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MEASURES FOR WATER SCARCITY IN PAKISTAN

Muhammad Ejaz Tanveer,
Yawar Rasheed

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By

Muhammad Ejaz Tanveer[1], Yawar Rasheed[2]

Abstract:

Pakistan is an agrarian economy that is heavily dependent on the water of its rivers. The average annual surface water availability from Indus Basin is 145 MAF while groundwater extraction is about 50 MAF. As the population increases, food demand also proportionately increases. In 1951 Pakistan was at a comfortable water availability level of 5,650 m^3/capita/annum which has now dropped to around 908 m^3/capita/annum in 2018 due to the fast population growth rate of the country. Out of 145 MAF, 10 MAF is lost as seepage and evaporation from rivers and streams. Around 46 MAF is the conveyance loss in canals and distributaries. Nearly 86 MAF reaches farm gate which does not meet cropping requirements keeping in view the conventional irrigation methods. The gap is being met by groundwater pumping besides on average 28 MAF surface water flows down to the sea every year. One of the targets set under the National Water Policy (NWP) is the reduction of 33 percent in the 46 MAF river flows that are lost in conveyance, through an accelerated program of water course lining especially in saline and semi-saline areas. Another target is the increase of at least 30 percent in water use efficiency by producing "more crop per drop". This paper presents the status of reduction in conveyance losses and adopted reduction methods will be discussed in detail as well as the present position of increase in the efficiency of water use by producing more crop per drop.

Keywords: Ground Water, Conveyance Losses, Indus Basin, National Water Policy (NWP), Pakistan.

1. Introduction

Water is an essential element of life. Almighty has blessed Pakistan with abundant water resources in the shape of rainfall, glacial runoff, rivers, and groundwater. The major contribution of rain comes in the form of monsoon rains. Despite these resources, Pakistan is one of the most water-stressed nations, with a per capita water availability of less than 1000 cubic meters. Pakistan is facing serious water scarcity mainly due to inefficient usage, both surface and groundwater resources are stressed.

Pakistan's economy is largely based on its agriculture. The current proportion of agriculture towards the GDP of the country is 19.8 % (Pakistan_F.D, 2018-19). Irrigated agriculture in the Indus Basin is the major user of water in Pakistan. Water

[1] Superintending Engineer (Floods) O/o CEA/CFFC, MoWR, Islamabad, Pakistan. engrejaz96@gmail.com

[2] Assistant Engineer (Floods), O/o CEA/CFFC, Islamabad

is therefore a critical resource for its sustained economic development. In order to fully utilize the surface water resources, the Indus Basin Irrigation System (IBIS) has emerged as the largest contiguous irrigation system in the world. The IBIS comprises three large dams, eighty-five small dams, nineteen barrages, twelve inter-river link canals, forty-five canal commands, and 0.7 million tube wells. About 80% of the cultivated area of Pakistan is under irrigation and about 90% of all food is produced from this area (Economic_Division, 2008-09). The population growth rate in Pakistan is very high, which has placed the water supply under stress. The food requirements of this ever-increasing population demand higher food production, which may be possible through water-efficient technologies.

One of the targets set under the National Water Policy (NWP) is the reduction of 33 percent in the 46 MAF river flows that are lost in conveyance, through an accelerated program of water course lining especially in saline and semi-saline areas. Another target is the increase of at least 30 percent in water use efficiency by producing “more crop per drop”.

The canal irrigation system of the Indus Basin of Pakistan is facing several operational problems resulting in a high degree of loss of water during the conveyance of irrigation water to agricultural lands. These water losses result in constrained water supplies of canal water in the Indus Basin. Water losses from these canals have major impacts on surface water supplies which must be minimized and managed. It may be the most cost-effective for augmenting water supplies. Water courses are used to convey water from canals to fields. A large amount of water is lost in these watercourses because of high conveyance losses on its way to the farm's level. Seepage, percolation, cracking, and damage of the earthen water courses are the main causes of poor conveyance efficiency (Ali, 2011). Water losses in the improved/lined and unimproved/unlined watercourses ranged from 35–52% and 64–68%, respectively (Usman, 2009).

Water for irrigated agriculture in Pakistan is under threat due to utilization of flooding irrigation techniques for irrigation of crops to fulfil the food requirements of the ever-increasing population which wastes a huge quantity of irrigation water. Most of the farmers are still using flood irrigation wasting about 50–60% of applied irrigation water. Therefore, water-efficient irrigation technologies are required to improve agricultural productivity by preserving water resources (Qureshi et al., 2010). It is considered that mismanagement of irrigation water is one of the main reasons for low agricultural production. Farmers had more discharge at the inlet of their fields when conveyance losses were reduced which had a significant effect on water distribution (Sarwar et al., 2001). There are social as well as technical problems associated with the management of irrigation water in Pakistan. Water-efficient technologies such as precision land levelling, drip, and sprinkler irrigation systems have been introduced in many parts of the world. Keeping in view the water-stressed country, there is a need to adopt these technologies for management and the conservation of irrigation water in Pakistan.

The measures taken to address water scarcity in Pakistan by the Government will be discussed in the paper besides the use of efficient watering systems such as drip irrigation and sprinklers to reduce water consumption by plants and help in the conservation of water. This paper aims to provide policymakers, water managers, and stakeholders with an understanding of the measures that can be taken to address water scarcity in Pakistan. For this purpose, secondary data has been obtained from the already published research papers, national and international reports on water and internet sources.

2. Impacts of Water Scarcity in Pakistan

Water scarcity in Pakistan has severe and far-reaching impacts on various sectors of society. Agriculture, which accounts for a significant portion of Pakistan's economy is severely affected by water scarcity. The limited availability of water leads to lower crop yields, reduced income for farmers, and food insecurity. This has implications for the country's economy and food security, as agriculture employs a large portion of the population and provides essential food items. Lack of access to safe drinking water is a significant health issue, particularly in rural areas, leading to water-borne diseases and health problems such as malnutrition, stunted growth, and infant mortality. Water scarcity also leads to conflicts between different regions and communities over the distribution of water resources. Furthermore, industries that rely on water, such as textiles and manufacturing, are forced to curtail their operations, resulting in job losses and economic losses. The impacts of water scarcity are further compounded by climate change, which is exacerbating the problem in Pakistan by reducing rainfall and increasing the frequency of extreme weather events. The water scarcity problem in Pakistan is multifaceted and requires a concerted effort from the government, civil society, and private sector to implement sustainable solutions.

The water stress index developed by Falkenmark in 1986 is used to measure water scarcity between freshwater resources and population (Damkjaer & Taylor, 2017). It is based on an approximate minimum level of water required per person to maintain an adequate quality of life in a moderately developed country in an arid zone. When the annual availability of internal renewable freshwater is equal to or less than 1,000 cubic meters per person, it is called water scarcity. Pakistan's surface water availability per person was 5,260 cubic meters in 1951. It had fallen close to 1,000 m^3 per person in 2016 and is expected to continue decreasing (MoWR, 2018). This situation will be further worsened with projected increase in population of about 230 million by 2025. Pakistan has been threatened with number of water challenges which include severe water shortage, inadequate storage, and reduction in storage capacities of the existing reservoirs due to sedimentation, low irrigation efficiency, low land and water productivity and mining of groundwater.

Allah Almighty has blessed Pakistan with plenty of surface and sub-surface water resources. The Indus River and its western tributaries, bring out annually about an average of 142 Million Acre Feet (MAF) of water. Out of this water, around 104

MAF water is withdrawn through canals. In addition to this, Pakistan currently extracts approximately 61 cubic kilometres of water from its aquifers each year, which far exceeds sustainable limits. The abstraction of groundwater during 2013-14 was 50.2 MAF, which has remained stagnant for the last 15 years. As a result, Pakistan is commonly considered to be both water-stressed (high water withdrawals relative to availability) and water-scarce (low water availability per capita) (Sleet, 2019). Pakistan has the capacity to store for around 30 days which not only limits the amount of water available during the dry season but also contributes to flooding during wet seasons, as there are few dams to store the excess water. Sedimentation has also aggravated the problem. Naturally exists silt in rivers trapped by reservoirs, sinking to the bottom, thereby decreasing storage capacity. According to a hydrographic survey conducted in 2015, the storage capacity of the Tarbela Dam has declined by 35 percent since it was commissioned.

Water Apportionment Accord (WAA) was signed amongst the provinces on 16th March 1991 and approved by the Council of Common Interest (CCI). Through this accord, Indus River System Authority (IRSA) was established in 1991 to regulate and monitor the distribution of water sources of Indus Rivers following the WAA amongst the provinces. As per IRSA, last five (5) years' water availability figures may be given in **Table-1** below:

ACTUAL SURFACE WATER AVAILABILITY IN MILLION ACRE FEET (MAF)

PERIOD	Kharif	Rabi	Total	% age (Increase or decrease
AVG. SYSTEM USAGE	67.1	36.4	103.5	
2014-15	69.3	33.1	102.4	-1.1
2015-16	65.5	32.9	98.4	-4.9
2016-17	71.4	29.7	101.1	-2.3
2017-18	70.0	24.2	94.2	-9.0
2018-19	59.6	24.8	84.4	-18.5

According to Pakistan Agriculture Research Council (PARC) estimates, wheat, cotton, rice, sugarcane, and fodders crops require water around 16, 26, 40, 47, and 18 inches respectively (Dahri et al., 2008). These five major crops cover 81% of the irrigated area and consume 85% of water available for crop consumptive requirements which include i) wheat 23.0 MAF, ii) rice 18.5 MAF, iii) cotton 14.7 MAF, iv) sugarcane 10.5 MAF; and v) fodders 7.9 MAF. It means a total of around 76 MAF of water is required for these crops. The other crops require only 14.3

MAF which constitutes around 15 % of total water available for crop consumptive requirements. However, under the traditional practices around 20, 35, 65, 70, and 27 inches of water was used for wheat, cotton, rice, sugarcane, and fodders crops, respectively which consumed around 106 MAF water. It is indicated in Tarbela Dam Impact Study that high delta crops like rice and sugarcane increased remarkably after the commissioning of the Tarbela dam.

Irrigation is the artificial application of water to crops through appropriate methods. These methods are surface irrigation and pressurized irrigation. Surface irrigation includes basin/flood irrigation, border irrigation, and furrow irrigation. Pressurized irrigation methods include sprinkler irrigation, bubbler irrigation, and drip irrigation systems. Basin or flood irrigation has the lowest irrigation efficiency whereas drip irrigation has the highest irrigation

efficiency. Apart from high losses from the irrigation system, low crop yields per unit of both

land and water are the other issues faced by irrigated agriculture in Pakistan. The irrigation efficiency of basin, border, and furrow methods are around 50, 55, and 65 percent whereas sprinkler, bubbler, and drip have irrigation efficiency around 75, 90, and 85 percent respectively. Nowadays water is becoming scarce, therefore, it becomes imperative to use it more efficiently. High-Efficiency Irrigation Systems (HEIS) such as sprinklers and drip have the potential to achieve high efficiencies.

The Indus Basin environment (flat topography, poor natural drainage, porous soils, and semi-arid climate with high evaporation) irrigation without adequate drainage will inevitably lead to rising water tables and salinity. The increase in the diversion of river flows for irrigation and seepage from canals, watercourses, and irrigated areas has meant a gradual rise in the groundwater table. Due to age, overuse, and poor maintenance, canal delivery is extremely inefficient. Average delivery efficiency is 35–40 percent from the canal head to the root zone,

with most losses occurring in watercourses. The loss of such a large proportion of surface water reduces water availability for crops and contributes to waterlogging and salinity. Another issue of deferred maintenance of irrigation system, Pakistan's irrigation and drainage system has been deteriorating because of deferred maintenance and utilization beyond design capacities. The goal of making Pakistan a water-efficient country can be achieved by minimizing conveyance and field application losses. First of all, it needs to be checked which options are presently available to us for taking immediate actions to minimize these losses. The overall scarcity, non-availability of water at the right time, and inefficient utilization of available water appear to be the leading factors that restrict expansion in irrigated areas and cause the gap between the actual and potential yields. The saving in irrigation water through sprinkler irrigation has been found as 46% to 68% for different crops with an average of more than 50%. It means that with the given quantum of water, irrigated area can be increased by 1.5 times through the use of Sprinkler Irrigation System as compared to surface method. However, high cost

and economic considerations limit the use of sprinkler irrigation systems to fruit trees, vegetables, and high-value crops for specific areas. The sprinkler irrigation system was found more financially feasible because a 68% water saving and 17% increase in yield was obtained. As per one study's results, water use efficiency was 1.77 kg/m3 for sprinkler irrigation method while for surface irrigation method it was 0.895 kg/m^3 (Ghani Akbar et al., 2007). As per the study conducted in Sindh Province of Pakistan, application losses have been calculated for coarse (46.5% & 16% for wild flooding/cotton & sprinkler/cotton), medium (45.8% & 0% for wild flooding/cotton & sprinkler/cotton) and fine soils (42.7% & 14.9 % for wild flooding/cotton & sprinkler/cotton) concerning different crops and irrigation methods.

Efforts are underway to modernize and improve the irrigation network in Pakistan, including the introduction of new technologies and practices such as drip irrigation and laser land levelling. The government is also working to enhance the efficiency of the system by reducing water losses and improving maintenance.

3. Existing Measures for Addressing Water Scarcity in Pakistan

Several measures are being implemented to address water scarcity in Pakistan, including both policy and infrastructure-based solutions. The government has implemented policies such as the National Water Policy, which focuses on sustainable water use and management. The National Water Policy Implementation Framework outlines strategies for water conservation and demand management. Additionally, investments have been made in improving the infrastructure for water storage and distribution, such as the construction of large dams, water reservoirs, and canals. The government has also promoted the use of efficient irrigation techniques and rainwater harvesting to reduce wastage and increase water use efficiency. Furthermore, civil society and private sector organizations are implementing community-based solutions, such as building small-scale water storage facilities and providing training on sustainable water use practices. However, challenges remain, including the need for greater investment in water infrastructure, improvements in water management practices, and addressing issues such as groundwater depletion and water pollution.

The Federal as well as Provincial governments during the last twenty years have constructed various small/ medium dams to store water generated from the rains/ floods to avoid damage to the lives and properties and for its beneficial use. Province/Agency-wise detail of dams constructed during last twenty (20) years are as under **Table-2**:

SR. NO.	PROVINCE/ AGENCY	GROSS STORAGE CAPACITY (AFT)	NO. OF DAMS
1.	Punjab	169,222	31
2.	Sindh	275,222	80
3.	KP + Merged Area	194,980	40
4.	Balochistan	504,489	462
5.	WAPDA	1,656,681	4
	Total:	**2,800,594**	**617**

4. Measures Taken by Provinces of Pakistan

Selective Lining of Irrigation Channels Phase-III with length of 450 miles has been completed under ADP scheme. Improvement in irrigation water supply at tail reaches of Irrigation Channels (length of 680 miles) by June 2024. Under ongoing PSDP lining project, 1050 miles of lining have been completed. The lining of over 6,500 Nos. watercourses have been completed which results in water conservation of over 750,000-acre feet per annum. Over 15,000 Nos. watercourse lining will be done by 2026-27, which will result water conservation over 3 MAF/Annum as well as conveyance efficiency enhancement by 25 % in project areas.

The total length of completed lined channels is 372.39 miles, resulting in approximate water saving 457.30 cusecs. Under PSDP program in Sindh province, 56 channels have been lined. Lining of 32 channels of 302.71 miles length are underway. Under provincial ADP, 86 schemes around 1183.883 miles of length have been completed. 20 number schemes are under progress to line 318.59 miles of Irrigation Channels.

Under various PSDP-assisted projects, lining of water courses has been undertaken and so far, 3,000 water courses have been completed. Work on HEIS is in progress on an area of 11650 acres to reduce conveyance losses.

In Punjab, promotion of high-efficiency irrigation systems, Laser Land Levelling and other conservation technologies are the priority areas of the Punjab Agriculture Department (OFWM). Installation of high-efficiency irrigation systems has been completed on over 35,000 acres since 2018 (total 100,000 acres in entire Punjab). Laser land levelling units have been provided to over 4,000 farmers since 2018 (total 16,000 units). Further, it has been planned to install high-efficiency irrigation systems on another 75,000 acres and provide 6,000 Laser Land Levellers to farmers till 2026-27, which will result in saving of about 30-50% water in project areas vis-à-vis improvement in water application and water use efficiencies. There is a potential of 1.88 MAF of water storage in Potohar region. Out of which 0.26 MAF has already been tapped by construction of 57 small dams.

Keeping in view the significant and positive results/outcomes of completed Sindh Water Sector Improvement Project (WSIP), need of future investment in irrigation sector, the World Bank, which is one of strategic development partners of Government of Sindh, expressed its interest to continue its financial support in the water sector through an integrated approach. The Concept Proposal for Sindh Water and Agriculture Transformation Project (SWAT) has been agreed between the Government of Sindh and the World Bank. The overarching theme of SWAT is the water and agricultural nexus. The project development objective is to increase agricultural water productivity and improve water resources management. Under Component-1 of the Project Water Resources Management following main tasks will be focused, (a) Support for WRM and Irrigation Policy and Institutional Reforms (water law, restructuring irrigation department, & pricing reform), (b) Sindh Strategic Water Plan and updating Right Bank Master Plan. (c) Hydro-Agro Informatics (HAI) Program (HAI Centre, remote sensing, flow, groundwater, floods & drought, ag extension). The Irrigation Department Government of Sindh is implementing the feasibility study namely Ground Water Investigation and Mapping in Sindh through Pakistan Council of Research in Water Resources (PCRWR). The study is focused to achieve the objectives of, (1) Analysing spatial variations in depth to water table on a seasonal basis (Pre-Monsoon and Post Monsoon), (2) Demarcation of spatial variation in groundwater quality, identification of useable groundwater pockets, assessment of canal water discharges and calculation of seepage rate. The Outcome of this study will facilitate sustainable management of water resources in Sindh Province. However, specific outcomes are envisaged as, (i) Demarcation of fresh groundwater zone for the installation of tube wells along the canals, (ii) Identification of sections of canals where lining is feasible, (iii) Demarcation of usable groundwater for the development of zones and, (iv) Prioritizing for increased water allowance during shortage of surface water supplies. The outcomes of the study will be useful for effective management as well as regulation of groundwater resources in the Lower Indus Plain.

Numerous check dams, ponds, and weirs, etc have been constructed all over the province including the Merged Districts as an effective means for Rainwater Harvesting. Irrigation Department has recently enhanced rates of Aabiyana in line with Government Policy. Under various PSDP/ADP/Donor assisted projects, agricultural department also increased the water storage capacity by establishing water storage tanks, earthen ponds, and check dams.

5. Recommendations

Enhance reliance on surface water supplies through the construction of new storage reservoirs/ dams. System losses calculations can be made more robust and reliable through reliable water accounting models and reliable research data. A fair assessment of water availability and demand to define appropriate planning and water resource development. Measures for enhancing water productivity include replacing high delta crops with low delta crops with more value and agro-ecological zoning to define and implement a suitable cropping pattern.

References

Ali, H. (2011). Practices of Irrigation & On-farm Water Management: Volume 2 (Vol. 2). Springer Science & Business Media.

Dahri, Z., Ahmad, S., & Moshabbir, P. (2008). Adjusting crops and cropping pattern with water availability. Water Shortage and Future Agriculture in Pakistan - Challenges and Opportunities, 56-67.

Damkjaer, S., & Taylor, R. (2017). The measurement of water scarcity: Defining a meaningful indicator. Ambio, 46(5), 513-531. https://doi.org/10.1007/s13280-017-0912-z

Economic_Division. (2008-09). Pakistan Economic Survey, Governament of Pakistan Finance Division, https://www.finance.gov.pk/publications_latest.html#pub-1.

Ghani Akbar, G., Hussain, Z., & Yasin, M. (2007). Problems and potentials of permanent raised bed cropping systems in Pakistan. Pakistan Journal of Water Resources, 11(1), 11.

MoWR. (2018). Ministy of Water Resources, Governament of Pakistan, https://mowr.gov.pk/.

Pakistan_F.D. (2018-19). Governament of Pakistan Finance Division, https://www.finance.gov.pk/survey_1819.html.

Qureshi, A. S., McCornick, P. G., Sarwar, A., & Sharma, B. R. (2010). Challenges and prospects of sustainable groundwater management in the Indus Basin, Pakistan. Water resources management, 24(8), 1551-1569.

Sarwar, A., Bastiaanssen, W. G., & Feddes, R. (2001). Irrigation water distribution and long-term effects on crop and environment. Agricultural Water Management, 50(2), 125-140.

Sleet, P. (2019). Water resources in Pakistan: scarce, polluted and poorly governed.

Usman, M. (2009). Comparison of water losses between unlined and lined watercourses in Indus Basin of Pakistan. Pakistan Journal of Agricultural Sciences. 46. 280-284.