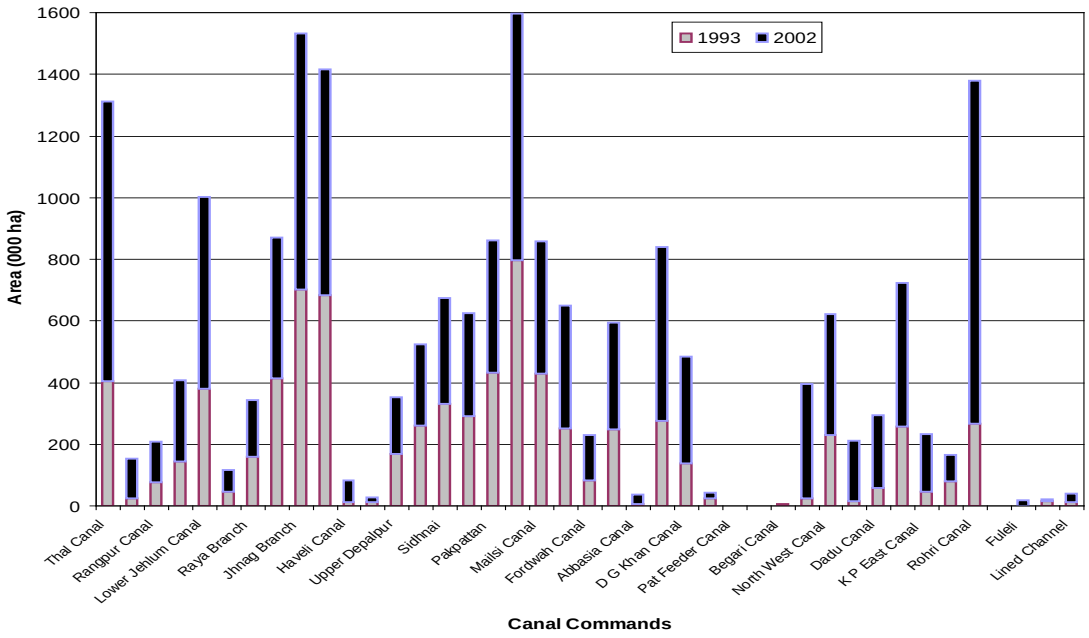


Figure 2: Increase in area with a groundwater table depth of 300 cm over a period of 10 years (1993-2003) in different canal commands of Punjab and Sindh provinces.

2.2 Deterioration of groundwater quality

The quality of groundwater in the Indus Plains varies widely, both spatially and with depth and is related to the pattern of groundwater movement in the aquifer (Qureshi et al., 2008). There are large numbers of saline groundwater pockets in the canal command areas of Punjab. About 77% (4 million ha) of the area in Punjab province has access to fresh groundwater. Saline waters are mostly encountered in central Doab areas. Cholistan area in the southern Punjab is well known for highly brackish waters, which cannot be used for drinking purposes. In some parts of Punjab, there are also reports of high flouride content (7-12 mg/l) and high concentrations of arsenic (50 μg/l) in the groundwater. Spatial distribution of groundwater quality and comparison of groundwater qualities over a period of 25 years (1977-2003) in the Punjab province is shown in Figure 3.

In the Sindh province, about 28% of the area has access to fresh groundwater. Large areas are underlain by poor quality of groundwater (Figure 3). In the lower parts of the Indus plain, the area of fresh groundwater is confined to a narrow strip along the Indus River. Excessive pumping of this layer is causing salt water intrusion into fresh groundwater areas. This situation has already abandoned 200 public tubewellslocated in the fresh groundwater zone of Sindh province (Qureshi et al., 2004).

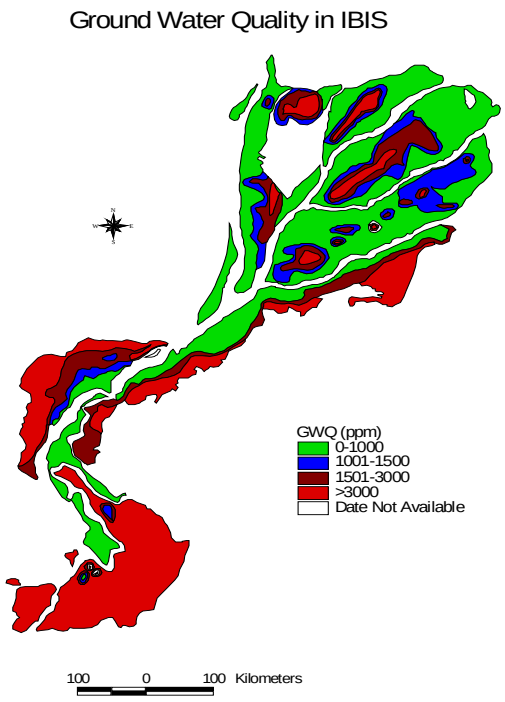


Figure 3: Groundwater quality of the Indus Basin (Qureshi et al., 2004).

2.3 Socio-economic and environmental impacts

Declining groundwater tables and land degradation as a result of poor quality groundwater use for irrigation has seriously affected the social fabric of Pakistani society. Drying up of karez systems in Balochistan have increased the livelihood burden on women due to immigration of spouses for income supplementation. On average, a woman must carry more than 200 liters of water every day over long distances, which creates an enormous burden on her time and physical capacities. Similar conditions also exist in the Cholistan area of Punjab where women have to walk miles to bring fresh drinking water from natural streams as groundwater is very deep and hazardous to health.

Soil salinity remains a hazard for the Indus basin and threatens the livelihood of farmers, especially the small-scale ones. The extent of salt-affected lands has decreased to about 4.5 million hectares from about 6 million hectares in 1980s (WAPDA, 2007). Land degradation is reducing the production potential of major crops by 25%, valued at an estimated loss of US $ 250 million per year (Haider et al., 1999). Groundwater overdraft has also led to sea water intrusion in the coastal areas of the Indus basin which is threatening ecology of wetlands. Important aquatic resources, mangrove forests and coastal areas need to be protected. Mangrove forests cover 130,000 ha and are an important source of firewood and provide the natural breeding ground for shrimps. Similarly fresh water fish are an important source of protein along the Indus.

3 PROBLEMS OF GROUNDWATER MANAGEMENT

Until recently the management of groundwater in Pakistan did not receive much attention because the resource was in abundance and therefore the focus remained primarily on its development as discussed above. The spectacular expansion of agriculture helped lift millions out of poverty. However, the situation began to turn serious when such unregulated exploitation brought many aquifers under severe stress and threatened the sustainability of this resource.

The major reason for these negative developments is that the management of groundwater could not keep pace with its development. Over the last three decades, Pakistan has tried several direct and indirect management strategies to control overexploitation of groundwater but these have so far remained ineffective.

3.1 Non-implementation of regulatory laws

Over the last three decades, government has introduced many laws for regulating groundwater in Pakistan. In 1980s, licensing system was introduced to restrict installation of private tubewells in the critical areas (where groundwater was falling at faster rate and/or where groundwater quality was deteriorating). At the provincial level the groundwater regulatory framework for Punjab province was prepared in the 1990s with the assistance of the World Bank. The national groundwater management rules were also drafted under Provincial Irrigation and Drainage Authority (PIDA) act in 1999-2000 and included in the Canal act of 2006. Similar law was developed by the Balochistan government (Balochistan Groundwater Rights Administration Ordinance, 2001). These rules suggested demarcation of critical areas, provision of licenses for the installation of tubewells especially in critical areas and registration of all tubewells (ACE-Halcrow, 2003). This regulatory framework was submitted to the provincial governments for implementation. However, like many other laws, these recommendations could not get the attention of the government and the problem of groundwater management remains a challenge.

Despite plethora of laws and policies developed by government, no serious effort was made for implementing them. In addition to historical neglect, the provision of human and financial resources for the groundwater management remains very limited. Unlike the management of surface water resources (Lohmar et al., 2003), there has been no effort to manage aquifers that span beyond administrative provincial boundaries. Another complication in the management of groundwater was that no single organization was responsible for managing the total resource base.

In addition to a lack of respect for the law and corruption in the public sector, the large number of groundwater users was also the major reason for the ineffectiveness of licensing policy in the Pakistani context. Institutional solutions to groundwater management have also proved to be far more complex than was originally thought. The government is usually under pressure to produce and secure food to feed the population and reduce poverty especially in rural areas where more than 70% of the population lives. With major investments in surface water and irrigation systems having declined sharply, the development of the groundwater resource allowed the expansion of irrigated agriculture to continue. With many farm families now highly dependent on groundwater for their livelihoods, the national government was reluctant to implement the regulatory laws.

3.2 Energy-groundwater nexus in Pakistan

Direct management of an economy with such a large number of players through enforcing laws, installing licensing and permit systems and establishing tradable property rights did not prove to be effective in Pakistan (Shah, 2007). Drawing on the models used in India where energy pricing policies provided an entry point for indirect management of groundwater (Shah, 2007), Pakistan also explored indirect management of groundwater through manipulation of energy prices, realizing that the characteristics of the relationship between groundwater and energy in Pakistan are somewhat different from that of India.

Progressive increases in electricity tariffs during 1990s coupled with the unannounced extended power cuts in the rural areas resulted in the stagnation of electric tubewells and a two fold increase in diesel tubewells. This clearly shows that pricing policies were meant to facilitate collection of revenues and not to control groundwater extraction. Changing tactics of the

government only forced farmers to shift from one mode of energy use to another but could not help resolve the real issue of groundwater overdraft. This clearly demonstrates the need to search for more innovative ways to solve the problem of groundwater over-exploitation while maintaining and improving on the current levels of agricultural production for the growing population in the country.

4. PROSPECTS OF GROUNDWATER MANAGEMENT

4.1 Sustainable management of conjunctive use of surface and groundwater

In Pakistan, groundwater is usually used in conjunction with the surface water. While doing so, farmers tend to decrease the salinity of irrigation water in an attempt to avoid soil salinization. In most of the canal command areas, conjunctive use of surface water and groundwater is equally practiced in head and tail ends of the canal system. One of the key disadvantages of this unmanaged conjunctive use is that upstream areas are subjected to rising water tables and water-logging whereas tail-end users are aggravating their salinity problems due to the bad quality of the groundwater. Therefore effective conjunctive use should be encouraged that will allow a combination of surface and groundwater use to farmers in such a way that equity in availability of water of acceptable quality is ensured all along the channel.

4.2 Improving productivity through resource conservation technologies

Resource conservation technologies such as precision land levelling, zero tillage, bed and furrow planting have also shown considerable reduction in water application at the field level. The studies done by IWMI (Ahmad et al., 2007) have found that in the Rechna Doab sub-basin zero tillage and laser leveling technologies for wheat was considerably increased during 2000-2003 from around 15% to above 35%. The area under ZT increased exponentially during 2003-04 with wheat sown on an area of 400,000 ha.

4.3 Promoting rainwater harvesting in rain-fed areas

The rain-fed areas of Pakistan contribute about 10% of the total agricultural production. However, production levels of rain-fed areas are very low i.e. 1-1.5 t/ha. Oweis and Hachum (2001) argue that production potential of these areas can be doubled by providing one or two supplemental irrigations at critical growth stages of the crop. Where farmers are already doing this they are generally relying on groundwater extraction. However, they should be encouraged to harvest rain water and adopt watershed management strategies to both improve the productivity of rain-fed systems and reduce the demands on groundwater.

4.4 Introduction of policy reforms

Due to the peculiarities of Pakistan's groundwater socio-ecology, a multi-dimensional policy approach is needed. In Balochistan province, for example, the policy of providing subsidies on electricity needs to be reviewed. Currently, the annual subsidy on agricultural tubewells is Rs. 8.5 billion (US$ 140 million). This subsidy is mainly provided to only 2.5% of the farmers who own deep electric tubewells. In the Punjab province, more efforts are needed to review existing cropping patterns for areas where hydrological conditions suggest that additional groundwater resources are insufficient to support intensive agriculture. Separate strategies should be developed for large commercial farmers and for small poor farmers who are totally dependent on groundwater for protecting their livelihoods. Cropped areas for different crops should be fixed on the basis of the country's food requirements and the availability of water resources. In areas such as Cholistan desert where groundwater resources are not yet tapped due to lack of resources of the local population, groundwater still presents the opportunity to secure the livelihoods of the large population living in this region.

5. CONCLUSIONS

It is heartening to note that the groundwater resource which helped in boosting Pakistan's agriculture and reducing poverty in rural areas is now fast turning into a catastrophe. For effective groundwater management, farmers need to be taken into confidence to implement possible technical, scientific, institutional and political tools to protect key strategic aquifers with regard to quality and quantity. Policies should also be formulated for the economic transition of the population that currently depends on intensive irrigated agriculture to earn their living. This is essential to reduce pressure on groundwater resources and to create political space for direct management of the resource base.

Pakistan must learn that development of groundwater resources without proper planning and management strategy has paid back very badly. Therefore Pakistan needs a serious debate about whether to pump their aquifers to the maximum and face the consequences thereafter, or be more proactive now, better manage abstraction and invest in recharge today. For effective groundwater management, Pakistan is required to introduce frameworks and instruments that are suitable to its needs. The frontline challenge is not just supply-side innovations but to put in place a range of corrective mechanisms before the problem becomes either insolvable or not worth solving.

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