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Challenges in Water Security to Meet the Growing Food Requirement

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Managing Water Scarcity in Pakistan: Moving Beyond Rhetoric

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Abstract

Water scarcity of a country can be measured by the four indicators (i) Falkenmark indicator (ii) Water Resources Vulnerability Index (iii) IWMI's Physical and Economic Water Scarcity Indicators and (iv) Water Poverty Index. According to these four indicators, Pakistan is a now a water-scarce country. There are number of reasons for this water scarcity such as (i) increased population, urbanization and industrialization (ii) inadequate storage (iii) sediments in the existing reservoirs(iv) low overall system efficiency and (v) unutilized potential of hill torrents. The potential options to overcome these issues include: (i) construction of small and large dams where possible (ii) improving the surface water governance with proper pricing (iii) legislating and restricting indiscriminate groundwater abstraction (iv) controlling increase in population (iv) improving conveyance and application efficiencies (v) changing the existing cropping patterns *i.e.* by adopting low delta crops (vi) adopting proper irrigation scheduling and (vii) using saline groundwater, in conjunction with canal water, or independently with salt tolerant crops. However, an integrated approach is required to optimally use the water resources.

1. Introduction

Pakistan has one of the largest irrigation systems in the world comprising three major reservoirs with a design capacity of about 20 billion cubic meters (BCM), 23 barrages, headworks and siphons, 45 main irrigation canals commanding an area of about 16.6 million hectare (Mha). Irrigated agriculture is the backbone of the economy of the country where over 93% of the available water resources are consumed. Irrigation is used on 80% of all arable land and produces almost 90% of all food and fiber requirements. It is one of the largest sectors of economy accounting for around a quarter of the country's gross domestic product (GDP). Agriculture employs 44% of the labor force, supports 75% of the population, and accounts for 60% of foreign exchange earnings (Qureshi, 2011; Briscoe and Qamar, 2006).

The total geographical area of Pakistan is about 80 Mha, of which about 17Mha is irrigated whereas dryland farming is practiced on 12 Mha. The average annual rainfall ranges from less than 100 mm in the south and south-west to over 1000 mm in the north and north-east. Over 70% of this rainfall occurs in the Monsoon season (from July to September). The drylandscontribute less than 10% of the total agricultural production of the country as crops in these areas depend completely on rainfall for their water needs. This contribution may further reduces if the rainfall is untimely and insufficient (Iqbal*et al.*, 2012).

2. Water Scarcity in Pakistan

What is water scarcity? When an individual does not have access to safe and affordable water to satisfy

her or his needs for drinking, washing or their livelihoods we call that person water insecure. When a large number of people in an area are water insecure for a significant period of time, that area is water scarce. Water quality (both for drinking and agricultural purposes) also leads to water scarcity (Rijsberman, 2006). Now the questions arise? Is there a real water scarcity in Pakistan?If yes, to what extent?What are the major reasons for water scarcity?What are the tangible solutions (beyond rhetoric) to overcome water scarcity?

Water scarcity of a country can be measured by the four indicators (i) Falkenmark indicator (ii) Water Resources Vulnerability Index (iii) IWMI's Physical and Economic Water Scarcity Indicators and (iv) Water Poverty Index (Rijsberman, 2006). Falkenmark Indicator (Falkenmark*et al*., 1989),provides a relationship between available water and the human population. According to it, the countries whose per capita water resources are less than 1700 m^3/person are said to be water-stressed countries. When per capita water availability falls below 1000 m^3/person, the country is said to be a water-scarce country. However, when per capita water availability falls below 500 m^3, a country experiences an absolute water scarcity.

Figure 1 shows population and per capita water availability in Pakistan. With increase in population, per capita water availability is decreasing. In 1950, per capita water availability in Pakistan was over 5000 m^3. However, in 1990 Pakistan touched the water-stress line and during 2005, it crossed water-scarcity line. If the present situation continues, Pakistan will approach absolute water scarcity line by 2025.

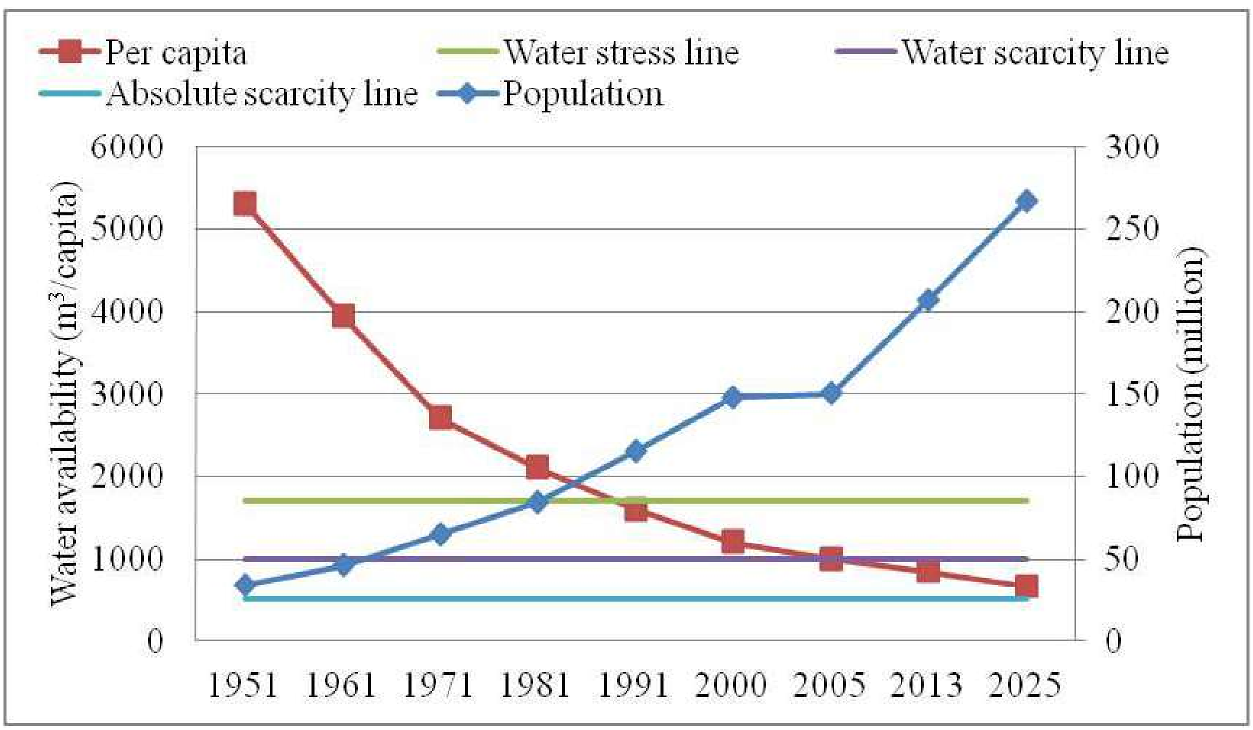

Figure 1: Per capita water availability vs. population

The 2nd indicator is the Water Resources Vulnerability Index (WRVI)(Raskin et al., 1997). It compares national annual water availability with the total annual withdrawals (in percent). If annual withdrawals are between 20-40% of the annual water supply, the country is said to be water scarce. If it

exceeds 40%, the country is said to be severely water scarce.

The total surface water available in Pakistan is about 190 BCM whereas available groundwater is about73 BCM. Therefore, the total water available both surface and groundwater becomes 264 BCM. The total surface water diversions (uses) are about 140 BCM whereas groundwater contributes about 62 BCM. Therefore, the total water used is about202 BCM. Hence WRVI comes to be (202/264) 77%.

The 3rd indicator is IWMI's Physical and Economic Water Scarcity Indicators (Seckleret al., 1998). According to these indicators, the countries that will not be able to meet the estimated water demands in 2025, even after accounting for the future adaptive capacity are called “physically water scarce”. The countries that have sufficient renewable resources but would have to make very significant investment in water infrastructure to make these resources available to the people are called “economically water scarce” In Pakistan the water shortfall that was 11% in 2004 will increase to 31% by 2025 (GoP, 2001). Due to this shortage of water and increase in population, there will be food shortfall of about 70 million tons by 2025 (ADB, 2002). As Pakistan have to make significant efforts and investment to meet the water shortage, therefore, it is both physically and economically water-scarce country.

The 4th indicator is Water Poverty Index (Sullivan et al., 2003). It has five components: (i) access to water (ii) water quantity, quality and variability (iii) water uses for domestic, food and productive purposes(iv) capacity for water management and (v) environmental aspects.

According to Water poverty Index, if water is available but is of poor quality, the country is still a water scarce country. Pakistan Council of Research in Water Resources (PCRWR) implemented a series of national projects to monitor drinking water quality in Pakistan. Figure 2 shows results of the Drinking Water Quality Monitoring Program (2002-2006) from 24 major cities of Pakistan. According to the survey, more than 80% samples were found unsafe for human consumption (Figure 2).

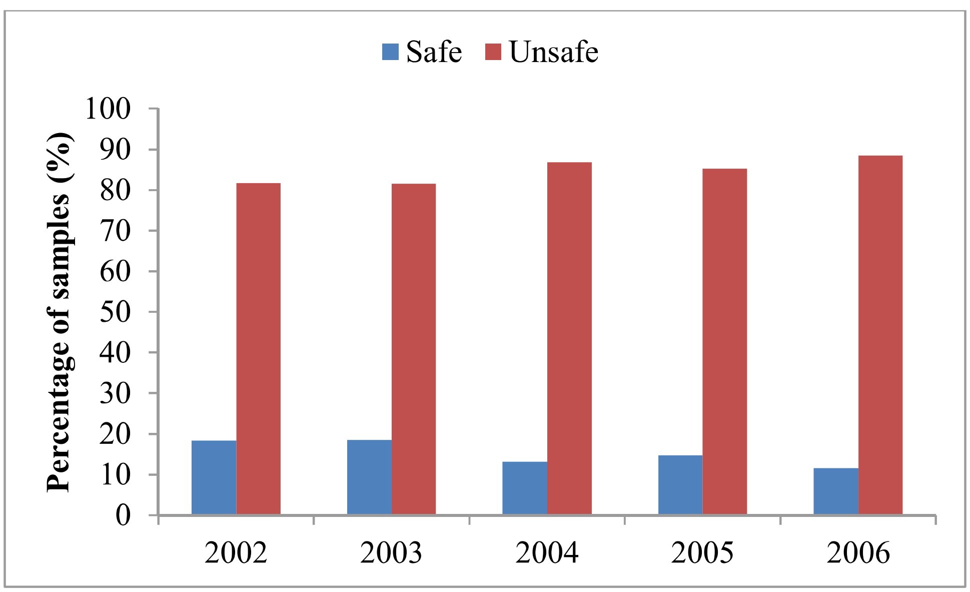

Figure 2: Drinking water quality monitoring program (2002-2006)

The major contaminants found were bacteria, arsenic, nitrate and fluoride. Another survey was conducted in the rural areas of Pakistan from 2004 to 2011. The situation was almost similar in the rural areas as out of 14,000 samples collected, only 2,550 (18%) were found safe and 82% drinking water

samples were found unsafe according to the drinking water standards.

Table 1: Drinking water quality profile of rural areas (2004-2011)

Sr. No.	Province	Districts	Tehsils	Union Councils	Villages	Samples Collected	No. of Water Samples			
							Safe		Unsafe	
							No.	%age	No.	%age
1	Punjab	12	49	1227	2090	10440	2183	21	8257	79
2	Sindh	3	12	54	149	745	212	28	533	72
3	KP	4	6	211	240	1200	89	7	1111	93
4	Balochistan	4	12	54	298	1465	05	0.3	1460	99
5	Federal Capital Area	1	1	21	30	150	61	41	89	59
Total		24	80	1567	2807	14000	2550	18	11450	82

Table 2: Water quality assessment of water supply schemes (2006-2012)

Province	Districts surveyed	Water supply schemes	Surveyed water supply schemes			Functional	Samples safe for drinking (%)	
			Total	Urban	Rural		Urban	Rural
Punjab	33	4100	3883	746	3137	2725	17	23
Sindh	22	1300	1247	123	1124	529	5	5
KP	16	3000	2203	474	1729	1710	63	26
Balochistan	14	1600	1034	480	554	968	20	13
GB/AJK/FATA	10	2000	1794	18	1776	1379	8	2
Total	95	12000	10161	1841	8320	7311	23	14

Over 10,000 existing water supply schemes were also surveyed from 2006 to 2012 from the four provinces including GilgitBiltistan (GB) and Azad Jammu and Kashmir (AJK). About 72% water supply schemes were functional. Out of the 72% functional schemes, only 23% in urban and 14% in rural areas were providing safe drinking water. However, Pakistan Vision 2025 (GoP, 2013) sets a target to ensure clean drinking water to all Pakistanis by 2025.During the past years, many efforts were made by the government for provision of safe drinking water to the masses. But the intended objectives could not be met. The major reason behind this is the sustainability issue of the technologies implemented for water filtration and treatment. The countries which are providing safe drinking water to their masses have focused on the basic treatment and filtration systems. Moreover, the bulk water supply is being treated and has made tape water as safe water. In our country, though it will be quite expensive because water supply charges are not based on the consumption; the supply may be rationalized through introduction of water meters.

Therefore, according to the four indicators discussed above, Pakistan is a now a water-scarce country.

3. Major Causes of Water Scarcity

3.1 Increase in Population

The population in the country is increasing at an alarming rate and is expected to touch the figure of 250 million by the year 2025. This will not only have pressure on the already dwindling water resources but will also put many changelings for the food security.

3.2 Inadequate Water Storage

One of the major reasons of water scarcity is inadequate storage. The per capita water storage of Pakistan is also far less as compared to other countries. The per capita water storage of Australia and USA is over 5000 m^3, China 2200 m^3, Egypt 2362 m^3, Turkey 1402 m^3, Iran 492 m^3, while in Pakistan it is 159 m^3. Aswan High dam on Nile River has a storage of about 1000 days, Colorado and Murray-Darling rivers of 900 days, South Africa Orange River 500 days, India 320 days and Pakistan only of 30 days (Qureshi, 2011).Due to inadequate storage, Pakistan has lost more than 120 BCM of water during the floods of 2010, 2012 and 2014 besides having devastating effects on infrastructure, crops, livestock and human. Pakistan Vision 2025 however, envisages a targetof 90 days storage by the year 2025.

The present water storage capacity of three major reservoirs is only 9% of the average annual inflow, against the world average of 40%. Due to sedimentation in the reservoirs, the capacity is being lost at a rate of 0.27 BCM per year. By 2010 the reservoirs had already lost about 8.1 BCM of their storage capacity (Iqbalet al., 2012).

3.3 Low System Efficiency

Due to age and poor maintenance of the irrigation system, the overall efficiency is less than 40%. For example, out of 142 BCM of water available at the canal head works, hardly 55 BCM is being used by the crops (GoP, 2001). The remaining 87 BCM (61%) is lost during conveyance through canals, distributaries, minors and watercourses and during application in the fields. The water lost through seepage in areas underlain by fresh groundwater is a temporary loss as it can be pumped back when required. However, it is an energy loss since energy is required to pump this water. In areas underlain by saline groundwater, this is permanent loss, as it cannot be used for irrigation/drinking and may lead to water logging and salinity (Ashraf et al., 2000).

Table 3: Water Losses in the Irrigation System

Location	Delivery at Head (BCM)	Losses(BCM)	Losses(%)
Canals	143	22	15
Distributary & minor	121	8	7
Watercourses	113	35	31
Fields	78	23	29
Crop Use	55		
Total		87	61

Source: GoP (2001).

3.4 Inequity in Water Distribution:

The irrigation system was designed to convey water to all the users in the command area in an equitable manner. However, as mentioned above, more than 60% of water is lost within the system *i.e.* from canal head to the fields. These losses further aggravate the problem of water scarcity, particularly towards the tail end. It also affects the equity in the distribution of water*i.e.* irrationally high water withdrawals at the canal head at the cost of water allocation for the tail enders. The tail enders face three prone problems due to inequity of water distribution: (i) they do not get canal water (for which they pay and have the right to get it); (ii) due to less recharge available, there is more stress on groundwater resulting in increased water-table depth and reduced profitability (more tubewell installation and operational costs). In certain cases, the most commonly used centrifugal pumps become uneconomical to install due to increased water-table depth; (iii) the groundwater quality is also deteriorating due to saline water intrusion from the deeper depths and from the adjoining saline water areas. Therefore, higher groundwater use is also causing soil salinization. Once soils are salinized, these take long time to reclaim.

3.5 Low Crop Yield and Water Productivity:

The average yields in Pakistan are far lower than the potential yields. For example, average wheat and rice yields are 2,276 kg/ha and 1,756 kg/ha, respectively. In addition to water shortage, lack of inputs, poor irrigation practices, and secondary salinization are the other major factors in low crop yields. The water productivity of crops is also far below than its achievable levels, perhaps it is the lowest in the world. For example, for wheat it is 0.5 kg/m^3 compared with 1.0 kg/m^3 in India and 1.5 kg/m^3 in California (IWMI 2000). Similarly, the water productivity of maize is also very low (0.3 kg/m^3). The water productivity of maize is the highest, in Argentina (2.7 kg/m^3). The potential gap in the water productivity of various crops shows that there is a tremendous scope for the improvement in water productivity that can help increase both horizontal and vertical expansion of agriculture (Ashraf *et al*., 2010; Qureshi, 2011).

3.6 Water Logging and Salinity

Waterlogging and salinity pose a serious threat to the agriculture.The Indus basin irrigation system brings about 33 million tons (MT) of slats to the system out of which only 16.4 MT flows to the sea. Out of 16.6 MT of the salts that are retained in the system, only 2.2 MT are disposed off into the evaporation ponds. Therefore, 14.4 MT of salts are retained in the system every year (Qureshi, 2011). Moreover, over one million tubewells are pumping water to supplement canal water supplies (World Bank, 2007). However, over 70% tubewells are pumping sodic water (Qureshi and Barrett-Lennard,998). As a result, salt affected soils have become an important threat to the irrigated agriculture. Problems of soil salinity are more serious in Sindh Province where about 54% of the irrigated area is saline due to low rainfall, high evapotranspiration rates and shallow saline groundwater (Qureshi*et al*., 2008).

3.7 Groundwater Depletion

The Indus Basin Irrigation System was designed for an annual cropping intensity of 75% and the water is being supplied to the farm on weekly rotational basis called "*warabandi*". The farmers receive their share of water once in a week for the period related to their lands and the cropping pattern. The farmers who have access to groundwater have increased cropping intensity to over 150%. However, there is no groundwater regulatory framework in Pakistan and any one can install any number of tubewells anywhere at any depth and can pump any amount of water at any time (Ashraf *et al*., 2012). Due to indiscriminate pumping, the groundwater is depleting at an alarming rate. It has been reported

that out of 43 canal commands, the water table was declining in 26 canal commands due to rapid increase in groundwater abstraction (Bhutta*et al*. 2000). In Balochistan, the situation is even worse and in some rivers basins, the water table is declining at a rate of more than 3 m per year. This is mainly due to hyper arid climate and prevailing flat rate of electricity in the province.

3.8 Neglect of the Rainfed Areas

Over the last forty years, maximum investment in Pakistan has been on the irrigated agriculture and the rainfed areas have almost been neglected. The rainfed areas constitute about 40% of the culturable areas of the country. The average yields of major crops in these areas are far lower than their achievable potentials. The major reasons for this low agricultural productivity are (i) low and erratic rainfall, causing stress at critical growth stages, (ii) soil erosion, resulting in loss of water and fertile topsoil, (iii) poor use of land and resources due to small and fragmented land holdings and (iv) low agricultural inputs (Ashraf *et al*. 2007).

These areas however, have a great potential to contribute to livelihood and food security of the poorest due to: (i) wide gap between current level of agricultural productivity and its potential, (ii) largely belong to poor communities and (iii) large area available for out-scaling of promising interventions. Further, supplemental irrigation, if available, can boost up the production through crop diversification as well as intensification (Iqbal*et al*., 2012).

4. Potential Options to Overcome Water Scarcity

4.1 Increase Water Storage

A water short fall of over 30% in 2025 means, further storage requirements of the order of 27 BCM (3-4 large dams). Therefore, there is dire need to develop new storage reservoirs through construction of large and small dams. Water and Power Development Authority (WAPDA) has identified a potential of over 59 BCM of water that can be stored on Indus and its tributaries. However, during the last four decades, no major reservoir has been built in the country. Due to inter-provincial conflicts, the focus of the governments has been on the construction of small dams. Besides providing irrigation water, these small dams have several advantages. They recharge the groundwater, provide water for domestic and municipal purposes, control erosion, are close to the point of use, help develop aquaculture and also provide recreational activities.

Small dams have however certain limitations like they lose 50% of their impoundments to evaporation due to high surface area to volume ratio. . The seepage and percolation losses in these reservoirs are about 20% of their volume against 5% in large dams. Moreover, their small storage volume does not allow seasonal or annual carryover, and there are safety problems of handling the overflow during extreme storm events. The unit cost of water in small dams is 4-7 times higher as compared to large dams (Keller, 2000; Sakthivadivel, 1997).

The large dams nevertheless, store a huge amount of water that can be used for irrigation, hydropower generation (the cheapest source of energy), to meet the environmental flow requirements of the river. These dams control floods, provide water throughout the year, and act as buffer during dry season and dry years. The large dams however, requires huge investment, appropriate sites, considerable time for feasibility study, completion of the project, face resettlement and environmental issues, and more importantly require national consensus. Therefore, the small dams should be constructed wherever possible however, these cannot be alternate of large dams.

4.2 Manage the available water

No additional water has been injected into the system during the last forty years (Briscoe and Qamar, 2006). It is pertinent to clarify that Mangla raising project (3.9 BCM) has only compensated storage capacity lost due to sedimentation since commissioning of the reservoirs. Moreover, there is no chance for such addition in the near future therefore, much of the future food production will need to come from the efficient use of the available water resources. Pakistan Vision 2025 sets a target of improving the efficiency in exiting water usage in agriculture by 20%. This can be achieved by:

- Improving the conveyance and application efficiencies through canals and watercourse improvements
- Improving farm layouts and leveling of fields
- Using high efficiency irrigation systems such as bed and furrow irrigation, pressurized irrigation (sprinkler, drip)
- Restricting the high delta crops such as rice to certain areas of high rainfall and more suitable soil conditions (heavy-textured soil)
- Adopting proper irrigation scheduling (when to apply water and how much to apply to a crop?);
- Using saline groundwater, in conjunction with canal water or directly with better soil and crop management practices, reuse of wastewater etc.
- The practices of keeping water standing in the rice fields need to stopped, since now it has been established that rice do not need standing water. Rather it can be grown on bed and furrows and even with sprinklers (Soomro et al., 2015).

4.3 Proper Maintenance of the Irrigation System and Price Rationalization

Indus Basin Irrigation System was built centuries ago. Inadequate maintenance of the system has resulted into deterioration of the system with overall poor efficiency of the irrigation system. The poor cost recovery is also one of the main reasons for deferred maintenance of the system. The canal water is being provided to the farmers almost free i.e. (at flat rate of Rs. 333/ha per year i.e. Rs. 123 for Rabi cops and Rs. 210 for Kharif crops). Ashraf *et al*., (2010) reported that in the command area of Lower Bari Doab Canal (LBDC), the cost of pumped water was 3-7 times higher as compared to the canal water. Since then there is more than 300% increase in fuel prices whereas the cost of the canal water is almost the same. Similarly, Shah *et al.*, (2008) reported that in India, per hectare cost of groundwater irrigation ranged from 1.5 times to 8 times the cost of irrigating with surface water. Atthe extreme, the cost of supplemental irrigation with gensets could reach 100 times the cost of gravity supply. Therefore, cost of one hour of pumped water is more than the annual cost per acre of canal water supply. The water therefore, needs to be considered as an economic good and should be appropriately priced.

4.4 Approval of National Water Policy

Pakistan has one of the largest irrigation systems in the world. However, it does not have a national water policy. A draft National Water Policy was prepared in 2002 and still has not been approved by the competent form. Since then a lot of changes has been occurred in the water sector. This national water policy needs to be revised and approved in consultation with all the stakeholders particularly after 18th amendment in the constitution of Pakistan.

4.5 Integrated River Basin Management Plan

During the last three decades, a number of technologies and practices have been developed on

efficient use of water resources and to control soil salinity at the field levels. However, these technologies have not been transformed on the basin level. Water applied at one point has consequences at the other points. For example, water lost at one location may be recovered at the other locations or water lost at one point may result into water logging at the other points. There is need to develop an Indus Basin Management Plan involving major research and development departments and agencies working in the basin. Technologies and practices developed at field level should be synthesized and applied at the basin level.

4.6 Formulation of a Groundwater Regulation Authority

A regulatory framework should be devised and strictly implemented for the installation and operation of tubewells to reduce and control the over extraction of groundwater. Subsides given to users of groundwater *viz* flat electricity rates in particular should be withdrawn.

4.7 Improvement in Water Productivity

The water productivity can be increased either by increasing the crop yield or by reducing the water applied. In irrigated areas, there is little potential for further increasing the crops yield due to declined potential areas and reducing marginal benefits. However, there is great scope in increasing the water productivity by reducing the water applied though (i) precision land levelling, (ii) proper layout of the field, (iii) appropriate irrigation methods such as bed planting and (iv) by adopting proper irrigation scheduling. These are simple methods and techniques that can help increase the water productivity many folds. However, the availability of equipment such as laser leveller and bed planter to common farmers is a big issue. To solve this issue, these equipment may be provided to the Agricultural Service Providers (ASPs) on subsidy basis with appropriate training and back up support.

Pressurized-irrigation systems such as sprinkler and drip have the potential to achieve high application efficiency and water productivity. However, their installation and operational costs are very high as compared to surface irrigation systems. In Pakistan, a weekly rotational canal water supply prevails where conversion from surface to pressurized irrigation is neither economically viable nor socially acceptable. Since early 80s, a number of projects have been implemented by various federal and provincial agencies. However, none of these projects could provide the desired results. The main reasons were: (i) high capital cost (ii) non-availability of local material (iii) no back up support (iv) complicated and over designed systems (v) small land holdings (vi) farmer's misconceptions about the system (vii) lack of knowledge about irrigation scheduling and (viii) flat rate of electricity in Balochistan.

Therefore, for the installation of these systems, the selection of right area, right crop, right farmer and right material is very important. Moreover, the design of the system should be simple so that common farmer can easily operate it. Potential areas for these systems include: Pothwar Plateau, desert and semi desert areas, uplands of Balochistan, riverian belts, green houses and tunnels.

4.8 Watershed Management

High intensity rainfalls, steep slopes, and erodible soils without adequate protection have led to extensive soil erosion in the area and the consequences are devastating. The Indus River in Pakistan brings an annual sediment load of 435 million tonne and an average sediment concentration of 2.49 kg/m^3. According to an estimate, the Indus River is adding 500,000 tonne of sediment to the Tarbela reservoir every day reducing the capacity of the reservoirs (Iqbal *et al*., 2012). Therefore, water should be considered as a resource and its management should start from watersheds. A comprehensive watershed management program should be developed and implemented.

4.9 Focus on Dryland Agriculture

4.9.1 Rainwater Harvesting

Water is one of the most important limiting factors in the agricultural production of rainfed areas. The rainfall in these areas varies from less than 200 mm to over 1000 mm, 70% of which occurs during the summer months of July–September (Ashraf *et al*., 1999). Due to high intensity, short duration rainfalls and a lack of watershed management and rainwater harvesting activities, this precious water is lost as surface runoff. This is not only the loss of water but also results in loss of fertile topsoil. There is a need to harvest as much as of this currently lost water as possible either on the surface or underground. Stored water can be used as supplemental irrigation to act as a buffer against crop failure during dry seasons.

4.9.2 Management of Hill torrents' Water Resources

The hill torrents are a major water resource in the country, estimated to be 24BCM/year, that needs to be harnessed. A number of technologies have already been developed by research and development agencies for the distribution and application of hill torrents runoff. These technologies need to be applied at larger scale. Because this water is available for a short period of time, there is need to store this water for its subsequent uses. This will also help in controlling flash floods which has become common features of these areas. Moreover, the watershed of these torrents should also be managed. This will help reduce flash floods and will increase the groundwater recharge.

4.10 Reuse of Wastewater and Drainage Water

On one hand drainage water and wastewater are nuisance and on the other hand, these are resources that can be used to narrow the gap between water demand and supply. There is potential of over 13 BCM of drainage effluents. Similarly, the wastewater generated from sixteen major cities exceeds 5 BCM. The wastewater is either being thrown into the water bodies without any treatments threatening the ecosystems. The same is being subsequentlyused for irrigation in the peri-urban areas posing serious health and environmental impacts. Technologies and practices have been developed for the use of drainage water and treatment of wastewater. These techniques should be economized and replicated for the reuse of drainage and waste waters.

4.11 Mass Awareness Campaign

Most of the problems associated with the water sector have risen from illiteracy and lack of knowledge and understanding of water conservation practices and high efficiency irrigation systems. An extensive social awareness campaign is required using mass media and a village-to-village campaign of extension services. Moreover, effective extension service mechanism must be developed to transfer new and efficient irrigation methods, technologies, and practices to farmers.

4.12 Water Resources Data Management

A number of research and development agencies are collecting data related to water resources development and management. However, this data are in piecemeal and scattered and is hardly available for planning purposes. Moreover, the reliability of data is also an issue. Therefore, an appropriate institution should be made responsible to gather and synthesize the data. This data should be regularly updated and available on the internet.

5. Conclusions

Pakistan is fast becoming a water scarce country due to number of issues such as increase in population, urbanization and industrialization, inadequate water storage facilities, sedimentation in the existing reservoirs, inefficient use of the available water and neglect of the dryland areas. However, most of these are management issues and the present situation can be averted by adopting both hard path (control of population, construction of new reservoirs, development of groundwater regulatory framework) and soft path (improving the land and water productivities, focusing on dryland agriculture). This requires a paradigm shift and commitment from all the stakeholders right from policy maker to water users (farmers, general masses).

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