ENSURING PAKISTAN'S WATER SECURITY

A Case for Large Dams

It will not be out of place to mention that during the last four decades, no major reservoir has been built in the country. It has been noticed that whenever any effort is made to construct new reservoirs, certain lobbies in and outside Pakistan start questioning the construction of dams and propose some alternate solutions with the intention to shift direction of the policymakers and planners to their points of view.

The shortfall between water demand and supply that was 11% in 2004, is estimated to reach 31% by 2025. A water shortfall of over 30% in 2025 means further storage requirements of the order of 20 MAF (3-4 large dams).

Small dams have 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 flood events.

Large dams store a huge amount of water that can be used for irrigation, hydropower generation (the cheapest source of energy), and to meet the environmental flow requirements of the river. These dams control floods, provide water throughout the year, and act as a buffer during dry season and dry years.

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Background

With an arid climate, agriculture in Pakistan's Indus Plains – the country's food basket – cannot be practised without irrigation. The Indus River and its tributaries are the principal source of water to feed the vast irrigation network that enables crop growth over 80% of arable lands sufficient to meet 90% of the food and fiber requirements of over 220 million people.

Pakistan's national security is linked with its food security which is directly linked with water security. Any decline in water quantity and quality will have serious consequential negative impact on the food security. Due to climatic reasons, the water flowing in the Indus River System is highly skewed with almost 80% total annual water flow occurring in three months (July-September) of the monsoon season. This necessitates the importance of having storage reservoirs to meet water shortage during the remaining period.

Currently, a hot debate is going on in the country on alternate solutions and whether to use large or small dams to store surplus water during high flow period. Proponents of each are forwarding their arguments in favor of their points of view. However, in this article effort has been made to build a case for constructing large dams to create the much-needed storage reservoirs in Pakistan. It will not be out of place to mention that during the last four decades, no major reservoir has been built in the country. It has been noticed that whenever any effort is made to construct new reservoirs, certain lobbies in and outside Pakistan start questioning the construction of dams and propose some alternate solutions with the intention to shift direction of the policymakers and planners to their points of view.

Large Dams – The Global Scenario

What constitutes a large dam? One broad definition largely used by the dam industry is "a dam which is higher than 15 m (taller than a four-story building)". According to this definition there are more than 57,000 large dams worldwide. A sub-classification of large dam is a mega dam with a height exceeding 150 m. There are more than 300 mega dams worldwide.

Cost of energy is the most important input for any industry. Dams provide, most of the time, uninterrupted the cheapest and cleanest source of energy as water is a free input for power production. A classic example is China who is providing cheap energy to its industry due to which cost of production is less as compared to other sources of energy used as input. This has led China to sell its products at relatively much lower cost thus capturing the world market.

China leads the construction of large dams with over 40% of the world's total (Table 1). China's Three Gorges Dam is the world's largest dam (175 m height and 2.4 km length) with 600 km long reservoir. It reached its final height in 2010 and has hydropower generating capacity of 22,500 MW. The dam is a symbol of China's technological and economic progress and has

Table 1
Large Dams in the World

Sr. No.	Country	Total Dams (Nos.)
1	China	23,841
2	USA	9,263
3	India	4,408
4	Japan	3,130
5	Brazil	1,365
6	Korea	1,338
7	Canada	1,150
8	South Africa	1,116
9	Spain	1,064
10	Turkey	973
11	Iran	594
12	Australia	567
13	Pakistan	162

Source: World Register of Dams (2020)

substituted burning of 30 million tons coal every year. The dam has not only controlled the devastating floods but also improved the navigation. Pakistan has over 150 large dams as per the broad definition (Table 1) but only two of these can be classified as mega dams – Tarbela and Mangla.

Why We Need Storage Reservoirs?

The primary reason for constructing dams is creating water reservoirs to enable use during low flow period. Pakistan's population is increasing at an alarming rate and is expected to exceed 250 million by the year 2025. This will not only exert greater pressure on the already dwindling water resources but will also present many challenges for food security. The shortfall between water demand and supply that was 11% in 2004, is estimated to reach 31% by 2025. A water shortfall of over 30% in 2025 means further storage requirements of the order of 20 MAF (3-4 large dams).

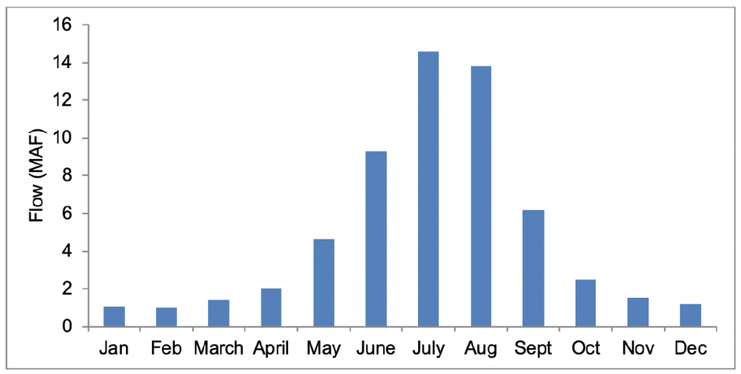
Compared to other countries, the per capita available water storage of Pakistan is also less. The annual per capita water storage of Australia and the U.S. is over 5000 m^3, China 2200 m^3, Egypt 2362 m^3, Turkey 1402 m^3, Iran 492 m^3, while in Pakistan it is only 159 m^3. Aswan High Dam on Nile River 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. This implies that if due to any reason, at any point in time the inflows to the dams becomes zero, the completely filled dams can provide water to meet requirements for only 30 days (one month). However, under similar conditions, Aswan High Dam can provide water for 1000 days (about three years). The present water storage capacity of three major reservoirs in Pakistan is only 9% of the average annual inflow, against the world average of 40% (Briscoe and Qamar, 2006).

Even this storage is at high risk of losing its capacity. Due to lack of watershed management in the catchments, the soil erosion is taking place at an alarming rate. The Indus River in Pakistan ranks third in the world with an annual sediment load of 435 million tons. According to an estimate, the Indus River is adding 500,000 tons of sediment to the Tarbela Reservoir each day, due to which the dam has already lost about 35% of its reservoir capacity. Therefore, new reservoirs would also be needed to replenish the depleting reservoirs capacity.

The other reasons for having large storages are:

- **Transfer Water from Western to Eastern Rivers.** Due to Indus Waters Treaty (IWT) 1960 with India, Pakistan lost three eastern rivers. Almost no water is now flowing into these rivers except some wastewater. Therefore, Pakistan needs storage to regulate/transfer water from western rivers to the eastern rivers to keep these rivers alive and to keep the command areas of these rivers irrigated. Unfortunately, the dam critics have never bothered to look at the dried eastern rivers and the loss of ecosystems/livelihood of the people residing in these areas.
- **Transfer Water Between and Within the Years:** Pakistan depends on a single source viz. Indus River where flow variability over the years and within a year is very high (Fig. 1). In such a case, the construction of storage reservoirs becomes important

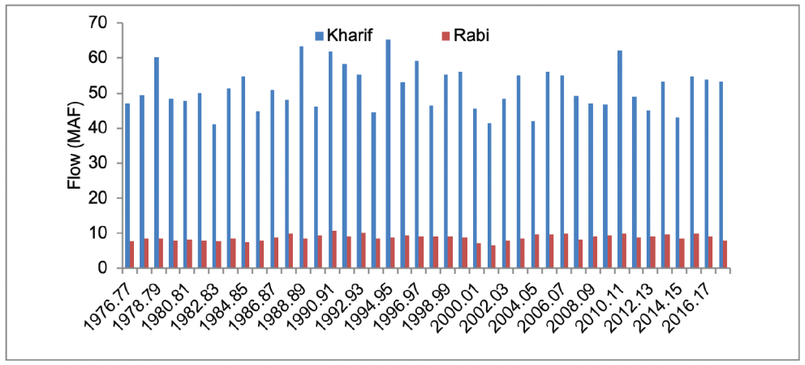
Fig. 1
Monthly Average Flow of the Indus River at Tarbela (1976-2020)



Source: IRSA unpublished data

Fig. 2

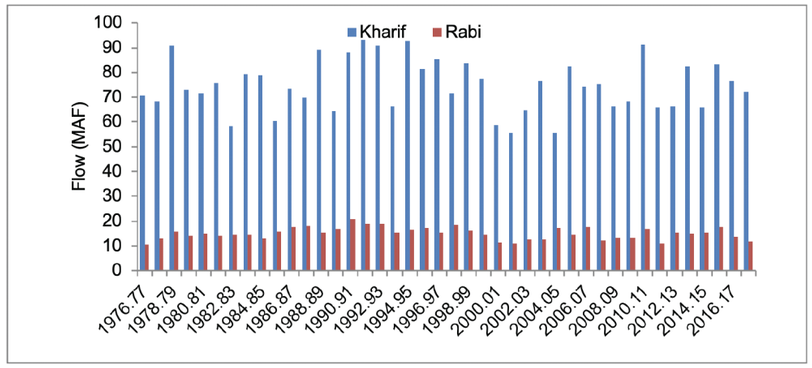
Water Inflows at Tarbela During Kharif and Rabi Seasons



Source: IRSA unpublished data

Fig. 3

Water Inflows at Kalabagh During Kharif and Rabi Seasons



Source: IRSA unpublished data

to ensure water availability through transfer from the wet season to the dry season and from the wet years to the dry years. Figures 2 and 3 show that about 86% and 14% water is received in Kharif and Rabi seasons, respectively. These figures also show that Rabi flows are almost consistent whereas there is a lot of variability in Kharif flows.

▪ **Control Floods.** One of the major functions of dams and reservoirs is to control floods. Pakistan has seen some major devastating floods in the past. Floods have become stories of the past in many countries due to the construction of large dams. A recent example is the Three Gorges Dam of China that has made devastating floods of the Yangtze River a story of the past. Water stored during floods helps mitigate any drought or low-flow conditions during the subsequent years and seasons. Due to inadequate storage, Pakistan has lost more than 90 MAF of water during the floods of 2010, 2012 and 2014 besides having devastating effects on infrastructure, crops, livestock and human. If this water had been stored, it could have helped provide water during the low flow period to various sectors including the Indus delta.

▪ **Mitigating Climate Change Impacts.** Pakistan is highly vulnerable to impacts of climate change. According to the Global Climate Risk Index, Pakistan is the world's 7th most vulnerable country negatively affected by climate change during the period 1996-2015 and it faces an average annual loss of USD 3.8 billion (Jan et al., 2017). According to Young et al., (2019), Climate change will exacerbate water insecurity. The flow variability between and within years may increase, leading to increased severity of floods and droughts. The greatest challenge from climate change would be increased water demand, especially for irrigated agriculture. They predicted 5-15% increase in water demand by 2047 in addition to the increase in demand from a growing population. Therefore, new reservoirs would be needed to account for anticipated flow variability due to climate change.

▪ **Cheap and Clean Hydropower.** Cost of energy is the most important input for any industry. Dams provide, most of the time, uninterrupted the cheapest and cleanest source of energy as water is a free input for power production. A classic example is China who is providing cheap energy to its industry due to which cost of production is less as compared to other sources of energy used as input. This has led China to sell its products at relatively much lower cost thus capturing the world market. For this reason, the large hydropower projects have already been built in high-income countries (HICs) with most current development activity in the low-income countries (LICs) (Grigg, 2019). Pakistan's total installed capacity of energy production is about 18,000 MW whereas a single dam in China (Three Gorges) has more capacity than Pakistan's total. Due to lack of reliable and affordable energy, Pakistan's industry faces huge challenges and many industries have either been closed, shifted to other countries or are running below their potential. Energy produced through other sources such as furnace oil is not only many times costly but is also not environment friendly. Pakistan has to rely on other countries for the import of furnace oil, which drains precious foreign exchange reservoirs. Moreover, timely availability of furnace oil is an issue that has been highlighted in the country during the recent oil crisis.

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Major Concerns Over the Construction of Large Dams

Since the government has started work on the construction of Diamer-Bhasha (8.1 MAF storage with 4500 MW hydropower) and Mohmand (1.239 MAF storage with 800 MW Hydropower) dams, there is an ongoing debate among various circles on these dams. Some of the frequently debated points are:

▪ **Is Pakistan really a water scarce country?** Dr. William Young, World Bank Lead Water Resource Specialist wrote a blog in 2017 on "Five myths about water in Pakistan". In this blog, he tried to establish that Pakistan is a water-rich country and the only issue is the mismanagement of water resources, therefore, it does not need any additional reservoir. Dr. Young and his colleagues in 2019 wrote another report on "Pakistan getting more from water" which is an extended and more elaborative version of his earlier blog. According to them, Pakistan's challenge is not the availability of water, but access by and management across various sectors, primarily agriculture, industries, municipal services, and the environment. Increasing demand by all sectors as a consequence of population increase, economic growth, and climate change will accentuate the need for better cross-sectoral management.

There are more than twenty water scarcity indicators being used worldwide. However, the four indicators that are widely used to define the water scarcity in any country or region are: (i) Falkenmark Indicator, (ii) Water Vulnerability Index, (iii) IWMI's Physical and Economic Indicator, and (iv) Water Poverty Index. Pakistan Council of Research in Water Resources (PCRWR) has analyzed in detail these indicators and concluded that if the situation continues i.e., population keeps on increasing at the same rate and the water resources remain constant, Pakistan will be touching the absolute water-scarcity line by 2025. This report triggered the nation to think seriously about water situation in Pakistan.

▪ **Water will not be enough to fill dams.** One of the arguments is that there is no additional water to be stored in the dams. The most recent floods of 2010, 2012 and 2014 have already answered this question. During these floods more than 90 MAF of water was lost besides having devastating effects on infrastructure, crops, livestock and humans.

▪ **Focus/attention on small dams.** Another argument is that instead of investing in large dams, Pakistan should invest in small dams which are easy to construct and there are less environmental issues related to them. No doubt, small dams have multiple benefits such as they can be useful in providing irrigation water, recharging aquifers, providing water for domestic and municipal purposes, controlling erosion, are in close proximity to the point of use, help developing aquaculture and also provide recreational activities.

However, small dams have 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 flood events. The unit cost of water in small dams is 4-7 times higher as compared to large dams (Keller, 2000). Because of their small storage capacities, they cannot be used for hydropower

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The Government of Punjab has constructed about 50 small dams over the last four decades. The total storage capacity of these dams is 0.1 MAF. Therefore, to replace Diamer-Bhasha Dam (capacity 8.1 MAF), 4200 small dams would be needed. Do we have sites for such a high number of small dams? Moreover, small dams cannot be constructed on large rivers and large dams cannot be constructed on small rivers.

Large dams store a huge amount of water that can be used for irrigation, hydropower generation (the cheapest source of energy), and to meet the environmental flow requirements of the river. These dams control floods, provide water throughout the year, and act as a buffer during dry season and dry years. These can also be constructed using cascade approach where water is recycled many times before final use. The large dams, however, require 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 the alternate of large dams.

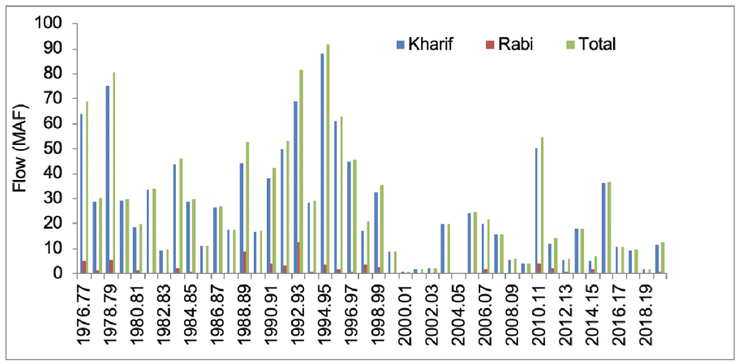
▪ **Focus attention on water conservation.** There is an argument that instead of building large dams, Pakistan should focus more on water resources management as more than 60% of the water is lost in the system during conveyance and application in the field. It has been reported that by doing so water close to the storage capacity of Diamer-Bhasha Dam can be saved – a dam equivalent concept. Factually speaking, water resources management is very important to improve conveyance efficiency, water productivity and equitable distribution of water. A number of initiatives have already been taken up by the federal and provincial governments to improve water productivity. However, there is an argument that the field scale reduction in irrigation application do not translate into real water savings especially in the areas where deep percolation from the root zone can be reused as groundwater irrigation and the water savings at the field scale disappear when one goes up in scale. Therefore, with the management of the available water resources, cropping intensity, water productivity and net income of the farmers can be improved. However, no additional water will be available to inject into the system.

▪ **Large dams are not economically sustainable.** One of the main arguments is that large dams require huge cost and the developed world is no more focusing on large dams. Why do developing countries like Pakistan need to invest in large dams? Young et al., (2019) argued that due to Pakistan's low economic productivity of water in irrigation and rapid rates of reservoir sedimentation, it is hard to justify the costs of major new storages. Hydropower generation does justify new dams, but these could be run-of-the-river facilities (not storage), with lower social and environmental impacts. However, economic contribution from water-use in hydropower generation is significant. This is totally a misconception and a misleading statement. As mentioned earlier, irrigation produces almost 90% of all food and fiber requirements of the country and is ranked among the top ten countries of the world in the production of all major crops. Besides contributing 19.5% to Pakistan's GDP, it employs 42% of the labour force, agriculture sector constitutes 64% of export earnings and provides livelihoods to 62% of the population of the country. For example, 40% of Pakistan's population directly or indirectly benefits from Tarbela Dam and the cost of the dam was recovered within less than ten years after its completion. Through forward and backward linkages in the economy, the total benefits were probably about twice those of the direct power and irrigation benefits (Briscoe and Qamar, 2006). As shown in Table 1, the HICs have already installed large hydropower and irrigation projects and harvested their benefits. The LICs have equal right to benefit from large dams in the best public interest.

• **The Indus Delta will die.** There is an apprehension that upstream storage will result in decreased river water inflow into the Arabian Sea, leading to seawater intrusion into the coastal area and thus will have an adverse impact on the coastal ecosystem, especially the mangrove ecosystem. This is an important issue and phenomenon of seawater intrusion needs to be closely monitored so that the extent and causes of seawater intrusion are thoroughly explored in long term studies. Some studies suggest that saline water intrusion in coastal area is also connected to rise in the sea level. Moreover, international experience in controlling the seawater intrusion, particularly in the closed basins, needs to be studied. This argument is countered by the fact that there are huge variations in the flow downstream Kotri, ranging from 0.29 MAF to 91.86 MAF (as shown in Fig. 4). Ecosystem sustainability in the Indus delta requires freshwater availability throughout the year and not only during 2 to 3 monsoon months. The Independent Panel of Experts in 2005 recommended that a total volume of 25 MAF in any 5 years period (an annual equivalent amount of 5 MAF) be released in a concentrated way as flood flow (Kharif period) is to be adjusted according to the ruling storage in the reservoirs and the volume discharged in the previous four years. An escapage at Kotri Barrage of 5000 cusecs throughout the year is considered to be required to check seawater intrusion, accommodate the needs for fisheries and environmental sustainability, and to maintain the river channel. The implementation of these recommendations is only possible if large storages are built to regulate water from the high-flow period to the low-flow periods. Pakistan Vision 2025, National Water Policy, 2018 and Water Apportionment Accord 1991 put great emphasis on the construction of new reservoirs.

Fig. 4

Flow Downstream Kotri



Source: IRSA unpublished data

Conclusion

There is no doubt that large dams are a source of lifeline for the water security of the country. Besides providing the cheapest and clean energy, they help control floods, provide water for irrigation, regulate flow from high flow to low flow seasons, from a wet year to dry year, and can act as buffer against the vagaries of climate change. Construction of small dams and water resources management in all sectors are important; however, they cannot be an alternative to large dams. ■

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