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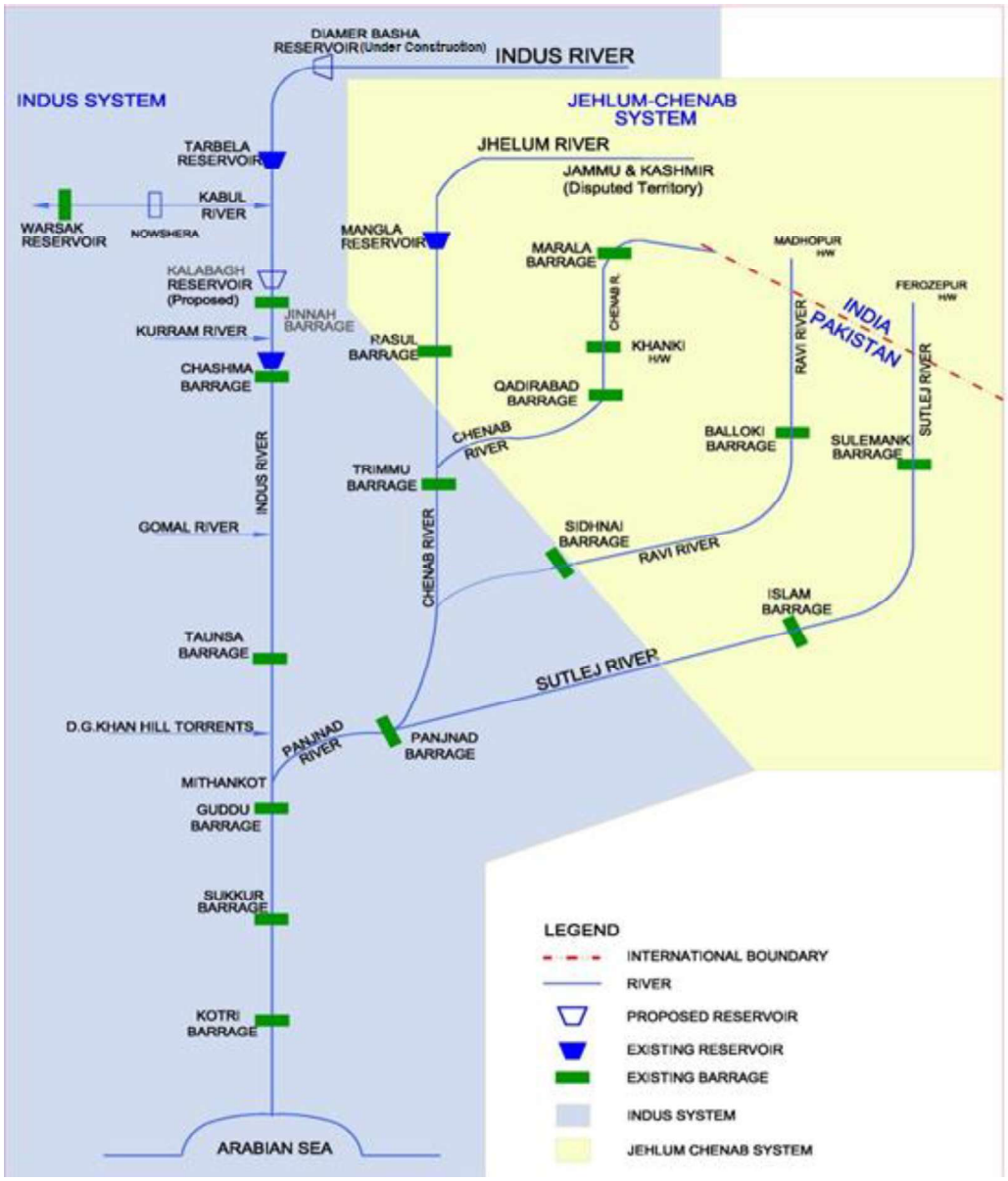
WHAT NEXT AFTER DIAMER BASHA DAM?

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By

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SYNOPSIS

Due to ideal lay of land, climate suitable for year round agriculture and perennial river supplies, Indus Plains have been practicing irrigation since time immemorial. However, systematic weir controlled irrigation started under British era during early 19th century, Resultantly at the time of independence in 1947, Pakistan possessed the largest contiguous Indus Basin Irrigation System (IBIS) of the world.

As political boundaries were drawn without regard to hydrology of Indus River System (IRS), in 1948 India created a unilateral water dispute. This was finally resolved through Indus Waters Treaty (IWT), 1960. Accordingly, waters of three Eastern Rivers (Sutlej, Beas and Ravi) were assigned to India while waters of three Western Rives (Indus, Jhelum and Chenab) were assigned to Pakistan with limited uses in Indian Occupied Kashmir. To compensate Pakistan for loss of Eastern Rivers, Indus Basin Project (IBP) was constructed in Pakistan from 1960-74 including eight inter-river link canals and three storages (Mangla, Chashma and Tarbela).

IBP infrastructure enabled Pakistan to increase pre-Treaty IBIS withdrawals from 88 to 105 MAF. However, these could not be sustained due to rapidly depleting storages. Consequently, IBIS withdrawals are now stagnating around 97 MAF against 117 MAF allocated under Water Apportionment Accord 1991 with specific provision for addition of storages, which went abegging.

Position was further compounded by Indian water aggression under the garb of Treaty permitted hydro-electrics power development on Wester Rivers. So far, India has created significant storage capacity through this facility in violation of Treaty provisions. Despite Pakistan's protests against gross violation of IWT, India is going ahead with further rapid development and equipping itself with sizeable storage to hurt Pakistan's irrigated agriculture through maloperation.

Despite significant developments in other sectors since Independence, Pakistan's economy is still agrarian. Thus about 95% of its present population (216 million), and increasing rapidly, is dependent on irrigated agriculture in Indus Plains.

Superimposed upon multiple water related challenges is the intensifying climate change adverse impact due to global warming. According to 'Global Risk Index 2023', Pakistan is 5th ranked country, which is going to hurt Pakistan economy grievously. A recent Study by Asian Development Bank projects that under high end global warming scenario, by 2070 yields of Pakistan major crops (rice, maize and wheat) may drop below 35 to 45% with consequent GDP reduction by about 20%.

With geographic limitations, burgeoning population, mounting water / security challenges, the only option available to Pakistan is constructing additional IRS storages after expected completion of Diamer Basha Dam Project in 2030. Fortunately, WAPDA is now actually pursuing 'Water Storages Under Planning-Years 2035-60'. It is, therefore, recommended that out of these storages four (Chieniot, Kalabagh, Akhori and Low Skardu) with aggregate live capacity of about 16 MAF may be constructed in IRS over the period of 2027-2050.

WHAT NEXT AFTER DIAMER BASHA DAM?

1. Irrigated Agriculture in Indus Plains

Due to lay of land and suitable climate, agriculture is possible in Pakistan during the whole year. This, combined with fertile alluvial lands, provides ideal conditions for agriculture in the Indus Plains. Sizeable perennial flows from Indus River System (IRS) have enabled practicing of agriculture since time immemorial.

1.1. Pre-Historic

Firm evidence of irrigated agriculture in Indus Plains goes back to at least 2000-4000 years BC. This facilitated establishment of famous Indus Civilizations of Mohenjo-daro and Harrapa. These flourished along Indus and Ravi Rivers, respectively.

1.2. Historic

During the historic times, or even earlier, a number of cities developed along banks of IRS. Famous among which were Lahore, Multan and Sukkur.

During high flow season (Kharif), irrigated agriculture was basically practiced through river flood supplies. During the low flow season (Rabi), the residual river water moisture from floods was supplemented by lifting water from the adjacent recharged dug wells through the famous 'Persian Wheels'.

This flourishing agriculture turned India into to metaphoric 'Golden Sparrow', which attracted lot of invaders from North and North-west. Initially, the invaders plundered the wealth of India and returned after leaving behind a vast devastation. However, later on they started settling by staying around. This process accelerated, particularly during about 1000 years Muslim Rule of India, which finally ended with cessation of Mughal Empire by the British after the Independence War of 1857.

Construction of canals through diversion of river water started with 'Shah Nehr' in 17th century by Emperor Shah Jahan to provide water supply for Shalimar Garden in Lahore. Later on, one of the first weir controlled canals (Upper Bari Doab) was constructed in Indus Plains by the British in 1859, more or less following the alignment of Shah Nehr.

In tandem, construction of inundation canals started, which could utilize only high river flows for spate irrigation. In this process, a vast network of inundation canals developed particularly on Indus, Jhelum and Sutlej Rivers.

1.3. British Era

The first weir controlled Sirhand Canal on Sutlej River was constructed by the British in 1830. However, canal construction process got impetus after defeat of the Sikh Army by the British in 1848. After this full control of Punjab, including NWFP, the British started systematic development of weir-controlled irrigation in Indus Basin.

Starting from Upper Bari Doab Canal (UBDC) in 1859, this process continued till independence in 1947. It resulted in establishment of a very vast network of Indus Basin Irrigation System (IBIS). Resultantly, the largest contiguous irrigation system of the world was created, which turned the Indus Plains into 'bread basket' of India. 'Indus Basin Bread Basket of India in 1947' is shown in Fig.-1.

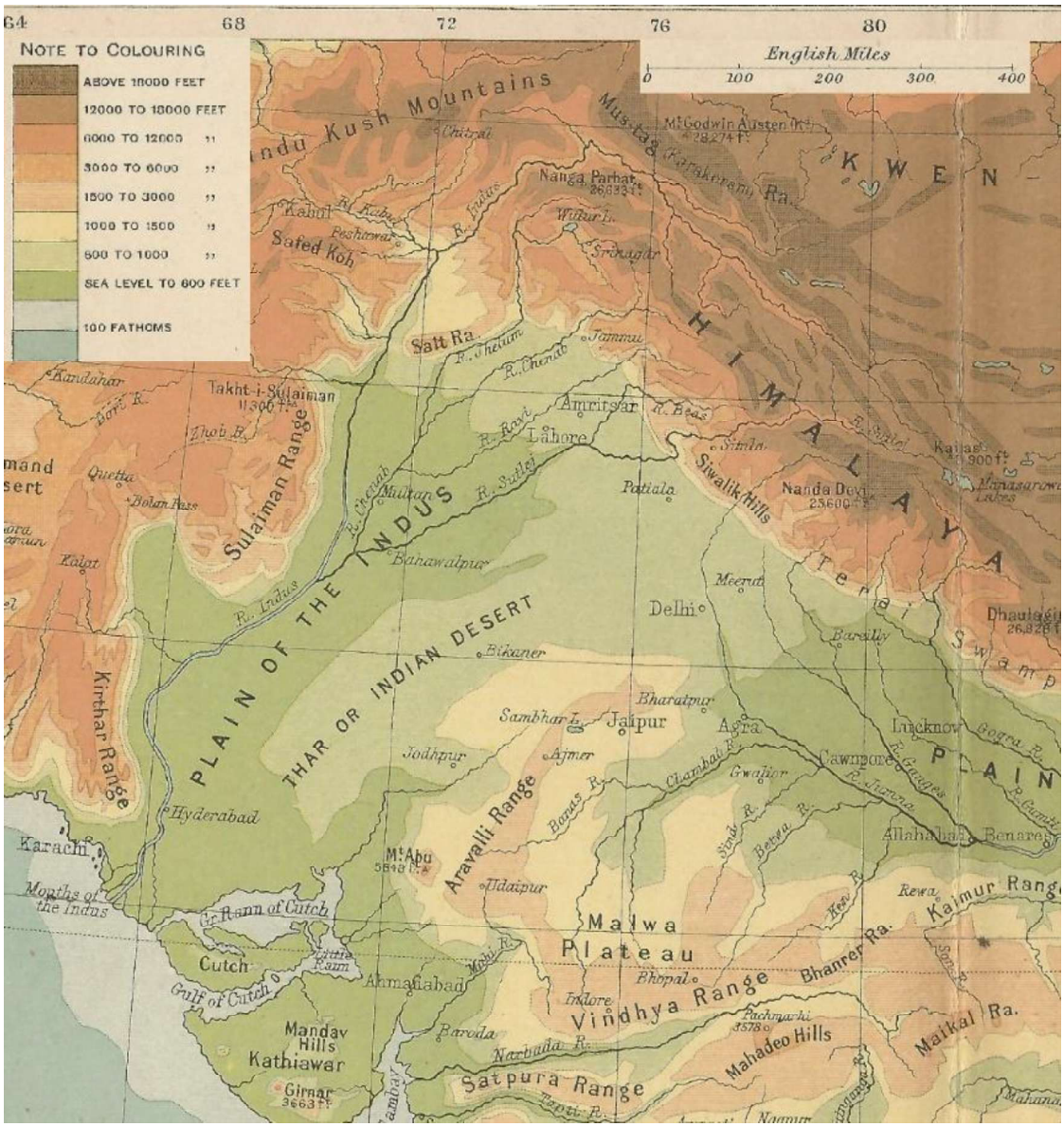


Figure-1: Indus Basin, Bread Basket of India in 1947

Indus Basin Irrigation System (IBIS) inherited by Pakistan at the time of Independence in 1947 comprised: 13 barrages and headworks; 45 main irrigation canals; 38000 miles of distributaries and minors; 90,000 water courses; and command area of 35 million acres (MA).

1.4. Post-Independence Weir Controlled Irrigation Developments in Pakistan

In 1947, plans were on the anvil to convert large network of inundation canals on Indus River System (IRS) to weir-controlled supplies. Despite serious set-back by the Indus Rivers Water Dispute, unilaterally created by India in 1948, Pakistan went ahead with completion of following three barrages on the Indus River, which equipped a large network of inundation canals with weir-controlled supplies: -

i. Kotri Barrage-1956
ii. Taunsa Barrage-1958
iii. Guddu Barrage-1962

Chorology of Indus Basin Development in Pakistan' is shown in Annex-01. After Indus Waters Treaty in 1960, a vast irrigation replacement infrastructure was created through Indus Basin Project (IBP) by 1973. Wasrsak Dam was constructed prior to IBP, while Chashma Right Bank Canal and Greater Thal Canal (Stage I) completed afterwards. This followed Kachhi Canal which is presently under construction. Corresponding schematic representation through Timeline For Major Irrigation and Water Resources Infrastructure in Pakistan, 1830 to Present' is contained in Annex-02.

1.5. Run-of-River Canal System Withdrawals After 1947

Due to above developments, 1950 average canal head system withdrawals of 67 MAF increased to about 88 MAF during 1960-67 even under run-of-river supplies. This was prior to the first live storage induction into the System through 5.3 MAF of Mangla in 1967 under Phase-I of Indus Basin Project (IBP).

2. Indo-Pakistan Water Dispute and its Resolution

2.1. Indus Waters Dispute and Tri-partite Negotiations

Soon after Independence, a water dispute was created in April 1948 through unilateral stoppage of water supplies to Pakistan canals off-taking from headworks located in India. This threatened even existence of Pakistan, which heavily depended on irrigated agriculture.

After stalemate for 3-years, in 1951 Indo-Pakistan water dispute negotiations started under aegis of the Work Bank.

2.2. Signing of Indus Waters Treaty

After nine years (1951-1960) of lengthy and hectic engagement, both India and Pakistan singed Indus Waters Treaty (IWT) on 19 September 1960. It was consummated in Karachi by the then President of Pakistan Ayub Khan and Prime Minister of India, Jawaharlal Nehru in partnership with World Bank. Simultaneously, an Indus Basin Development Fund (IBDF) was established under administration of the World Bank for construction of 'Replacement Works' in Pakistan with fixed contribution from India and grants from the Western Friendly Countries.

In January 1961, the Treaty was ratified by both the countries in New Delhi. However, under Article XII (2) the Treaty, it entered into force retrospectively from 01 April 1960.

2.3. River Water Allocations to Parties Under Treaty

As per IWT, all the waters of three Eastern Rivers (Ravi, Beas and Sutlej) were allocated to India for un-restricted use except during the specified transition period. Transition period would begin on 01 April, 1960 (6 months before signing of the Treaty) and end on 31 March, 1970. However, on specific request from Pakistan, this would be extendable upto a maximum of three years with payment of penalty.

Pakistan shall receive for un-restricted use, all the waters of three Western Rivers (Chenab, Jhelum and Indus) without any interference by India except for insignificant

domestic and non-consumptive uses and some specified agricultural uses before their waters enter Pakistan. Particularly, non-consumptive water use for generation of hydro-electric power from run-of-river plants on Western Rivers in India shall remain within limitations of the Treaty.

2.4. Funding for Construction of Replacement Plan in Pakistan

As mentioned above, concurrent with signing of Treaty, IBDF was established for financing the cost of Replacement Works in Pakistan to compensate for the water ceded to India on Eastern Rivers. According to IBDF, a fixed replacement cost was tagged for India. Responsibility of the extra cost was pledged to be shouldered by the grants from Western Friendly Countries. India accepted the proposal and committed US $174 million. For construction of Replacement Plan an aggregate funding of US$894 million would become available under IBDF.

A little earlier, in 1958 before signing of Treaty, Pakistan established an Indus Basin Advisory Board (IBAB), which prepared the Replacement Plan. This was later on named Indus Basin Project (IBP) for implementation through above mentioned IBDF under administration of the World Bank.

3. Implementation of Indus Basin Project

Indus Basin Project (IBP) was implemented in Pakistan over the period of 1960-74 in a sequence as shown in Table-1.

Table-1: Sequential Implementation of Indus Basin Project in Pakistan

Sr. No.	Infrastructure	Designed Discharge / Capacity	Between Rivers Linkage / Location	Implementation Period / Commissioning
1.	**Link Canals**			
	Trimmu – Sidhnai	11,000 cusecs	Chenab - Ravi	1960-65
	Sidhnai – Mailsi	10,000 cusecs	Ravi – Sutlej	
	Mailsi – Bahawal	4,000 cusecs	Sutlej – Bahwal Canal	
	Rasul – Qadirabad	19,000 cusecs		
	Qadirabad – Balloki	18,000 cusecs	Jhelum - Chenab	1965-68
	Balloki Suleimanki II	6,500 cusecs	Chenab - Ravi	
	Taunsa – Panjnad	12,000 cusecs	Ravi – Sutlej	1966-68
	Chashma – Jhelum	21,000 cusecs	Indus – Jhelum Indus – Chenab	1968-71
2.	**Barrages**			
	Sidhnai	167,000 cusecs	Ravi	1965
	Mailsi Syphon	429,000 cusecs	Sutlej	1965
	Qadirabad	900,000 cusecs	Chenab	1967
	Rasul	850,000 cusecs	Jhelum	1967
	Marala	1,100,000 cusecs	Chenab	1968
	Chashma	950,000 cusecs	Indus	1971
3.	**Storages**			
	Mangla	5.4 MAF	Jhelum	1967
	Chashma	0.8 MAF	Indus	1971
	Tarbela	9.5 MAF	Indus	1974 a)
	Total	15.7 MAF		

Sr. No.	Infrastructure	Designed Discharge / Capacity	Between Rivers Linkage / Location	Implementation Period / Commissioning
4.	**Remodeling of Existing Works**			
	Balloki - Suleimanki Link I Marala - Ravi Link BRDB Link Balloki Headworks	18,500 cusecs 22,000 cusecs 5,000 cusecs 200,000 cusecs	Ravi – Sutlej Chenab – Ravi Chenab – Ravi – Sutlej Ravi	1965-68

a) Initial filling after substantial completion.

After implementation of IBP, the Indus Basin Irrigation System is Schematically shown in Fig.-2.

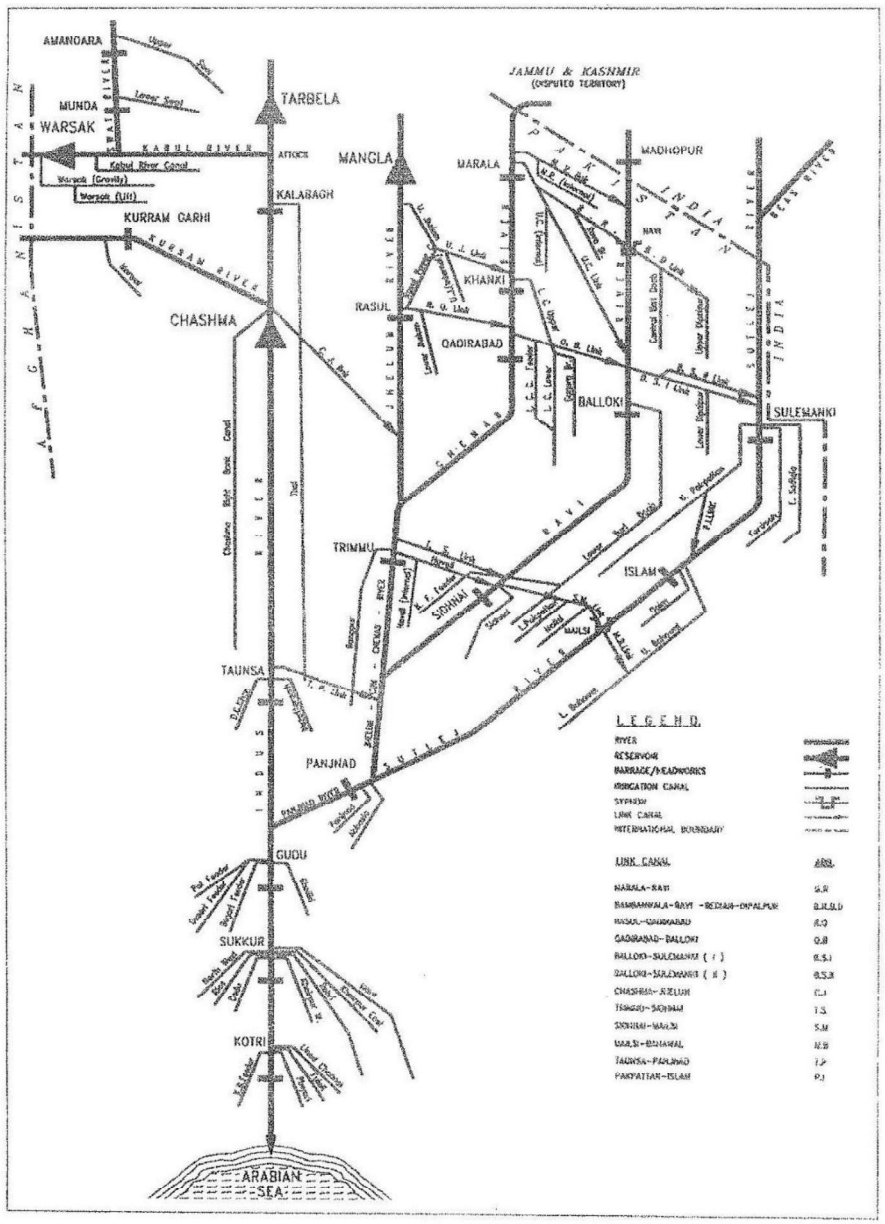


Figure-2: Schematic Diagram of Indus Basin Irrigation System After Implementation of IBP

4. Impact of Indus Basin Project on System Canal Withdrawals and their sustainability

4.1. Impact

With implementation of IBP, Pakistan possessed an integrated irrigation system with regulated river supplies through storages having initial live capacity of 15.7 MAF. This enabled progressive sizeable increase in System canal withdrawals as shown in Table-2.

Table-2: Progressive System Canal Withdrawals Before, During and After Completion of IBP

Period	Average System Canal Withdrawals (MAF)	Live Storage Availability (MAF)	Period
1960-67	88	-	Pre-Mangla
1967-71	95	5.3	Pre-Chashma
1971-77	95	6.0	Pre-Tarbela
1977-82	105	15.7	Post-Tarbela

Average system canal withdrawals of 105 MAF in post-Tarbela period of 1977-82 synergized with very large investments in: Salinity Control and Reclamation Projects (SCARPs); and extensive development of private irrigation tube wells. Thus, Pakistan's agriculture entered the era of 'Green Resolution' with surplus production for local consumption as well as export. As a spin-off, it enabled establishment of sizeable agro-based industries of: textile; sugar; and fertilizers.

4.2. Sustainability of Post-IBP Canal Withdrawals

Under IWT, Pakistan was constrained to cede perennial supplies of Eastern Rivers in exchange for rapidly depleting storages on the Western Rivers. Therefore, World Bank Indus Special (Lieftinck) Study 1968, envisaged that a major storage would be added to the Indus System after every 10-15 years after IBP not only to sustain post-Tarbela uses but provide for additional development.

As no major storage could be constructed after IBP, post-Tarbela (1977-82) average canal withdrawals of 105.3 MAF could not be sustained later on due to rapid depletion of on-line storages without replacement.

4.3. Actual Post-Tarbela System Withdrawals

Due to rapid sedimentation of three on-line reservoirs (Mangla, Chashma, & Tarbela) and absence of any additional storage, it was not possible even to sustain post-Tarbela System withdrawals of 105.3 MAF as shown in Table-3 (for yearly details refer to Annex-03).

Table-3: Post-Tarbela IBIS Withdrawals

Period	Average System Canal Withdrawals (MAF)	On-Line Storage Availability (MAF) a)			Period
		Starting	Ending	Average	
1977-82	105.3	15.7	15.0	15.4	Post-Tarbela
1982-92	104.1	15.0	13.8	14.4	Pre-Accord
1992-02	101.4	13.8	12.5	13.2	Post-Accord
2002-12	96.2	12.5	11.0	11.8	Post-Accord
2012-24	97.1	13.7	12.2	13.5	Post-Raised Mangla

a) Derived from Annex-04 'Actual and Planned Storage Capacity of on-line Reservoirs Through 2035'

Table-3 shows that against the basic target of 105.3 MAF (1977-82), by now the average System withdrawals have progressively reduced to 97.1 MAF.

5. Inter-Provincial Water Apportionment Accord

Upon signing of IWT in 1960, an inter-provincial water dispute started. Notwithstanding establishment of two Commissions, namely Fazle Akbar (1970) and Haleem (1983), the dispute got finally resolved through Inter-Provincial Water Apportionment Accord, 1991. Utilizing post-Tarbela (1977-82 average) canal withdrawals of 105.3 MAF as base, the Accord allocated additional supplies of about 12.4 MAF to the provinces (with major share for NWFP and Balochistan). However, achievement of these additional allocations was subject to construction of major water storages. Consequently, Water Apportionment Accord (WAA) contained a specific recommendation that additional major storages be constructed, wherever feasible.

Unfortunately, however, no such major storage project could be taken up even after WAA, due to one reason or another. At last long, physical implementation of Diamer Basha Dam Project was started by the Government in 2020 with local funding after failure to obtain any international financing whereas its PC-I was approved in 2009.

6. System Storage Capacity Through 2035

'Actual and Projected Live Storage of on-line Reservoirs Through 2035' is depicted in **Annex-04.** This shows that supplementing till end of the current decade in 2030, before Diamer Basha, will be only to the extent of 2.2 MAF from small re-regulating storages for hydropower projects of Mohmand, Dasu and Kurram Tangi. It has been be optimistically assumed that Diamer Basha Dam will be commissioned in 2030. This will boost the available storage from 13.8 to 20.2 MAF. However, by 2035 this available capacity is projected to come down to 19.5 MAF.

Induction stage particulars of multi-purpose storages through 2030 are listed in **Table-4.**

Table-4: Indus River System – Induction of Live Storage Capacity By 2030 Through Multi-Purpose Projects

Sr. No.	Dam Project	River	Induction Stage Live Storage (MAF)	Installed Capacity (MW)	Actual / Anticipated Project Commissioning
1.	Mangla	Jhelum	5.3[a)]	1000	1967
2.	Chashma	Indus	0.7	180	1971
3.	Tarbela	Indus	9.6	1,750 [b)]	1977
4.	Mohmand	Swat	0.7	800	2027
5.	Dasu (Stage I)	Indus	0.6	2,160	2028
6.	Kurram Tangi	Kurram	0.9	83	2029
7.	Diamer Basha	Indus	6.4	4,500	2030
8.	**Total**			**10,473**	

a) Addition of 2.9 MAF in 2014 through raising
b) Initial Installation now being enhanced to about 6800 MW upon completion of Tarbela 5th Extension in 2027

7. Pakistan's water Related stresses and adverse socio-economic implications

Pakistan is now facing the following factual and or impending water related stresses with consequent adverse socio-economic implications:

i. Very fast growing (over 2% per annum) population with reduced per capita water availability to the level of 'Absolute Scarcity' according to internationally accepted criteria (after Falkenmark).

ii. Shortfall in meeting grain production requirement of the burgeoning population requiring additional irrigation.

iii. Rapid sedimentation of on-line reservoirs with inability, not to speak of WAA additional allocations, to sustain even post-Tarbela Canal System Withdrawals.

iv. Indian water aggression on Western Rivers with significant agriculture hurting capabilities against Pakistan.

v. 'Global Climate Risk 2023' ranking Pakistan as the 5th most vulnerable country to climate change.

7.1. Per Capita Water Availability and Impact of Rapid Population Growth

i. In 1951, with a population of about 30 million, then West Pakistan was water affluent with per capita water availability (PCWA) of 5650 m^3.

ii. At the time of dismemberment of Pakistan in 1971, it had a population of about 60 million with corresponding PCWA of 3200 m^3.

iii. By the time of start on WAA implementation in 1992, it stood at 1700 m^3 with a population of about 100 million and was knocking at the door of 'water stress'.

iv. By 2002 it further reduced to 1350 m^3 with a population of about 125 million, and was well within 'water stress' category.

v. By 2012 it touched 1000 m^3 with population about 170 million and entered the stage of 'Water Scarcity'.

vi. By 2019 it was well within actual 'Water Scarcity' with a PCWA of 908 m^3/s and a population of about 190 million.

vii. By now (2025), it is knocking at the dour of 'Absolute Scarcity' with PCWA of 550 m^3 and estimated population of 248 million.

Super-imposed upon this fast dwindling PCWA, is the rapid depletion of three on-line storages of IBP (refer Annex-04). Consequently, System Canal Withdrawals after attaining level 105 MAF (1977-82) have now reduced to about 97 MAF (refer Table-3) while during this period population has increased from about 180 to 250 million.

Aforgiven grim situation is represented in **Fig.3** 'Progressive Pakistan's Per Capita Water Availability, Population Growth and IBIS Withdrawals'.

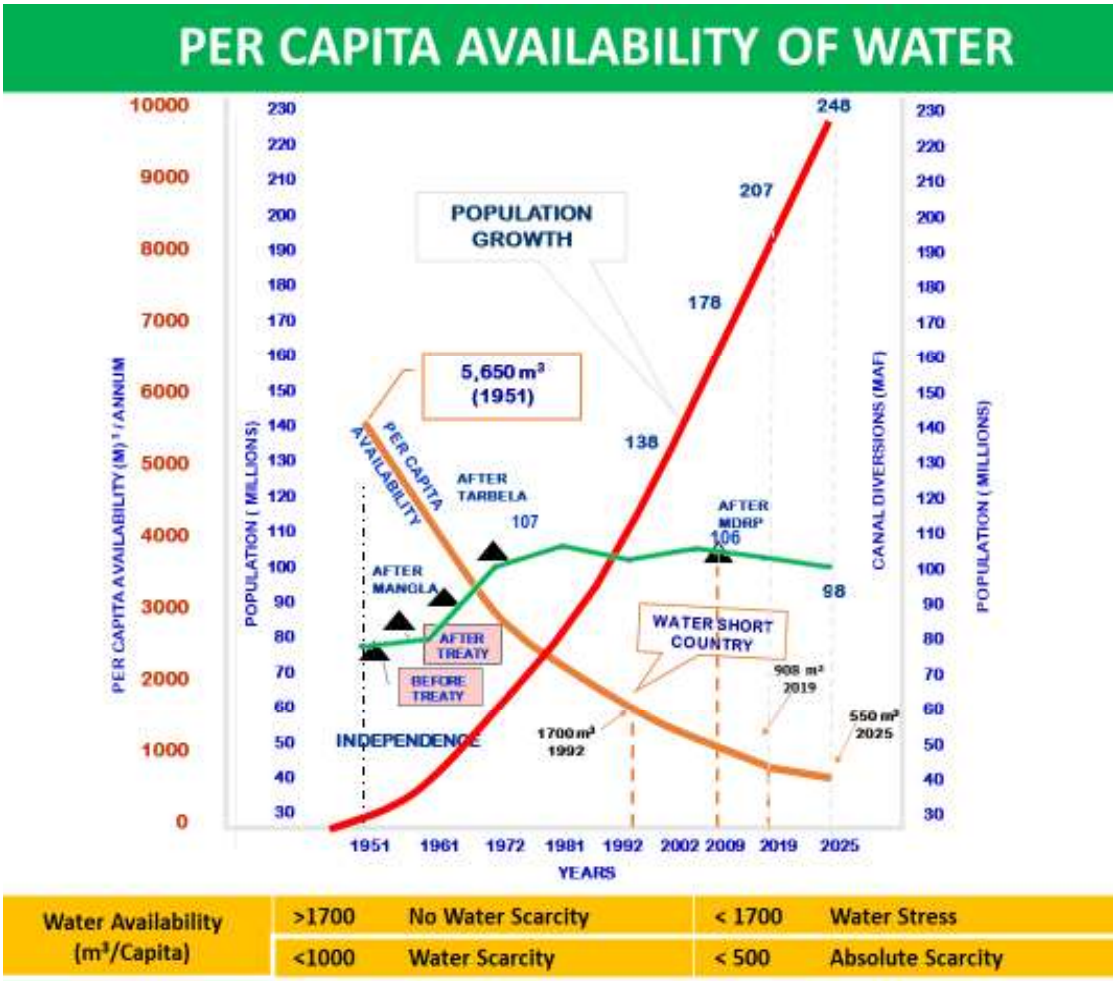


Figure-3: Progressive Pakistan's Per Capita Water Availability, Population Growth and IBIS Withdrawals

7.2. Actual Grain Production Versus Requirements of Pakistan

In 1990, it was estimated that actual grain production was about 20 million tonnes (MT). This, more or less, matched with requirement of about 22 MT for a population approaching 100 million.

By 2025, the projected grain requirement would increase to 53 MT with a shortfall of 18 MT despite normal growth under existing water constraints. Unfortunately, Pakistan is now facing more or less similar situation in this regard.

The above situation is depicted in **Fig.4 '**Pakistan-Actual Grain Production Versus Requirements'.

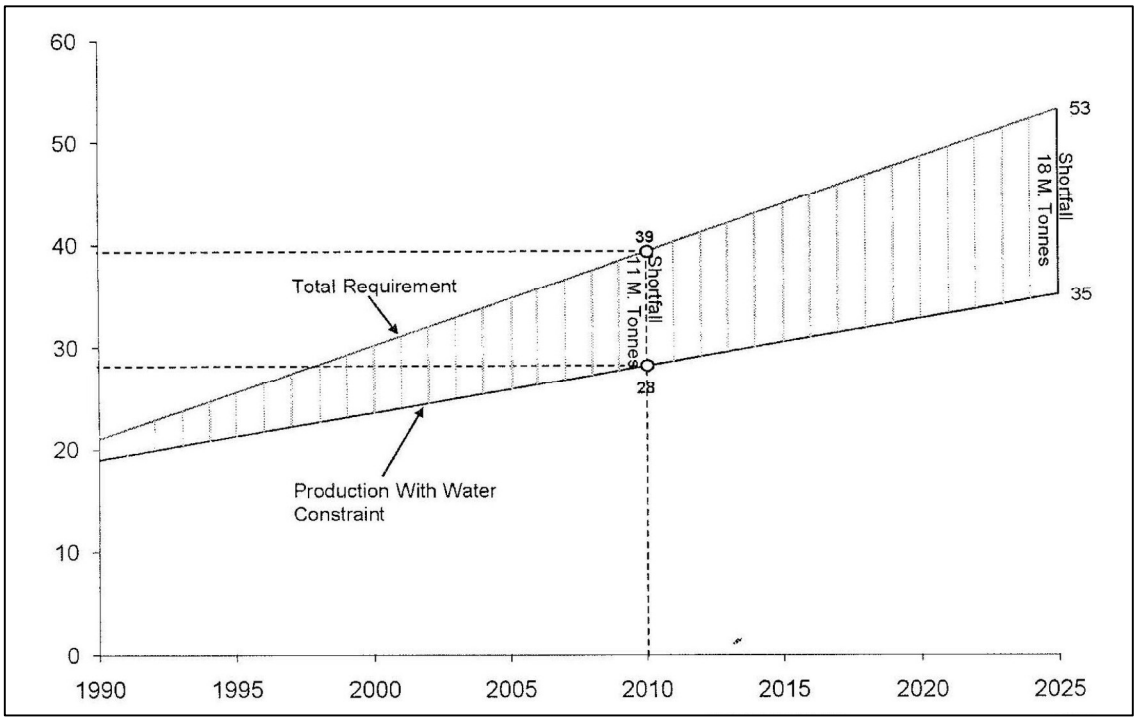


Figure-4: Pakistan – Actual Grain Production Versus Requirements

7.3. Rapid Sedimentation of On-Line Reservoirs

The position has been dealt with in the preceding Section 6 as well as depicted in Annex-04 'Actual and Projected Live Storage of On-line Reservoirs Through 2035'

7.4. Global Warming and Climate Change

Till last decade of 20th century it was being debated whether global warming was posing a real threat to the humanity? However, by the start of 21th century it assumed reality and triggered world-wide climate change with adverse all round impacts.

With the above serious alert, UN sprang into action and along with multiple related agencies, established International Panel for Climate Change (IPCC). Further, the issue of climate change was periodically discussed / reviewed in Conferences of Parties (COPs). Last COP 29 was held in Baku (Azer Baijan) in November 2024.

According to IPCC Fourth Assessment Report (AR4) issued in 2007, the average global temperature increased by 0.6°C over the period from 1901-2000. It was projected to increase between 1.8-4.0 °C by the end of 21st century under different scenarios.

7.4.1. Global Warming Triggers

Global warming, and consequently the climate change, is resulting from increasing concentrations of green house gases (GHGs) in the atmosphere, caused by the use of fossil fuels and other anthropogenic activities.

Basic cause of this phenomenon is increase of CO_2 concentration (main component of GHGs) in the atmosphere from a pre-industrial (mid-18th century) value of about 280 ppm to 379 ppm in 2005 (IPCC AR4, 2007). According to this report, the concentration increased by only 20 PPM over 8000 years prior to industrialization. However, it had risen by nearly 100 ppm since 1750. The annual concentration growth rate was larger during the previous 10 years from 1995-2005 with an average of 1.9 ppm / year, which came largely from fossil fuel consumption and the effects of land use change. It was estimated that since 1750 about 2/3rd of anthropogenic CO_2 emissions had come from fossil fuel burning and about 1/3rd from land use change.

7.4.2. Implications for Pakistan

Pakistan, located in sub-tropical temperate region, has a warm climate and its economy, being largely agrarian, is highly climate sensitive. According to '2023 Global Climate Risk', Pakistan was ranked as the 5th most vulnerable country to climate change. Some 50-80% of average annual river inflows to Indus River System (IRS) are generated by snow and glacier melt in Hindu Kush-Karakoram and part of Western Himalayan Ranges. Upper Indus Basin (UIB), mostly Karakoram part, has more than 5,000 glaciers which cover a total area of about 5900 sq. miles (15,000 sq. km). Their importance can be judged from the fact that the stored volume of water in these glaciers is equivalent to about 14 years of average IRS flows. Therefore, their current and future status in the context of changing climate is of vital concern to Pakistan. This poses a serious threat to national water security and underscores the need for immediate launching of a research effort through coordination between various concerned national agencies backed by national cooperation. Focus of this particular research should be to: project the impacts of climate change on inflows of IRS; and propose way forward to cope with these adverse hydrological impacts.

7.4.3. Projected Global Temperature Changes

According to IPCC (AR4, 2007), future increases in global average temperature were expected to be in the range 1.8 °C-3.4°C over the 21st century. This document contained a Special Report on Emissions Scenarios (SRES) labeled: B1 – low GHG emissions and 1.8°C temperature increase; A1B – Medium GHG emissions with 2.8°C temperature increase; and A2-high GHG emissions with 3.4°C temperature increase.

Latest (2023) projections indicate that above scenarios were conservative. With increasing global GHG emissions and other related factors, it is projected that the global temperature changes scenarios over the 21st century may be much worse and occur in the following sequence: -

i. Temperature rise upto 2060: 2.6°C.
ii. Temperature rise upto 2070: 4.5°C.
iii. Temperature rise upto 2090: 8.5°C.

The above scenarios have been labeled as Representative Concentration Pathways (RCPs). All the above emission scenarios were expected to be accompanied by much increased impacts on global precipitation including: extreme events of flooding and droughts; accelerated melting of glaciers; and sea level rise, etc.

7.4.4. Temperature and Precipitation Trends in Pakistan

i. Projected Temperature Trends

Till about middle of 20th century temperature tends over Pakistan were seen very much tallying with the global trends, whereas future projections showed that the rate of increase of average temperature over Pakistan could be higher as compared to the global trend.

Area average mean annual temperature over Pakistan increased by 0.6 °C over the period of 1901-2000 in agreement with the global trend. Mean annual temperature increase over Pakistan during 48-year period of 1960-2007 was about 0.24 °C per decade as compared to the global 0.06°C, reflecting trend of much increased rate of warming.

During the period of 1901-2000, increase in mean annual temperature in northern half of Pakistan was 0.8°C versus the national average of 0.6°C. Early Summer (April, May) temperatures (both mean and maximum) increased in all parts of Pakistan during the period of 1951-2000. During the same period, Balochistan Plateau became warmer in all the seasons. Temperatures (both mean and maximum) during the monsoon season dropped throughout Pakistan during 1951-2000 except in Balochistan Plateau. During 1951-2000, Greater Himalayan region (the abode of sizeable glaciers feeding the Indus River System) had a warming trend on annual basis as well as in all seasons except monsoon season and in post-monsoon season (Oct-Nov), where it dropped slightly.

Latest temperature trends in Pakistan are not available but the indications are that these are rising significantly higher than previous projections. This is manifested in increasing trend of unseasonal heat waves, particularly in southern Pakistan. Recent (2024) example of Northern Pakistan is that till November which used to be onset of winter, actual temperatures were somewhat similar to late September.

As scenario of IPCC (AR4, 2007) projected global temperature rise to 3.4°C by 2080. It also projected average temperature changes over Pakistan as well as Northern half (above 31° N) and Southern half (earlier 31° N) as shown in **Table-5.**

Table-5: Projected Temperature Changes in Pakistan By 2080 Under A2 Scenario of IPCC (AR4, 2007)

Period	Changes in Temperature (°C)		
	Overall Pakistan	Northern Pakistan	Southern Pakistan
Annual	4.38 ± 0.44	4.67 ± 0.23	4.22 ± 0.18
Summer	4.13 ± 0.26	4.56 ± 0.28	3.90 ± 0.26
Winter	4.47 ± 0.20	4.72 ± 0.24	4.33 ± 0.18

Table-4 indicates that temperature increases in both summer and winter would be higher in Northern than in Southern Pakistan. However, temperature increases in Northern and Southern parts of Pakistan could be higher in winter than in summer.

ii. Projected Precipitation Trends

Area averaged mean annual precipitation over Pakistan increased by 25% during the previous century (1901-2000). During 1951-2000, monsoon precipitation increased everywhere except in coastal regions (where there was a significant drop) and the Western Balochistan Plateau. During the same period, winter rains increased by 26-57% in Sub-Montane, Central & Southern Punjab, and North-Eastern Balochistan and decreased by 13-20% in Sindh and Western Balochistan. During 1951-2000, Greater Himalayan region experienced the highest growth in monsoon precipitation (86%) and a nominal decrease (2%) in winter (December-March) precipitation.

Projected precipitation changes in Pakistan under A2 Scenario of IPCC (AR4-2007) were as shown in **Table-6.**

Table-6: Projected Precipitation Changes in Pakistan By 2080 Under A2 Scenario of IPCC (AR4-2007)

Period	Changes in Precipitation (mm)		
	Pakistan	Northern Pakistan	Southern Pakistan
Annual	3.48 ± 5.78	1.13 ± 3.95	4.28 ± 9.46
Summer	12.16 ± 8.91	1.08 ± 8.35	51.07 ± 39.78
Winter	-5.12 ± 4.78	-2.24 ± 4.10	-20.51 ± 9.05

Rather large variations in Table-6 made it difficult to draw any definite conclusions about change in precipitation with time. There was however, some subsequent (2011, 2012 & 2022) precipitation increase in summer and decrease in winter in the Southern parts of Pakistan. Particularly, 2022 unprecedented summer rainfall increase in South (Sindh and Balochistan) caused excessive flooding with vast devastation. Simultaneously, in Northern Pakistan the monsoons have become less pronounced through: late occurrence; and shifting their centre of gravity form north to north west.

7.4.5. Impact on Water Availability

i. Spatial Rainfall Variability

Annual rainfall in the country is low and erratic, with national average of around 278 mm. it varies from about 160 mm during a dry year (2002) to over 440 mm in a wet year (1994). This precipitates an average of 180 MAF of rainwater over the country's total land area. Spatial variation of rainfall is also huge. It varies between 1500 mm in the northern mountainous areas and northern Punjab to less than 100 mm in the south with southern Punjab and upper Sindh getting about 150 mm per annum. About 80% of the annual rainfall occurs during the monsoon period of July to September. In Pakistan, being located at the western edge of the monsoons system, heavy summer rains normally used to occur in the north-eastern part of the country. However, as mentioned above the recent trend indicates shift toward north west. Monsoons are also becoming highly variable from year to year as well as unpredictable. Climate

change is also enhancing variability of winter precipitation in upper Indus Basin comprising rainfall snow and ice over glaciers.

ii. Primary Water Source

Pakistan's primary source is surface water of Indus River System (IRS) predominantly fed by glacier and snow melt from Hindukush-Karakoram-Himalayas (HKH) mountain ranges. Shares of main water contributors to IRS are: Indus 44%; Kabul 16%; Jhelum 16%; Chenab 19%; and Others 5%.

iii. Average Rim-Station Inflows

Average annual rim-station inflows of the Western Rivers (Indus / Kabul, Jhelum and Chenab) and Eastern Rivers (Ravi and Sutlej) over the record period of 1977-2024 were about 142 (MAF) (refer Annex-03). These varied between low of about 99 MAF in 2002 to high of 177 MAF in 1992.

iv. Climate Change Induced Early Kharif Rim-Station Variability

In early Kharif (April-June), critical crop sowing season, the variability is becoming more pronounced due to impact of climate change. In 2021, this Author carried out a case study of comparative variability in early Kharif Western Rivers inflows. The results are summarized in **Table-7.**

Table-7: Comparative Early Kharif Western Rivers Inflow Variability

Month	Early Kharif Inflows (MAF)									Variability (+) or (-)	
	Average (2010 - 2020)					Actual (2021)					
	Indus	Kabul	Jhelum	Chenab	Total	Indus	Kabul	Jhelum	Chenab	Total	
April	2.0	2.1	2.9	1.4	**8.4**	1.4	1.0	2.5	0.9	**5.8**	-31%
May	4.3	3.2	3.4	2.1	**13.0**	3.7	2.5	3.3	1.5	**11.0**	-15%
June	8.8	3.9	3.2	3.2	**19.1**	8.2	3.4	3.4	2.6	**17.6**	-8%
Total	**15.1**	**9.2**	**9.5**	**6.7**	**40.5**	**13.3**	**6.9**	**9.2**	**5.0**	**34.4**	-15%

Table-7 shows that the maximum reduction of 31% occurred in the critical cotton sowing season of April with overall reduction of 15%. With anticipated further accentuation of this trend, it is imperative that a sizeable early Kharif carry-over storage should be available in the System to sustain the critical crops sowing in early Kharif. Unfortunately, already depleted on-line storages are unable to provide this facility to IBIS and get fully consumed by the end of Rabi season in March.

7.4.6. Projected Impact on Agriculture

Recently, Asian Development Bank (ADB) issued 'Asia-Pacific Climate Report 2024'. Regarding climate impacts in the Region / countries. It states that: -

i. Impact will be very serious on agriculture with disproportionate affect on poor and vulnerable communities.

ii. Changes will be most pronounced in terms of increasing extremes.

iii. Somewhat lower CO_2 concentration could partially counter other climate change impacts on crops, but to a limited extent.

iv. There will be very serious progressive reduction in gross domestic product (GDP).

It further examines the climate change impacts on crop yields under a high ground emission scenario. Taking 2020 as base under this High End Emission Scenario, the Report projects country-wise effects on major crops corresponding to 2035, 2050 and 2070. Projected impacts on yield of major crops of rice, maize and wheat in Pakistan will be alarming as indicated in **Table-8**.

Table-8: Projected Effects of Climate Change on Yields of Major Crops in Pakistan Under High End Emission Scenario Against 2020 Base

Crop	Projected Effect on Yield Through 2070		
	2035	2050	2070
Rice	-5%	-20%	-35%
Maize	-10%	-25%	-40%
Wheat	-5%	-30%	-45%

Climate change will also effect the labour productivity as projected in **Table-9.**

Table-9: Projected Effect of Climate Change on Labour Productivity in Pakistan Under High Emission Scenario Against 2020 Base

Time Scenarios	Projected Impact on Labour Productivity (+) or (-)
2035	-5%
2050	-18%
2070	-25%

Correspondingly projected impact of climate change on gross domestic product (GDP) of Pakistan is summarized in **Table-10.**

Table-10: Projected Effect of Climate Change on Gross Domestic Product of Pakistan Under High End Scenario and 2020 Base.

Base Year	Project Effect on GDP
2035	-2.5%
2050	-11%
2070	-21%

7.5. Indian Water Aggression on Western Rivers of Indus Basin

7.5.1. Indus River Basin

i. Extent

Indus Basin (refer Fig.1) stretches from Himalayan mountains in the north to dry alluvial plains of Sindh province in southern Pakistan. Basin area in Pakistan is around 224,000 sq. miles (582,000 sq. km). This comprises about 52% of the Basin spread over Azad Jammu and Kashmir, whole provinces of Punjab and Khyber Pakhtunkhwa, most of Sindh province and the eastern part of Balochistan.

Drainage area lying in India is approximately 146,000 sq. miles (380,000 sq. km). it constituencies about 34% of the Basin and lies in the States of: Jammu and Kashmir

(disputed territory); Himachal Pradesh; Punjab; Haryana; and Rajasthan. Only about 8% of the Basin lies in China and remaining 6% in Afghanistan accounting only of 11% area of the country.

ii. Beneficiary Population In Indus Basin

It is estimated that the recent (2023) beneficiary population in the Basin is about 235 million as per country-wise break-up in **Table-11**.

Table-11: Estimated Beneficiary Population of Indus Basin

Sr. No.	Country	Dependent Population [a] (Million)		
		Actual 2017	Estimated 2023	(%)
1.	Indian Occupied Jammu and Kashmir: -			
	i. Kashmir Valley	4.0	4.4 [c]	
	ii. Jammu	3.0	3.3 [c]	
	iii. Ladakh	0.3	0.3 [c]	
	Sub-total 1 (i+ii+iii)	**7.3**	**8.0**	**3.4**
2.	Pakistan			
	i. Four Provinces	202.5 [b]	229.4 [b]	
	ii. Azad Jammu & Kashmir	4.0	4.4 [c]	
	iii. Gilgit Baltistan	2.0	2.2 [c]	
3.	**Sub-total 2 (i+ii+iii)**	**208.5**	**216.0**	**92.1**
4.	Afghanistan	10.0 [d]	10.6 [c]	4.5
5.	**Total (1+2+3+4)**	**225.8**	**234.6**	**100.0**

a) Nominal population of China has been ignored.
b) Assumed as 95% of total population as per census.
c) At assumed annual compound growth rate of 1.7% from 2017.
d) Assumed as equal to 25% of population.

It is noteworthy that about 92% of current Basin population resides in Pakistan, while IWT has allocated supplies of Western Rivers comprising about 82% of Basin river flow.

iii. Climate

Climate is not uniform over the Basin. It varies from sub-tropical arid and semi-arid to temperate sub-humid on the plains of Sindh and Punjab provinces of Pakistan to alpine in the mountainous highlands of North.

In semi-arid Lower Indus Basin Plain (Pakistan), December to February is the cold season with mean monthly temperatures varying between 14 to 20 °C. Mean monthly temperatures during March to June vary from 42 to 44 °C. In Upper Indus Plain of Pakistan mean temperature ranges from 23 to 49 °C during summer and from 2 to 23 °C during winter.

Annual precipitation ranges between 4 to 20 inches (100 and 500 mm) in the lowlands to a maximum 80 inches (2000 mm) on mountain slopes. Snowfall at higher altitudes above 8200 feet (2550 m) accounts for most of the river runoff.

Upper Indus Basin high mountainous region limits intrusion of monsoons, influence of which weakens north-west ward. Most of precipitation falls in winter and spring and originates from westerlies. Monsoonal incursions in lower catchment bring occasional rain to trans-Himalayan areas but even during summer months not all precipitation derives from monsoons and or Arabian sea moisture.

Climatic variables are strongly influenced by altitude. Northern arid valley floors receive precipitation from 4 to 8 inches (100 to 200 mm). This increases to 24 inches (600 mm) at 14400 feet (4400 m). Glaciological studies suggest precipitation accumulation rates of 60 to 80 inches (1500 to 2000 mm) at 18000 feet (5500 m).

From 1961 to 1999 there were significant increases in winter, summer and annual precipitation accompanied by climatic warming whilst summer showed a cooling trend. These trends further accentuated with activated climate change at the start of 21st seriously impacting water resource availability as well as variability.

7.5.2. Indian Aggression on Western Rivers

As per Treaty, Pakistan has been allocated three Western River except for some limited consumptive / non-consumptive uses in the Occupied Jammu and Kashmir.

i. Consumptive Uses

Consumptive uses basically cover agricultural developments Provisions in this regard are contained in Annexure C to the Treaty titled 'Agricultural Use by India from the Western Rivers'. Accordingly, over and above the existing cropped area of 462,000 acres on the effective treaty date of 01 April 1960, India will make withdrawals from the Western Rivers only to the extent necessary to meet the irrigation needs of additional cropped area of 239,000 acres.

ii. Non-Consumptive Uses

Non-consumptive use will include flood control and run-of-river hydro-electric generation.

iii. Permitted Storage on Western Rivers

Provisions in this regard are covered under Article III (4) of the Treaty. These are further elaborated in Annexure E titled 'Storage of Waters by India on the Western Rivers'. Accordingly, the aggregate storage capacity of all reservoirs which may be constructed by India on each of the river systems are shown in **Table-12.**

Table-12: Storage Capacity Permitted to India Under the Treaty on Western Rivers

Sr. No.	River System	Purpose of Storage With Capacity (MAF)			Total (MAF)
		General [a]	Hydropower [b]	Flood [b]	
1.	Indus	0.25	0.15	0.00	0.40
2.	Jhelum (excluding Jhelum Main)	0.50	0.25	0.75	1.50
3.	Jhelum Main	0.00	0.00	0.00	0.00
4.	Chenab (excluding Chenab Main)	0.50	0.60	0.00	1.10
5.	Chenab Main	0.00	0.60	0.00	0.60
6.	**Total**	**1.25**	**1.60**	**0.75**	**3.60**

a) Consumptive use for development of additional cropped area of 239,000 acres.
b) Non-consumptive use for run-of-river hydro-electric generation and flood control.

Under the garb of hydro-electric generation, India has waged water aggression against Pakistan whereas the related permitted storage of 1.6 MAF is meant for annual / short-term re-regulation of run-of-river projects. India is constructing these run-of-river facilities in complete violation of Treaty provisions. Consequently, India has already created sizeable storage capacities on Western Rivers with substantial hurting capability against Pakistan through maloperation. The issue has been constantly agitated by Pakistan under the Treaty dispute resolution mechanisms by reference to National Experts and or International Court of Justice but without much success. As of now (2024) India has already created a hurting capability of about 1.1 MAF as shown in **Table-13.**

Table-13: Indian Existing Hurting Capability Created Through Hydroelectric Projects on Western Rivers

Sr. No.	Hydro-Electric Project	River Basin	Gross Storage Capacity (MAF)	Installed Generation Capacity (MW)	Year of Actual / Scheduled Completion	Dispute Resolution Status Under Treaty
1.	Salal	Chenab	0.228	690	1987	Mutual agreement
2.	Baghliar	Chenab	0.381	450 [a]	2008	Adverse decision against Pakistan by Neutral Expert
3.	Kishenganga	Jhelum	0.180	330	2018	Unfavorable decision against Pakistan by International court of Justice (ICJ)
4.	Pakal Dul	Chenab	0.102	1000	2024	Now decisions under concurrent deliberations of ICJ and Neutral Expert
5.	Ratle	Chenab	0.235	850	2024	
6.	**Total (1 to 5)**		**1.126**	**3320**		

a) Stage I development with ultimate capacity of 900 MW

Interestingly, already developed Indian storage of 1.126 MAF is not such off from total Treaty permitted Indian storage of 1.6 MAF **(Table-12)** for hydropower development on Western Rivers. Currently, India has a long list of hydro-electric projects: under construction; in the pipeline; and under planning. Thus, the ultimate Indian development in this respect is going to substantially exceed the Treaty limitation of 1.6 MAF. Creation of this potential adversity is obviously going to hurt Pakistan's irrigated agriculture directly and consequent serious socio-economic implications for the dependent population currently estimated as 216 million **(Table-11).**

8. Projected system canal withdrawals upon induction of diamer basha storage

It has been optimistically assumed that the ongoing storage under construction by WAPDA including Diamer Basha will be completed by 2030 in the following sequence:-

i. Mohmand Dam (0.7 MAF) – 2027
ii. Dasu Dam (0.6 MAF) – 2028
iii. Diamer Basha Dam (6.4 MAF) 2030

System storage availability with these additions has been shown in Annex-04 'Actual and Project Live Storage of on-line Reservoirs Through 2035'. Accordingly, projected available progressive live storage with induction of Diamer Basha in 2030 and expected system additional canal withdrawals are shown in **Table-14**.

Table-14: Projected System Canal Withdrawals Upon Induction of Diamer Basha Storage in 2030

1.	Available Live Storage in 2030	20.2 MAF
2.	Sustaining post-Tarbela System Average Withdrawals of 105 MAF	15.7 MAF
3.	Balance for Partial Additional Para 2 Accord Allocations with Assumed 60% [a)] Storage Requirement (7.5x06)	4.5 MAF
4.	Projected Total System Canal Withdrawals in 2030	112.5 MAF [b)]

a) As per computations in Annex-05.
b) Comprising post-Tarbela withdrawals of 105 MAF and partial Additional Para 2 Accord Allocations of 7.5 MAF.

Table 14 shows that after induction of Diamer Basha Dam in 2030, besides restoring post-Tarbela system withdrawals of 105 MAF, 7.4 MAF out of 12.4 MAF Additional Para 2 Accord Allocations could be also provided thus aggregating to 112.5 MAF.

9. Need For Induction of Additional System Storages After 2035

Annex-04 shows that by 2035 Post-Diamer Basha storage availability of 20.2 MAF will reduce to 19.5 MAF due to sedimentation. Thus, even to sustain projected 2030 System withdrawals, progressive induction of additional storage will become necessary.

It has been also highlighted in the preceding that Pakistan is now facing multiple socio-economic and water related stresses with dire consequence on: water security; sustainability of its agrarian economy; and socio-economy. Further, some of critical

ameliorating / adaptation measures to cope with effects of climate change may be out of Pakistan's reach or capability. The main reason would be lack of required internationally committed funding. Recent example was CoP 29 held in Baku during November 2024 without any firm commitment of climate financing by the developed countries. As usual, in the proverbial sense, in COP 29 the parties 'Assembled, Discussed and Dispersed'.

Notwithstanding, the above bleak picture, Pakistan still has the fallback option of constructing additional river water storages on IRS after 2035. This will need national political will and commitment including resuscitation of Kalabagh Dam Project.

10. WAPDA's Post-2030 Plan For Storages

This is contained in WAPDA's November 2024 presentation to the Government of Pakistan as 'Water & Power Challenges & Prospects'.

From the list of WAPDA's planned multi-purpose storage additions upto 2060 in this presentation, at least four projects could be prioritized for construction by 2050 based on current engineering preparedness and optimistic projection. The suggested list along with proposed prioritization and implementation schedule is shown in **Table-15**.

Table-15: Prioritized List of Suggested Medium Term Storage Inductions on Indus River System Upto 2050 Including Implementation Schedule

Sr. No.	Dam Project		Live Storage Capacity (MAF)	Generation Capacity (MW)	Engineering Preparedness Status (Nov. 2024)	Suggested Implementation Schedule
	Location	River				
1.	Chiniot	Chenab	0.9	80	i. Feasibility Study, 2019 ii. Detailed Engineering Design & Tender Documents in hand since 2022	2027-31
2.	Kalabagh[a)]	Indus	6.1	3600	Detailed Engineering Design & Tender Documents Completed in 1987 but construction stalled due to unfortunate inter-provincial disharmony	2032-39 [a)]
3.	Akhori	Indus (Off Channel)	6.0	600	i. Feasibility Study 2025. ii. Engineering Design & Tender Documents by 2039	2040-45
4.	Skardu (Low	Indus	3.2	1500	i. Pre-feasibility Study-2020 ii. Feasibility Study by 2040 iii. Detailed Engineering Design & Tender Documents by 2045	2046-50
5.	**Total**		**16.2**	**5780**		

a) Subject to prior consensus of all the provinces (to be pursued vigorously by GoP) and design / environmental updations

11. Conclusions and Recommendations

11.1. Conclusions

i. a. Due to ideal lay of land and climate suitable for year-round cropping, Indus Plains have been practicing inundation irrigated agriculture since pre-historic times.

b. During historic times, systematic weir-controlled irrigation development was started by the British through construction of Sirhind Canal in 1930 on River Sutlej. By the time of Independence in 1947, Pakistan inherited the largest contiguous irrigation system of the world serving as 'Bread Basket' of United India.

ii. a. As political boundaries of the two countries were drawn without considering hydrology of Indus River System, this enabled India to create unilateral Indo-Pakistan Indus Water Dispute in 1948 soon after the Independence.

b. With initial stalemate and prolonged negotiations under aegis of the World Bank, the dispute was resolved in 1960 through Indus Waters Treaty (IWT).

c. According to Treaty, waters of the three Eastern Rivers (Sutlej, Beas and Ravi) were allocated to India. Similarly, waters of three Western Rivers (Chenab, Jhelum and Indus) were allocated to Pakistan but with permission to India for limited consumptive / non-consumptive use in Occupied Kashmir.

d. To compensate for the water lost to India on the Eastern Rivers, Pakistan was allowed to construct Replacement Works in its territory on the Western Rivers including storages.

e. For construction of Replacement Works, concurrent with Treaty, an Indus Basin Development Fund (IBDF) was created under administration of the World Bank with fixed contribution from India and grants form Western Friendly Countries.

iii. a. Replacement Works, popularly known as Indus Basin Project (IBP), were completed by Pakistan over the period of 1960-74 including 8 inter-river link canals along with barrages and three storages (Mangla, Chashma & Tarbela) with live capacity of 15.7 MAF.

b. In the period upto 1962, despite being engaged in Indus Water Dispute, Pakistan converted large Indus Inundation Canals network to weir-controlled supplies through construction of barrages (Kotri, Taunsa and Guddu).

c. As a result of above developments, by 1974 Pakistan had a regulated and integrated Indus River System with 45 canals system commanding an area of 35 million acres.

iv. a. With weir-controlled supplies, river integration and sizeable storages, the run-of-river mode irrigation system turned into regulated supplies throughout the year.

b. As a consequence of IBP, pre-Treaty Indus Basin Irrigation System (IBIS) withdrawals of 88 MAF increased to 105.4 MAF in post-Tarbela period after full commissioning of this storage in 1977.

c. Unfortunately, however, this quantum jump in IBIS withdrawals could not be sustained as under the Treaty Pakistan had ceded perennial supplies of the Eastern Rivers and accepted their substitution by rapidly depleting reservoirs.

v. a. Simultaneously, with completion of IBP, inter-provincial water dispute started. This was finally resolved through Inter-Provincial Water Appurtenant Accord (WAA) in 1992.

b. Assuming further addition of replacement-cum-development storage facilities, WAA enhanced post-Tarbela (1977-82) 105.4 MAF withdrawals of IBIS by about 12 MAF through formal allocations to the provinces. Unfortunately, on the other hand, uptil now it has not been possible even to sustain post-Tarbela withdrawals due to non-induction of any major storage into the System after Tarbela.

vi. a. By the start of WAA implementation in 1992, on-line IBP storage of 15.7 MAF had already depleted to 13.8 MAF.

b. Uptil now (2024) this on-line storage has further reduced to 12.2 MAF despite raising of Mangla (2.9 MAF) in 2014.

c. Consequently, average post-Tarbela withdrawals of about 105 MAF are now stagnating around 97 MAF.

vii. a. Currently, four dam projects, Mohmand, Dasu, Kurram Tangi and Diamer Basha are under construction which will enhance system storage capacity to 20.2 MAF in 2030.

b. Besides meeting the shortfall of about 7.4 MAF (105.4-97.1) between post-Tarbela and present IBIS withdrawals, this may also enable for the first time partial attainment of 7.5 MAF out of additional 12.4 MAF allocated under Para 2 of Accord.

viii. a. Despite significant contribution by other sectors since Independence, Pakistan's economy is still essentially agrarian, with about 95% of the current population (216 out of 277 million) still dependent for its livelihood on Indus River System.

b. Pakistan's population is growing rapidly, and even assuming a conservative rate of 2% per annum, it is projected to exceed 300 million by 2040.

c. Sustained provision of food and fiber for this burgeoning population would pose an existential challenge to Pakistan further compounded by adverse climate change impacts being a front-line country.

d. Last, but not the least, will be accelerated Indian Water Aggression against Pakistan on the Western Rivers.

ix. Water related stresses facing Pakistan are:

a. Per capita water availability of 5650 m^3/s in 1951 (affluence stage) has reduced to 550 m^3/s at present and Pakistan is knocking at the door of 'Absolute Scarcity'.

b. Rapid sedimentation of Indus River System storages with constant need for sustainability through augmentation.

c. According to Global Climate Risk Index 2023, Pakistan is ranked as 5^{th} most vulnerable country.

d. Global warming is triggering extreme variations in rainfall pattern with alternate floods and droughts, with particular impact on Pakistan's primary source of surface water from snow-cum-glacial melt in Upper Indus Basin.

x. According to Asian Development Bank 'Asia-Pacific Climate Report 2024', under high end global warming scenario the projected adverse climate impacts upto 2070 in the Region including Pakistan could be:

   a. Increased crop water requirements with concurrent reduction in yield of major food crops up to the extent of about 25% and consequent reduction of Pakistan GDP by about 10%.

   b. Serious impact on agriculture with disproportionate effect on the poor communities.

xi. a. India has launched Water Aggression against Pakistan through gross violation of Treaty limitations for developing non-consumptive uses on Western Rivers.

   b. Main element of this aggression is continuous development of run-of-river hydroelectric projects.

   c. Treaty permits a total non-consumptive re-regulation storage of 1.6 MAF for hydro-electric development.

   d. Against this, India has already developed 1.1 MAF with potential agriculture hurting capability against Pakistan through construction of six hydro-electric projects despite serious objections by Pakistan under provisions of the Treaty.

   e. No relief has been obtained by Pakistan despite referring the above projects to Neutral Experts and or International Court of Justice. Some of these are still under deliberation in these forums while India is continuing with their construction.

   f. India is going in a big way to construct further hydro-electric facilities on the Western Rivers and a number of projects are either in the pipeline or under engineering studies.

   g. Cumulative impact of above Indian Water Aggression on Pakistan could be disastrous.

xii. a. Due to above mentioned political and socio-economic challenges, further compounded by adverse climate change impacts, Pakistan is threatened by water / food security risks with dire consequences.

   b. To cope with above challenges only in-house option available to Pakistan is induction of additional IRS storages both in the short, medium and long term contexts.

11.2. Recommendations

i. From among WAPDA's 'Post-2030 Plan of Storages' it is recommended that the following four dams be prioritized for implementation upto 2050 in the suggested sequence: -

   a. Chinot Dam on Chenab (0.9 MAF) 2027-31
   b. Kalabagh Dam on Indus (6.1 MAF) 2032-39
   c. Akhori Dam as an Indus off-Channel Storage (6.0 MAF) 2040-45
   d. Low Skardu Dam on Indus (3.2 MAF) 2046-50

ii. Simultaneously, Pakistan should vigorously pursue with the concerned International Agencies of the UN for:

a. Redressal of grievances against Indian water aggression on Western Rivers under dispute resolution mechanism of the Treaty.
b. Seeking financing for mitigation / adaptation to cope with adverse impacts of climate change being 5th ranked according to 'Global Climate Risk Index 2023'.

12. Acknowledgements

Thanks are due to Mr. Zeeshan Riaz Tarar, System Analyst, Indus River System Authority (IRSA) for computing and furnishing the updated 'Post-Tarbela Behaviour of Indus Basin Irrigation System' as contained in Annex-03.

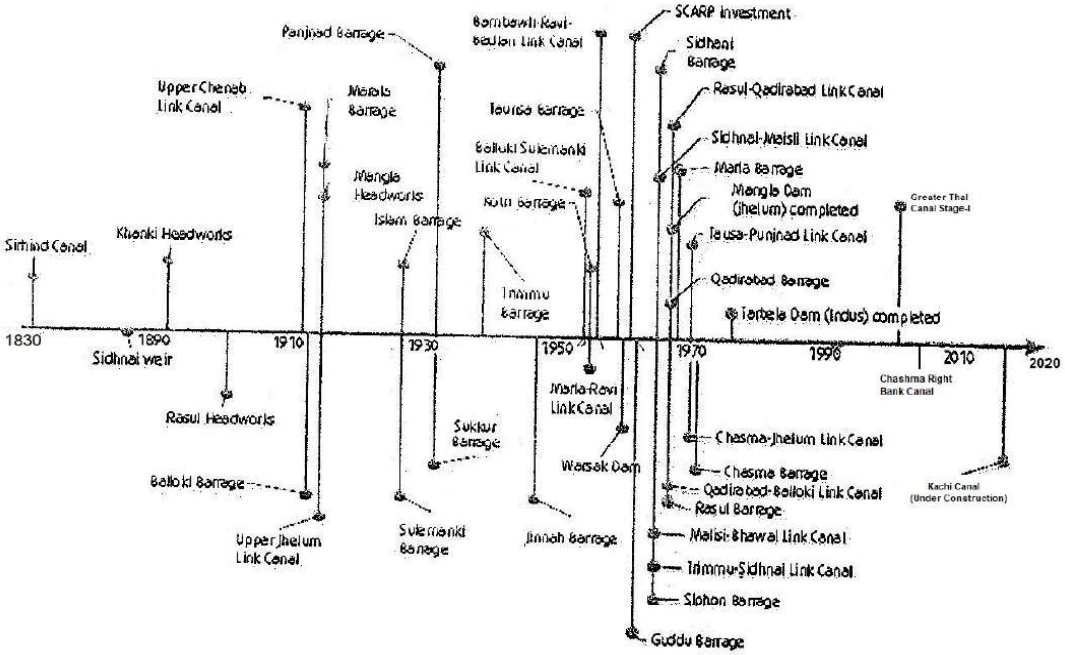
Special thanks are also due to Mr. Shahid Hamid, Adviser (Hydrology and Water Management) WAPDA for sharing the information regarding 'Water Storages Under Planning Stage Years 2035-60'.

ANNEXURE 01

Sr. No.	Project	Year of Completion
1.	Sirhind Canal on Sutlej River	1830
2.	Upper Bari Doab Canal on Ravi River	1859
3.	Lower Chenab Canal on Chenab River	1982
4.	Sidhnai Canal on Ravi River	1882
5.	Lower Jhelum Canal on Jhelum River	1901
6.	Lower and Upper Swat, Kabul River and Paharpur Canals in Khyber Pakhtunkhwa (previous North West Frontier Province)	1885-1914
7.	Triple Canal Project Linking Jhelum, Chenab and Ravi Rivers	1907-1915
8.	Sukkur Barrage on Indus River	1932
9.	Sutlej Valley Project on Sutlej River	1933
10.	Haveli Canal Project on Chenab River	1939
11.	Thal Canal on Indus River	1947
12.	Kotri Barrage on Indus River	1955
13.	Taunsa Barrage on Indus River	1958
14.	Gudu Barrage on Indus River	1962
15.	**Chashma Barrage on Indus River**	**1971**
16.	**Chashma Right Bank Canal (Three stage construction Ex. Chashma Barrage)**	**1986-2005**

ANNEXURE 02

TIMELINE OF MAJOR IRRIGATION AND WATER RESOURCES INFRASTRUCTURE IN PAKISTAN, 1830TO PRESENT



ANNEXURE 03

POST-TARBELA BEHAVIOUR OF INDUS BASIN IRRIGATION SYSTEM

(MAF)

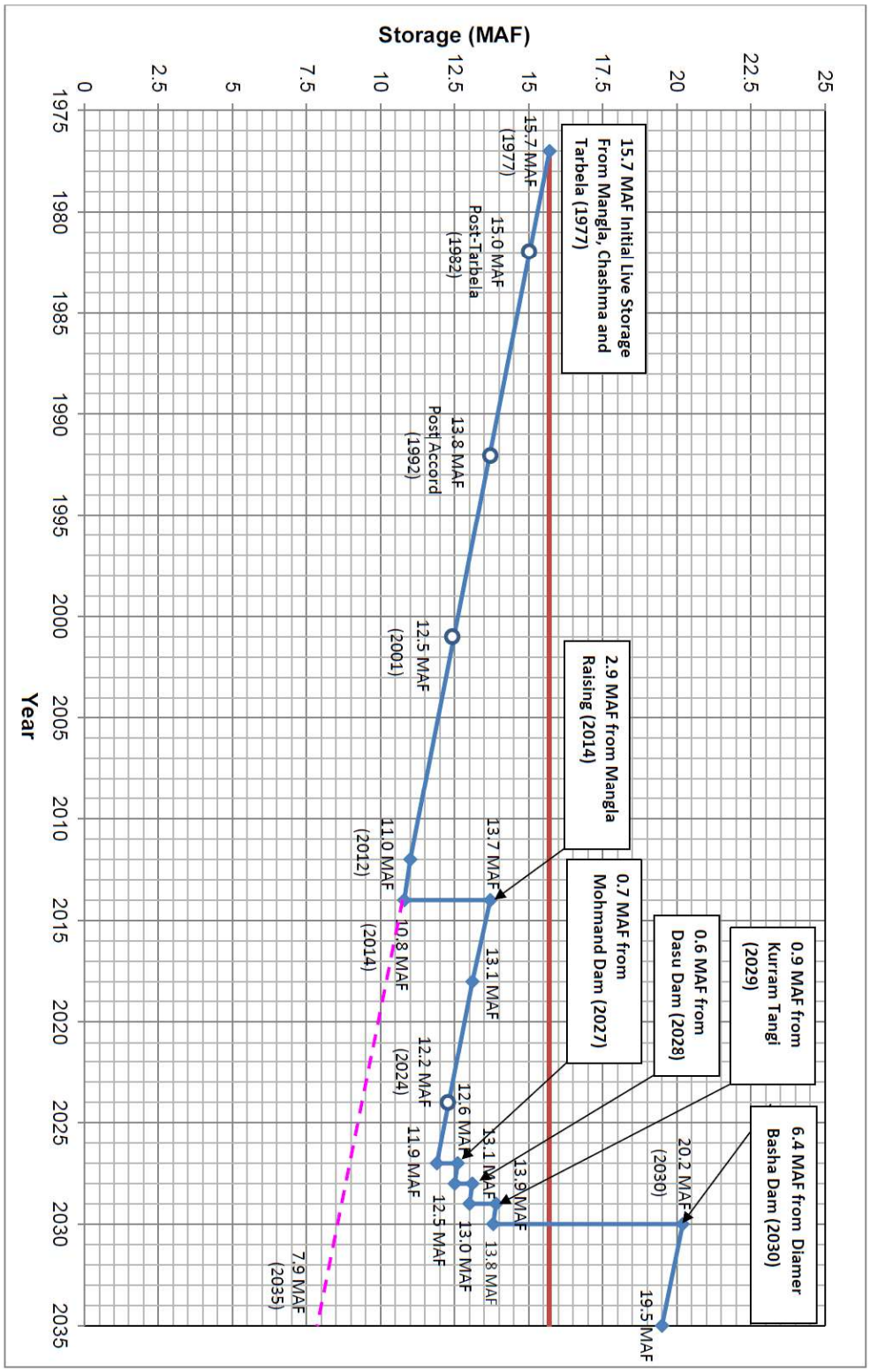
Year	Rim-Station Inflows [a]	Total Canal Head Withdrawals [b]	Outflow to Sea
1977-78	139.957	102.20	30.39
1978-79	183.448	96.24	80.59
1979-80	137.104	104.67	29.81
1980-81	145.229	106.94	20.10
1981-82	147.841	101.39	33.79
Average	**150.72**	**102.29 (105.3)** [c]	**38.94**
1982-83	128.317	103.23	9.68
1983-84	157.456	100.38	45.91
1984-85	139.641	101.02	29.55
1985-86	123.613	96.15	10.98
1986-87	152.985	106.07	26.90
1987-88	144.077	108.32	17.53
1988-89	177.981	104.87	52.86
1989-90	134.337	101.84	17.22
1990-91	176.017	109.53	42.34
1991-92	176.765	109.05	53.29
Average	**151.12**	**104.05**	**30.63**
1992-93	179.167	103.345	81.49
1993-94	133.876	111.144	29.11
1994-95	178.655	98.213	91.82
1995-96	173.996	104.698	62.76
1996-97	169.900	113.237	45.40
1997-98	151.693	104.355	20.79
1998-99	161.869	109.794	35.15
1999-00	132.131	105.666	8.83
2000-01	103.975	85.753	0.77
2001-02	99.048	77.249	1.93
Average	**148.43**	**101.35**	**37.81**
2002-03	118.886	91.085	2.37
2003-04	138.820	101.130	20.19
2004-05	113.538	85.923	0.29
2005-06	146.366	104.528	24.54
2006-07	144.347	97.853	21.72
2007-08	127.677	102.465	15.84
2008-09	122.966	95.406	5.82
2009-10	120.513	96.738	4.07

Year	Rim-Station Inflows a)	Total Canal Head Withdrawals b)	Outflow to Sea
2010-11	163.665	92.121	54.53
2011-12	125.393	94.459	14.12
Average	**132.22**	**96.17**	**16.35**
2012-13	125.506	93.637	6.01
2013-14	148.169	102.527	18.28
2014-15	138.785	107.021	6.86
2015-16	163.236	102.819	36.61
2016-17	135.155	105.920	10.57
2017-18	130.082	98.504	9.49
2018-19	113.648	88.435	1.79
2019-20	139.948	98.565	12.66
2020-21	127.818	100.618	15.25
2021-22	116.117	95.668	2.11
2022-23	118.738	75.643	42.15
2023-24	131.318	95.454	14.29
Average	**132.38**	**97.07**	**14.67**
(1977-78 to 2023-24)	**141.82**	**99.86**	**26.09**

a) Western Rivers (Indus at Kalabagh+Jhelum at Mangla+Chenab at Marala) and Eastern Rivers flows into Pakistan

b) Withdrawals from 1977-78 to 1981-82, include only gauged canals of NWFP (Now KP) while ungauged civil canal are excluded C) Total System withdrawals including 3 MAF of ungauged civil canals in NWFP (now KPK)

ANNEXURE 04


ACTUAL AND PROJECTED LIVE STORAGE CAPACITY OF ONLINE RESERVOIRS THROUGH 2035
Storage (MAF)
Year
15.7 MAF Initial Live Storage From Mangla, Chashma and Tarbela (1977)
2.9 MAF from Mangla Raising (2014)
0.7 MAF from Mohmand Dam (2027)
0.9 MAF from Kurram Tangi (2029)
0.6 MAF from Dasu Dam (2028)
6.4 MAF from Diamer Basha Dam (2030)
15.7 MAF (1977)
15.0 MAF Post-Tarbela (1982)
13.8 MAF Post Accord (1992)
12.5 MAF (2001)
11.0 MAF (2012)
10.8 MAF (2014)
13.7 MAF
13.1 MAF
12.2 MAF (2024)
12.6 MAF
11.9 MAF
13.1 MAF
13.9 MAF
12.5 MAF
13.8 MAF
13.0 MAF
20.2 MAF (2030)
19.5 MAF
7.9 MAF (2035)

ANNEXURE 05

INDUS BASIN IRRIGATION SYSTEM

BASIS FOR PROVIDING ADDITIONAL DEMANDS DURING SCARCITY

1. CANAL CAPACITY FACTORS

Month & 10 Daily Period	Average Canal Capacity Factor	Source of Water Supply	Remarks
Oct 1 to Mar 3	0.5	Storage	Existing flow-cum-storage fully committed
April 1 to 3	0.5	Flow-cum-Storage	Partial contribution from flow during high snowmelt conditions
May 1 to 3	0.8		
Jun 1 to Aug 3	1.0	Surplus Flow	Flow surplus also available for additional storage
Sep 1	1.0		
2	1.0		
3	0.8	Flow-cum-Storage	Including river channel gains after floods

2. ANNUAL RATIOS OF CANAL CAPACITY FACTORS BETWEEN SURPLUS FLOW AND SCARCITY PERIODS

1. Average Annual Canal Factor = $\frac{0.5x18+0.6x3+0.8x3+1x10+1+1+8}{36} = \frac{26}{36} = 0.72$
2. Accumulative Capacity Factors: -

   i. Scarcity Period (Sep 3 to May 3): 14
   ii. Surplus Flow Period (Jun 1 to Sep 1): 12

3. Ratio Between Requirement of Storage and Surplus Flow Periods = 0.54: 0.46≈ $\underline{0.6: 0.04}$